ERIA Research Project Report 2011, No.8

# ECONOMIC AND WELFARE IMPACTS OF DISASTERS IN EAST ASIA AND POLICY RESPONSES

Edited by
**YASUYUKI SAWADA**
**SOTHEA OUM**

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December, 2012

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This report consists of the papers from ERIA's research project on "Economic and Welfare Impacts of Disasters in East Asia and Policy Responses" in Fiscal Year 2011-12. It aims to improve our understanding on how the past and potential impacts of disasters on productions, demands, regional development, and welfare captured by income, poverty and health outcomes, and in depth analysis on economic policy implications at national and regional level. This project also aims at creating policy recommendations for reforms at the national level and explores the prospects for regional cooperation framework.

All papers presented in this report were presented in two workshops held in Jakarta and Bangkok in 2011 and 2012.

We would like to express our appreciation and gratitude, first and foremost, to the members of our project for their scholarly contribution to the completion of this research.

We are deeply indebted to Professor Fukunari Kimura, Chief Economist of ERIA, for his intellectual guidance, encouragement, and supports for the research project.

ERIA management support is crucial for the completion of this research. We are profoundly grateful for the strong support provided by our Executive Director, Prof. Hidetoshi Nishimura, and all esteem staffs of ERIA, especially Yunita Nababan and Fadriani Trianingsih for their excellent efforts to ensure the successful delivery of the project.

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**Yasuyuki Sawada**

**Sothea Oum**

# EXECUTIVE SUMMARY

Natural disasters, whether they occur in advanced or developing nations, can destroy people's livelihoods. Extreme natural and man-made events have recently hit both developed and developing countries. We see vividly the devastating and still ongoing 2011 earthquake, tsunami, and nuclear radiation crisis in Japan that has killed tens of thousands of people and resulted in damages of around US$200 to 300 billion. Hundreds of thousands of lives were lost in the Indian Ocean tsunami, Hurricane Katrina, and the earthquakes in central Chile, Haiti, the Sichuan province of China, northern Pakistan, and the Hanshin area of Japan. Disasters are created not only by nature but also by humans. The tsunami disaster in Tohoku was accompanied by a serious technological disaster involving a nuclear power plant's leaking radioactive matter. Economies around the world are still being impaired by the global financial crisis triggered by the 2008 Lehman Shock. Nations in Africa are still at war and involved in conflicts, and terrorist attacks are having serious impacts even on advanced nations. Natural and man-made disasters show distinct trends across the globe: Natural and technological disasters have been increasing more rapidly in frequency, in terms of the average occurrence of disaster per country per year, than financial crises and violence-related disasters.

As we continue our ceaseless efforts to recover from different disasters around the world, we are rediscovering the importance of advance preparations, such as drawing up emergency plans, disseminating and teaching emergency knowledge, conducting evacuation drills, constructing early warning systems, and investing in infrastructure.

Investments in physical infrastructure have been and will be indispensable as an ex ante risk management policy in strengthening resilience of individuals, households, communities, and a country. These investments include dams for flood control, seawalls and tsunami barriers, cyclone shelters, a barrier to control soil erosion, irrigation systems for droughts, earthquake-resilient houses and buildings, and disaster early-warning systems. Experiences of developed nations in the region such as Japan tell that investments in infrastructure dramatically reduced human and physical losses due to natural disasters. Multilateral and bilateral development partners can play an important role in filling the investment gap in these disaster-mitigation infrastructures in developing Asian countries.

While advanced nations can deal with a major disaster by managing their own domestic financial resources, developing nations, which carry diverse risks of major disasters, have weak fiscal groundwork and are less tolerant of such risks. Different disasters come in combination, as was the case with the Great East Japan Earthquake and conflicts in Africa. There are a few emerging innovative ideas to strengthen the complementarities among the market, the state, and the community in the context of disaster management and coping.

It is imperative to develop formal mechanisms to diversify aggregate disaster risks at national and regional levels. We may need to elaborate on multi-country risk pooling schemes, i.e., regional funds, to cover sovereign disaster risk. Against natural disasters, regional level index insurance such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF) and the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) can function effectively to support the disaster affected country with immediate liquidity in the aftermath of a catastrophic disaster, by using the insurance mechanism in addition to microcredit and microinsurance schemes to enhance the disaster resilience of individual households and firms. While regional index insurance schemes are based on public-private partnership (PPP), the microcredit and insurance programs are supported by informal community enforcement mechanisms. Complementarities among the market, the state, and the community will therefore be vital.

In the case of economic disasters in Asia, the Chiang Mai Initiative Multilateralisation (CMIM) has been and will continue playing an important role. The CMIM is a bilateral or multilateral currency swap arrangement involving pooling foreign exchange reserves, and was designed as an ex post coping mechanism in case of a financial crisis. Further development of Asian bond markets will also be indispensable, because bond markets are composed of a large number of individual bond holders, enabling idiosyncratic risks to be diversified away effectively, and it is generally considered that bond markets provide effective risk-sharing mechanisms. In order to diversify the shocks caused by disasters, developed bond markets can potentially play an important role.

To further improve national and regional risk management capabilities, a global system of pooling the risks of the four types of disasters would be effective for both developing and advanced nations wishing to diversify the risks of disasters. In other words, we should also work on the securities and reinsurance markets to develop a global disaster insurance system that would encompass various regional frameworks such as CCRIF, PDRFI, and CMIM beyond disaster types, i.e., natural, technological, economic, and violence related disasters.

When we consider the actual form of such a system, there are numerous issues involved. It is not clear, for example, whether it would be an institutionalized system such as a disaster fund, or something more flexible such as a coordination forum. Yet the Asian region has experienced diverse forms of disaster, including floods, typhoons, earthquakes, epidemics, and the financial crises of the late '90s. It is worth pursuing reforms that undertake comprehensive preparations against the risks of a variety of disasters in Asia.

# Economic and Welfare Impacts of Disasters in East Asia and Policy Responses

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## 1. Background

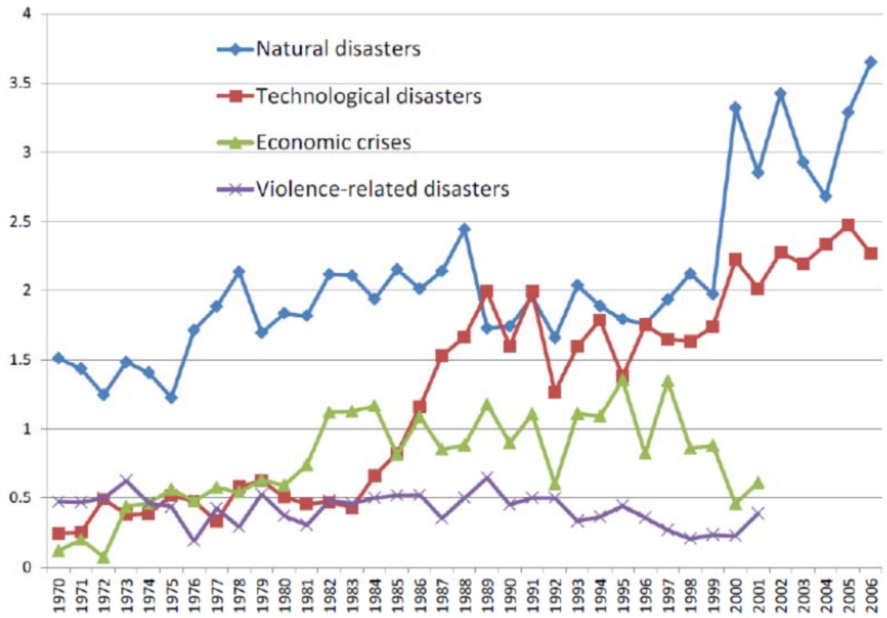
Natural disasters, whether they occur in advanced or developing nations, can destroy people's lives. There is no preventing the occurrence of natural disasters, whether earthquakes, tsunami, or typhoons. However, it is possible to prevent or at least mitigate damage arising from disasters, both in terms of the number of human casualties and economic impacts, and preparedness is what makes a key difference. Indeed, at the recent high-level forums in East Asia, such as the 4th East Asia Summit (EAS) in Cha-am Hua Hin, Thailand, held on 25 October 2009, the Fifth EAS on 30 October 2010 in Hanoi, Viet Nam, the Sixth EAS in Bali, Indonesia, on November, 2011, and the Seventh EAS in Phnom Penh, Cambodia, on November 2012, the leaders noted and reiterated the need to enhance disaster management cooperation for the region. The Special ASEAN-Japan Ministerial Meeting in April 2011 also emphasized the need to strengthen such cooperation through sharing of exercises and lessons-learned as well as conducting training and capacity building programs for disaster preparedness, emergency response, relief, and reconstruction efforts. The Chair's statement at the 18th ASEAN Summit held in Jakarta, Indonesia 7 - 8 May 2011, noted the potential trans-boundary impact of accidents at nuclear plants in the aftermath of the Fukushima incident. They agreed that ASEAN should engage as appropriate in information-sharing and promote transparency on relevant nuclear related issues in the region. The aim was to achieve the goal of building disaster-resilient societies and move towards a safer community by the year 2015. The 4th ERIA Governing Board Statement on June 3, 2011 also recognized that knowledge sharing and exchange of technologies relating to disaster risk management on a regional basis is essential.

In general, disasters can be classified into four major groups (Sawada and Shimizutani, 2008). The first type is natural disasters which comprise hydrological disasters (floods), meteorological disasters (storms or typhoons), climatological disasters (droughts), geophysical disasters (earthquakes, tsunamis and volcanic eruptions), and biological disasters (epidemics and insect infestations). The second type of disaster is technological disasters, i.e., industrial accidents (chemical spills, collapses of industrial infrastructure) and transport accidents (by air, rail, road or water transport). The final two disasters are manmade which include economic crises (hyperinflation, banking crisis, and currency crisis) and violence (terrorism, civil strife, riots, and war).

The Center for Research on the Epidemiology of Disasters (CRED) in Belgium, organizes detailed, long-term time series data on natural disasters per country. The Center also disseminates data on technological disasters. For economic crises and disasters resulting from the violence of war, Professors C. Reinhart of the University of Maryland and K. Rogoff of Harvard University (both in the U.S.) produce cross-country panel data.

Figure 1 shows the average occurrence of each of the four types of disaster per country per year. We can see that while natural and technological disasters are increasing rapidly, financial crises and war are maintaining stable patterns. Even so, they are not showing any trends toward reducing in frequency. These disaster trends indicate the importance of careful preparations in reducing the damage arising from disasters.

**Figure 1: Occurrence Frequency of Four Types of Major Disasters in the World (Average per Country)**




*Note*: Prepared by the author based on the database of the CRED (natural disaster and technological disaster) and the database of Professors Reinhart and Rogoff (economic crisis and war).

According to the World Disasters Report (2010), Asia is the continent most prone to disasters (see table 1). During the past decade Asia experienced more than 2,900 disasters (40% of the world total), affecting more than 2 million people (85%), killing more than 900,000 people (84%) and causing more than US$ 386 billion in damage (39%). Yet, availability of formal insurance mechanisms is quite diversified even across developed countries in the region, not to mention in developing nations. Cabinet Office (2011) reported that the total property losses of the Japanese earthquake tragedy in March 2011 would amount to more than US$ 200 billion or even 250 billion, but according to Munich Re (2012)[1] and World Bank (2012)[2], only US$ 40 billion or 16-20% of the overall damage was covered by private insurance. In the case of the Great Hanshin-Awaji Earthquake of Japan in January 1995, the insurance coverage rate was even lower (Sawada and Shimizutani, 2008). These figures can be compared with about US$ 13 billion of the US$ 16 billion in total property losses that was covered by private insurance in the case of the February 2011 earthquake in Christchurch, New Zealand.

**Table 1: Distribution of Disasters by Continent, Total Number of Disasters, People Affected, Deaths, and Damage from 2000 - 2009**

| | Total Number of Reported Disasters | Number of People Affected | Number of People killed | Estimated Damage (in millions of US dollars (2009 prices)) |
|---|---|---|---|---|
| Africa | 1,782 | 306,595 | 46,806 | 12,947 |
| Americas | 1,334 | 73,161 | 32,577 | 428,616 |
| **Asia** | **2,903** | **2,159,715** | **933,250** | **386,102** |
| Europe | 996 | 10,144 | 91,054 | 146,414 |
| Oceania | 169 | 658 | 1,665 | 12,612 |
| Total | 7,184 | 2,550,273 | 1,105,352 | 986,691 |

*Source*: The International Federation of Red Cross and Red Crescent Societies (2010)

Obviously, the costs of disasters would pose threats to both short and longer term development in the region, by disrupting production and flows of goods and services, worsening the balance of payments and government budgets, derailing economic growth, income distribution, and poverty reduction. Disasters also pose negative

[1] http://www.munichre.com/en/media_relations/press_releases/2012/2012_01_04_press_release.aspx
[2] http://wbi.worldbank.org/wbi/Data/wbi/wbicms/files/drupal-acquia/wbi/drm_kn6-2.pdf

effects on social structures and the environment.

In response to these emerging issues, this study intends to address the impacts of prevailing disasters on aspects of economies such as production, demand, and welfare in East Asia, and to draw economic policy implications at national and regional level. The study will cover the ASEAN +6 economies and will comprise chapters addressing two aspects: first, the past and potential impacts of disasters on production, demand, regional development, and welfare, captured by income, poverty and health outcomes and, second, in-depth analysis on the economic policy implications of disasters at national and regional level.

This project aims at creating policy recommendations for reforms at the national level and explores the prospects for a regional cooperation framework. Results from the study are expected to provide policy indications on how to improve the effectiveness of market and non-market disaster management systems within each country studied, as well as recommendations towards forging a framework for regional cooperation.

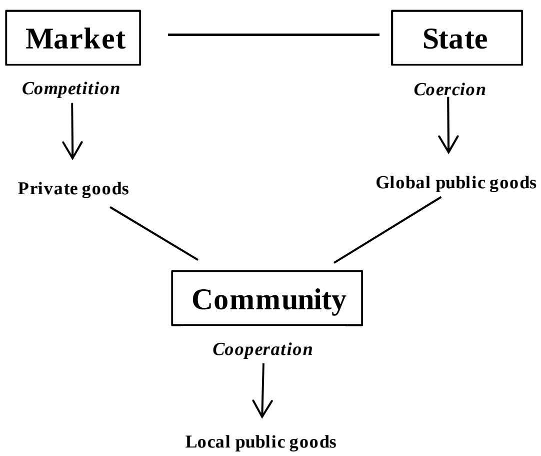
## 2. Overview of Chapters

This report is composed of five parts. First, five chapters discuss general aspects of a variety of ex ante risk management and ex post risk-coping mechanisms for dealing with disasters at community, national, and regional levels. Second, three chapters investigate the household-level welfare impacts of disasters by investigating the consumption poverty effect using household-level micro-data. Third, disaster impacts on production networks, urban management, and aggregate regional economies are examined. Fourth, two chapters focus on the health dimensions of natural disasters. Finally, four chapters investigate other issues of disaster management, such as agricultural development, food securities, and environmental sustainability.

### 2.1. Overall ex ante Risk Management and ex post Risk-coping Mechanisms for Dealing with Disasters at Community, National, and Regional Levels.

The general risk management and coping strategies mentioned above imply divided roles of market, state, and community.

**Figure 2: The Community, the Market, and the State in the Economic System according to Hayami (2009)**




*Source*: Hayami (2009)

According to Hayami (2009), the market is the mechanism that coordinates profit-seeking individuals and firms through competition using price signals (Figure 2). Naturally, the market has an advantage in matching the demand and supply of private tradable goods. The state is the mechanism that forces people to adjust their resource allocations by command of the government. Typically, the state plays an important role in supplying global or pure public goods. In contrast, the community is the mechanism that guides community members to voluntary cooperation based on intensive social interactions, facilitating supply of local public goods such as the provision of reciprocal social safety nets, the conservation of commons, e.g., village common land and local irrigation facilities and the enforcement of informal transactions.

Previous empirical studies can provide insights into how more effective disaster management can be facilitated by strengthening complementarities among markets functioning using price signals, state enforcement mechanisms, and the community informal insurance mechanisms. According to Kahn (2005), natural disasters occur in advanced and developing nations alike, but when a nation is democratized and has better governance, the number of casualties is drastically reduced owing to disaster risk information that is communicated and shared, well-developed early warning systems and infrastructure and other risk management mechanisms that are well planned to prevent or mitigate the impact of disasters. Since the insurance market for natural disasters is far from complete, the government plays an important role in disaster management and rehabilitation. For example, a report by the World Bank and the United Nations (2010) describes how Bangladesh, where frequent cyclones have affected several hundred thousand people, has significantly reduced the number of casualties by investing in emergency infrastructure such as improving its early warning system, which operates via radio, and building numerous cyclone shelters. Having noted this, Yang (2008) used data on the world's storms of the past 30-plus years to show that their economic damage has been enormous. That tells us that we should balance emergency information systems and infrastructure that prevent injury to people with market-based insurance systems that prevent economic damage, so as to prepare ourselves for natural disasters. In a study of the Chuetsu Earthquake, Ichimura, *et al.* (2006) found that earthquake insurance and public transfers had functioned quite well.

***In Chapter 1***, Sawada overviews different approaches towards an effective disaster risk coping strategy and regional cooperation on disaster management. He finds that advanced nations can deal with major disasters by managing their own domestic financial resources. But developing nations, which carry diverse risks of major disasters, have weak fiscal groundwork and are less tolerant of such risks.

In order to develop formal mechanisms to diversify aggregate disaster risks at national and regional levels, he suggests the need to elaborate on multi-country risk pooling schemes, i.e., regional funds, to cover sovereign disaster risk. Against natural disasters, index insurance at the regional level, such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF) and the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) can function effectively to support the disaster-affected country with immediate liquidity in the aftermath of a catastrophic disaster. He also discusses the roles of microcredit and micro-insurance schemes in enhancing the disaster-resilience of individual households and firms.

In the case of economic disasters, the Chiang Mai Initiative (CMI) has been and will continue playing an important role. Further development of Asian bond markets will also be indispensable, because bond markets are composed of a large number of individual bond holders, enabling idiosyncratic risks to be diversified away effectively, and it is generally considered that bond markets provide effective risk-sharing mechanisms. To further improve national and regional risk management capabilities, a global system of pooling the risks of the four types of disasters would be effective for both developing and advanced nations to diversify the risks of disasters.

Noy in ***Chapter 2*** discusses operational aspects in facilitating national and regional risk management capacities. He first presents a typology of disaster impacts that distinguishes between direct and indirect damage. He discusses indirect costs in the aggregate by examining variables such as GDP, fiscal accounts, consumption, investment, and the balances of trade and payments, and distinguishes between the short- and long- run.

The chapter concludes by identifying necessary future policy changes, in particular the construction of better and more robust early-warning systems, and suggests that the best way to incentivize disaster risk reduction (DRR) policy is through a dedicated fund- a Global Fund for DRR- that will support this work. Noy proposes that countries should be constantly evaluated for their DRR plans, and given 'Seals of Approval.' The evaluation process would allow a 'grading' of DRR policy and the allocation of the contingent 'seal of approval' for these policies. The positive externality from such a fund, with its associated monitoring and evaluation functions, would enable countries who receive this DRR 'seal of approval' to more easily insure themselves explicitly (with re-insurers) or implicitly by issuing Catastrophic Bonds (CAT bonds) and further enable multi-year insurance. All three developments (re-insurance, CAT bonds and multi-year) will be made easier by having a 'seal of approval', since that seal will alleviate investors/insurers concerns regarding the moral hazard generated by disaster-contingent financial support.

***In Chapter 3***, Nakata identifies the issues that would be central in designing a possible regional insurance scheme or mechanism for East Asia. The main focus is on the risk sharing mechanism for catastrophe risks to households in the region and providing a consistent explanation for apparent anomalies concerning the demand for catastrophe insurance within the subjective expected utility framework. The key finding is that the number of observations would inevitably be insufficient to warrant a robust probability estimate for a rare event. The inherent lack of such a robust probability estimate leads to diverse probability beliefs.

Nakata concludes that a desirable insurance scheme is the one such as an index-based insurance scheme which can eliminate any idiosyncratic shock generated by a catastrophe, given the possible moral hazard issues inherent to indemnity insurance. Moreover, since voluntary subscriptions are likely to lead to insufficient levels of insurance, an insurance scheme with subscriptions by local governments, in conjunction with *ex post* payments/compensation to the affected households, would be more desirable. However, the underwriting costs for index insurance may well not be low, whether the index insurance will be supplied and priced by insurance suppliers or traded on the capital market.

Chantarat *et al*. explores, in ***Chapter 4,*** innovations in index-based risk transfer products (IBRTPs) in depth as means of addressing important insurance market imperfections that have precluded the emergence and sustainability of formal insurance markets in developing countries, where uninsured natural disaster risk remains a leading impediment to economic development. The Chapter provides an analytical framework for, and empirical illustrations of the design of nationwide and scalable IBRTP contracts, to analyze hedging effectiveness and welfare impacts at the micro level, and to explore cost-effective risk-financing options. Thai rice production is used in the analysis, with the goal of extending the methodology and its implications in enhancing the development of national and regional disaster risk management in Asia.

Using household level data in estimating basis risk and so simulating contracts' hedging effectiveness, Chantarat, *et al*. find that the optimal provincial contract, based on basis risk, minimizing the combination of moving dry spell and excessive rain spell indices, could result in up to a 25% reduction in the variations of household income available for consumption. The return to scale in terms of cost effective portfolio pricing can be achieved as part of a nationwide, multi-seasonal coverage insurance program.

The transparency of these weather indices and control measures could in fact further promote the possibility of cost effective risk transfers in the international market. Numerical results on the potential impacts on household welfare, agricultural loan portfolios and government of this nationwide program under various market arrangements show that the purely market driven program was found to result in more than 50% reductions in the probabilities of household consumption collapsing to zero, in means and variations of five-year accumulated debt and annual loan default rates. Properly layering insurable nationwide risk, they further found public financing of tailed risk beyond the 20-30% capped to insurer's payout rates to result in substantial reduction in market premium rates. These in turn resulted in up to twice the impacts of the purely market-driven program, though with substantially smaller budget exposures for the government, relative to the current government program. There could thus be a strong case for public financing of tailed risk in enhancing development values and the market viability of Thailand's nationwide index insurance program.

Aldrich in ***Chapter 5*** investigates the new mechanisms through which social capital and networks assist with disaster recovery unlike traditional approaches which have focused primarily on factors external to disaster-affected communities.

These new mechanisms include the choice between “exit” and “voice” in the sense of Hirschman (1970); elimination of barriers to collective action; and provisions of informal insurance and mutual aid.

Through examples such as the 1923 Tokyo earthquake, the 1995 Kobe earthquake, the 2004 Indian Ocean tsunami, and the 2011 compound disaster in Tohoku, Japan, this Chapter seeks to underscore a potentially efficient and cost effective response to crises.

This chapter has suggested a new paradigm for thinking about disaster recovery and for designing emergency management responses. Moving beyond “bricks and mortar” approaches to recovery, it stresses that the ties between residents may serve as a critical engine during what may be a long and difficult recovery process. Rather than merely responding to disasters as they occur in the future, visionary decision makers in these and other countries should move to embrace a social-capital based approach to policy making. Bringing residents to the forefront and increasing community involvement in planning will ensure a strong future for these important countries.

## 2.2. Household Level Welfare Impacts of Disasters

This part starts with ***Chapter 6*** by Sann, *et al*. on Cambodia, who map the pattern of risks faced by the poor and vulnerable in rural areas of Cambodia, where the consequences of natural disaster are posing an increasing threat to their livelihoods. The damage caused by flood and drought is comparable, although the flood of 2011 was the most extensive of recent disasters. The Chapter presents the linking of social protection interventions to address the entitlement failure of poor and vulnerable people suffering from the negative impacts of flood and drought on welfare captured by household consumption. Since the data analyses in this chapter show that ex post supports from the government or NGOs were ineffective, there is a strong need at the policy level to design social protection interventions to emphasize ex-ante instruments rather than the ex post response to natural disasters, focusing on emergency assistance and relief. Cash transfer programs provide direct assistance in the form of cash to the poor. Ex-ante cash transfer programs can play a crucial role in strengthening poor households' resilience by encouraging them to invest in business rather than spending on food. Microfinance schemes can also facilitate ex-ante income diversification that can bolster households against widespread natural disasters.

***Chapter 7,*** Trung focuses on Vietnam which is located in one of the five cyclone centers on the planet and therefore is prone to many natural hazards. It is estimated that Vietnam is hit by 4.3 storms and more than 3 floods per year. This Chapter provides an evidence-based welfare assessment of natural disasters, and recommendations to policymakers, to help the country move toward effective disaster risk management. More specifically, the Chapter examines the welfare impact of Typhoon Damrey which hit Vietnam in September 2004 using the propensity score matching method applied to micro-data from the Vietnam Household Living Standard Survey (VHLSS) 2006. The Chapter finds that the storms greatly affect household welfare and livelihoods captured by rice production, household income, food expenditure, household expenditure and house repairs over the 12 months: While short-term aftermaths are tremendously high, the impact of natural disasters can also persist, bringing down living standards for some time. Based on a review of existing studies, the chapter suggests an array of recommendations with the hope that they can make positive contributions to the policy-making process in Vietnam, enabling it to achieve its declared goals. The recommendations focus on measures and approaches relevant for national implementation of effective programs such as the National Target Program to Respond to Climate Change (NTP-RCC) as well as regional collaboration such as adaptation and mitigation framework for South Asia to cooperate in climate change and food security policies.

***In Chapter 8***, Poaponsakorn analyzes the causes of Thailand's 2011 flood, its impact on agriculture and household expenditure and income, and the government's response. He finds that highest recorded rainfall, including five tropical storms, unregulated land-use patterns, and flood mismanagement are the causes of the major flooding in Thailand in 2011. Using 2009 and 2011 Socio-Economic Survey data, the empirical results show that the flooding caused significant negative welfare impact, reducing total household expenditures by 5.7% to 14%. These findings are consistent with the reported negative national GDP growth of 8.9 % in the fourth quarter of 2011. The study also finds that the 2011 floods had a negative impact on the money and wage incomes of some middle income households in the flooded areas.

The Chapter also finds several weaknesses in the current information for flood management. Despite the huge volume of information on the impact of flooding on output and damage to property, no government agency has paid attention to computerizing the flood data-base and information system and strengthening the capability of their information centers. As precautionary policy measures, important ideas need to be urgently implemented, notably construction of a digital elevation map, investment in satellite images, including updated land-use patterns, and the digitization of village boundaries. Moreover, the capability of statistical agencies and agencies responsible for flood management should be urgently strengthened in the following areas: data collection, data base development, data processing and reporting using IT, and human resource development. Secondly, these agencies should be encouraged to communicate and exchange information and ideas with other data users.

### 2.3. Disaster Impacts on Production Networks, Urban Management, and Aggregate Regional Economy

Ando in ***Chapter 9*** attempts to shed new light on domestic and international production networks in machinery industries, and examines how economic crises and natural disasters affected the networks, mainly from the viewpoint of Japan's exports. The Chapter finds that regardless of whether creating a demand or a supply shock, the economic or natural disasters revealed the stability and robustness of production networks in the machinery sectors. In order to respond to massive shocks, firms try to save costs by preserving existing transaction channels for parts and components. As a result, exports in machinery parts and components tend to be sustained and are likely to recover rapidly even if they are temporarily disrupted. Even the behavior of firms involved in the production networks and suffering from the floods in Thailand also confirms the existence of strong 'continuation' forces, and the deployment of efforts to keep production networks in being, in consideration of the various transaction cost implications of discontinuing a network.

Since once production networks are moved away from the original locations, it is not easy to get them back. It is also important to deal with various concerns in the business environment, lest private firms utilize the crisis as a trigger for removing production blocks to other countries.

***Chapter 10***, Layton examines New Zealand's history of natural disasters and its vulnerability to various types of disaster. The series of earthquakes that affected Christchurch, New Zealand's second largest city, between September 2010 and early 2012 is considered as a case study. The significant effects of the events on the population, labor market, reported crime, urbanization and location of businesses and production of the region are also described.

The case study suggests that New Zealand's arrangements for natural disasters worked well in most regards, given its comprehensive disaster monitoring and management regime. Lessons were also learnt leading to further improvement of the regime. The case study also highlights the advantage of international co-operation in search and rescue, maintaining security for people and property and victim identification in the response to natural disasters. It also suggests that while high rates and levels of disaster insurance ameliorate the financial impact of disasters, they can complicate the achievement of an effective recovery. This is because insurance funds increase the alternatives available to the affected population and investors, in respect of reinvestment and rebuilding the damaged region. The lag before insurers will accept new risks can also create delays and impede the momentum to recovery.

***In Chapter 11,*** Isono and Kumagai discuss the long term economic impact of natural disasters on the countries concerned by using the IDE/ERIA Geographical Simulation Model (GSM) constructed jointly by Institute of Developing Economies (IDE) and Economic Research Institute for ASEAN and East Asia (ERIA). Using IDE/ERIA-GSM and short-run forecasts, the authors estimate the seriousness of the flooding in Thailand in 2011 in relation to long term economic performance. Their simulation results show that the negative long-run impacts of the floods will be moderate, because many companies' first reaction to the floods was to seek relocation of their production site within Thailand.

They conclude that if the Thai government had not offered good recovery measures, such as facilitation measures to help firms move some production blocks from affected provinces, the flood's negative impacts would have been larger. The government should provide a good disaster insurance scheme, and develop tangible flood countermeasures. However, stimulating R&D activities and innovation is also indispensable. If Thailand had experienced an interruption in R&D activities, and other countries had gone ahead in 2011, the possible negative impacts compared to the baseline scenario would have been much larger.

### 2.4. Health Dimensions of Natural Disasters

Satapathy in ***Chapter 12*** provides a qualitative analysis of a broad range of issues in disaster psychosocial support and mental health services in India during the past two decades. The Chapter is limited to analysis of the issues in disasters caused largely by natural hazards. The impact of any disaster on the mental health of the survivors is enormous and affects the post-disaster reconstruction process directly and indirectly. Psychological and mental health services and interventions are very much country and culture specific, although the core recovery objectives and principles may remain similar and constant in all countries. The severity of symptoms is directly related to the magnitude and extent of trauma experienced, and the associated factors either aggravating life conditions or supporting the speedy recovery of the survivors in the aftermath of a disaster.

Evidence-based research in India reveals that to overcome the issues of inadequate mental health professionals, absence of institutional mechanisms for service provision and ambiguous financial provisions for the same, the existence of community-based psychosocial support and mental health services has been successful in past large scale disasters. Such community-based services, therefore, would perhaps remain as a viable, more culturally approved and less stigmatizing option available to the country. Nevertheless, the ASEAN countries are still evolving with their own successful models of post-disaster mental health care service provision. And learning from and adapting good practice prevailing in one country may result in expediting their initiatives in this regard. Regular experience-sharing platforms in this region would enable all the countries to overcome many challenges so as to achieve their objectives.

***Chapter 13*** by Lai and Tan is on Singapore, which is vulnerable to both natural and man-made disasters alongside its remarkable economic growth. They focus on lessons from Singapore's experience in fighting the 2003 SARS epidemic and discuss implications for future practice and research in disaster risk management.

Singapore's experience with SARS strongly suggests that risk mitigating measures can be effective only when a range of partners and stakeholders such as government ministries, non-profit organizations, and grass-roots communities become adequately involved. This is also critical to disaster risk management. Whether all of these aspects are transferrable elsewhere needs to be assessed in future research. Nonetheless, this unique discipline has certainly helped Singapore come out of public health crises on a regular basis. Singapore's response to the outbreak of SARS offers valuable insights into the kinds of approaches needed to combat future pandemics, especially in Southeast Asia.

### 2.5. Disaster Management in Agricultural Development, Food Security, and Environmental Sustainability

Chan reviews flood risk management in Malaysia in ***Chapter 14***. While Malaysia lies in a geographically stable region and is relatively free from natural disasters, it is affected by flooding, landslides, haze and other man-made disasters. Annually, flood disasters account for significant losses, both tangible and intangible. He finds that disaster management in Malaysia is traditionally almost entirely based on a government-centric top-down approach. The National Security Council (NSC), under the Prime Minister's Office, is responsible for policies, and the National Disaster Management and Relief Committee (NDMRC) is responsible for coordinating all relief operations before, during and after a disaster. In terms of floods, the NDMRC would take the form of the National Flood Disaster Relief and Preparedness Committee (NFDRPC). The NFDRPC is activated via a National Flood Disaster Management Mechanism (NFDMM). The NFDMM is largely targeted towards handling monsoon flooding. Consequently, this mechanism is less than effective and should be re-modeled into something more pro-active.

At the operational level of flood management, the Drainage and Irrigation Department (DID) is the responsible agency. However, being an engineering-based organization, the DID's approach is largely focused on structural measures in controlling floods. It needs to embrace a more holistic approach towards flood management via a multi-disciplinary effort. Non-structural measures are easy to implement, less expensive and community-friendly, and need to be employed more widely. There is also a need for greater stakeholder participation, especially from NGOs, at all levels in the disaster cycle. Capacity building for NGOs, local communities and disaster victims is also necessary. The disaster management mechanism should also adopt more non-structural measures, bring in state-of-the-art technology and cooperate internationally with other countries for addressing trans-boundary disasters.

In ***Chapter 15***, Lassa examines the impact of disasters and climate hazards on Indonesian agricultural and food crops. The findings are that natural catastrophes have already caused a great deal of loss. Loss accumulation over the last decade has caused significant leakage of central government funds and reduced agricultural production. The average rate of losses during 2003-2008 was 1%. Average area expansion was 2% per annum during the same period. This suggests that expansion is always held back by losses, by as much as 1%. Therefore, hazard mitigation and adaptation strategies are needed for all agricultural crops.

Flood management and water management in agricultural fields should be continuously integrated and sustained. In addition, it has become clear that earthquakes and tsunami mitigation in the agricultural infrastructure should also be considered. Global discourse concerning risk management for future drought, within the context of agricultural adaptation to climatic change, suggests needs for developing drought resistance seeds. Agricultural catastrophe insurance has been barely recognized in Indonesia. Most of the losses are therefore largely uninsured, suggesting the importance of new risk transfer mechanisms such as crop insurance programs. The challenge is to find ways of making such a policy a reality in the future in both the local and the national context.

In ***Chapter 16,*** Israel and Briones analyze the impacts of natural disasters (particularly typhoons, floods and droughts) on agriculture, food security and natural resources and the environment in the Philippines. In general, they found that: a) typhoons, floods and droughts have an insignificant impact on overall agricultural production at the national level, yet typhoons may have a significant negative impact on paddy rice production at the provincial level; b) typhoons such as Ondoy and Pepeng in 2009 have a significant negative impact on the food security of households in the affected areas; c) households have varying consumption and non-consumption strategies to cope with the impacts of typhoons; and d) the different impacts of typhoons, floods and droughts on the natural resources and environment have not been quantitatively assessed in detail, although available evidence suggests that these are also substantial.

Based on their results and findings, they recommend the following. First, since typhoons may have significant negative impacts on rice production at the local level as opposed to the national level, assistance for rice farmers and the agriculture sector as a whole should be made more site-specific, zeroing in on the affected areas that actually need it. Second, those assisting affected households and areas in overcoming the resulting ill-effects of natural disasters should consider not only consumption strategies, such as the provision of emergency food aid, but also non-consumption strategies, such as the provision of post-disaster emergency employment. Third, while the available evidence suggests that the natural resources and environment sector is significantly affected by natural disasters, it is currently of less concern, as attention is presently focused on agriculture. It may now be high time to provide concrete assistance to this sector, in particular the provision of defensive investments and rehabilitation expenditures to cope with natural disasters.

Wei, *et al*. focus on disaster risk management in China in ***Chapter 17***. Due to its complicated climatic and geographic conditions and distinct spatial-temporal variations, China is one of the countries which are severely hit by various kinds of natural disasters with high frequency and wide distribution. The Chapter analyzes the impacts of natural disasters on livelihood security of people, agriculture safety, and economic security in the past 30 years. They find a high vulnerability in China's economic system to natural disasters. Moreover, climate change will further exacerbate the vulnerability of the social-economic development system to natural disasters.

They conclude that in order to deal effectively with the high risk of natural disasters and build a low disaster risk society, there is an urgent need to implement a comprehensive strategy of disaster reduction for sustainable development. They advocate an integrated disaster risk management approach throughout the whole process of natural disaster management. China faces increasingly complex natural situations for disaster management but has insufficient experience both for creating appropriate institutions and for capacity building. Accordingly, capacity-building for comprehensive disaster prevention and reduction will have to be strengthened, and sustainable development coexisting with disaster risks need be realized, so as to reduce the vulnerability of the socio-economic development system to natural disasters.

## 3. Policy Implications

There is a set of important policy implications derived from papers presented in this volume. First, informal social safety net mechanisms based on community or local enforcement mechanisms should be strengthened and complemented through market and state involvement. In particular, microcredit and insurance programs should be promoted by government to facilitate consumption smoothing and livelihood sustainability among those affected by natural disasters.

Second, it is imperative to develop formal mechanisms to diversify aggregate disaster risks at national and regional levels. There may need to be increased multi-country risk pooling schemes, for example regional funds, to cover sovereign disaster risk. Against natural disasters, regional level index insurance schemes can be designed through public-private partnership (PPP) such as index type risk-transfer mechanisms sold by private insurer with extreme losses underwritten by contingent loan schemes of international financial institutions and aid donor agencies to complement the lack of re-insurance coverage. Third, to further improve national and regional risk management capabilities, a global system of pooling the risks of the different types of disasters, such as natural and technological disasters, economic crisis, and conflicts, would be effective for both developing and advanced nations wishing to diversify the risks of disasters. It is also worth pursuing reforms that undertake comprehensive preparations against the risks of a variety of disasters in Asia.

Fourth, complementarities among the market, the state, and the community will be the key. The market is a resource allocation mechanism using price signals, the state is the mechanism based on legal enforcement, and the community is a mechanism based on social norms. Overall safety nets against natural disasters should be provided by an optimal mix of these resource allocation mechanisms. For example, market-based microinsurance programs could be supported by community and state enforcement mechanisms, and regional disaster funds could utilize insurance market transactions. Overall, however, intra-regional state cooperation is indispensable for East Asia.

Finally, investments in physical infrastructure are indispensable as an ex ante risk management policy in strengthening resilience of individuals, households, communities, and a country. These investments include dams for flood control, seawalls and tsunami barriers, cyclone shelters, a barrier to control soil erosion, irrigation systems for droughts, earthquake-resilient houses and buildings, and disaster early-warning systems. Experiences of developed nations in the region such as Japan tell that investments in infrastructure dramatically reduced human and physical losses due to natural disasters. Multilateral and bilateral development partners can play an important role in filling the investment gap in these disaster-mitigation infrastructures in developing Asian countries.

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# CHAPTER 1

# Approaches towards Effective Disaster Risk-coping Strategies and Regional Cooperation on Disaster Management

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## 1. Introduction

Natural disasters, whether they occur in advanced or developing nations, can destroy people's livelihoods. Extreme natural and man-made events have recently hit both developed and developing countries. Witness the ongoing effects of the devastating earthquake, tsunami, and nuclear radiation crisis in the Tohoku region of Japan, that has killed tens of thousands of people and resulted in damage of around US$200 to 300 billion (Cabinet Office, 2011). Hundreds of thousands of lives were also lost in the Indian Ocean tsunami, Hurricane Katrina, and earthquakes in central Chile, Haiti, the Sichuan province of China, northern Pakistan, and the Hanshin area of Japan. Disasters are created not only by nature but also by humans. The tsunami disaster in Tohoku was accompanied by a serious technological disaster involving a nuclear power plant's leaking radioactive matter. Around the world, economies are still being suffering from the global financial crisis triggered by the 2008 Lehman Shock. Nations in Africa are still at war and involved in smaller conflicts, and terrorist attacks, and the threat of terrorist attacks are having serious impact even on advanced nations. Natural and man-made disasters show distinct rising trends across the globe: Natural and technological disasters have been increasing more rapidly in frequency, in terms of the average occurrence of disaster per country per year, than financial crises and violence-related disasters (Cavallo & Noy, 2009; Kellenberg & Mobarak, 2011; Strömberg, 2007).

As we continue our ceaseless efforts to recover from different disasters around the world, we are rediscovering the importance of advance preparations, such as drawing up emergency plans, disseminating and teaching emergency knowledge, conducting evacuation drills, constructing early warning systems, and investing in infrastructure. Moreover, we began to realize the importance of risk finance schemes such as individual- and national-level parametric insurance arrangements as an indispensable part of ex ante interventions. How should we protect ourselves and the people of the entire world from catastrophe? In this Chapter, we will summarize different approaches towards effective disaster risk-coping strategies, and regional cooperation on disaster management.

This Chapter is organized as follows. In Section 2, we set conceptual framework of disaster risk management and coping mechanisms/strategies. Section 3 discusses innovative frameworks such as microcredit, microinsurance, and regional insurance pooling scheme to strengthen ex ante risk management capacities. In Section 4, we summarize policy implications to enhance effective insurance capacities by encompassing schemes against a variety of natural and man-made disasters.

## 2. Conceptual Framework

### 2.1. Household-level Strategies

In response to the wide variety of shocks caused by natural and manmade disasters, households have developed and employ formal and informal insurance mechanisms. We classify such uses of insurance mechanisms into ex ante risk management and ex post risk-coping behaviors. First, household risk management strategies are defined as activities for mitigating risk and reducing income instability before the resolution of uncertainties. These strategies might include investments in earthquake-proof housing, an insurance contract subscription, and access to an early-warning system. It has been known that these ex ante management strategies are cost-effective instruments to mitigate losses due to disasters (World Bank and United Nations, 2010). This is driven mainly by the significance of the welfare costs of disaster risks. Using the framework of the Arrow-Pratt risk premium, we can capture the negative welfare costs of risks by calculating how much money households would be willing to pay to completely eliminate income variability. Mathematically, such an amount of money is represented by *m* which satisfies the following relationship: $u(\bar{y}-m)=E[u(\tilde{y})]$ , where $u(\cdot)$ is a well-behaved utility function, $\tilde{y}$ is a stochastic income, $\bar{y}$ is its mean value, and the variable *m* represents a standard risk premium. Taking a first-order Taylor expansion of the left-hand-side around *m*=0 and a second-order Taylor expansion of the right-hand-side around the mean income gives:

$$\frac{m}{\bar{y}} = \frac{1}{2}\underbrace{\left(-\frac{u''(\bar{y})\bar{y}}{u'(\bar{y})}\right)}_{\text{Coefficient of RRA}} \times \underbrace{\left(\frac{\sqrt{Var(\tilde{y})}}{\bar{y}}\right)^2}_{\substack{\text{Coefficient of} \\ \text{Variation}}},$$

This indicates that, approximately, the fraction of average income that a household would be willing to give up can be calculated as half of the coefficient of relative risk aversion multiplied by the square of the coefficient of variation of income. Sawada (2007) shows the estimated welfare costs of risks in India and Pakistan. These results indicate that the welfare cost of risks is at least 10% and can be 30-50% of household income. Since natural and manmade disasters can generate larger income volatilities than these income fluctuations, the welfare costs estimated here may be regarded as lower-bound estimates of the negative welfare impacts of natural or manmade disasters.

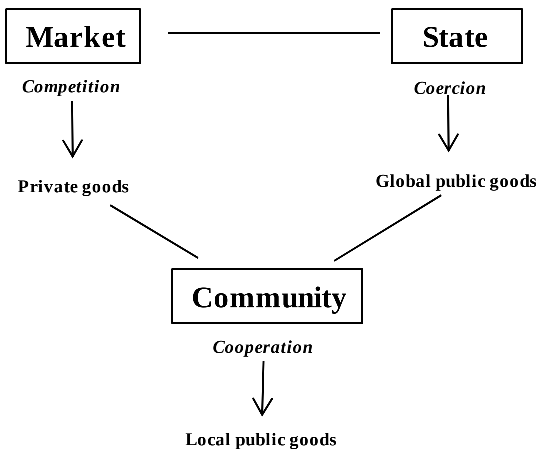
These figures indicate the importance of ex ante risk management mechanisms and strategies in reducing the welfare costs of disasters. However, it is often difficult by nature to elaborate such mechanisms and strategies because the disasters are typically characterized by rare events, and sometimes even worse, they are unforeseen. Also, disaster risks may be correlated in nature, which could not be diversified away within a region or country. Thus, the aggregated macro welfare cost can be non-negligible. Indeed, Barro (2009) found that macro welfare loss due to disasters can be as large as 20% of welfare. The significance of potential risk management implies two important issues. First, it is indispensable for government to strengthen national and regional level market and non-market insurance mechanisms against natural disasters. Second, risk-coping strategies become important because even if households, communities, and governments adopted a variety of risk management strategies, a disaster can happen unexpectedly, causing serious negative impacts on household welfare.

Accordingly, against these unexpected natural disasters, it is indispensable for people to adopt ex post risk-coping strategies which are defined as ex post strategies to reduce consumption fluctuations and to maintain desirable levels of livelihood. In general, the existing literature identifies the following different mechanisms for coping with risk. First, households can employ different market mechanisms, such as credit markets, to reallocate future resources to today's consumption, insurance market transactions to eliminate losses resulting from disasters, and ex post labor market participation to utilize market returns to human capital. Second, people can adopt self-insurance mechanisms such as consumption reallocation by cutting back luxury expenses while maintaining total calorie intakes and dis-saving financial and physical assets, i.e., utilization of precautionary saving. Finally, households can adopt non-market insurance mechanisms such as public transfers from the government, and informal private aids from networks based on extended family, relatives, and communities. Against unexpected natural disasters, ex post risk-coping is indispensable

### 2.2. The Market, State, and Community Triangle in Disaster Management and Coping

The general risk management and coping strategies mentioned above imply the divided roles of market, state, and community as elaborated by Hayami (2009). As is shown in Figure 1, the economic system is composed of three domains, *i.e.*, market, state, and community, interacting with each other.

**Figure 1: The Community, the Market, and the State in the Economic System: A Framework by Hayami (2009)**




*Source*: Hayami (2009)

According to Hayami (2009), the market is the mechanism that coordinates profit-seeking individuals and firms through competition using price signals. Naturally, the market has an advantage in matching the demand for and supply of private tradable goods. The state is the mechanism that forces people to adjust their resource allocations by command of the government. Typically, the state plays an important role in supplying global or pure public goods. In contrast, the community is the mechanism that guides community members to voluntary cooperation based on intensive social interactions, facilitating supply of the local public goods such as the provision of reciprocal social safety nets, the conservation of commons, and the enforcement of informal transactions.

To address the roles of the market, the state, and the community in facilitating disaster management and coping, it will be useful to classify two different types of risks by the level at which they occur, i.e., idiosyncratic and aggregate risks. Idiosyncratic risks affect specific individuals and/or firms while aggregate shocks affect groups of households, an entire community and region, or a country as a whole. This distinction is important because the geographic level at which risks arise determines the effectiveness of market and non-market institutions in dealing with risk.

On the one hand, a risk that affects a specific individual can be traded with other people in the same insurance network through informal mutual insurance and a well-functioning formal insurance or credit market. In the last two decades, micro-development economists have shown that households have, to some extent, developed formal and informal risk-coping mechanisms against a wide variety of idiosyncratic risks (Townsend, 1994). The community-based mutual insurance mechanism can be effective, provided that all the members contribute due informal insurance premiums, according to the principle of reciprocity dictated by customs and norms (Hayami, 2009). The community can enforce the collection of due contributions from community members by means of the reputation/opprobrium/ostracism mechanisms. In short, the community can play an important role in weathering losses caused by natural disasters, if such losses are largely idiosyncratic.

Yet, according to the NatCatService data of one of the largest reinsurance companies, Munich Re, the proportion of insured losses of overall losses caused by disasters in the world is quite limited, around 20% on average.[1] Currently, formal insurance mechanisms combating natural disasters are quite limited. Indeed, studies based on micro-data show the overall ineffectiveness of formal and informal insurance mechanisms in dealing with natural disasters (Kohara, *et al.*, 2006, Sawada & Shimizutani, 2007 & 2008).

On the other hand, a risk that affects an entire region cannot be insured within the region and thus community mechanisms can only function imperfectly. Natural, technological, and manmade disasters are likely to fall into this category of aggregate or covariate risks. As we have seen, efficient risk sharing mechanisms are likely to be absent, especially for a natural disaster as a rare, covariate event. In fact, the extent to which a risk is idiosyncratic or correlated depends considerably on the underlying causes. These risks should be covered by well-designed formal market or similar arrangements backed by the public enforcement mechanisms in which region-specific risks are diversified away across regions. If these mechanisms cannot work properly or are difficult to set, households are forced to insure themselves against shocks by using self-insurance measures. For example, by analyzing a 1998 survey of areas

[1] In the formal insurance market, the insurers need international reinsurance markets to pool disaster risks. Yet, it is known that reinsurance markets and trades of catastrophe (CAT) bonds are still thin.

affected by Hurricane Mitch, Morduch (2004) found that for 21% of households, the main response to the hurricane was not to use savings, nor to borrow money; the main response was a drastic reduction in consumption. This suggests that these households are constrained from borrowing against shocks. By investigating how victims of the Great Hanshin-Awaji (Kobe) earthquake in 1995 coped with their unexpected losses, Sawada and Shimizutani (2005) found that households without borrowing constraints can borrow and/or dissave to respond to damages caused by the earthquake, while those under a constraint are unable to cope with housing losses effectively.

## 3. Towards Effective Disaster Risk-coping and Regional Cooperation on Disaster Management

To facilitate more effective disaster management by strengthening complementarities among the market functioning under the price signals, the state enforcement mechanisms, and the community informal insurance mechanisms, we can learn insights from previous empirical studies. According to Kahn (2005), natural disasters occur in advanced and developing nations alike, but when a nation is democratized and has better governance, the number of casualties is drastically reduced owing to disaster risk information that is communicated and shared, early warning systems that are developed, and infrastructure and other risk management mechanisms that are well developed to prevent or mitigate the impact of disasters. Since the insurance market for natural disasters is far from complete, the government plays an important role in disaster management and rehabilitation. For example, a report by the World Bank and the United Nations (2010) describes how Bangladesh, where frequent cyclones have affected several hundred thousand people, has significantly reduced the number of casualties by investing in emergency infrastructure such as improving its early warning system, which operates via radio, and building numerous cyclone shelters. Having noticed this, Yang (2008) used data on the storms around the world of the past 30-plus years to show that the economic damage has been enormous. This tells us that, to prepare ourselves for natural disasters, we should balance emergency information systems and infrastructure that prevent damage to people with market-based insurance systems that prevent economic damage. In a study of the Chuetsu Earthquake, Ichimura, *et al.* (2006) found that earthquake insurance and public transfers had functioned quite well.

**Innovative Ideas**

There are a few emerging, innovative ideas which strengthen the complementarities among the market, the state and the community in the context of disaster management and coping. Here, we discuss microcredit and microinsurance.

*Microcredit*

While it has been rather long known that the remarkable performance of microcredit programs is based on community enforcement mechanisms, multiple roles of microcredit have been identified in the recent literature. Poor households are not just struggling entrepreneurs using microcredit programs for business facilitation. They are complicated households seeking to manage expenses (consumption credit), cope with emergencies (disaster protection), and seize opportunities. Potentially, microcredit programs can play a role in disaster insurance: For example, most micro-finance institutions in Bangladesh introduced a flexible repayment system in 2002, which permits members to reschedule installments during disasters. Also, a Bangladesh microfinance institution, BURO Tangail, initiated a special loan program called "disaster loan" for disaster affected clients in the wake of the disastrous floods of 1998 (Wright & Hossain, 2001). Such a loan program can function effectively as an ex post risk-coping instrument for disaster-affected individuals in poor regions.

*Microinsurance*

Another innovative idea is to use a new microinsurance program called "index insurance" or "parametric insurance contracts" which are written against specific aggregate events such as drought or flood defined and recorded at a regional level (Hazell, 2003; Morduch, 2004; Skees, *et al.*, 2004). This type of insurance pays out on storms that exceed a pre-designated speed, rainfall that falls short of a threshold level, and earthquakes that exceed a certain seismic intensity. It is an excellent system that alleviates the time and costs required by conventional indemnity-based insurance systems to assess damage.

As such, index insurance involves a number of positive aspects; they can cover the aggregate correlated events; they are affordable and accessible even to the poor; they are easy to implement and privately managed; and they are free from the moral hazard, adverse selection, and high transaction costs that have plagued traditional agricultural insurance contracts such as crop insurance schemes. The World Bank and other institutions have been piloting weather-based index insurance contracts in Morocco, Mongolia, Peru, Vietnam, Ethiopia, Guatemala, India, Mexico, Nicaragua, Romania, and Tunisia.

Since natural disasters are typically aggregate events, index insurance is thought to be an appropriate instrument to combat them. Yet, there are three major constraints to designing index-type insurance against natural disasters. First, natural disasters are often characterized by a rare event which makes it difficult to design actuarially fair insurance. Since obtaining historical data on the pattern of natural disasters is hard, it is almost impossible to set appropriate premiums for insurance.

Secondly, and related to the first issue, even if appropriate premiums are set, the poor who potentially should demand insurance against natural disasters may find it difficult to recognize the value of index-type insurance against natural disasters. This may be inevitable, because natural disasters are often characterized by unforeseen contingencies by their very nature, and because the poor seem often to be myopic, with high time-discount rates. Indeed, human beings do tend to ignore rare bad events (Camerer & Kunreuther, 1989). Moreover, the existence of the “basis risk” with which an individual could incur damage but cannot be compensated sufficiently, will also deter demand for index insurance. This problem has been identified as an inevitable drawback of index insurance because index contracts essentially tradeoff basis risk for transaction costs (Morduch, 2004; Hazell, 2003).

Nakata, *et al.* (2010) utilize a unique survey dataset collected jointly by the Research Institute of Economy, Trade and Industry (RIETI) of Japan and the Center for Agricultural Policy in Vietnam (CAP), which they call the RIETI-CAP survey. The dataset is a resurvey of subsamples of the Vietnam Household Living Standards Survey (VHLSS) 2006 households. They employ hypothetical questions on avian influenza

(AI), flood (FL), and drought index insurance in Vietnam. According to their analysis of this unique data set, a past experience dramatically increases the probability assessment of the event (10 and 100 times for AI and FL) and willingness to pay (WTP) for the insurance (30% and 50% for AI and FL). A first loss experience tends to have a large impact on the subjective loss probability, and consequently on the willingness to pay for insurance, especially for flooding insurance (both index and indemnity-based insurance). This indicates that it would be less likely for a household with no past loss experience to purchase flooding insurance, even if the insurance premium is actuarially fair in accordance with the loss probability model of the insurance supplier.

They also found that people may not behave in accord with the subjective expected utility framework as far as AI insurance is concerned. In other words, it is not clear that the subjective loss probability drives the behavior of the people concerning AI insurance. This is not very surprising, since AI involves mutations of viruses, and so there are possible unforeseen contingencies. This makes it harder to agree on the terms and conditions of insurance.

*Index Insurance as a Mitigation Device in Human-Made Disasters*

Miguel, *et al.*, (2004) use data from 41 countries in Africa from 1981to 1999 to find a robust causality between drought, a type of natural disaster, and conflict, a type of human-made disaster. This signifies that preventative action taken against natural disasters could also prevent conflicts. Today, we are capable of issuing early warnings of drought risk based on rainfall measurements and vegetation indices obtained from satellite images. Accordingly, Miguel (2009) proposes a new type of foreign aid-Rapid Conflict Prevention Support (RCPS), which would reduce the risk of conflicts by using this information to estimate droughts and natural disasters, and by transferring aid immediately. Foreign aid provisions would be targeted to drought or other disaster vulnerable countries beforehand. Indeed, Botswana, Africa's economic superstar for the past 40 years, has been implementing a Drought Relief Program (DRP). It can safely be said that the drought insurance played an important role in its success (Miguel, 2009).

*Regional Index Insurance*

Index insurance or parametric insurance can be designed for disaster risk pooling at regional level. One example is the Caribbean Catastrophe Risk Insurance Facility (CCRIF), which is a parametric, multinational hazard insurance fund for hurricanes and earthquakes that works with the international reinsurance market and was established as the first of its kind in the world. Haiti was a member of the Facility, and after the Haiti Earthquake in January 2010, the government received $7.75 m in earthquake insurance - around twenty times its premium - as soon as two weeks after the quake. While the amount is not necessarily significant, the Haiti government received insurance payouts very quickly, indicating the importance of preparing a new insurance system such as CCRIF.

Another example is the Pacific Disaster Risk Financing and Insurance Program which builds on the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) through a joint initiative between the Secretariat of the Pacific Community (SPC/SOPAC) founded in 2007, the World Bank, and the Asian Development Bank, with financial support from the Government of Japan and the Global Facility for Disaster Reduction and Recovery (GFDRR). PCRAFI aims to enhance the disaster risk management and to reduce the financial vulnerability of the Pacific Island Countries (PICs) against natural disasters. It will do this by improving their financial response capacities while protecting their long term fiscal balances.

The PDRFI Program provides the PICs with tailor-made advisory services for disaster risk modeling and assessment tools, financial instruments for national disaster risk financing and insurance strategies, and catastrophe risk insurance market development.[2] There are three project components. The first component is institutional capacity-building for disaster risk financing through setting national disaster risk financing strategies, and technical assistance to design and implement their integrated financial strategy against natural disasters. The second component is Pacific

[2] Countries receiving technical assistance in disaster risk financing and insurance through the PDRFI Program include Papua New Guinea (PNG), Fiji, the Solomon Islands, Vanuatu, Samoa, the Federal States of Micronesia (FSM), Tonga, Kiribati, the Republic of the Marshal Islands, Palau, the Cook Islands, Tuvalu, Nauru, Niue and Timor-Leste. The Pacific catastrophe risk insurance pilot was launched in November 2012 with Vanuatu, Tonga, the Marshall Islands, the Solomon Islands, and Samoa.

disaster risk insurance market development, aiming to offer technical assistance to improve disaster risk insurance solutions in the Pacific. The final component is the Pacific Disaster Risk Financing and Insurance (PDRFI) Pilot Program which is piloting natural disaster derivatives aimed at serving as support measures for disaster prevention and disaster mitigation through a Public-Private Partnership (PPP). The Pacific Disaster Risk Financing and Insurance Program is the first of a series of applications of PCRAFI to be developed in disaster risk management and urban/infrastructure planning.

As part of Japan's international cooperation in disaster prevention, the Japanese government announced it would "establish an insurance system as natural disaster support in Pacific island countries" at the 6th Pacific Islands Leaders Meeting (PALM) held in May 2012. Accordingly, this program was established in collaboration with Pacific island countries (governments), the World Bank and private-sector insurance companies.

Let us also touch upon preparations for economic crises. The Group of Twenty nations/regions (G20) and other meetings are discussing the installation of an early warning system that predicts and helps to counter the currency and financial crises that have occurred frequently since 1990. But as Rose & Spiegel (2011) points out, current research has not yet developed a sufficiently reliable early warning system. Preparations for economic crises, however, have been enhanced. In 2009, for example, the International Monetary Fund (IMF) established a new prevention facility against economic crises. In the East Asia region, the Chiang Mai Initiative (CMI), a bilateral currency swap agreement to be implemented in times of a currency crisis, expanded to a multilateral framework (CMIM) in 2010.

## 4. Policy Implications

Advanced nations can deal with a major disaster by managing their own domestic financial resources. But developing nations, which carry diverse risks of major disasters, have weak fiscal groundwork and are less tolerant of such risks. Different disasters tend to come in combination, as was the case with the Great East Japan Earthquake and conflicts in Africa.

First, it is imperative to develop formal mechanisms to diversify aggregate disaster risks at national and regional levels (Table 1). We may need to elaborate on multi-country risk pooling schemes, i.e., regional funds, to cover sovereign disaster risk. Against natural disasters, regional level index insurance such as CCRIF and PDRFI can function effectively to support the disaster affected country with immediate liquidity in the aftermath of a catastrophic disaster, by using the insurance mechanism. Microcredit and microinsurance schemes can also enhance the disaster resilience of individual households and firms. While the regional index insurance schemes are based on PPP, the microcredit and insurance programs are supported by informal community enforcement mechanisms. Hence, complementarities among the market, the state, and the community will be the keys to success.

In the case of economic disasters, the Chiang Mai Initiative (CMI) has been and will be playing an important role. CMI is a bilateral or multilateral currency swap arrangement pooling foreign exchange reserves, and was designed as an ex post coping mechanism against a financial crisis. Further development of Asian bond markets will also be indispensable because bond markets are composed of a large number of individual bond holders, and idiosyncratic risks can therefore be diversified away effectively. It is generally considered that bond markets form effective risk-sharing mechanisms. In order to diversify the shocks caused by disasters, developed bond markets can potentially play important roles.

To further improve national and regional risk management capabilities, a global system of pooling the risks of the four types of disasters would be effective for both developing and advanced nations needing to diversify the risks of disasters. In other words, we should also work on the securities and reinsurance markets to develop a global disaster insurance system that would encompass various regional frameworks such as CCRIF, PCRAFI, and CMIM beyond existing disaster types.

When we consider the actual form of such a system, there are numerous issues involved, such as whether it would be an institutionalized system like a disaster fund, or something more flexible such as a coordination forum. Yet the Asian region has experienced diverse forms of disasters, including floods, typhoons, earthquakes, epidemics, and the financial crises of the late '90s. It is worth pursuing reforms that undertake comprehensive preparations against the risks of a variety of disasters in Asia.

**Table 1: Towards Effective Disaster Risk-coping Strategies and Regional Cooperation: A Summary**

| | | | | |
|---|---|---|---|---|
| **Disaster type:** | Natural | Technological | Wars and Conflicts | Economic |
| | ↓ | ↓ | ↓ | ↓ |
| | **Overall effectiveness of market and non-market insurance mechanisms** | | | |
| | ↑ | ↑ | ↑ | ↑ |
| **Ex post risk-coping:** | Credit and labor market, and transfers | ? | Drought insurance | Consumption reallocation, labor, and transfers |
| | ↑ | ↑ | ↑ | ↑ |
| **Policy instruments I: (for each disaster)** | Microcredit/microinsurance | ? | Early warning system | Early warning system |
| | \| | \| | \| | \| |
| **Policy instruments II:** | **Global/regional pooling facility?** | | | |

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# CHAPTER 2

# Natural Disaster and Economic Policy for ASEAN and the Pacific Rim: A Proposal for a Disaster Risk Reduction 'Seal of Approval' Fund

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*Many of the most destructive natural disasters of the past few decades occurred in ASEAN or other Pacific Rim countries. Even without these catastrophic infrequent events, some ASEAN members are buffeted by repeated and very frequent natural disasters; and many are very vulnerable to future disasters associated with the changing climate. Understanding the impact of disasters on development, on the spatial evolution of income, and the risks that the region faces in terms of future events and their likely consequences all seem to be important components of an understanding of the region's economy. The chapter employs a typology of disaster impacts that distinguishes between direct and indirect damages; with the indirect costs accounted for in the aggregate by examining variables such as GDP, the fiscal accounts, consumption, investment, and the balance of trade and the balance of payments. These costs can also be further divided between the short- and long-run. These distinctions are used in the discussion that analyzes vulnerabilities in the ASEAN region. The chapter concludes by identifying needed future policy changes, in particular the construction of better and more robust early-warning systems, and suggests that the best way to incentivize disaster risk reduction (DRR) policy is through a dedicated fund, a Global Fund for DRR, that will support this work.*

***Keywords***: ASEAN, Pacific Rim, natural disasters, indirect impacts, global fund.

## 1. Disasters in South-East Asia

Many of the most destructive natural disasters of the past few decades occurred in Pacific Rim countries. During the past century for example, the most lethal earthquake (Tangshan, China, 1976), the most lethal tsunami (Aceh, Indonesia, 2004), and some of the most lethal storms and floods have all occurred in Asia bordering the Pacific.[1] Other catastrophic natural disasters like the exceptionally strong earthquake in Chile in 1960 that generated a Pacific-wide tsunami, the most destructive natural disaster in modern history in terms of destroyed property (Tohoku, Japan, 2011), or the Mexico City earthquake of 1985, are all examples of how natural disasters play a significant part in the economies of almost all the Pacific Rim countries.

Even without these catastrophic infrequent events, some Pacific Rim countries are buffeted by repeated and very frequent natural disasters (e.g., the Philippines experiences, on average, 5.8 destructive tropical storms annually). The countries of the Pacific Rim, as well as the volcanic islands and coral atolls of the Pacific Ocean itself, are also some of the most vulnerable to future disasters that may be associated with the changing climate and most are within the Ring of Fire - the globally most geologically active region.[2]

Robert Barro has argued that the infrequent occurrence of economic disasters leads to much larger welfare costs than continuous economic fluctuations of lesser amplitude (Barro, 2006 & 2009). He estimated that for the typical advanced economy, the welfare cost associated with large economic disasters such as those experienced in the twentieth century amounted to about 20 % of annual GDP, while normal business cycle volatility only amounted to a still substantial 1.5 % of GDP. For developing countries, which usually suffer from more frequent natural disasters

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[1]The five most lethal events in Pacific Rim nations (1970-2008) were all initiated by earthquakes: China 1976, Indonesia 2004, China 2008, Peru 1970 and Guatemala 1976. In these five events, 585,000 people died.

[2]The Ring of Fire is an inverted U-shape region, whose Western tip is New Zealand. The region then encompasses the archipelagos of Indonesia, the Philippines, and Japan, the Russian Far East, the Aleutian Islands, Alaska, and then down the Western Coast of the Americas all the way to Tierra Del Fuego at the very southern tip of the continent. This region experiences by far the majority of the volcanic activity and earth movements recorded worldwide.

of all types, and of even greater magnitude than in advanced economies, these events have an even greater effect on the welfare of the average citizen.

Understanding the history of disasters in the Pacific Rim, their impact on development, on the spatial evolution of income, and the risks that the region faces in terms of future events and their likely consequences all seem to be important components of an understanding of the region's economy. After all, the disruptions in many multinationals' supply chains that occurred after the 2011 Tohoku earthquake/tsunami and the 2011 Bangkok floods demonstrated persuasively the potentially global impact of these types of disasters – especially for a region whose countries' level of trade integration within the global economy is very high.

I employ a typology of disaster impacts that distinguishes between direct and indirect damages. Direct damages are the damage to fixed assets and capital (including inventories), damages to raw materials and extractable natural resources, and of course mortality and morbidity that are a direct consequence of the natural phenomenon. Indirect damages refer to the economic activity, in particular the production of goods and services, that will not take place following the disaster and because of it. These indirect damages may be caused by the direct damages to physical infrastructure or harm to labor, or because reconstruction pulls resources away from the usual production practices. These indirect damages also include the additional costs that are incurred because of the need to use alternative and potentially inferior means of production and/or distribution for the provision of normal goods and services (Pelling, *et al*. 2002).

These costs can be accounted for in the aggregate by examining the overall performance of the economy, as measured through the most relevant macroeconomic variables. These are GDP, the fiscal accounts, consumption, investment, and, especially important for the comparatively globalized countries of the Pacific Rim, the balance of trade and the balance of payments. These costs can also be further divided, following the standard distinction in macroeconomics, between the short run (up to several years) and the long run (typically considered to be at least five years, but sometimes also measured in decades). I use these distinctions in the discussion that follows.

## 2. Data on Regional Disasters

### 2.1. The Past

The Emergency Events Database (EM-DAT), maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the Catholic University of Louvain, is the most frequently used resource for disaster data.[3] EM-DAT defines a disaster as an event which overwhelms local capacity and/or necessitates a request for external assistance. For a disaster to be entered into the EM-DAT database, at least one of the following criteria must be met: (1) 10 or more people are reported killed; (2) 100 people are reported affected; (3) a state of emergency is declared; or (4) a call for international assistance is issued. Natural disasters can be hydro-meteorological, including floods, wave surges, storms, droughts, landslides and avalanches; geophysical, including earthquakes, tsunamis and volcanic eruptions; and biological, covering epidemics and insect infestations (these are much less frequent). The data report the number of people killed, the number of people affected, and the amount of direct damages in each disaster. Since biological events are much more anthropogenic, and the data collected on them are much less reliable; we will not discuss these in what follows.

We present disaster data for all the countries of the Pacific Rim, but exclude the small island-nations of the Pacific itself.[4] The disaster-types we include are earthquakes, temperature extremes, floods, storms, volcanic events, and wildfires. Natural disasters, as defined in the EM-DAT database, are common events. The five worst disasters (in terms of the three measures of disaster magnitude) are given in Table 1. In the Pacific Rim region, the five disasters with the highest mortality are all earthquakes, with a total of almost 600,000 people killed. In terms of people affected, floods in China dominate the list, although aggregate mortality for these is fairly low (about 10,000 people in total). Hurricane Katrina in the U.S., and the Kobe earthquake in Japan were by far the costliest disasters (in terms of damage to

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[3] The data is publicly available at: http://www.emdat.be/

[4] The following are included: Australia, Canada, Chile, China PR, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Indonesia, Japan, Korea (South), Malaysia, Mexico, New Zealand, Nicaragua, Panama, Papua New Guinea, Peru, Philippines, Russia, Taiwan, United States, and Vietnam.

infrastructure) until the March 2011 earthquake/tsunami in Tohoku, which dwarfs both disasters with damages estimated at more than US$200 billion, about twice as much as the amount estimated for Katrina.

**Table 1: Worst Disasters in the Pacific Rim 1970-2008**

| Worst Disasters (# of people killed) | | | | |
|---|---|---|---|---|
| Country (year) | Type | # Killed | # Affected | Damages |
| China PR (1976) | Earthquake | 242000 | 164000 | 5600 |
| Indonesia (2004) | Earthquake | 165708 | 532898 | 4451.6 |
| China PR (2008) | Earthquake | 87476 | 45976596 | 30000 |
| Peru (1970) | Earthquake | 66794 | 3216240 | 530 |
| Guatemala (1976) | Earthquake | 23000 | 4993000 | 1000 |
| Worst Disasters (# of people affected) | | | | |
| China PR (1998) | Flood | 3656 | 238973000 | 30000 |
| China PR (1991) | Flood | 1729 | 210232227 | 7500 |
| China PR (1996) | Flood | 2775 | 154634000 | 12600 |
| China PR (2003) | Flood | 430 | 150146000 | 7890 |
| China PR (1995) | Flood | 1437 | 114470249 | 6720 |
| Worst Disasters (damages in US$ million) | | | | |
| United States (2005) | Storm | 1833 | 500000 | 125000 |
| Japan (1995) | Earthquake | 5297 | 541636 | 100000 |
| China PR (1998) | Flood | 3656 | 238973000 | 30000 |
| China PR (2008 | Earthquake | 87476 | 45976596 | 30000 |
| United States (1994) | Earthquake | 60 | 27000 | 30000 |

*Source*: author's calculations from EMDAT.

**Table 2: Vulnerability A - Worst Disasters per country**

| Country | Worst Three Disasters (1970-2008)[1] | | | # killed[2] | # of large disasters[3] |
|---|---|---|---|---|---|
| Australia | wildfire 1983 | Storm 1974 | Flood 1984 | 176 | 0 |
| Canada | Storm 1998 | Storm 1987 | Storm 1975 | 68 | 0 |
| Chile | Earthquake 1971 | Earthquake 1985 | Flood 1993 | 374 | 1 |
| China | Earthquake 1976 | Earthquake 1974 | Earthquake 2008 | 349476 | 84 |
| Colombia | volcano 1985 | Earthquake 1970 | Earthquake 1999 | 23416 | 10 |
| Costa Rica | Storm 1988 | Storm 1996 | Earthquake 1991 | 126 | 0 |

| Country | Worst Three Disasters (1970-2008)[1] | | | # killed[2] | # of large disasters[3] |
|---|---|---|---|---|---|
| Ecuador | Earthquake 1987 | Flood 1983 | Flood 1998 | 5525 | 3 |
| El Salvador | Earthquake 1986 | Earthquake 2001 | Flood 1982 | 2444 | 5 |
| Guatemala | Earthquake 1976 | Storm 2005 | Flood 1982 | 25133 | 4 |
| Honduras | Storm 1998 | Storm 1974 | Flood 1993 | 22974 | 4 |
| Indonesia | Earthquake 2004 | Earthquake 2006 | Earthquake 1992 | 173986 | 20 |
| Japan | Earthquake 1995 | Flood 1972 | Flood 1982 | 6100 | 10 |
| Korea | Flood 1972 | Flood 1998 | Storm 1987 | 1558 | 9 |
| Malaysia | Storm 1996 | Earthquake 2004 | Flood 1970 | 411 | 0 |
| Mexico | Earthquake 1985 | Flood 1999 | Storm 1976 | 1736 | 22 |
| N Zealand | Storm 1988 | Flood 1985 | Storm 1997 | 13 | 0 |
| Nicaragua | Earthquake 1972 | Storm 1998 | Storm 2007 | 13520 | 4 |
| Panama | Flood 1970 | Earthquake 1991 | Storm 1988 | 108 | 0 |
| Papua NG | Earthquake 1998 | Storm 2007 | Earthquake 1993 | 2407 | 2 |
| Peru | Earthquake 1970 | Earthquake 2007 | Storm 1998 | 67831 | 6 |
| Philippines | Earthquake 1976 | Storm 1991 | Earthquake 1990 | 14368 | 17 |
| Russia | Earthquake 1995 | Ex temp 2001 | Ex temp 2001 | 2597 | 3 |
| Taiwan | Earthquake 1999 | Storm 2001 | Storm 2000 | 2453 | 2 |
| U. S. | Storm 2005 | Ex temp 1980 | Ex temp 1995 | 3763 | 19 |
| Vietnam | Storm 1997 | Storm 1985 | Storm 1989 | 5231 | 20 |

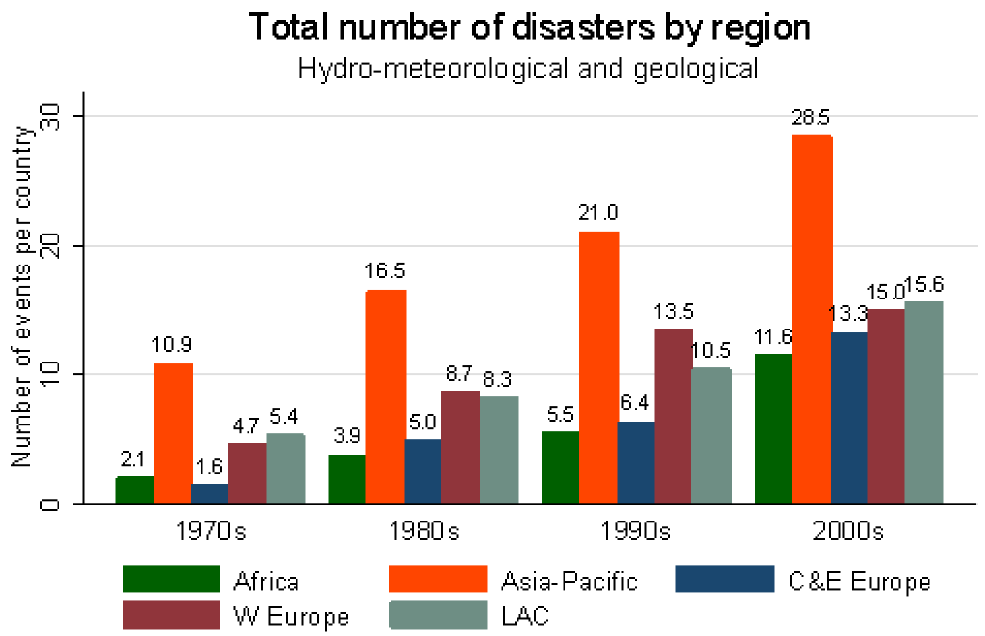
*Note*: [1] The worst three disasters in terms of the number of fatalities.
[2] Measures the sum of fatalities in the three worst disasters experienced in each country.
[3] Measures the number of disaster events for which there were more than 100 fatalities, more than a thousand people affected, and damages of more than a million US$ (this is a significantly higher threshold than the one used by EMDAT – we further did not count disasters for which the number of fatalities was unavailable).
*Source*: author's calculations from EMDAT.

A list of the three worst disasters for each Pacific Rim country and their aggregate toll (in terms of mortality), is provided in Table 2. It provides some limited insight into the vulnerabilities of each country both in terms of the kinds of disasters that are likely to wreak the most damages and how big these damages are likely to be. Not surprisingly, there are very few Pacific Rim countries for which earthquakes are not part of the most dangerous disaster list: these are Australia, Canada, Honduras, Korea, New Zealand, the U.S. and Vietnam. But, after the 2011 earthquake in Christchurch, New Zealand can no longer be considered relatively earthquake safe, and most predictions are that a large West Coast quake in the U.S. will also dwarf any impact from other American disasters. Thus, past recent experiences is only of limited use in assessing future vulnerabilities in the face of catastrophic but rare events.

The last column in Table 2 measures vulnerability differently, by counting the number of large events in the past 40 years. In this case, we adopt a threshold that is ten times higher than the one used by EM-DAT, since the dataset includes many relatively minor events (from a macroeconomic perspective). Using this measure, Indonesia, China and the Philippines stand out as highly vulnerable.

Figure 1, taken from Cavallo & Noy (2011), plots the average number of natural disaster events (hydro-meteorological and geophysical) per country in the period 1970-2008. The figure shows that the incidence of disasters has been growing over time everywhere in the world. In the Asia-Pacific region for example, which is the region with the most events, the incidence has grown from an average of 11 events per country in the 1970s to over 28 events in the 2000s. In other regions, while the increase is less dramatic, the trend is similar. However, these patterns appear to be driven to some extent by improved recording of milder events, rather than by an increase in the frequency of disasters. Furthermore, truly large events—i.e., conceivably more catastrophic—are rarer. At this point, there is no credible evidence that the frequency of catastrophic events is increasing, though that is most clearly a possible prediction given the projected evolution of climatic conditions in the next century.

**Figure 1: Frequency of Disasters by Geographic Region**




*Source*: Cavallo & Noy (2011).

### 2.2. The Future

A recent report by the Intergovernmental Panel on Climate Change (IPCC, 2012), the *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* concludes that there will be a "likely increase heat wave frequency and very likely increase in warm days and nights across Europe….likely increase in average maximum wind speed and associated heavy rainfall (although not in all regions)…. very likely contribution of sea level rise to extreme coastal high water levels (such as storm surges)…." (IPCC, 2012).[5] While the report is fairly skeptical about the robustness of many of the predictions available in the scientific literature about catastrophic high-risk low-probability natural disasters, it does argue that "For exposed and vulnerable communities, even non-extreme weather and climate events can have extreme impacts".

In its latest comprehensive report from 2007, the IPCC states that: "Warming of the climate system is unequivocal, as is now evident from observations of increases

[5]By 'very likely' the IPCC refers to 90-100% probability, while 'likely' means 66-100% probability (IPCC, 2011).

in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" (IPCC, 2007). The IPCC report projects that by the year 2100, average global surface temperature will increase by between 1.8° Celsius and 4° Celsius depending on the success of emissions mitigation strategies.[6] The projected increase in sea surface temperatures will potentially impact both the frequency and intensity of tropical storms. Several studies posit that, as global sea surface temperatures rise, hurricanes may become more numerous or intense, the range of hurricanes will increase to the north and south of the current "hurricane belt", or their location and typical paths will change (e.g., Webster, *et al*. 2005; Li, *et al*. 2010; Mendelsohn, *et al*. 2012;Elsner, *et al*. 2008; and Emanuel, *et al*. 2008).

More recent predictions than the 2007 IPCC report regarding global sea level rise are considerably more alarming as more information on glacial melting has become available. Rahmstorf (2007), for example, predicts a sea level rise of 0.5 to 1.4 meters by 2100 while Vermeer & Rahmstorf (2009) predict rises of up to 1.9 meters. These sea level rises, besides posing ongoing difficulties to low-lying areas, will certainly also increase the damages caused by storm wave surges and earthquake induced tsunamis. Whatever climate models are used, however, there is wider agreement that the combination of sea level rise and deterioration in coral reef ecosystems will make coastal areas considerably more vulnerable to storms, regardless of whether storms will indeed be more frequent or more intense (or both).

The impact of global climate change on the incidence of other types of natural disasters is even less well understood., but there is some preliminary evidence, mostly from model exercises, that droughts and floods will become more common and more severe (e.g., IPCC, 2007). For now, we have no evidence that the incidence of geophysical disasters is likely to change over time or be affected by any of the climatic changes that are predicted to occur. The frequency of large earthquakes appears to be fairly constant with, on average, 17 large earthquakes (magnitude 7.0-7.9) and about one mega earthquake (magnitude 8.0 and above) per

[6]Different climate models, yield somewhat different results, but the consensus is well represented by this range.

year.[7] However, as we already observed about the future damages from earthquake-generated tsunami waves, one can easily conclude that even if the probability of geophysical events will not be impacted, the ways in which these natural events will interact with the local economy may clearly change over time.

## 3. Determinants of Initial Disaster Costs

When evaluating the determinants of disasters' direct costs, most research papers estimated a model of the form: $DIS_{it} = \alpha + \beta \mathbf{X}_{it} + \varepsilon_{it}$; where $DIS_{it}$ is a measure of direct damages of all disasters in country *i* and time *t*; using measures of primary initial damage such as mortality, morbidity, or capital losses. $\mathbf{X}_{it}$ is a vector of control variables of interest with each research effort distinguishing different independent variables. Typically $\mathbf{X}_{it}$ will include a measure of the disaster magnitude (e.g., Richter scale for earthquakes or wind speed for hurricanes) and variables that capture the "vulnerability" of the country to disasters (i.e., the conditions which increase the susceptibility of a country to the impact of natural hazards). $\varepsilon_{it}$ is generally assumed to be an independently and identically distributed (iid) error term.

Kahn (2005) estimates a version of this model and concludes that while richer countries do not experience fewer or less severe natural disasters, their death toll is substantially lower. In 1990, a poor country (per capita GDP< US$2000) typically experienced 9.4 deaths per million people per year, while a richer country (per capita GDP> US$14,000) would have had only 1.8 deaths. This difference is most likely due to the greater amount of resources spent on prevention efforts and legal enforcement of mitigation rules (e.g., building codes). In particular, some of the policy interventions likely to ameliorate disaster impact, including land-use zoning, building codes and engineering interventions are rarer in less developed countries.

[7] A one point increase in earthquake magnitude entails a 10 times increase in earth movement and a 32 times increase in the amount of energy released, so a 9.0 earthquake is dramatically different from an 8.0 one. For historical information about earthquake frequencies, see: http://earthquake.usgs.gov/earthquakes/eqarchives/.

This finding, however, does not imply that higher damages in developing countries are inevitable. The contrast between storm preparedness in Cuba vs. Haiti, or in Burma vs. Bangladesh, clearly demonstrates that even poor countries can adopt successful mitigation policies and that successful mitigation does not only depend on financial resources and the ability to mobilize them. Even in wealthier countries, there are dramatic differences in the degree of preparedness; Japan, for example, has constructed a nation-wide earthquake warning system that successfully managed to stop all high-speed rail a few seconds before the damaging earthquake shock waves arrived in the Sendai region on March 11th, 2011 – no other country has installed such a system.

A consistent finding of several studies (i.e., Kahn, 2005; Skidmore & Toya, 2007; Raschky, 2008; Strömberg, 2007) is that better institutions—understood, for instance, as more stable democratic regimes or greater security of property rights—reduce disaster impact. Typhoon Nargis that hit Burma in May 2008 provides a tragic contrast to this insight. Apparently, the Burmese government was warned about the nearing storm two days before it arrived, but did little to warn coastal residents. In addition, the government interrupted post-disaster relief efforts and restricted access by international NGOs to the affected area; more than 138,000 people were killed. Nargis is an extreme case, but other countries that experience periodic storms and flooding, such as the Philippines, also appear comparatively unprepared.

Anbarci, *et al*. (2005) elaborate on the political economy of disaster prevention. They conclude that inequality is important as a determinant of prevention efforts: more unequal societies tend to have fewer resources spent on prevention, as they are unable to resolve the collective action problem of implementing costly preventive and mitigation measures. Collective action difficulties may be overcome in communities whose inter-communal ties are stronger. As Aldrich (2012, in this volume) discusses, when people feel an affinity with their neighbors, organizing them to act communally both in preparing for disasters, mitigating their consequences and reconstructing are all done more easily.

Besley & Burgess (2002), using data from floods in India, observe that disaster impacts are lower when newspaper circulation is higher, which leads to more accountable politicians and a government that is more active in preventing and mitigating impacts.[8] Compounding this question of accountability is the apparent unwillingness of the electorate to punish politicians who had under-invested in preparedness while failure to provide generous post-disaster reconstruction funds does appear to be an important determinant of post-disaster electoral success (Healy & Malhotra 2009 and 2010). The benefits of generous post-disaster government intervention also appear to be long-lasting (Bechtel & Hainmueller, 2011). Not surprisingly, politicians respond to these incentives, and thus increase their generosity in allocating post-disaster assistance in election years (Cole, *et al*. 2012). Thus, even in democracies, politicians rarely face the optimal incentives in terms of disaster prevention and/or mitigation.

To summarize, while the damage caused by disasters is naturally related to the physical intensity of the event, a series of economic, social, and political characteristics also affect vulnerability. A by-product of this analysis, of course, is that these characteristics are therefore potentially amenable to policy action. In particular, the collective action problems that the literature identifies can potentially be overcome with the design of decision-making mechanisms that take these problems into account. Political incentives are probably more difficult to alter, but robust public scrutiny with the assistance of an activist and investigative media can assist in that process. There is growing awareness among the Pacific Rim countries' policymakers of the importance of not only mitigation but of reducing vulnerability to the economic pain that is likely in a disaster's aftermath. In the November 2011 ministerial meeting of Asia-Pacific Economic Cooperation (APEC), the leaders issued a statement that details these concerns and describes the steps that APEC countries are encouraged to take in order to become more resilient (APEC, 2011).

In addition to all these incentive problems that inhibit the desire to act, the resources needed are also typically only provided *ex post* rather than *ex ante*. Both private donations channeled through NGOs and public sector resources (from foreign or domestic sources, or both) generally become available only in the aftermath of

[8] An equally plausible explanation for this finding is that newspaper circulation is a representation of more cohesive communities with higher 'social capital' (see Aldrich in this volume).

catastrophic events, and are not available beforehand to prevent or mitigate any likely event.

## 4. Economic Impacts – Are Disasters a Poverty Trap?

A disaster's initial impact causes mortality, morbidity, and loss of physical infrastructure (residential housing, roads, telecommunication, and electricity networks, and other infrastructure). These initial impacts are followed by consequent impacts on the economy (in terms of income, employment, sectoral composition of production, inflation, etc.). These indirect impacts, of course, are not pre-ordained, and the policy choices made in a catastrophic disaster's aftermath can have significant economic consequences. For example, by using a non-equilibrium dynamic growth model, Hallegatte, *et al*. (2007) show that a country experiencing disastrous events may find itself unable to adequately reconstruct and may remain stuck in a post-disaster poverty trap. Thus, while post-disaster policy choices clearly have a direct economic impact in the short run, they potentially also have long-run consequences.

### 4.1. Short-run

The short-run impacts of disasters are usually evaluated in a regression framework of the form: $Y_{it} = \alpha + \beta \mathbf{X}_{it} + \gamma DIS_{it} + \varepsilon_{it}$; where $Y_{it}$ is the measured variable of interest (e.g., per capita GDP), $DIS_{it}$ is a measure of the disaster's immediate impact on country $i$ at time $t$, $\mathbf{X}_{it}$ is a vector of control variables that potentially affect $Y_{it}$, and $\varepsilon_{it}$ is an error term. Noy (2009) estimates a version of this equation and, in addition to the adverse short-run effect already described in Raddatz (2007), he describes some of the structural and institutional details that make this negative effect worse. Noy (2009) concludes that countries with a higher literacy rate, better institutions, higher per capita income, higher degree of openness to trade, higher levels of government spending, more foreign exchange reserves, and higher levels of domestic credit but with less open capital accounts are better able to withstand the initial disaster shock and prevent further spillovers into the macro-economy. These findings suggest that access to reconstruction resources and the capacity to utilize them effectively are of paramount importance is determining the speed and success of recovery.

Raddatz (2009) uses vector autoregressions (VARs) to conclude that smaller and poorer states are more vulnerable to these spillovers, and that most of the output cost of climatic events occurs during the year of the disaster. His evidence, together with Becerra, *et al.* (2010), also suggests that, historically, aid flows have done little to attenuate the output consequences of climatic disasters.[9]

Even if aid inflows are typically not substantial enough to assist in complete reconstruction, bigger countries may be capable of engineering the inter-sectoral and inter-regional transfers required to fully mitigate the economic impact of natural disasters (Coffman & Noy, 2010, and Auffret, 2003). The importance of inter-regional transfers was highlighted by the massive mobilization of reconstruction resources following the catastrophic Sichuan earthquake of 2008. The Chinese government spent lavishly on reconstruction, with about 90% coming from the central government and only 10% financed locally in Sichuan.[10] The rebuilt infrastructure in the destroyed counties (which were remote and under-developed pre-quake) appears to be significantly superior to its previous state. Therefore, while direct losses may be high in large countries because of the increased wealth exposure, the greater capacity to absorb shocks means that indirect losses may be lower, and/or that the size of the damage may be lower relative to the size of the country.

Noy & Vu (2010) further focus on the importance of inter-regional transfers in Vietnam, and find that the post-disaster impact on economic activity across Vietnamese provinces appears to be determined by the provincial ability to attract reconstruction resources from the central government.

[9] Loayza, *et al.* (2009) notes that while small disasters may, on average, have a positive impact (as a result of the reconstruction stimulus), large disasters always pose severe negative consequences for the economy in their immediate aftermath.

[10] Data obtained from http://www.china.org.cn/china/earthquake_reconstruction/2010-01/25/content_19302110.htm (accessed on 11/11/11).

Very little research has attempted to examine household data and determine the effects of natural disasters on household expenditures. An important exception is Sawada & Shimizutani (2008) who examine household data after the 1995 Kobe earthquake in Japan. They find that, even in a rich country, credit-constrained households experienced significant reductions in consumption, while households with access to credit did not. Further evidence on the importance of credit is suggested by the Rodriguez-Oreggia, *et al.* (2009) findings of a significant increase in poverty in disaster-affected municipalities in Mexico.

**4.2. Long-run**

Theoretically, the likely impact of natural disasters on growth dynamics is not clear. Standard neo-classical frameworks that view technical progress as exogenous—e.g. the Solow-Swan model with exogenous saving rate sand the Ramsey-Cass-Koopman model with consumer optimization—all predict that the destruction of physical capital will enhance growth since it will drive countries away from their balanced-growth steady states. In contrast, endogenous growth frameworks do not suggest such clear-cut predictions with respect to output dynamics depending on the approach used to explain the endogeneity of technological change. For example, models based on Schumpeter's creative destruction process may also ascribe higher growth as a result of negative shocks (Hallegatte & Dumas, 2009), as these shocks can be catalysts for re-investment and upgrading of capital goods. Yet the AK-type endogenous growth models, in which the technology exhibits constant returns to capital, predict no change in the growth rate following a negative capital shock; though the economy that experiences a destruction of the capital stock will never go back to its previous growth trajectory. Endogenous growth models that have increasing returns to scale production generally predict that a destruction of part of the physical or human capital stock results in a lower growth path and consequently a permanent deviation from the previous growth trajectory.

To date, the empirical work on this question has also failed to reach a consensus. Skidmore & Toya (2002) uses the frequency of natural disasters in a cross-sectional dataset to examine long-run growth impacts of disasters, while Noy & Nualsri (2007) uses a panel of five-year country observations, as in the extensive literature that followed the work by Barro (1997). Intriguingly, they reach diametrically opposing conclusions, with the former identifying expansionary and the latter contractionary disaster effects. More recently, Jaramillo (2009) finds qualified support for the Noy & Nualsri (2007) conclusion.

Skidmore & Toya (2002) explain their somewhat counterintuitive finding by suggesting that disasters may be speeding up the Schumpeterian "creative destruction" process that is at the heart of the development of market economies. Cuaresma, *et al*. (2008), however, find that for developing countries, disaster occurrence is associated with less knowledge spillover and a reduction in the amount of new technology being introduced rather than with an acceleration of these processes.

Cavallo, *et al.* (2010) provide the most recent attempt to resolve this debate. They implement a new methodology based on constructing synthetic controls–i.e., a counterfactual that measures what would have happened to the path of the variable-of-interest in the affected country in the absence of the natural disaster. Using this methodology, they don't find any significant long-run effect of even very large disasters, except for very large events that were then followed by political upheavals. For these events, they find economically very substantial and statistically significant negative long run effects on per capita GDP.

Another possibility is suggested in Coffman & Noy (2012), where the question is the impact of a specific event (a hurricane) on an isolated Hawaiian island. In this instance, the authors conclude that while there was no long-term impact on per-capita variables, this is largely because the disaster led to an out-migration from which the island has never completely recovered (the net population loss was a very significant 15%). Whether this pattern can be observed for other catastrophic events is not well established, though casual observation suggests that these irreversible out-migrations also happened in the case of New Orleans after hurricane Katrina, while in the city of Kobe after the earthquake of 1995 the population did not move away in spite of persistent decreases in incomes (see Vigdor, 2008 and Dupont & Noy, 2012, respectively). There is much speculation that the same will be true for the Tohoku region of Japan that was hit by the March 2011 tsunami.

### 4.3. Fiscal Impacts

As we observed previously, disasters are likely to generate significant inter-regional transfers and/or international aid. Accurate estimates of the likely fiscal costs of disasters are useful in enabling better cost-benefit evaluation of various mitigation programs and in determining the appropriate level of insurance against disaster losses.[11]

On the expenditure side, publicly financed reconstruction costs may be very different from the original magnitude of destruction of capital, while on the revenue side of the fiscal ledger, the impact of disasters on tax and other public revenue sources has also seldom been quantitatively examined. Using panel VAR methodology, Noy & Nualsri (2011) and Melecky & Raddatz (2011) estimate the fiscal dynamics likely in an "average" disaster; they acknowledge, however, that the impacts of disasters on revenue and spending depend on the country-specific macroeconomic dynamics occurring following the disaster shock, the unique structure of revenue sources (income taxes, consumption taxes, custom duties, etc.), insurance coverage and the size of the financial sector, and government indebtedness.

The implications of these findings for the Pacific Rim region are quite obvious given the high degree of vulnerability of almost all countries in the region. Mexico's FONDEN (a disaster fund) provides an example of an ex-ante fiscal provisioning for disaster reconstruction, but this, while prudent, amount to a form of self-insurance, which may be very costly in the case of a developing economy with substantial borrowing costs.[12] Chile, in contrast, has used some of the funds available in its Sovereign Wealth Fund (the Copper Fund) to pay for reconstruction following the destructive earthquake of February, 2010. Japan, which can easily pursue counter-cyclical fiscal policy, resorted to additional borrowing to pay for the 2011 Tohoku earthquake reconstruction costs.

One way to overcome this lack of sufficient explicit insurance is for countries to mutually insure each other. While this is difficult to envision politically within any

[11]Insurance could be purchased directly (maybe through re-insurance companies), indirectly through the issuance of catastrophic bonds (CAT bonds), or through precautionary savings

[12]In addition to FONDEN, Mexico is also one of the biggest issuers of CAT bonds. Even so, the provisioning of FONDEN has recently been insufficient to cover the costs of disasters in 2010 (see http://www.artemis.bm/blog/2010/09/16/fonden-mexicos-disaster-fund-exceeds-its-annual-budget/ accessed 11/12/11).

Pacific-Rim-wide grouping such as APEC, it may be more politically palatable and therefore practical in smaller and more geographically well-defined groupings like ASEAN (or ASEAN+3).

### 4.4. Disaster as an Opportunity?

Some argue that disasters provide an impetus for change, which can bring on positive economic changes that have long-term beneficial dynamic impact on the economy. Change can lead to "creative destruction" dynamics that entail replacing the old with new technologies and with upgrades of superior equipment, infrastructure, and production processes. The rapid growth of Germany and Japan after the destruction they experienced in World War II is widely used as an example of such beneficial dynamics. Even in these cases, however, empirical research failed to identify a long-term beneficial effect, at best finding a return to the pre-shock equilibrium (Davis & Weinstein, 2002, and Brakman, *et al*. 2004).

Besides the potential 'creative' introduction of new technologies to replace the ones that had previously been destroyed, a large natural disaster changes political power dynamics in ways that may facilitate radical change. Rahm Emanuel, Barak Obama's former chief of staff, was often quoted as saying, "you never want a serious disaster to go to waste . . . it's an opportunity to do things you could not do before".[13] The evidence to date, however, does not suggest that after accounting for the loss of life and property, one can identify beneficial aspects to the destruction wrought by natural disasters.

## 5. A Disaster Risk Reduction Fund

Perrow (2007) argues that public policy should focus on the need to "shrink" the targets: lower population concentration in vulnerable (especially coastal) areas, and lower concentration of utilities and other infrastructure in disaster-prone locations. This advice also stems from the awareness that more *ex-post* assistance to damaged

[13]Emanuel, at a Wall Street Journal event (see WSJ, Nov. 21, 2008).

communities generates a "Samaritan's dilemma," i.e., an increase in risk-taking and a reluctance to purchase insurance when taking into account the help that is likely to be provided should a disaster strike.[14]

Constructing efficient and timely warning systems is clearly a desirable policy that is less controversial and more easily implementable. The 2004 South-East Asian tsunami, for example, led to an extension of the Pacific Tsunami Warning System to regions of Indonesia and the Indian Ocean that were previously unprotected. Operating warning systems, however, remains a long-term goal, and progress towards it can still be improved in cost-effective ways in most countries. A recent review of progress under the Hyogo Framework for Action adopted by the UN in 2005 concluded that in preparing early warning systems in the Asia Pacific: "achievement[s] are neither comprehensive nor substantial." (UNISDR, 2011, p. 8).

The difficulty of developing an effective early-warning-system should not be underestimated. On April 11, 2012, a powerful earthquake (8.6 on the Richter scale) occurred not far offshore Banda Aceh, the city that was inundated by the 2004 South-East Asian tsunami with about 25 thousand people killed (Doocy, *et al*. 2007). By 2012, there was an early warning system in place for tsunami hazard in Aceh, but since everyone attempted to evacuate at the same time, roads became gridlocked very quickly as people were frantically trying to flee (Rondonuwu, 2012). There were also wide-spread reports of various operational failures of the warning system in this instance. Luckily, no significant tsunami was generated by the earthquake, but the inadequacy of a system developed specifically to prevent mortality if a repeat of the 2004 catastrophe were to occur was demonstrated quite starkly. Investment in effective mitigation and risk reduction is neither cheap nor easy as it also requires securing an effective response to the warnings that are supplied. Yet, the magnitude of benefits, in terms of life saved per dollar spent, are very large if these systems manage to prevent the very catastrophic disasters that occur all too frequently.[15]

If early-warning systems are indeed cost effective, why are they not being implemented wholeheartedly? As we discussed previously in analyzing the general

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[14] See, for example, the discussion in Raschky & Weck-Hannemann (2007).

[15] Kydland, Finn E., Robert Mundell, Thomas Schelling, Vernon Smith, and Nancy Stokey, 2012. Copenhagen Consensus: Expert Panel Findings. http://www.copenhagenconsensus.com/Admin/Public/DWSDownload.aspx?File=%2fFiles%2fFiler%2fCC12+papers%2fOutcome_Document_Updated_1105.pdf

underinvestment in preparedness, the answer is most likely political. In many cases, initiating the development of a disaster risk reduction (DRR) policy is clearly needed, and this can probably be best carried out with external support/incentives from the multilateral organizations. The World Bank, in particular, has been working on this front, but a dedicated fund, a Global Fund for DRR (GF-DRR), that will incentivize and support this work can and should result in the optimal allocation of resources for this task. Many developing countries lack coherent planning for disaster preparedness and risk reduction, and the knowledge collected by the international organizations (esp. the World Bank), together with the funds to support this planning, can lead to a very cost effective implementation of a much more global DRR policy.

An appropriate DRR policy may primarily involve the funding of early warning systems in most cases, but may also involve other preparatory steps; DRR may mean retrofitting essential infrastructure for earthquakes (especially hospitals and other building where many people reside or work), moving people permanently away from wave-surge prone coastal regions or river flood-plains, or establishing more robust communication networks that will not collapse in the aftermath of a catastrophic event. Beyond costs, the appropriate steps needed depend on the broadly-defined institutional details, the current state of the economy, and predictions regarding likely future disaster risks.

Since all three factors (institutions, economy and disaster risk) are inherently local and widely varying, it would be difficult to attempt to devise a universally appropriate policy menu, or to argue for a universal implementation of any specific policy. Preparation of DRR is taking place, but much more needs to be done; especially since economic conditions are changing, and risk patterns are appearing to change as well. Future economic exposure to tropical storms, for example, is predicted to quadruple by 2100, with roughly half of this increase associated with higher population and property in vulnerable areas and half resulting from changing patterns in terms of new predicted storm tracks and storm intensities (Mendelsohn, *et al*. 2012).

The International Monetary Fund (IMF) has been involved in post-crisis intervention for several decades. The lessons the IMF has learned, in terms of avoiding perverse incentives—e.g., moral hazard and adverse selection—and leading countries to adopt ex-ante sound policies, are as relevant to natural disasters. Essentially, the idea is that countries will be constantly evaluated for their DRR plans, and given ‘Seals of Approval.’ A country whose plans are favorably evaluated will have access to support for DRR projects and in addition will have access to an Emergency Disaster Fund should it be required (one can establish triggers that automatically provide affected countries access to pre-specified sums as grants or concessional loans). The evaluation process already undergoing through the Hyogo Framework umbrella may serve as a good starting point for developing the evaluation and scoring mechanisms that would allow a ‘grading’ of DRR policy and the allocation of the contingent ‘seal of approval’ for these policies.

An additional positive externality from such fund with its associated monitoring and evaluation functions, would be enabling countries who receive this DRR ‘seal of approval’ to more easily insure themselves explicitly (with re-insurers) or implicitly by issuing Catastrophic Bonds (CAT bonds) and further enable multi-year insurance. All three developments (re-insurance, CAT bonds and multi-year) will be made easier by having a ‘seal of approval’ since that seal will alleviate investors/insurers concerns regarding the moral hazard generated by the disaster-contingent financial support.

While macro-level explicit or implicit insurance has been growing in popularity in the last decade (see the discussion of a rice index insurance in a companion paper in this volume), the vast majority of CAT bonds, for example, are still issued by local organizations in developed countries or specialized insurance companies. Governments, at the local or national level, do not yet appear to avail themselves of these insurance opportunities, and the establishment of a ‘seal of approval’ may be the catalyst that will increase utilization of these new financial tools for handling catastrophic risk.

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# CHAPTER 3

# On the Design of Regional Insurance Schemes/Mechanisms for East Asia

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*This paper identifies the issues that would be central in designing a possible regional insurance scheme or mechanism for East Asia. The main focus is on the risk sharing mechanism for catastrophe risks households in the region incur. We apply the theoretical observations by Nakata et al. (2010) that provide a consistent explanation for the apparent anomalies concerning the demand for catastrophe insurance within the subjective expected utility framework. The key observation is that the number of observations would be inevitably insufficient to warrant a robust probability estimate for a rare event. The inherent lack of a robust probability estimate leads to diverse probability beliefs. We evaluate the various insurance schemes in terms of social welfare. In doing so, we adopt a measure that is based on the* ex post *social welfare concept in the sense of Hammond (1981), since the standard Pareto optimality criterion is problematic in the presence of diverse beliefs, for it ignores the regrets or pleasure* ex post *caused by 'incorrect' beliefs. Although the* ex post *social welfare may have an expected utility form, we only focus on the* ex post *utility frontier rather than specifying a particular social probability. We postulate that a desirable insurance scheme is the one that eliminates any personal catastrophe state.*

***Keywords:*** catastrophe, demand for insurance, diverse beliefs, ex post social welfare.

## 1. Introduction

East Asia has historically been hit numerous times by catastrophic natural disasters. Last year alone, the region suffered from the great earthquake and tsunami in Japan and the great flooding in Thailand. Whilst it would be impossible to prevent the occurrence of a natural disaster itself, every effort should be made to prevent and limit the level of damages natural disasters could inflict. Nevertheless, some damage or loss from natural disasters is inevitable—especially for catastrophes, which implies the need for an insurance mechanism.

Catastrophe insurance or insurance for natural disasters, however, is not very common in practice. The fact that a catastrophe typically incurs a macro risk invalidates the application of the strong law of large numbers, on which a typical insurance mechanism is based. This is the reason why catastrophe insurance is often backed or indirectly supplied by the government. Nevertheless, there is evidence that the demand for catastrophe insurance is often weak, even though the insurance premium is apparently set favourably to the (potential) buyers.

This paper examines the issues that are key to design a regional insurance scheme for catastrophes or natural disasters. The presumed target of the possible insurance schemes examined in the paper is the household sector, rather than the corporate sector. Nevertheless, many issues raised in this paper would remain valid for insurance schemes that target the corporate sector. In the analysis, we apply the theoretical explanation for the weak demand for catastrophe insurance given by Nakata, *et al*. (2010). The key observation of Nakata, *et al*. (2010) is that rare events by definition take place very infrequently, which implies that no robust probability estimate of a rare event would be readily warranted by empirical or scientific evidence. Thus, diverse probability beliefs would be inevitable, which in turn results in a weak demand for catastrophe insurance. Based on this observation, we compare several insurance schemes that differ in terms of the payment structure and also regarding the subscription structure. To be more specific, we compare conventional indemnity insurance and index insurance with respect to the payment structure, whilst we also compare direct subscription by households, subscription by local governments, and subscription by national governments with respect to the subscription structure.

Once we allow for diverse beliefs, the welfare evaluation of a regional insurance scheme is not straightforward. Since the standard Pareto optimality is based on the *ex ante* preferences of the agents that govern their decisions, the standard Pareto optimality is inherently an *ex ante* criterion. With diverse beliefs, agents would be making 'incorrect' decisions or 'mistakes', although such 'mistakes' are not understood as mistakes a priori by the agents themselves. If we know the true probability, then we may still be able to evaluate how agents are making mistakes, and consequently we may evaluate the insurance schemes with respect to the true probability. However, it is rather unreasonable to assume such knowledge, especially for rare events.

Thus, the use of the standard Pareto criterion calls for a significant value judgement, since *ex ante* preferences do not capture regrets or pleasure arising from the outcomes of decisions made in accord with incorrect subjective beliefs. Such arguments can be found in Diamond (1967) and Drèze (1970), while Starr (1973) introduces the notion of *ex post* optimality, which is based on realised allocations rather than prospects of future allocations, with which the standard *ex ante* optimality is defined. Starr (1973) shows that the two concepts do not coincide generically, when beliefs are heterogeneous. Hammond (1981) introduces the notion of the *ex post* social welfare optimum, which is based on an expected social welfare function, where the expectation is with respect to the social planner's probability (or the social probability) rather than with respect to the subjective beliefs of the agents. Hammond (1981) shows that the *ex post* social welfare optimum does not coincide with the usual *ex ante* social welfare optimum when the subjective beliefs are heterogeneous. However, the choice of the social probability for the *ex post* social welfare function is not trivial. Thus, it is important to identify the conditions under which a reasonably high level of *ex post* social welfare can be assured, even when we do not know the social probabilities.

In this regard, the absence of personal catastrophe states for everyone would assure a reasonably high level of *ex post* social welfare, as Nakata (2012) shows in a dynamic general equilibrium model with diverse beliefs.[1] Note that the existence of a personal catastrophe state is not very damaging from the *ex ante* point of view if the agent

[1] We use the term a 'personal catastrophe state' to describe a state in which an agent is left with an extremely low level of wealth.

believes that the probability of such a state is extremely low, which implies that an agent may choose to allow for the emergence of personal catastrophe states.

Based on the above observations, this paper therefore compares the various insurance schemes from the viewpoint of the *ex post* social welfare. In particular, we examine conventional indemnity insurance and index insurance. In doing so, we pay attention to the subscription structure, i.e. direct subscriptions by households, subscriptions by local governments, and subscriptions by national governments.

## 2. Insurance Demand under Diverse Beliefs

In this section, we first review the three stylised facts regarding demand for catastrophe insurance based on aggregate data. Then, we show that the willingness-to-pay for insurance is almost linear in the subjective loss probability when the loss probability is very small, by numerical examples. By following Nakata, *et al*. (2010), we then show that subjective loss probabilities may well be very diverse and unstable for rare loss events, which in conjunction with the almost linear property of the willingness-to-pay, provides a consistent explanation for the three stylised facts.

### 2.1. Stylised Facts about Catastrophe Insurance

It is well reported that there are some anomalies regarding the demand for insurance that appear to be incompatible with the standard expected utility framework. First, there is evidence that insurance for catastrophes, such as earthquakes or flooding, is not very widely purchased, even though many policies against catastrophes are subsidised by governments to keep the premiums favourable to the buyers, e.g. earthquake insurance in Japan and the National Flood Insurance Program (NFIP) in the United States.[2] In contrast, it is widely known that commonly sold insurance policies such as travel insurance, home insurance and medical insurance, have a substantial mark-up. Yet, many people voluntarily elect to purchase such policies. Hence, insurance for

[2] Kunreuther, *et al*. (1978) is one of the pioneering works that reported this "anomaly." Also, see Michel-Kerjan (2010) for the history of NFIP.

catastrophes is purchased with less frequency compared to insurance for moderate risk (e.g. travel insurance), even if the premium is often set more favourably for catastrophe insurance (stylised fact 1). Furthermore, (a) market penetration is much lower in areas that have historically been less frequently hit by catastrophes, even if the premiums are adjusted to reflect the lower frequencies (stylised fact 2), and (b) market penetration jumps up immediately after a catastrophe (stylised fact 3).[3]

The above three stylised facts present difficulties in designing a catastrophe insurance scheme that would enjoy a wide subscription. Although it appears that these facts are in contradiction with the model of insurance demand based on the standard expected utility framework, the apparent incompatibility becomes less straightforward once we allow for diverse subjective beliefs. In what follows, we introduce a simplified version of the framework by Nakata, *et al*. (2010), which attempts to explain the three stylised facts above simultaneously within the subjective expected utility framework.

### 2.2. The Willingness-to-pay for Catastrophe Insurance

Consider an agent who is facing some uncertainty. We assume for simplicity that there are only two states, state 1 (the no-loss state) and state 2 (the loss state), with $x > 0$ being the loss in state 2. Let $W$ denote the initial wealth of the agent. Then, the final wealth is $W$ in state 1 and $W - x$ in state 2 when there is no insurance.

Assume that the agent is a risk-averse expected utility maximiser, who makes some probability estimate of the two states; $\pi$ is the agent's subjective probability of the no loss state. Now, assume that any loss up to $b$ $(\leq x)$ can be covered by insurance with a premium of $\rho_b$. With this insurance, the final wealth becomes $W - \rho_b$ in state 1 and $W - x + b - \rho_b$. Agent $h$ purchases the insurance if

$$\pi \cdot u(W) + (1 - \pi) \cdot u(W - x) \leq \pi \cdot u(W - \rho_b) + (1 - \pi) \cdot u(W - x + b - \rho_b)$$

while the agent is indifferent between purchasing and not purchasing when an equality

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3 See for instance, Dixon, *et al*. (2006), and Browne and Hoyt (2000).

holds. This observation leads us to define the agent's willingness-to-pay for this insurance as $\hat{\rho}_b$, satisfying the following equation:

$$\pi \cdot u(W) + (1-\pi) \cdot u(W-x) = \pi \cdot u(W-\hat{\rho}_b) + (1-\pi) \cdot u(W-x+b-\hat{\rho}_b)$$

The willingness-to-pay is almost linear in the loss probability $(1-\pi)$ when $(1-\pi)$ is very small as the following numerical example illustrates.

**Example: Effects of loss probability and degree of risk aversion**

Suppose an agent possesses a property of 100, but it is subject to a damage of 30 with subjective probability $\pi$. We assume that the loss can be fully insured (i.e. $x = b = 30$), and the willingness-to-pay for such an insurance policy $\hat{\rho}^{\pi}$is computed by

$$\hat{\rho}^{\pi} \coloneqq 100 - u^{-1}[\pi \cdot u(100) + (1-\pi) \cdot u(70)].$$

Table 1 reports the values of $\hat{\rho}^{\pi}$ for different values of loss probability $\pi$and those of the degrees of relative risk aversion $\gamma$ for a power utility $u(w) = w^{1-\gamma}/(1-\gamma)$.

**Table 1: Effects of Loss Probability and Degree of Risk Aversion**

| $1-\pi$ | $10^{-1}$ | $10^{-2}$ | $10^{-3}$ | $10^{-4}$ | $10^{-5}$ | $10^{-6}$ |
|---|---|---|---|---|---|---|
| $\gamma$ | 3.50 | $3.56\times10^{-1}$ | $3.57\times10^{-2}$ | $3.57\times10^{-3}$ | $3.57\times10^{-4}$ | $3.57\times10^{-5}$ |
| $\gamma$ | 4.11 | $4.27\times10^{-1}$ | $4.28\times10^{-2}$ | $4.29\times10^{-3}$ | $4.29\times10^{-4}$ | $4.29\times10^{-5}$ |
| $\gamma$ | 4.83 | $5.16\times10^{-1}$ | $5.20\times10^{-2}$ | $5.20\times10^{-3}$ | $5.20\times10^{-4}$ | $5.20\times10^{-5}$ |

Note that a catastrophe is typically rare, but causes a huge damage. In the example, this is characterised by a very small true loss probability $(1-\pi^*)$. The trouble is that no one really knows the true probability $\pi^*$ even if we may all agree that $(1-\pi^*)$ is 'very small'. However, both 1 in 1 million (or $10^{-6}$) and 1 in 10,000 (or $10^{-4}$) are small probabilities, yet the willingness-to-pay for the latter is approximately 100 times of the former, regardless of the degree of relative risk aversion in the above example. Nakata, *et al*. (2010) focuses on this feature to explain the above three stylised facts within the subjective expected utility framework. In what follows, we briefly explain the argument of Nakata, *et al*. (2010).

### 2.3. Diverse Beliefs and Rationality

The main idea of Nakata, *et al*. (2010) is simple. It is based on the fact that rare events are by definition observed very infrequently.[4] More specifically, rare events tend to be unprecedented even if the probability is not zero; thus, the empirical relative frequency tends to be zero. This implies that both a loss probability of 1 in 1 million and that of 1 in 1 billion would be consistent with data of no loss out of 100 observations. However, an insurance premium based on a probability of 1 in 1 million and that based on a probability of 1 in 1 billion will be very different in scale. In contrast, just one occurrence of a rare event will typically result in an inflated empirical relative frequency. This is compatible with stylised fact 3, i.e. an immediate jump in the market penetration upon occurrence of a catastrophe. The key observation is that the empirical data for rare events would not be sufficiently large to warrant a robust probability estimate, which would restrict diversity in terms of insurance premium or willingness-to-pay for insurance.

We illustrate the point more specifically by the following simplified version of the model in Nakata, *et al*. (2010). Suppose there are two states for each period, where state 1 is the no-loss state and state 2 is the loss state. The sequence is known to be i.i.d. Let $\pi$ denote the probability of state 1 in each period. Table 2 reports $P_{\pi}\{\text{no loss}\}$, the probability of observing no losses for different levels of $\pi$, when we fix the length of the sequence as 100.Observer that when $\pi$ is as low as 0.9999 (i.e. the probability of the loss states is 1/10000), the probability of observing no loss for 100 observations is approximately 0.99. This means that for any $\pi \geq 0.9999$, up to about 99% there will be no loss for 100 periods. Hence, the scale of loss probabilities that are compatible with the empirical frequency may vary substantially for rare events, particularly unprecedented events (any probability less than 1/10000 is very plausible when there

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[4] In the macroeconomics literature, Rietz (1988) introduced a rare disaster state to resolve the equity premium puzzle. His framework has attracted renewed attention recently—e.g., Weitzman (2007) and Barro (2009).

are 100 periods). In other words, the diversity of beliefs may well be very large in terms of the scale of the loss probability even if all agents are rational in the sense that their beliefs are compatible with the empirical data.

**Table 2: Probability of Observing No Loss in 100 Period**

| $\pi$ | $P_\pi\{\text{no loss}\}$ |
|---|---|
| 0.999999999 | 0.999999900 |
| 0.999999 | 0.999900050 |
| 0.9999 | 0.990049339 |
| 0.999 | 0.904792147 |
| 0.99 | 0.366032341 |

The large diversity in the subjective loss probability has a significant implication for the insurance demand. Recall that the willingness-to-pay for the insurance is almost linear in the loss probability when the loss probability is very small. Thus, a large diversity in the scale of subjective loss probability will imply a large diversity in the willingness-to-pay for the insurance. It follows that there may well be many agents whose willingness-to-pay is lower than the insurance premium offered by the insurance provider, even if the premium is set at an actuarially fair level with respect to the subject probability of the insurance provider.

Next, we observe the large impact of just one loss event on the class of subjective loss probabilities that are compatible with the empirical data. Table 3 reports the upper bound (2) of the proposition in the appendix for the probability of observing exactly one loss event in 100 periods for different values of $\pi$. It is obvious that one realisation of the loss state out of 100 periods/samples is not compatible with any $\pi$ greater than 0.999. This means that one occurrence of a rare event is typically incompatible with beliefs that assign a very low probability to such an event. As a result, one occurrence of a rare event may well result in a substantial revision of beliefs of the agents so that their willingness-to-pay for the insurance rises rapidly since the willingness-to-pay is almost linear in $(1-\pi)$ for small $(1-\pi)$ as the above numerical example illustrates. Note that this is consistent with stylised fact 2, and particularly, stylised fact 3.

**Table 3: Probability of Observing Exactly One Loss in 100 Periods**

| $\pi$ | Upper bound |
|---|---|
| 0.999999999 | $2.70468\times10^{-7}$ |
| 0.999999 | 0.000270441 |
| 0.9999 | 0.026780335 |
| 0.999 | 0.244962197 |

As noted above, the key observation is that the empirical data for rare events would not be sufficiently large to warrant a robust probability estimate that restricts diversity in terms of insurance premium or willingness-to-pay for insurance. Mathematically, the rate of convergence matters even if (we know that) the strong law of large numbers holds.

## 3. Welfare Measure under Diverse Beliefs

Let $U^h$ denote the utility of agent $h$, which may or may not have an expected utility form. It is then standard that a Pareto optimal allocation is characterised as a solution to the social planner's problem, which is based on a social welfare function such that $Z = \sum_{h=1}^{H} \lambda^h U^h$, where $\lambda^h$ is some positive weight attached to agent $h$. When $U^h$ has an expected utility form and the beliefs are homogeneous, the above social welfare function can be described as follows:

$$Z = E \sum_{h=1}^{H} \lambda^h u^h = \sum_{h=1}^{H} \lambda^h E u^h$$

since $U^h = Eu^h$ for all $h$. In contrast, when beliefs are heterogeneous, each utility function $U^h$ is based on a subjective probability.

However, as we explained briefly in the introduction, heterogeneity of beliefs invalidates the standard *ex ante* Pareto optimality and/or social welfare criterion. This is because by allowing for heterogeneous beliefs some agents inevitably hold incorrect beliefs, and such incorrect beliefs cause 'mistakes', which may results in regrets or pleasure *ex post*, even if they act optimally *ex ante* in accord with their beliefs. We use the term 'mistakes', since it is impossible to identify exactly if and how they made 'mistakes' by data when the beliefs are compatible with the data. Ignoring such regrets or pleasure calls for a significant value judgment, since it requires that the inability to hold the correct belief be penalised. In the context of natural disasters, the *ex ante* Pareto optimality requires that any *ex post* relief efforts would typically distort the allocation provided that the insurance policy was available prior to any very rare catastrophes.

Instead of taking such a strong value judgment, and to take *ex post* regrets or pleasure into account, it is probably reasonable to measure the welfare of the agents and the society as a whole with respect to an *ex post* measure. An *ex post* social welfare function is defined by

$$\hat{E}V(u^1, u^2, \dots, u^H)$$

where $\hat{E}$ is the expectation operator with respect to a social probability measure, $u^h$ is the *ex post* utility of agent $h$ (a random variable), and $V$ is a von Neumann-Morgenstern social welfare function, which is a function of the *ex post* utilities of the individuals.

Hammond (1981) shows that a socially optimal allocation based on an *ex post* social welfare function is not Pareto optimal in terms of the *ex ante* expected utilities of the agents unless all agents agree on the probability and the *ex post* social welfare function takes a special form such that

$$\hat{E}V(u^1, u^2, \dots, u^H) = \hat{E}\sum_{h=1}^{H} \lambda^h u^h = \sum_{h=1}^{H} \lambda^h \hat{E} u^h (1)$$

Note that when all agents hold rational expectations, the probability measure that defines $\hat{E}$ is identical to the one in the *ex ante* expected utility function of each agent, and consequently, the *ex post* optimal allocation is identical to the *ex ante* optimal allocation.

Even if we assume that the *ex post* social welfare function takes the form as (1) above, the choice of the social probability measure is not trivial, since there is no way to learn the true probability, and one can only *believe* that his probability belief is the true probability, although one may happen to hold the true probability as his belief. One easy resolution would be to *assume* that the modeller knows the true probability, while the agents in the model don't, and then specify the true probability as the social probability measure. However, such an assumption is not plausible, since apparently no objective justification can be given for the assumption. In other words, *we propose to take a view that the modeller and the agents in the model have equal knowledge and/or ability, rather than taking a paternalistic view that the modeller takes care of the agents in the model by assuming the modeller's possession of superior knowledge and/or ability*.

To follow the principle that the modeller and the agents in the model have equal knowledge and/or ability, the choice of the social probability must be objective, and at least the procedure must be one that can be agreed upon by anyone rational. The rationality requirement here should be a weak one, that the view must not be contradictory to evidence or empirical data. In other words, by taking a frequentist view of probability, and then we may define the acceptable range of subjective probabilities that are compatible with the empirical data. As Nakata, *et al*. (2010) argues and as was explained above, the range of acceptable subjective loss probabilities for rare events would be very large in terms of scale; for instance, 1 in 1,000 and 1 in 1 million are both compatible with the empirical data if the loss event concerned is unprecedented. One way is to define the social loss probability as the average of these acceptable subjective loss probabilities. In doing so, by assuming that the subjective loss probabilities are uniformly distributed, we will be effectively taking the least biased view, since a uniform distribution has the maximum entropy.

Moreover, the lack of knowledge of the subjective probability beliefs of the agents will cause a mechanism design issue, especially when we are to design a decentralised insurance mechanism. This is because we need to be able to predict the behaviour of the agents, which will be influenced by the subjective probability belief. In contrast, the lack of knowledge regarding tastes or degrees of risk aversion would not be too problematic as the above numerical example illustrates.

Suppose there are $S$ states (i.e. the set of all states is defined by $\mathcal{S} \coloneqq \{1, 2, \ldots, S\}$), and let $u^h(w_s^h)$ denote agent$h$'s *ex post* utility in state $s \in \mathcal{S}$ when its wealth level is $w_s^h$ . The *ex post* social welfare is characterised by the utility frontier $\left(\langle u_1^h \rangle_h, \langle u_2^h \rangle_h, \ldots, \langle u_S^h \rangle_h\right)$, where $\langle u_s^h \rangle_h \coloneqq (u_s^1, u_s^2, \ldots, u_s^H)$ for all $s$. The *ex post* social welfare would be not too far away from the *ex post* social optimum if there is no state $s$ in which $w_s^h$ is extremely low for some agent$h$, regardless of the functional form of $u^h$. This is a sufficient condition, not a necessary condition, to maintain a reasonably high level of *ex post* social welfare.

Note that this remains the same even if the *ex post* social welfare function does not have an expected utility form (1). Thus, a reasonably high level of *ex post* social welfare is maintained even if preferences of some or all agents do not have a standard expected utility representation and exhibit ambiguity aversion.[5] However, in the case of unawareness or unforeseen contingencies, the set $\mathcal{S}$ itself is unknown.[6] Thus, it is impossible to describe a full state contingent plan, and also the utility frontier $\left(\langle u_1^h \rangle_h, \langle u_2^h \rangle_h, \ldots, \langle u_S^h \rangle_h\right)$ is not well defined.The distinction between unawareness/unforeseen contingencies and the known state space may be important as the empirical study on insurance demand by Nakata, *et al*. (2010) suggests; the willingness-to-pay for flooding insurance is by and large consistent with the subjective expected utility framework, whilst it is not really the case for avian flu insurance, which appears to involve unforeseen contingencies, since mutation is not a foreseen contingency.

5 The Ellsberg paradox by Ellsberg (1962) illustrates the distinction between risk and ambiguity. The latter is formally described by Choquet integral; see Gilboa (1987) and Schmeidler (1989).

6 See Kreps (1979) and Dekel, *et al*. (2001).

## 4. Comparisons of Regional Insurance Schemes

In this section, we compare several insurance schemes for catastrophes or natural disasters from the viewpoint of the *ex post* social welfare.

### 4.1. The Macro Risk and the Strong Law of Large Numbers

As stated in the introduction, a typical insurance scheme is based on the strong law of large numbers. Namely, by letting $X^h$ denote the loss of household $h$, and assuming that $X^h$ is independent for all $h$,

$$\frac{1}{H}\sum_{h=1}^{H} X^h \to \bar{X} \text{as } H \to \infty,$$

where $\bar{X}$ is some constant. In other words, by expanding the membership of the insurance mechanism $\{1, 2, \dots, H\}$, the average loss per household will converge to a constant with probability one (with respect to a probability measure). In the language of economics, the assumption of independence of $X^h$ across $h$ is stating that each household's loss entirely consists of idiosyncratic risk. However, a catastrophe or a natural disaster typically violates the assumption of independence, which in turn implies the failure of the almost sure convergence of the average loss per household. In other words, a catastrophe incurs some macro risk.

Moreover, the treatment of the idiosyncratic part of the household loss requires great care. This is because it is not obvious at all under what probability measure the strong law of large numbers holds for the idiosyncratic part of the household losses. In other words, the precise properties of the idiosyncratic and the systematic risks of each household's loss are not very straightforward. The diversity of beliefs is inevitable and we need to take into account the impacts of the diversity of beliefs, as the numerical examples in section 2 illustrate.

## 4.2. Indemnity and Index Insurance

We consider two insurance contracts with different payoff structures: (a) indemnity insurance, and (b) index insurance. A conventional insurance contract is based on the actual loss or the indemnity, and we call the conventional insurance contract as indemnity insurance. Hence, a typical payoff structure of indemnity insurance that covers disaster type(s) $k$ for policyholder $i$ in state $s$ is

$$r_{k,s}^{i} = \min\{\max\{x_{k,s}^{i} - d, 0\}, b\} = \begin{cases} 0 & \text{if } x_{k,s}^{i} \leq d; \\ x_{k,s}^{i} - d & \text{if } x_{k,s}^{i} \in [d, b]; \\ b & \text{otherwise,} \end{cases}$$

where $x_{k,s}^{i}$ is the loss from type $k$ disaster policyholder $i$ incurs, $d$ is the deductible and $b$ is the maximum coverage. Thus, the payoff will exactly match the loss when $d = 0$ and $b \geq \max\{x_{k,s}^{i}, s \in \mathcal{S}\}$. Moreover, the price of the insurance (the insurance premium) is described as $\rho_{k}^{i}(d, b)$, i.e. it is a function of $(i, k, d, b)$. For standardised indemnity insurance, the premium is not exactly personal to the policyholder $i$, but is a function of the attributes of $i$. In such a case, $\rho_{k}(\theta, d, b)$, where $\theta$ is the attributes of the policyholder.

Meanwhile, index insurance is a contract whose payment is contingent on a set of pre-determined conditions, and is not based on the actual loss the policyholder incurs. Usually the pre-determined conditions (i.e. the trigger event) are easily observable and/or verifiable. For instance, a pre-determined amount (e.g. USD 1 million) of an earthquake index insurance contract will be paid to the policyholder if an earthquake that is at least as powerful as the specified level (e.g. magnitude 7.0) occurs in a specific location (e.g. the epicentre is within 100 miles from Tokyo's city centre). Thus, the payoff structure of a typical index insurance contract for the trigger event $k$ (i.e. the set of states $\mathcal{S}^{k} \subset \mathcal{S}$) is

$$r_{k,s} = \begin{cases} c & \text{if } s \in \mathcal{S}^{k}; \\ 0 & \text{otherwise.} \end{cases}$$

Note that the payoff $r_{k,s}$ is not a function of $i$, i.e. it is the same across the policyholders. There will be a discrepancy between the payment of the index insurance and the actual loss from the perspective of the insurance policyholder, and such discrepancy is often referred to as a basis risk in this context.

Each index insurance $k$ can be described as a zero-net supply security:

$$\sum_{i \in \mathcal{J}} z_k^i = 0,$$

where $\mathcal{J}$ is the set of all economic agents (households, firms, local governments, etc.) and $z_k^i$ is economic agent $i$'s position of index insurance $k$. Indeed, the market structure of the index insurance can be either (a) a competitive market along the line of a standard general equilibrium model, where all economic agents are price takers, or (b) a typical market for insurance products, where insurance companies control prices and hold short positions. Practically, the former case would require that the index insurance to be traded on the capital market, just like the catastrophe (CAT) bonds. In the latter case, we may fix the identity of the supplier of each index insurance $k$, i.e. we can simply add conditions such that $z_k^i < 0$ for the particular supplier $i$.

In the former case, the price $q^k$satisfies the following equation in equilibrium:

$$q^k = \sum_{s \in \mathcal{S}} \pi_s^i \frac{\partial u^i(w_s^i)}{\partial w_s^i} r_{k,s},$$

where $\pi_s^i$ is economic agent $i$'s subjective probability of state $s$, $w_s^i$ is agent $i$'s wealth in state $s$, and $u^i$ is agent $i$'s (indirect) utility function. This equation states that the agent may choose to allow for the occurrence of a state with a very low $w_s^i$ when $\pi_s^i$ is very small. In other words, agents that underestimate the catastrophe states would limit the purchase of index insurances that could compensate for the losses in those states.

It is clear that both types of insurance contracts are state contingent claims. Thus, the verification of the state is crucial. However, verification is much costlier and is more prone to moral hazard for the indemnity insurance than for the index insurance, since the latter only requires the verification of $s \in \mathcal{S}$, whilst the former requires the verification of $x_{k,s}^{i}$.

### 4.3. Evaluations of Different Insurance Schemes

Next, we attempt to compare and evaluate the indemnity and index insurance. In so doing, we consider three different cases concerning the identity of the policyholders: (a) households, (b) local governments, and (c) national governments. The first case is the most obvious one, in which each household directly purchases insurance policies. The second and the third are the cases in which the insurance policies are purchased by the governments (local or national), and the purchases may be financed by tax.

Let $N$ denote the set of countries (that participate in the regional insurance scheme), and $n$ its typical element, i.e. country $n$. Let $\mathcal{L}$ denote the set of all local governments in the region, and $l$ its typical element, i.e. local government $l$. If necessary, we let $\mathcal{L}^n$ denote the set of all local governments in country $n$. We may let $\mathcal{H}^l$ denote the set of all households in the area of the local government $l$.

#### *4.3.1. Direct subscriptions by Households*

We first consider the case in which each household is the potential policyholder of the insurance, either indemnity or index insurance. This is desirable with respect to the *ex ante* Pareto optimality criterion, since the choice made by each household will reflect its *ex ante* preference.

However, as we showed above, the subjective loss probability would be rather diverse especially for households who have experienced no major losses in the past. When the insurance premium is set by the supplier, this would result in a rather low level of subscription rate, since a large number of households would deem the premium too high. Also, for index insurance, when the market structure is competitive (i.e. all economic agents are price takers), households whose probability estimates for the catastrophe states are very low would not hold a position that would sufficiently cover the losses in the catastrophe states. In these cases, the *ex post* welfare of the economy would become very low, since some households would be left in a disastrous condition, if no relief efforts are made *ex post*.

*4.3.2. Subscriptions by Local Governments*

Next, we examine the case in which local governments are the potential policyholders of the insurance, instead of the households. For every local government $l$, the aggregate loss of the households in the governing area is $X^l \coloneqq \sum_{h \in \mathcal{H}^l} X^h$. When there is no macro risk at each local government level, this quantity is a constant. However, there typically remains a macro risk at this level especially for natural disasters. Thus, there are incentives for the local governments to share risk with other local governments within the country or within the whole East Asian region.

Moreover, to finance the insurance premium, the local government would either use its general tax income or impose a separate tax specific to the insurance. For index insurances, it is possible conceptually that the cost of the portfolio of index insurances may be zero, $\sum_{k \in \mathcal{K}} q^k z_k^i = 0$, where $\mathcal{K}$is the set of all index insurances. Either way, this scheme is effectively a two-tier risk sharing scheme. That is, (a) the risk sharing scheme amongst local governments, and (b) the risk sharing scheme within the governing area of each local government. The latter scheme should be designed so that it eliminates idiosyncratic risk at the household level.

One major advantage of this scheme over the one with direct subscriptions by households is that the subjective probability of $X^l$ would be less diverse than that of $X^h$ for household $h$ with no or very limited prior loss experience, since the empirical loss probability of $X^l$is larger than that of $X^h$ for households with no or very little prior loss experience. Thus, the conflict between the *ex ante* and *ex post* welfare measure would be less severe, at least in terms of decision making. However, many households with no prior loss experience may well view the scheme *ex ante* as a wealth transfer mechanism that would be disadvantageous to them.

The implementation of the risk sharing scheme within the governing area of each local government may be very costly and prone to moral hazard if it follows the design of indemnity insurance, i.e. the payments to the households are made against the claims made by the households. However, if the payments are made so that no household would be left in a devastating state even if they are not exactly matching the actual losses, the *ex post* welfare would be reasonably high.

*4.3.3. Subscriptions by National Governments*

Finally, we examine the case in which national governments are the potential policyholders of the insurance. For every national government $n$, the aggregate loss of the households in the governing area is $X^n := \sum_{h \in \mathcal{H}^n} X^h$. Clearly, the subjective probability of $X^n$ would be less diverse than that of $X^l$ for all $l \in \mathcal{L}^n$. In this case, the regional insurance scheme aims at sharing the macro risks at the country level, whilst the risk sharing within the country will be done through the tax system that would finance the regional insurance premium.

One major problem is that the determination of the insurance premium would be very political, as we observe in many international frameworks. This applies also to index insurance, since no national government would act as a price taker.

## 5. Conclusion

We have examined the possible issues that are key to design regional insurance schemes for catastrophes or natural disasters that mainly target the household sector. We first introduced a simplified version of the insurance demand model by Nakata, *et al*. (2010), which is consistent with the three stylised facts about catastrophe insurance demand. The key observation is that the robustness of a probability estimate of a rare event is very limited, which would result in a large diversity and variability in the scale of subjective loss probabilities for rare events.

When the probability beliefs are diverse, the standard Pareto criterion becomes dubious, because it is based on the *ex ante* preferences, which govern the decisions of the agents, but ignore the regrets for the mistakes made due to the 'incorrect' beliefs. Thus, it would be sensible to use the *ex post* welfare measure proposed by Starr (1973) and Hammond (1981). However, the choice of social probability for the *ex post* social welfare function with an expected utility form is not straightforward. Nevertheless, by making everyone avoid any catastrophe state would ensure that the *ex post* social welfare would be close to the *ex post* social optimum, regardless of the true social probability or the functional form of the *ex post* utility.

With this in mind, we evaluated various insurance schemes. For both the indemnity and index insurance schemes, voluntary direct subscriptions by the households are not desirable, since voluntary subscriptions by the households would most likely to lead to insufficient level of insurance coverage and the occurrence of personal catastrophe states for some agents due to the large diversity in subjective loss probabilities. Since the diversity in the loss probabilities would be less for aggregate losses at the local government level, an insurance scheme with subscriptions by local governments in conjunction with *ex post* payments/compensations to the affected households would be more desirable. Considering the possible moral hazard issues inherent to indemnity insurance, schemes based on index insurance appear to be more desirable. However, the underwriting costs for index insurance may well not be low, whether the index insurance will be supplied and priced by insurance suppliers or traded on the capital market.

The current paper leaves several important issues unexamined. First, supply side issues, including but not limited to the issues related to underlying costs, are not examined, and they require both empirical and theoretical examinations. Moreover, analyses based on a dynamical model would be needed. As noted above, catastrophes or natural disasters tend to incur risk at the aggregate level (i.e. macro risk). Thus, it is impossible to exactly match the insurance payment of indemnity insurance with fixed insurance premiums in every period. Hence, a dynamical model is needed to analyse the level of reserves needed to ensure smoothing of aggregate wealth or consumption over time, without falling to insolvency. Also, for index insurances traded on the capital market, the impacts of possible fluctuations in (relative) prices should be analysed by a dynamical model, since the fluctuations may well have significant impacts.

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## Appendix: The large deviation property

In what follows, we reproduce the exposition of Lemma 1.1.9 of Dembo and Zeitouni (1998) in Nakata, *et al*. (2010). Let random variable $X_t$ denote the loss in period $t$, and let $X_1, X_2, \dots, X_T$ be an i.i.d. sequence. Also, let $\mathcal{P}(\mathcal{A})$ denote the space of all probability laws on $\mathcal{A} \coloneqq \{a_1, a_2, \dots, a_S\}$. Furthermore, for a finite sequence (of realisations) $\mathbf{x}^T = (x_1, x_2, \dots, x_T)$, we define the empirical measure of $a_s$ as follows:

$$m_T^{\mathbf{x}}(a_s) \coloneqq \frac{1}{T}\sum_{t=1}^{T} \mathbf{1}_{a_s}(x_t), \quad \forall s,$$

where $\mathbf{1}_{a_s}(\cdot)$ is an indicator function such that

$$\mathbf{1}_{a_s}(x_t) = \begin{cases} 1 & \text{if } x_t = a_s; \\ 0 & \text{otherwise.} \end{cases}$$

Then, we define type $m_T^{\mathbf{x}}$ of $\mathbf{x}^T$ as

$$m_T^{\mathbf{x}} \coloneqq \left(m_T^{\mathbf{x}}(a_1), m_T^{\mathbf{x}}(a_2), \dots, m_T^{\mathbf{x}}(a_S)\right).$$

Let $\mathcal{M}_T$ denote the set of all possible types of sequences of length $T$, i.e.

$$\mathcal{M}_T \coloneqq \{\nu : \nu = m_T^{\mathbf{x}} \text{ for some } \mathbf{x}^T\}.$$

Also, the empirical measure $m_T^{\mathbf{x}}$ associated with a sequence of random variables $\mathbf{X}^T \coloneqq (X_1, X_2, \dots, X_T)$ is a random element of $\mathcal{M}_T$.

Let $P_\pi$ denote the probability law associated with an infinite sequence of i.i.d. random variables $\mathbf{X} = (X_1, X_2, \dots)$ distributed following $\pi \in \mathcal{P}(\mathcal{A})$. Also, the relative entropy of probability vector $\nu$ with respect to another probability vector $\pi$ is $H(\nu|\pi) \coloneqq \sum_{s=1}^{S} \nu_s \ln \frac{\nu_s}{\pi_s}$.

**Proposition (Lemma 1.1.9; Dembo and Zeitouni, 1998):** *For any* $\nu \in \mathcal{M}_T$*,*

$$(T+1)^{-S} e^{-TH(\nu|\pi)} \leq P_\pi(m_T^{\mathbf{x}} = \nu) \leq e^{-TH(\nu|\pi)} \qquad (2)$$

The proposition states that the probability of observing type $\nu$ for a sequence of length $T$ with respect to probability law $\pi^{\pi}$ has the lower and upper bounds as specified in (2).[7] Clearly, both the lower and upper bounds are decreasing in $H(\nu|\pi)$. Note that this result (and the results in the literature of large deviations) is very useful, since it may well be rather difficult to compute the exact probability $P_\pi(m_T^{\mathbf{x}} = \nu)$ in many cases. This difficulty arises from the fact that we need to consider all possible paths/sequences that belong to the specified type, which involves combinatorics. Moreover, from this result, we know that the relative entropy $H(\nu|\pi)$ characterises the probability $P_\pi(m_T^{\mathbf{x}} = \nu)$, although the bounds may not be very tight in some cases.

[7] $P_\pi(m_T^{\mathbf{x}} = \nu)$ is a likelihood function in the language of Bayesian statistics, in which case an explicit updating of beliefs is modelled. However, we do not assume such an explicit belief updating mechanism in the current paper.

# CHAPTER 4

# Index-Based Risk Financing and Development of Natural Disaster Insurance Programs in Developing Asian Countries


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*This chapter explores innovations in index-based risk transfer products (IBRTPs) as a means to address important insurance market imperfections that have precluded the emergence and sustainability of formal insurance markets in developing countries, where uninsured natural disaster risk remains a leading impediment of economic development. Using a combination of disaggregated nationwide weather, remote sensing and household livelihood data commonly available in developing countries, the chapter provides analytical framework and empirical illustration on showing design nationwide and scalable IBRTP contracts, to analyse hedging effectiveness and welfare impacts at the micro level, and to explore cost effective risk-financing options. Thai rice production is used in our analysis with the goal to extend the methodology and implications to enhance development of national and regional disaster risk management in Asia.*



***Keywords***: Natural disaster insurance, Index insurance, Reinsurance, Catastrophe bond, Rice production, Thailand.


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## 1. Introduction

There is growing evidence that the frequency and intensity of natural disasters continue to rise over the past decades (Swiss Re 2011a). This trend is likely to continue as the impact of climate change drives greater volatility in weather-related hazards (IPCC 2007). The low-income and developing countries suffered an increase of disaster incidence at almost twice the global rates large proportion of population still rely on agriculture and live in vulnerable environments (IFRCRCS 2011). Overall, costs per disaster as a share of GDP are considerably higher in developing countries (Gaiha & Thapa 2006). Over the past decade, Asia has been the most frequently and significantly hit region occupying 80% of the major natural disasters worldwide.[1]

Less than 10% of natural disaster losses in developing countries are insured as several markets imperfections have served to impede development of markets for transferring natural disaster risks. Adverse selection and moral hazard are inherent to any form of conventional insurance products when insured have total control of and private information on the indemnified probability. Transaction costs of financial contracts necessary for controlling these information asymmetries and for verifying claimed losses are extremely high relative to the insured value especially for smallholders. Limited spatial risk-pooling potential resulted from covariate nature of natural disaster losses further impedes the development of domestic insurance market, unless local insurers can transfer the risks to international markets.

Without effective insurance market, public disaster assistance and highly subsidised public insurance programs have been the key supports for affected population in developing countries. The increasing frequency and intensity of these

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[1] The major disasters of the decade leading to large number killed in Asia include the 2004 Indian Ocean tsunami (226,408 deaths), the 2008 Cyclone Nargis in Myanmar (138,375), the 2008 Sichuan earthquake in China (87,476), the 2005 Kashmir earthquake (74,648) and the 2001 major earthquakes in Gujarat, India (20,017). The recent major disasters leading to widespread affected populations in Asia include the 2010 floods in China (134 million people), the 2009 droughts in China (60 million people), the 2010 Indus river basin flood in Pakistan (more than 20 million people) and the 2011 river flood in Thailand (13.6 million people).The three costliest natural disasters in 2011 are all in Asia: earthquake and tsunami in Japan (USD 281 billion), river flood in Thailand (USD 45.7billion) and earthquake in New Zealand (USD 20 billion).

covariate shocks, however, could jeopardise the adequacy, timeliness and sustainability of these programs (Cummins & Mahul 2009). These public programs are largely prone to moral hazard, which could easily alleviate the program costs through induced risk taking incentives or underinvestment in risk mitigating activities among vulnerable populations. Without proper targeting, these programs could further crowd out private insurance demand impeding the development of healthy domestic insurance market.

Households in developing countries, thus, are disproportionally affected by disasters due to larger exposures but limited access to effective risk management strategies. While literatures analyse the wide array of informal social arrangements and financial strategies that households employ to manage risk, in nearly all cases these mechanisms are highly imperfect especially with respect to covariate shocks and in many cases carry very high implicit insurance premia. The resulting long-term impacts of catastrophic shocks on their economic development thus have been widely evidenced in the literatures (Barrett, *et al*. 2007 offers great review).

This chapter explores the potentials of the increasingly used index-based risk transfer products (IBRTPs) in resolving the key market imperfections that impede the development and financing of sustainable natural disaster insurance programs in developing countries. Unlike conventional insurance that compensates individual losses, IBRTPs are financial instruments, e.g., insurance, insurance linked security, that make payments based on an underlying index that is transparently and objectively measured, available at low cost and not manipulable by contract parties, and more importantly highly correlated with exposures to be transferred. By design, IBRTPs thus can obviate asymmetric information and incentive problems that plague individual-loss based products, as the index and so the contractual payouts are exogenous to policyholders. Transaction costs are also much lower, since financial service providers will only need to acquire index data for pricing and calculating contractual payments. There will be no need for costly individual loss estimations. Properly securitising natural disaster risk into a well defined, transparently and objectively measured index could further open up possibilities to transfer covariate risks to international reinsurance and financial markets at competitive rates.

As natural disaster losses are covariate, it would be possible to design IBRTPs based on a suitable aggregated index. These opportunities, however, come at the cost of basis risk resulting from imperfect correlation between an insured's actual loss and the behaviour of the underlying index on which the contractual payment is based. IBRTPs will be effective only when basis risk is minimised. The contracts need to also be simple enough to hold informed demand among clients with limited literacy in developing countries, and to be scalable to larger geographical settings to ensure efficient market scale. Trade-offs among basis risk, simplicity and scalability thus constitute the key challenges in designing appropriate IBRTPs for developing countries.

Over the past decade, IBRTPs have emerged as potentially market viable approaches for managing natural disaster risk in developing countries. The growing interests among academics, and development communities have resulted in at least 36 projects in 21 countries worldwide covering risks of droughts, floods, hurricanes, typhoons and earthquakes based on objectively measured area-aggregated losses, weather and satellite imagery products.[2] Contracts have been designed to enhance risk management at various levels ranging from farmers and homeowners as target users to macro level, allowing governments and humanitarian organisations to transfer their budget exposures in provision of disaster relief programs to the international markets.

The consensus, however, has not been reached if and how IBRTPs could work in developing country settings for several reasons. First, current literatures[3] tend to either lack rigorous analysis of basis risk and welfare impacts or use aggregated data to perform such analysis. Hence, less could be learnt *ex ante* about the value of the contracts to the targeted population. Second, contract designs to date are context

[2] Table A1 summarises the existing IBRTP projects piloted in Asia to date. Growing numbers of literature has also depicted opportunities and challenges of implementing IBRTPs. See IFAD and WFP (2010), Barnett, *et al*. (2008), for example, for review. See Chantarat, *et al*. (forthcoming, 2011, 2008, 2007), Clarke, *et al*. (2012) and Mahul and Skees (2007) for examples related to IBRTP designs in the developing world, and Mahul (2000) for examples related to agriculture in high-income countries.

[3] With the exception of some on-going new projects, see for example, Chantarat, *et al.* (forthcoming) and various piloted projects funded by USAID-I4 Index Insurance Innovation Initiative at http://i4.ucdavis.edu/projects/. These ongoing pilot projects undertake rigorous contract design and ex-ante evaluation using high-quality household welfare data in addition to their proposed ex-post evaluation through multi-year household-level impact assessment.

specific, making it very difficult to be scaled up in other heterogeneous settings. Finally, as most of the current studies are small in scale, less has been explored on the potentials for portfolio risk diversifications, transfers and financing.

This chapter complements existing literatures, especially on the rigorous analysis and applications of IBRTPs in Asia. We provide analytical framework and show empirically how to use a combination of disaggregated and spatiotemporal rich sets of household and disaster data, commonly available in developing countries, to design nationwide and scalable IBRTP contracts, to analyse hedging effectiveness and welfare impacts at a disaggregated level and to explore cost effective disaster risk-financing options. Our empirical illustration explores the potentials for development of nationwide index insurance program for rice farmers in Thailand. We analyse contract design based on three forms of indices:(i) government collected provincial-averaged rice yield, (ii) estimated area yield constructed from scientific crop-climate modelling and (iii) various constructed parametric weather variables. These indices differ in risk coverage, exposure to basis risk, level of simplicity and scalability. Disaggregated welfare dynamic data obtained from the multi-year repeated cross sectional household survey are then used to estimate basis risk and to evaluate the relative hedging effectiveness of these indices given the above trade-offs.

The nationwide design coupled with spatiotemporal rich indices data further allow us to explore portfolio risk diversification and transfers through reinsurance and securitisation of insurance-linked security in the form of catastrophe bond. And through simulations based on disaggregated nationwide household dynamic data, we finally explore potential impacts of the optimally designed index insurance program under various public-private integrated risk financing arrangements. Except for the existing literatures in Mongolia (Mahul and Skees 2007) and India (Clarke, *et al*. 2012), the paper is among the very first to study IBRTPs using a countrywide analysis. Using commonly available data sets further enhance scalability of our analysis to other settings in the region.

The rest of the chapter is structured as following. Section 2 provides analytical framework on the design, pricing and applications of IBRTPs. Section 3 presents the main empirical results illustrating the potentials of IBRTPs for rice farmers in

Thailand. Section 4 concludes with discussions on challenges and opportunities in implementing IBRTPs and implications of our studies for the rest of Asia.

## 2. Managing Natural Disaster Risks using Index-Based Risk Transfer Products

Consider a setting where household's stochastic livelihood outcomes, $y_{it}$, are exposed to natural disasters. In our case of Thai rice farmer, $y_{it}$ represents rice production[4] realised by household $i$ in province $l$ at year $t$.[5] Household's production can be orthogonally decomposed into the systemic component explained by a location aggregated index $z_t$– capturing location-aggregated risks – and the idiosyncratic variation unrelated with the index, $\varepsilon_{it}$, according to:

$$y_{it} = \bar{y}_i + \beta_i(z_t - \bar{z}) + \varepsilon_{it} \qquad (1)$$

where $\bar{y}_i$ and $\bar{z}$ denote expected or long-term average of the household's production and the aggregated index respectively. $\beta_i = \sigma(y_{it}, z_t)/\sigma^2(z_t)$ measures the sensitivity of household's production to the systemic risk captured by the location aggregated index.

**Underlying Index**

The key to designing effective IBRTP contract is to find a high quality aggregate index $z_t$ that can explain most of the variations in $y_{it}$ so that contractual payments based on $z_t$ can protect households from the major systemic production shortfalls. The imperfect relationship between the index $z_t$ and $y_{it}$, however, implies that $\beta_i$ and $\varepsilon_{it}$ will jointly determine basis risk associated with the contract. Low and insignificant $\beta_i$ and high variations in $\varepsilon_{it}$ could imply large basis risk.

The pre-requisites for appropriate index include (i) index being measured objectively and reliably by non-contractual party (to reduce the potential incentive

[4] In other cases, this measure might be household's income, asset or consumption. Note that consumption reflects its various income streams as well as net flows of informal social insurance and perhaps other stochastic payments.

[5] For simplicity, we drop location subscript $l$ throughout the chapter.

problems), (ii) index being measured at low cost, in near-real time (to enhance the timeliness of indemnity payout), (iii) index has extended high-quality historical profiles of at least 20-30 years (to allow for proper actuarial analysis) and (iv) index can explain great variations in insurable loss (to minimise basis risk). Three general forms of index are currently used in the design of IBRTPs worldwide.

First is the direct measure of production $\bar{y}_t = E_t(y_{it})$ for an aggregate location. Because $\bar{y}_t$capturesall the systemic risks that cause variations in the location-averaged outcomes, IBRTPs based on$\bar{y}_t$could offer multi-peril protection to household's production losses. The key is the spatiotemporal availability of $\bar{y}_t$ that can be measured accurately and efficiently at low cost and in timely manner by parties independent to the IBRTP contract.[6]$\bar{y}_t$ should also be representative at the micro level to minimise basis risk. The current commercialised contracts that rely on $\bar{y}_t$are, for example, the group risk plan in North America based on county-level yield (Knight and Coble 1997), the index-based livestock insurance in Mongolia based on area-aggregated census of livestock loss (Mahul and Skees 2007) and the recently piloted area yield insurance for rice farmers in Vietnam (Swiss Re, 2011b).

Alternatively, an estimated location average production can be established from scientific earth observation, agro-meteorological or disaster models or econometric approaches such that

$$\bar{y}_t = y(w_t) + \eta_t, \qquad (2)$$

Where $w_t$represents some representations of weather or natural disaster events that can explain most of the variations in $\bar{y}_t$ and are available with spatiotemporal rice historical profiles. $w_t$can be in some forms of accumulations or deviations from normal condition of station or gridded weather data, satellite imagery or other objectively measured magnitude and intensity of natural disasters, e.g., wind speed, scale of earthquake, etc. Depending on the chosen $w_t$, contract can be designed to cover single or multiple perils. From (2), an underlying index $z_t$ that triggers contractual payments thus can be constructed either from an estimated location-averaged production, $y(w_t)$, or directly from a simple measure of $w_t$.

[6]High-quality data of $\bar{y}_t$, however, might not be readily available in most of the developing countries.

From (1) and (2), these estimated index $y(w_t)$ or $w_t$ could be subjected to at least two additional sources of basis risk, relative to $\overline{y}_t$. First, $\eta_t$ represents additional variations in location-averaged production that could not be explained by either $y(w_t)$ or $w_t$. In the case of rice production, the index might not capture some non-weather related variations of production, e.g., pest or disease outbreaks, that could affect most of the insured. How well $w_t$ represents weather or natural disaster events experienced by the insured would further contribute to an additional source of basis risk.[7] The keys are that $w_t$ should be measured at the most micro level, and that (2) should be established at the most micro level using disaggregated data to minimise basis risk. Carter, *et al*. (2007) show that contract triggered by econometrically estimated $y(w_t)$ has poorer hedging performance relative to the area-yield insurance for cotton farmers in Peru.

The two forms of weather index, $y(w_t)$ or $w_t$, could differ slightly on the potential basis risk, simplicity and so scalability. The working assumption in favour of $y(w_t)$ is that by using complex scientific or econometric modelling potentially with exogenous controls, the established $y(w_t)$ could explain household production with higher accuracyand hence with lower basis risk relative to the simple $w_t$. The key potential shortfall is the potential for index $y(w_t)$ to be complex for targeted clients to understand and for scaling up to larger settings. For simple $w_t$, on the other hand, contract design can also minimise basis risk by incorporating exogenous controls – e.g., geographical information system (GIS), agronomic data, etc. – in the construction of $w_t$ or payout function. This would also involve trading simplicity with basis risk reduction. The transparency in the direct observation of $w_t$ might further enhance risk transfer potential into international market (Skees, 2008). The relative performance of the two forms of index has been mixed empirically, and has not been explored formally.

With $y(w_t)$, World Food Programme's Ethiopian drought insurance triggered payouts to protect farmers based on estimated livelihood losses measured by a scientific water requirement crop model (WFP 2005), and the index-based livestock

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[7]For example, station weather with relatively lower spatial distribution might be subjected to higher basis risk especially in areas with large microclimate. The increasingly available gridded weather data combining satellite and station weather data using GIS and distance weighting techniques are increasingly used as alternative indices.

insurance uses estimated livestock loss established econometrically from remote sensing Normalised Difference Vegetation Index (NDVI) to compensate Kenyan's herd losses from drought (Chantarat et al. forthcoming). Both risks have also been transferred to international market. With $w_t$, the rainfall and temperature index insurance contracts (designed relative to crop growth cycles) have been expanding in India since 2003 and sold to more than 700,000 smallholder farmers today with risks transferred into international markets (Gine, *et al.* 2007, Manuamorn, 2007). Contracts have also been expanding in many developing counties. Using simple correlations, Clarke, *et al.* (2012), however, finds that basis risk of the Indian contracts could be very high and heterogeneous across settings. Parametric indicators of natural disasters have also been used in the design of catastrophe insurance, e.g., for earthquake in Mexico and the Caribbean (World Bank, 2007).

**Index Insurance**

With the three general forms of underlying index, $z_t = \bar{y}_t, y(w_t), w_t$, a standard index insurance contract can be designed to compensate for production shortfall according to

$$\pi(z_t, z^*) = max\{z^* - z_t, 0\}. \qquad (3)$$

This standard payoff function thus specifies contract's coverage area $l$ and period $t$ when the index will be measured and a strike $z^*$ that triggers payout once the realisation of $z_t$ falls below it.[8] An optimal contract will involve insured households scaling up or down this standard contract to meet their risk profiles and compensation needed when $z_t$ falls below $z^*$.

An actuarial fair rate of this standard contract depends on strike level and can be calculated for each coverage location based on an empirical distribution of the underlying index:

$$E\pi(z_t, z^*) = \int \pi(z_t, z^*) f(z_t) dz_t. \qquad (4)$$

[8] This standard payoff function is equivalent to a put option on underlying index. Deviation from this standard payoff function includes a call option that triggers payout when index realisation is above strike level.

$f(z_t): S_z \to \Re$ can be obtained from the historical data or can be estimated parametrically or non-parametrically using historical index data.

**Optimal Contract and Hedging Effectiveness**

An optimal insurance design defines a combination of a standard contract and a coverage scale that maximises the insured's welfare. For simplicity, we consider a risk-averse household with preference over consumption represented by class of mean variance utility function with $\theta > 0$ representing an Arrow-Pratt coefficient of absolute risk aversion.[9] With stochastic net income from production $y_{it}$ under assumed deterministic price, insured household's income available for consumption can thus be written as

$$c_{it} = y_{it} + \alpha_i\big(\pi(z_t, z^*) - \delta E\pi(z_t, z^*)\big) \quad (5)$$

where $\alpha_i$ is a coverage choice that scales liability of the standard contract to meet household's risk profile.[10] $\delta > 1$ is a market premium loading factor. Subjected to (3), (4) and (5), an optimal coverage scale for $\pi(z_t, z^*)$ can thus be derived as

$$\max_{\alpha_i^*(\theta, z^*, \delta)} E(c_{it}) - \frac{\theta}{2}\sigma^2(c_{it}) \quad (6)$$

This simple mean variance utility representation allows us to derive an optimal insurance design $\{\pi(z_t, z^*), \alpha_i^*(\theta, z^*, \delta)\}$ for insured household in each coverage location with

$$\alpha_i^*(\theta, z^*, \delta) = \left|\rho_{y_{it}, \pi(z_t, z^*)}\right| \frac{\sigma(y_{it})}{\sigma\big(\pi(z_t, z^*)\big)} - \frac{(\delta - 1)E\pi(z_t, z^*)}{\theta\sigma^2\big(\pi(z_t, z^*)\big)}\,. \quad (7)$$

Household's optimal insurance coverage is thus increasing in the magnitude of the correlation between their production and the contractual payment, variations in their production and risk aversion. The optimal coverage is also decreasing in the premium loading. If the contract is actuarial fair, this optimal coverage scale will be equivalent to a typical financial hedge ratio.

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[9] In specific, we consider CARA utility function $U(c_{ilt}) = -e^{-\theta c_{ilt}}$ so that $EU(c_{ilt}) = E\big(-e^{-\theta c_{ilt}}\big) = E(c_{ilt}) - \frac{\theta}{2}\sigma^2(c_{ilt})$ under normally distributed consumption (Ljungqvist and Sargent, 2004).

[10] This scaling factor has been used widely in the literatures, e.g., Skees, *et al*. (1997).

By comparing expected utility of consumption with $(c_{it}^{\pi})$ and without contract $(c_{it}^{no\pi})$, we can quantify the magnitude of household's welfare gain from an optimal insurance contract as

$$EU(c_{it}^{\pi}) - EU(c_{it}^{no\pi}) = \frac{\theta}{2}[\sigma^2(c_{it}^{no\pi}) - \sigma^2(c_{it}^{\pi})] - [E(c_{it}^{no\pi}) - E(c_{it}^{\pi})]. \quad (8)$$

This implies that for a risk-averse household, welfare gain from insurance contract will be proportional to the variance reduction relative to the mean reduction in the insured consumption stream. Welfare gain thus increases in risk aversion and decreases in premium loading. The gain decreases with basis risk$(\beta_i, \varepsilon_{it}, \eta_t)$ through its effects on variance reduction.

With $U'(\cdot) > 0,$ the welfare measure in (8) can be translated into comparison of certainty equivalence, $\bar{c}_{it}$, with and without insurance. $\bar{c}_{it}$of stochastic production income streams is defined as the value of consumption that, if received with certainty, would yield the same level of welfare as the expected utility of the stochastic consumption stream. Hence, $U(\bar{c}_{it}) = EU(c_{it})$. The welfare improvement impact, $EU(c_{it}^{\pi}) - EU(c_{it}^{no\pi}) > 0,$ can thus be translated into $\bar{c}_{it}^{\pi} - \bar{c}_{it}^{no\pi} > 0,$ which reflects risk-reduction value of insurance and so the insured's willingness to pay in excess of the current price in order to obtain the insurance. This utility-based welfare measure thus allows us to formally compare hedging effectiveness across contract designs, households and locations with heterogeneous settings.[11]

**Portfolio Pricing and Risk Diversification**

With catastrophic natures of natural disaster risks, pricing a stand-alone contract in (4) – relying on marginal distribution of an index in one coverage location – will likely result in high market premium rate especially due to catastrophe load. Capacity to pool these covariate risks across larger geographical or temporal coverage, or with tradable securities (with potentially less correlated returns) might enhance cost effective pricing as part of a well-diversified portfolio.

In specific, the market premium rate of a standard index insurance contract priced as part of a portfolio $P$can be disaggregated into

[11] Parallel hedging effectiveness measures have been used in Cummins, *et al*. (2004).

$$\delta E\pi(z_t, z^*) = \left(E\pi(z_t, z^*) + c(\mathrm{P}_m)\right) \cdot k \quad (9)$$

Where administrative load $k$reflects some constant factor to cover all the transaction costs and an increasing function $c(\mathrm{P}_m)$ representing a catastrophe load to cover the total cost associated with securing the risk capital and obtaining reinsurance coverage to finance the catastrophic risk represented by probable maximum loss (PML), $\mathrm{P}_m$. Typically, PML can be established using Value at Risk (VaR) of the insurer's portfolio payouts net premium received at some ruin probability $1 - m,\ m \in (0,1)$. Specifically, consider an insurer's diversified portfolio consisting of index insurance contracts covering geographical locations (each with portfolio weight $\rho = \sum_i \alpha_i^*$) in the region.

$$\mathrm{P}_m(\mathrm{P}) = \mathrm{VaR}_m(P) = -\inf\{p \in \Re : F_P(p) > m\},\ \ \mathrm{P} = \sum \rho\left(\pi(z_t, z^*) - E\pi(z_t, z^*)\right) \quad (10)$$

Where P represent the portfolio's stochastic net payout position with cumulative density $F_P$. Thus, for any better diversified portfolio $\mathrm{P}^a$ with respect to $\mathrm{P}^b$, $\mathrm{P}_m(\mathrm{P}^a) < \mathrm{P}_m(\mathrm{P}^b)$ implying $c(\mathrm{P}^a) < c(\mathrm{P}^b)$. And so by (9), the risk reduction benefit of insurer's portfolio diversification will result in lower market insurance premium through reduction of required catastrophe load.

For portfolio pricing,[12] an empirical multivariate distribution of the underlying indices in the portfolio: $f(z_{1t}, z_{2t}, \ldots, z_{Nt}): S_z \rightarrow \Re$, needs to be established from observed historical data or estimated empirically by fitting a standard parametric distribution (e.g., multivariate normal distribution) or by using a non-parametric approaches taking into account the correlation structure of the indices(e.g. copulas).

Various national and regional catastrophe insurance pools have been created to enhance spatial diversifications of natural disaster insurance programs, e.g.,

[12] Another advantage of portfolio pricing that can incorporate larger spatiotemporal distribution of data series into statistical analysis is the potential efficiency gain from the reduction in sensitivity to outliers and hence low-quality data for some small contract areas. Buhlmann's empirical Bayes Credibility Theory (1967) has been widely used in the insurance industry for portfolio pricing. This has been used as the basis for ratemaking of the Indian Agriculture Insurance Company's modified National Agricultural Insurance Scheme since 2010 (Clarke, *et al*. 2012).

earthquake insurance program for homeowners in Turkish (Gurenko, *et al*. 2006), the area-yield based livestock insurance program in Mongolia (Mahul and Skees 2007) and various private and public weather index insurance programs in India (Clarke, *et al*. 2012). At the regional level, the Caribbean Catastrophe Risk Insurance Facility has been established as an insurance captive special purpose vehicle to provide 15participating countries with catastrophe index insurance for hurricanes and earthquakes. The facility acts as risk aggregator allowing countries to pool their country-specific risks into a better-diversified portfolio. This resulted in a reduction in premium cost of up to 40% of the USD 17 million premiums in 2007 (World Bank 2007). Similar regional risk pooling arrangement has been initiated for the Pacific islands (Cummins & Mahul 2009).

**Index-based Reinsurance**

Achieving cost effective pricing of a well-diversified insurance program relies on ability of risk aggregator to minimise cost of financing portfolio risk, especially the catastrophic layer, $c(\mathrm{P}_m)$. Typically, insurer first spreads the covariate risk inter-temporally by building up reserve over time at the cost of foregone investment return on capital.[13] The reserve, however, can be exhausted and would not be sufficient when catastrophic events strike. Reinsurance is the most common mechanism of transferring covariate risk from primary insurers to international markets.

Index-based reinsurance contracts have been increasingly used, as they could resolve market imperfections and thus result in lower reinsurance rates (Skees, *et al*. 2008). The common form is a stop-loss contract, which provides reinsurance payout when the insurer's portfolio payout exceeds some percentage of the fair premium received. For an insurer holding index insurance portfolio P, a $n\%$ stop-loss reinsurance payoff function with$n \geq 100\%$ can be written as

$$\pi(\mathrm{P}_t, n) = \max\left\{\sum \rho\, \pi(z_t, z^*) - n \sum \rho\, E\pi(z_t, z^*), 0\right\}. \qquad (11)$$

As in (9), market reinsurance rates will include administrative load as well as catastrophe load.

[13]In some setting, contingent debt is also used to spread covariate natural disaster risk inter-temporally.

Cummins and Mahul (2009) found that catastrophe reinsurance capacity is available for developing countries as long as their risk portfolio is properly structured and priced. Reinsurance prices also tend to be lower in developing countries than in some developed countries because of the added diversification benefit to the reinsurers and investors.[14] However, reinsurance pricing is also very volatile with premiums rising dramatically following major loss events.[15] Reinsurance thus might not be suitable for the highly catastrophic risk especially of extreme impacts but very rare frequency, as substantial catastrophe loads will be added to take into account extreme maximum probable losses and rare historical statistics to allow for proper actuarial analysis (Cummins and Mahul 2009, Froot 1999).

**Securitisation of Index Insurance Linked Security**

While there will always be an important role for reinsurance in transferring disaster risks, catastrophe bond (cat bonds)[16] are evolving into a cost-effective means of transferring highly catastrophic risks (Skees, *et al*. 2008, Cummins and Mahul 2009). Cat bonds involve the creation of a high-yield security that is tied to a pre-specified catastrophic event, and is financed by premiums flowing from a linked (re) insurance contract. If the event does not occur, the investor receives a rate of return that is generally a few hundred basis points higher than the LIBOR. If the event does occur, the investor loses the interest and some pre-defined portion (up to 100%) of the principal, so that funds are then used for insurance indemnity payments. The use of cat bonds linked with index (re) insurance has been growing and becoming more attractive to investors.

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[14]This can be evidenced from existing insurance programs in Mexico, the Caribbean, etc. In other settings, reinsurance is not in the form of stop-loss contract but rather in quota sharing to the domestic insurance pool. In Thailand, for example, reinsurer occupied 90% of the pooled risk portfolio of agricultural insurance.

[15]Guy Carpenter (2010) found that following very active hurricane seasons in 2004 and 2005, reinsurance prices increased dramatically for 2006 in the U.S. (76%) and Mexican (129%) markets comparing to ROW (2%).

[16]The market for cat bonds in the United States, Western Europe, and Japan, has been growing since the first transactions in the mid-1990s with more than 240 transactions in 1997-2007 (Swiss Re, 2007). Following the record losses from Hurricane Katrina, reinsurance premiums increased dramatically leading to greater interest in the use of cat bonds to transfer hurricane risk. This led to higher yield, which, in turn, generated more interest from investors.

Consider a multi-year cat bond linked with a reinsurance contract. The price of cat bond issued with face value $F$, annual coupon payment $c$ and time to maturity of $T$ years, at which the bondholder agrees to forfeit a fraction of the principal payment $F$ by the total reinsurance indemnity $\sum_{t \epsilon T} \pi(\mathrm{P}_t, \gamma)$ up to a cap $\overline{\Pi} < F$ can be written as

$$B\left(\sum_{t \epsilon T} \pi(\mathrm{P}_t, n), \overline{\Pi}, T\right) = e^{-rT} E\left[F - min\left(\sum_{t \epsilon T} \pi(\mathrm{P}_t, n), \overline{\Pi}\right)\right] + \frac{c}{r}(1 - e^{-rT}). \qquad (12)$$

Like a typical bond, cat bonds are valued by taking the discounted expectation of the coupon and principal payments under the underlying multivariate distribution of the indices in the reinsurance portfolio $f(z_{1t}, z_{2t}, \dots, z_{Nt})$ and the required rate of return on investment $r$.

The main advantage of securitising cat bond is the potential to avoid default or credit risk with respect to catastrophe reinsurance, as the catastrophic losses imposes a significant insolvency for reinsurers. In contrast, cat bonds permit diffusion of highly catastrophic risk among many investors in the capital market, the volume of which is many times that of the entire reinsurance industry.[17] Cat bond pricing has now been comparable to reinsurance and similarly rated corporate bonds, due to added market diversification, and as market and investors have gained experience with these securities.[18] Since the average cat bond term is 3 years, the prices of the contract are stable for multiple years. Cat bond prices are also found to be lower in developing countries as investors seek to diversify their portfolios with different

[17] Additionally, there is little credit risk. Just as is done when securitising credit risks, funds are secured in a Special Purpose Vehicle (SPV) so payment upon a triggering event is assured. The key limitations, however, is that there are significant transaction costs to establishing cat bonds. These costs include risk analysis, product design, legal fees, the establishment of SPVs and the special regulatory considerations that are needed to protect investors.

[18] Returns on cat bonds are about 1% above the return on comparable BB corporate bonds. Because of the increasing diversification since 2006 with bonds issued for Mexico, Australia and the Mediterranean countries, the three-year parametric cat bonds have been issued at the lower than 2 times expected loss(Guy Carpenter, 2008).

exposures and geographical areas (Guy Carpenter 2008, Swiss Re 2007 and Cummins and Mahul 2009).

Since 2006, the Mexican government has issued cat bonds to provide financing for the most catastrophic layer of the government-owned nationwide disaster insurance fund, FONDEN. At issue, the cat bonds were competitively offered at 235 basis points above LIBOR. If earthquakes of at least 8.0 Richter occur in a defined zone, investors will lose their entire principal, and so up to USD 160 million is then transferred to the government for disaster relief (FONDEN, 2006).

**Public-private Integrated Natural Disaster Risk Financing**

Viability of market for natural disaster insurance relies on cost effective risk financing. Risk layering offers novel approach in disaggregating insurable risk, so that the least expensive instrument can be chosen for each specific layer (Hofman and Brukoff, 2006) in an integrated risk financing. In developing countries, disaster risk financing involves combinations of national insurance pool, reinsurance and various forms of public support (financed by government budget or securitisation). An insurance indemnity pool can be created to allow local insurers to diversify their risks and contribute capital to the reserve pool, from where indemnity payments for higher frequency but lower impact losses can be drawn. Reinsurance could potentially be acquired for the relatively lower frequency but higher impact layer, when indemnity payments exceed the pool. And public supports prove to be important especially for the low frequency but catastrophic layer, where reinsurance costs could be prohibitive and private demand could be low (due to cognitive failure or the crowding out effect of the public disaster relief [19]).

Experiences in developing countries have shown that public supports in financing the tailed risk could have critical role in the development of market viable natural disaster insurance program. Existing programs include governments acting as reinsurers (where it is cost prohibitive or impossible to access international reinsurance market), providing financial support directly to local insurers for obtaining international reinsurance or other risk transfer instruments, or providing catastrophic insurance coverage for the tailed risk directly to targeted clients to

[19] See, for example, Kunreuther and Pauly (2004).

complement the market product. They can then used IBRTPs designed and targeted at the tailed risk as cost effective risk transfer instruments to protect their budget exposures.

In the on-going nationwide index-based livestock insurance in Mongolia, a complementary combination of commercialised insurance product for the smaller losses and public disaster insurance for the catastrophic losses are available nationwide. Government also provides 105% stop-loss reinsurance for the national indemnity pool using their budget and contingent loans (Mahul and Skees 2007). The Mexican state-owned reinsurance company, Agroasemex, has been offering unlimited stop-loss reinsurance for more than 240 self-insured fund, Fondos, which provide insurance against disaster affected agricultural production losses to households in 50% of the country's total insured agricultural area (Ibarra and Mahul 2004). Since 1999, the Turkish government has implemented compulsory earthquake insurance by establishing the Turkish catastrophe insurance pool and transfer extreme risk to reinsurance market (Gurenko, *et al*. 2006).

## 3. Index-based Disaster Insurance Program for Rice Farmers in Thailand

Rice is the country and region's most important food and cash crop. In Thailand, rice production occupies the majority of arable land with the largest proportion of farmers (18% of the population) relying their livelihoods on. Improving and stabilising rice productivity is thus one of the core prerequisites for the country's economic development. Thai rice production, however, has been increasingly threatened by natural disasters, especially droughts and floods.

Thai farmers typically take out input loans and expect to pay back with income raised through the harvested crop. Production shocks thus usually bring about increasing level of accumulated debt, as farmers could face difficulties in repaying their loans and in smoothing their consumption. These translate directly to high default risk facing rural lenders, especially the Bank of Agriculture and Agricultural Cooperatives (BAAC) holding the majority of agricultural loan portfolios in the country. While instruments that allow rice farmers to hedge other key risks are largely available – e.g., public rice mortgage program for hedging price risk – sustainable insurance that could insure farmers' production risks without distorting their incentives to improve productivity are still largely absent.

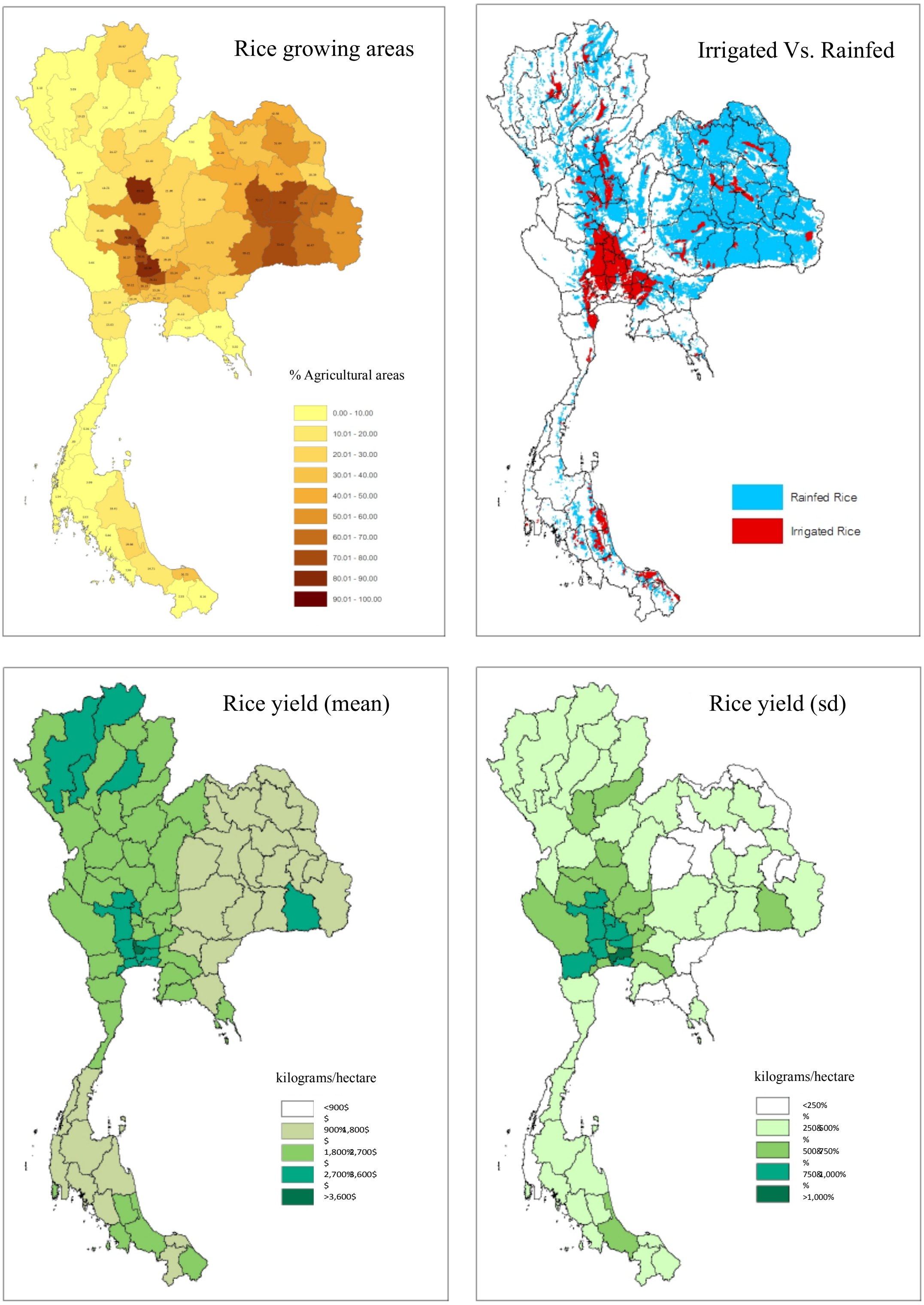
**Rice Production, Exposures to Natural Disasters and the Current Programs**

There are about 9.1 million hectares of rice growing areas in Thailand in 2010.[20] Figure 1 presents variations in rice paddy areas and production systems across the country's 76 provinces.[21] The key growing provinces, where rice paddy occupies at least 50% of the total arable areas, are clustered mainly in the central plain especially around Chao Phraya River basin and the lowland Northeast. Small numbers of rice growing provinces are also scattered around the upland North and the South.

Production regions vary in cropping patterns due to heterogeneous irrigation systems, ecology, soil and weather patterns. Irrigations are available in less than 25% of the total growing areas. These occupy most of the central provinces and some areas in the North and the South, allowing farmers to cultivate two crops a year. Yields thus tend to be higher in these regions. The majority of rainfed production occupies almost the entire key growing areas in the lowland Northeast, relies extensively on rainfall and so harvests lower yields. The main crop cycles typically start with the onset of annual rain, which usually comes during mid May-November and varies slightly across regions. The second crop can then be grown throughout the rest of the year depending on water availability. As the key growing areas around Chao Phraya River basin are flood prone, crop cycles deviate slightly in order to avoid extended flood periods.

[20]Data are obtained from the Office of Agricultural Extension, Ministry of Agriculture and Cooperatives, Thailand. There is no significant trend from the annual areas since 1980.
[21] The number of provinces has just recently increased to 77 with one additional province added in the Northeast 2011. Our spatiotemporal data are extracted using the un-updated 76-province GIS information.

## Figure 1: Growing Areas and Variations in Rice Production in Thailand



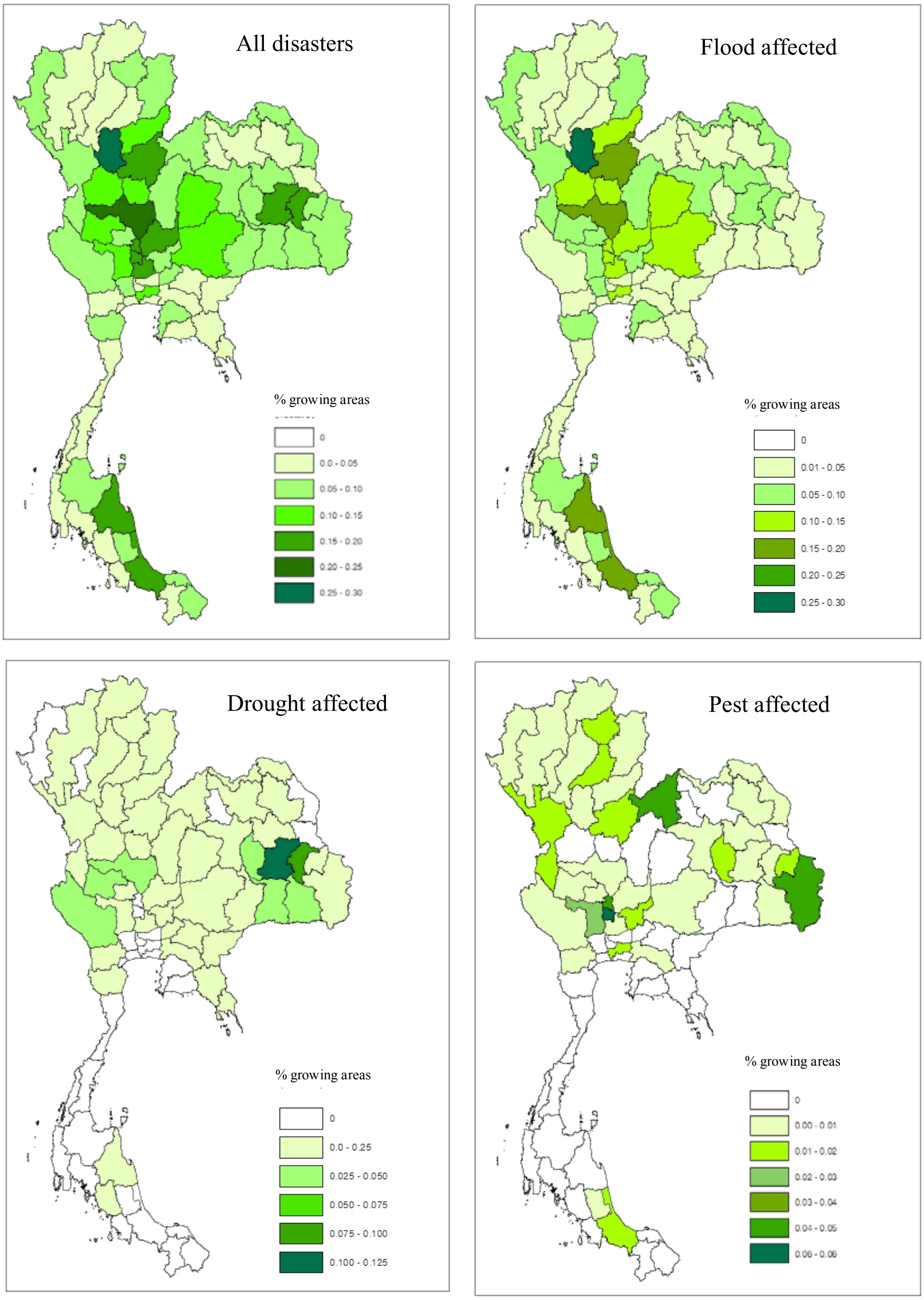

*Note*: Data are obtained from GISTDA, Ministry of Science and Technology for the two top graphs and from Ministry of Agriculture and Cooperatives for the two bottom ones.

Rice cropping cycle spans about 120 days from seeding to harvesting (Siamwalla and Na Ranong, 1980). Long dry spells and extended flood periods appear as the two key shocks affecting productions with increasing frequency. Sensitivity to these key disasters varies across different stages of crop growth. Figure A1 presents growth stages of rice crop and stage-specific vulnerability. According to World Bank (2006)'s collective scientific findings,[23] the first 105-day period from seeding to grain filing critically requires enough water (25-30 mm of rainfall per 10-day period), and thus is vulnerable to long dry spells that could result from late or discontinued rain. Farmers are also already well adapted to small dry spells by adjusting their planting periods or re-planting when loss occurs early in the cycle. As cycle progresses to maturity and harvesting (during the 105-120 day period that typically fall into the peak of seasonal rain), plants become vulnerable to extended flood that could come about at least when 4-day cumulative rainfall exceeds 250 mm. These drought and flood conditions established by World Bank (2006), however, depend critically on drainage and other geographical variables.

Catastrophic crop losses from dry spells typically occur in the rainfed areas during the onset of rain in July-August, whereas, losses from extended floods occur in the peak of rain during September-October. Exposures differ across regions. The north-eastern rainfed production are especially vulnerable to long dry spell, while most of the irrigated production in the central plain are subject to long periods of deep flooding annually. Productions in the South are vulnerable to floods caused by thunderstorms (Siamwalla and Na Ranong, 1980). Pest also serves as one of the key covariate risks for rice production. Figure 2 presents government records of incidences and spatial variations of actual rice crop losses from these three main shocks in 2005-2011. Flood losses occur with the highest frequency and significance relative to others.

[23]These results are obtained from PASCO, Co.'s study using a combination of scientific literature reviews, agro-meteorological model (DSSAT)with detailed geographical information and ground checking with the local experts in the key-growing province, Phetchabun, and flood plain modelling.

**Figure 2: Rice Growing Areas Affected by Key Disasters (2005-2011)**




*Note*: Data are obtained from Thailand Ministry of Agriculture and Cooperatives.

Over the past decade, the Thai government has been providing disaster relief program for farmers when disaster strikes. The program compensates about 30% of total input costs for farmers, who live in the government declared disaster provinces and are verified by local authorities to experience total farm losses. Government spends about 3,350 million baht[24] on average per year for rice farmers affected by droughts, floods and pests. And the program cost could increase up to 40% in some extreme years. Despite these tremendous spending, results from randomised farmer survey imply that the compensations are largely inadequate and subjected to serious delay especially from loss verification process (Thailand Fiscal Policy Office, 2010). There are also increasing evidence of moral hazard associated with the program, especially as farmers start growing the third crop off suitable season.

The nationwide rice insurance program–a top-up program for disaster relief –was piloted in 2011. The program was underwritten by a consortium of local insurers and reinsured by Swiss Re. At 50% subsidised premium rate of 375 baht/hectare nationwide, the program covered main rice season, and compensated farmers up to 6,944 baht/hectare (about30% of farmers' input costs) should they experience total farm losses from droughts, floods, strong winds, frosts and fires during the cropping cycle. To be eligible for compensation, farmers' paddy fields need to be in the government's declared disaster provinces, and the losses need to be verified by local authorities. About 1.5% of growing areas were insured in 2011. The flood resulted in a loss ratio of as high as 500% for the first year. Reinsurance prices thus inevitably increased more than double making it not market viable for the following years. This program continued in 2012 at the same (highly subsidised) rate but with government now taking the role as an insurer.[25]

The current program thus resumes various inefficiencies and market problems, commonly evidenced in the traditional crop insurance to jeopardise the program's sustainability (Hazell, *et al.* 1986). First, like other conventional insurance, the

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[24] USD 1= 31.81 baht (Bank of Thailand as of May 29, 2012). Figure A2 presents total budget spent in 2005-2011.

[25] At 1 rai (in Thai) = 0.16 hectare. For 2011, the subsidized price is 60 baht/rai with the payout at 606 bath/rai if lost crop is less than 60 days, or 1,400 baht/rai if lost crop is greater than 60 days of age. The scheme in 2012 continues with the same subsidized price but with single payout rate at 1,111 baht/rai. The local insurers also participate in the program in 2012 by taking some minimal percentages of insurable risk, leaving the major risk to the government.

program would be subjected to moral hazard, e.g., when it induces additional risky off-season rice cropping, etc. Second, high direct subsidisations distorted market prices and thus could reduce sustainability of the market in the longer run. This could further exacerbate incentive problems. Third, this voluntary program is offered at one single premium rate for farmers with different risk profiles. It could potentially signify adverse selection and moral hazard.[26] Fourth, because the government's declaration of disaster areas can be subjective in nature, asymmetric information at the government level could further arise. The highly subjective local verification of losses could potentially induce rent seeking at various levels, further affecting the commercial sustainability of this program. The highly subjective and non-transparent nature of loss measures would no doubt lead to increasing risk pricing in the international market. Finally, the program resumed inefficiencies in time and cost of loss verification in the relief program.

We explore the use of IBRTPs in developing an alternative and potentially more sustainable index-based rice insurance program that could effectively protect rice farmer's production income or input loan from these key covariate production shocks. The goal is also to explore how disaggregated household data and spatiotemporal disaster data sets commonly available in developing countries could be used to design nationwide, scalable contracts that could further permit rigorous analysis of micro-level welfare impacts and cost effective pricing through diversifications and transfers.

**Data**

Five disaggregated nationwide data sets are used in this study. The first four sets are used to construct objectively measured indices for index insurance design, and the last set represents variations in households' incomes from rice production, and thus is used to establish optimal contract design, basis risk and hedging effectiveness associated with various designed contracts.

First, measures of area-yield indices are drawn from the provincial rice yield data collected annually by the Office of Agricultural Extension at Thailand Ministry of Agriculture and Cooperatives (MoAC). The data are available for all the provinces

[26] Farmers in the risky areas would, in expectation, tend to be the majority of the purchasers of the cheaper contract relative to their risk profiles. And the heavily subsidised insurance contracts for those in the risky zones could further induce excessive risk taking behaviours.

nationwide from 1981-2010 and were collated from a combination of an annual survey of randomised villages in each province and official records by local agricultural extension offices. They are thus representative at the provincial level. Yield data reflect total yield from all crops harvested each year. To remove time trend potentially resulting from technical change, improvements in varieties, irrigations and other management practices, we de-trend the data using a robust Iterative Reweighted Least Squares Huber M-Estimator[27] to first estimate the time trend. The resulting estimated trended yield is thus obtained as $y_t^{tr} = \hat{a} + \hat{b}t.$ And so the de-trended yield series for each province is thus estimated as $y_t^{detr} = y_t + (T - t)\hat{b}.$

Second, objectively measures of weather indices are drawn from 20×20 kmgridded daily rainfall data obtained from the simulated regional climate model ECHAM4-PRECISE constructed by Southeast Asia System for Analysis, Research and Training (START) as part of their regional climate change projections. These simulated climate data were verified and rescaled to match well with the comparable data from observed weather stations (Chinvanno, 2011). These simulated weather data are available from 1980-2011.[28]

Third, estimated rice yield data were then constructed using an integrated crop-climate model developed by Pannangpetch (2009). High resolution GIS maps of soil types (1999), rice growing areas constructed by LANDSAT 5TM (2001) and ECHAM4-PRECISE weather were first overlaid in order to cluster geographical areas into distinct simulation mapping unit (SMU)[29] representing the smallest homogenous areas, where crop response to weather conditions could be uniform. DSSAT crop model was then used to estimate longitudinal estimated rice yields driven by ECHAM4-PRECISE weather controlling for exogenous time-invariant SMU-specific GIS characteristics and crop management. These estimated yields reflect total yields from one (two) crops harvested in the rainfed (irrigated) SMUs.

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[27] This trend estimation has been commonly used in agricultural time series especially when the underlying data are not normally distributed (Ramirez, *et al*. 2003).

[28] These also include projected future climate data and are available at http://www.start.or.th/. The resolutions of these data could be improved. Attempts are current made in gridding weather data at lower resolutions.

[29] This results in 9,254 SMUs covering all the 9.1 million hectares of rice growing areas nationwide. The size of constructed SMUs ranges from 0.16 to 35,900 hectares.

As the simulated yield variations are driven solely by variations in weather, these data can serve as objectively measured index for IBRTPs.

Fourth, the remote sensing Normalised Difference Vegetation Index (NDVI)[30] data are extracted from Tera MODIS satellite platform every 16 days from 2000-2011 throughout the country at a 500-meter resolution. NDVI data provide indicators of the amount and vigour of vegetation, based on the observed level of photosynthetic activity (Tucker, 2005). The data have been increasingly used for monitoring land use patterns, crop productions and disaster losses worldwide. We use NDVI data in detecting variations in crop cycles across regions. This knowledge is critical in the construction of appropriate weather indices that ally well with different stages of crop growth. Some GIS information characterising production systems that could condition the sensitivity of rice production to shocks and records of annual crop cycles are also obtained from MoAC for cross checking with NDVI data.

Fifth, household-level incomes from rice production data are obtained from multi-year repeated cross-sectional Thai Socio-Economic Survey (SES) surveyed nationwide every 2-3 years from 1998, 2000, 2002, 2004, and 2006 to 2009Thailand's National Statistical Office. Each round, a total of 34,000-36,000 households were randomly sampled from the sampled villages in all provinces (10-25 sampled households per village; 30-50 sampled villages per province). Because no household is sampled more than once during these surveys, our analysis thus can be based on repeated household cross sectional data.[31] Subset of households from the 6 rounds, who reported their socioeconomic status as farm operator and rice farming as the main household enterprise, are used in this study. The subsample size in each round ranges from 2,500-3,100households with households per province varying from 5 in the non-rice provinces to 150 in the key rice growing provinces. Because there is no direct measure of rice production, we use household's annual[32] income from crop production per hectare as a representation of $y_{it}$. This annual income

[30]Data are available worldwide and cost free. See https://lpdaac.usgs.gov/content/view/full/6644.

[31] This is also common to other nationwide repeated cross sectional household socioeconomic survey data available in other developing countries, e.g., the Indonesian SUSENAS, etc. And while certain counties were sampled repeatedly, amphoe identifiers were not available to allow for construction of amphoe-pseudo panel data.

[32] Farm incomes from the last month are also available, but the large variations in cropping patterns as well as survey timing constitute great difficulties in controlling for seasonality effects.

measure thus includes income from more than one cropping seasons in irrigated areas. Other household and area characteristics are also extracted from SES data.

All of the GIS variables are first constructed at pixel level before downscaling to provincial level, so that these can all be merged with household-level data. Table1 provides summary statistics of the key variables extracted from these five data sets. Overall, mean de-trended provincial averaged rice yield stands at 2,622 kilograms per hectare with high standard deviation capturing the variations across households and years. Household's averaged income from rice production is at 40,246 baht per hectare per year. This results from cultivating 1-3 crops (with 1.64 crops on average) a year. Total input costs are averaged as high as 49% of income[33] implying that households earn about 20,525 baht as farm profit per hectare per year. Mean rice-growing areas per household is about 1.92 hectares. About 89% of households take out input loan each season. And critically, their accumulated agricultural debt stands at an average of 141% of annual income in any given year. Apart from the lowland majority, 6% of total rice growing areas are upland, 12% is flood prone and 19% locates near river basin.

[33]These statistics align well with findings in Isvilanonda (2009).

### Table 1: Summary Statistics of Key Variables

| Variables | N | Mean | S.D. | Minimum | Maximum |
|---|---|---|---|---|---|
| *Rice production and rainfall* | | | | | |
| Rice growing areas, 1981-2010 - Country (million hectare) | 30 | 9.2 | 0.2 | 8.7 | 9.5 |
| - Province (% total area) | 2,240 | 53% | 24% | 2% | 92% |
| Annual cumulative rainfall (cm), 1980-2011 | 2,432 | 425 | 124 | 179 | 889 |
| Provincial yield (kg/hectare/year), detrended 1981-2010 | 2,240 | 2,622 | 868 | 710 | 5,398 |
| *Rice farming households* | | | | | |
| Household crop production income (baht/hectare/year) | 18,216 | 40,246 | 31,541 | 0 | 98,137 |
| Rice cropping land size (hectare) | 18,216 | 1.92 | 3.56 | 0.16 | 47.00 |
| Number of times cultivated rice per year | 18,216 | 1.64 | 1.13 | 1.00 | 3.00 |
| Number of members working on farm | 18,216 | 2.75 | 1.24 | 1.00 | 6.00 |
| Input and operating cost per cropping season (proportion of income) | 18,216 | 0.49 | 0.31 | 0.37 | 0.89 |
| Household takes out loans for input cost each season = 1 | 18,216 | 0.89 | 0.23 | 0.00 | 1.00 |
| Total outstanding agriculture loans (proportion of annual income) | 18,216 | 1.41 | 6.94 | 0.00 | 256.25 |
| Annual Interest rate on 12-month agricultural loan | 18,216 | 0.06 | 0.03 | 0.02 | 0.15 |
| Household size | 18,216 | 3 | 1 | 1 | 6 |
| Head age | 18,216 | 50 | 14 | 17 | 94 |
| Head female = 1 | 18,216 | 0.17 | 0.38 | 0.00 | 1.00 |
| Head highest education - primary = 1 | 18,216 | 0.85 | 0.38 | 0.00 | 1.00 |
| Head highest education - secondary = 1 | 18,216 | 0.05 | 0.20 | 0.00 | 1.00 |
| Head highest education - university = 1 | 18,216 | 0.00 | 0.00 | 0.00 | 0.00 |
| Head highest education - vocational = 1 | 18,216 | 0.00 | 0.06 | 0.00 | 1.00 |
| Own house = 1 | 18,216 | 0.96 | 0.18 | 0.00 | 1.00 |
| Own agricultural land = 1 | 18,216 | 0.81 | 0.42 | 0.00 | 1.00 |
| *Provincial production characteristics* | | | | | |
| Households' farm located in the irrigated areas = 1 | 77 | 0.22 | 0.43 | 0.00 | 1.00 |
| Upland areas (% total rice paddy) | 77 | 6% | 27% | 0% | 100% |
| Flood plain areas (% total rice paddy) | 77 | 12% | 47% | 0% | 100% |
| River basin areas (% total rice paddy) | 77 | 19% | 41% | 0% | 100% |
| *Indices (% of provincial long-term mean)* | | | | | |
| Provincial yield index, 1981-2010 | 2,240 | 100% | 14% | 41% | 146% |
| Estimated yield index, 1980-2011 | 2,432 | 100% | 24% | 57% | 146% |
| Cumulative rainfall index, 1980-2011 | 2,432 | 100% | 27% | 29% | 154% |
| Moving dry spell index, 1980-2011 | 2,432 | 100% | 35% | 38% | 165% |
| Moving excessive rain spell index, 1980-2011 | 2,432 | 100% | 31% | 41% | 179% |

### Index Insurance Designs for Thai Rice Farmers

Various spatiotemporal data sets allow us to explore various standard index insurance contracts for Thai rice farmers based on the following constructed indices.

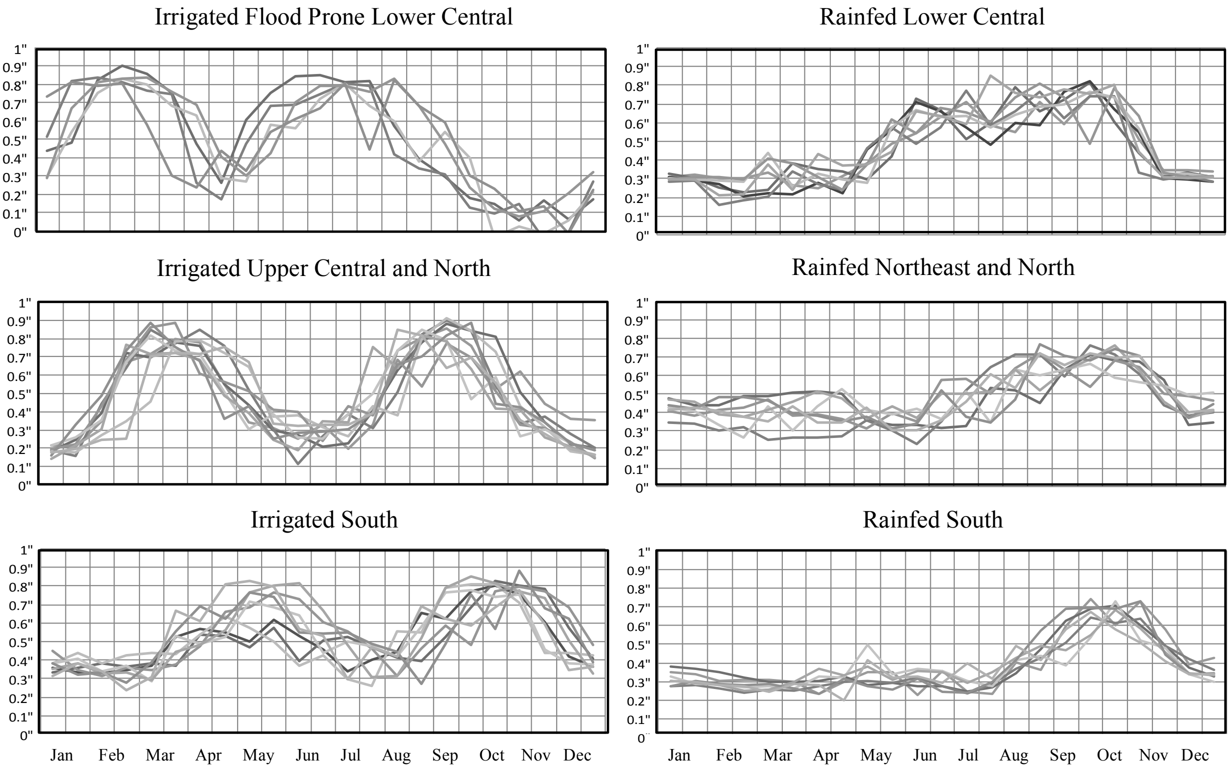
First, direct measures of area yields $\bar{y}_t$ can be constructed from annual provincial yield data. As it offers protection against any covariate risks affecting provincial yield, not just from weather, it could perform well in the case of Thai rice, where pest constitutes one of the key covariate threats. Second, estimated provincial yields $y(w_t)$ can be constructed from the SMU-specific modelled yields. To the extent that the complex crop-climate predictive model performs well in predicting weather-driven yield shocks, this index could provide good hedging effectiveness for farmers. Third, we explore various parametric weather indices$w_t$. But because the sensitivity of plants to weather shocks varies across stages of crop growth, knowledge of cropping cycles and how they vary spatially and temporally are thus critical.

**Cropping Cycles and Weather Indices**

Smoothing [34] the provincial NDVI data in a one-year window results in uni- or bi-modal patterns. Each of these NDVI modes corresponds well with one full 120-day crop cycle. These smoothed provincial NDVI patterns can then be clustered into six distinct zones with homogenous crop cycles presented in Figure 3. Normal starts of the main and second crops in the irrigated areas vary across flood prone lower Central (mid May, December), upper Central and North (July, January) and South (August, March). Normal starts of the main crop in the rainfed areas follow those of the irrigated zones with those of Northern Province sallying well with those of the North. The variations of crop cycles observed objectively from the patterns of NDVI also align well with the MoAC-collected records of cropping patterns in some key provinces.

[34] Simple local polynomial smoothing is used over all the pixels that fall into provincial boundary over 2000-2011.

**Figure 3: Contract Zones with Distinct Crop Cycles observed from NDVI**




These six distinct zone-specific crop cycles then form a basis for constructing provincial weather indices. For each crop cycle, we extend World Bank (2006)'s crop scientific findings and so explore two provincial dry spell indices covering weather conditions in the first 105 days and a flood index covering those in the 106-120 days of the cycle. These indices are constructed for both main and second crops in the two-crop zones opening a possibility that farmers can obtain insurance protection for both crops. All weather indices are constructed first at pixel level and then averaged toward provincial indices.

First, a simple cumulative rainfall index can be constructed from daily rainfall$R_d$as

$$CR_t = \sum_{d=1}^{105} R_d . \qquad (13)$$

The level of CR below some critical strikes thus could reflect the extent of dry spell that could in turn damage rice production. The key advantage of this is its simplicity. Hence this index has been used in various piloted projects including one in the north-eastern province in Thailand.[35] This simple index, however, might not reflect the extent of dry spell well, as it fails to take into account how rainfall is distributed within 105-day period. In particular, high CR could result from couple large daily rains and a long dry spell (that would otherwise damage crop).

Alternatively, a moving dry spell index, which measures the extent that 10-day cumulative rainfall falls below the crop water requirement (30mm for 10-day period) in each and every 10-day dry spell in the 105 cropping days, can be constructed as

$$MD_t = \sum_{\tau=1}^{96} \max\left(30 - \sum_{d=\tau}^{\tau+9} R_d, 0\right). \qquad (14)$$

MD above some critical strikes thus could better reflect the extent of dry spell that really matters to rice production. This index has widely been identified to better quantify the extent of dry spells. But because of its relatively more complexity, this index has not been used widely.[36]

Continuous excessive rainfall is the key cause of extended flooding periods in the paddy fields. World Bank (2006) found that the 4-day cumulative rainfall above 250 mm can trigger high probability of extended flood causing losses to harvesting rice crops. We thus quantify flood index using a moving excessive rain spell index to measure the extent that 4-day cumulative rainfall excess 250 mm as

$$ME_t = \sum_{\tau=106}^{117} \max\left(\sum_{d=\tau}^{\tau+3} R_d - 250, 0\right). \qquad (15)$$

I above some critical strike thus could indicate flood event. But the extent that ME could determine extended flooding period and crop losses should also vary across production systems, which in turn determine soil type, drainage system, crop variety, etc.

The three weather indices so far are constructed based on the assumption that insured cropping cycles in each year and province follow the six smoothed zone-specific patterns. Because famers tend to adjust their production annually in order to

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[35] Current contract piloted by JBIC and Sompo Japan insurance in Khon Kaen relies on simple cumulative rainfall are taken from July to September.

[36] For example, drought index insurance for maize piloted in Thailand since 2007.

adapt to small inter-year variations in rainfall patterns, using fixed crop cycles as a basis for index construction might result in mis-representations of crop losses from drought and flood events. Alternatively, indices can be constructed based on a dynamic crop cycle. Because successful seeding critically requires at least 25 mm of rainfall (World Bank 2006), the first day from the fixed zone-specific starting date when a 1-day, 2-day or 3-day cumulative rainfall exceeding 25 mm can be used to trigger the start of an insured cropping cycle, during when the underlying weather indices will be constructed. Appropriateness of dynamic crop cycle relies on the choice of cycle triggering threshold. We experiment among the three choices above and choose the optimal threshold that yields the highest explanation power of the constructed indices in predicting actual losses.

In order to effectively compare contracts designed with various indices, we standardise these indices into relative percentage forms with respect to their provincial-specific expected value.[37] Specifically, provincial indices can be constructed from $\mathbb{Z}_t = \bar{y}_t, y(w_t), CR_t, MD_t, ME_t,$ as $z_t = \mathbb{Z}_t/E_l(\mathbb{Z}_t)$. And so per-hectare payout of a standardised index insurance contract that protects household's insurable resulting from $\mathbb{Z}_t = \bar{y}_t,\ y(w_t),\ CR_t$ falling below their expected values can be rewritten from (3) as $\pi(z_t, z^*) = max\{z^* - \mathbb{Z}_t/E_l(\mathbb{Z}_t), 0\} \times \bar{y}$. An insurable $\bar{y}$represents provincial averaged production income or input cost per hectare to be insured. And the first term on the right-hand side reflects payout rate (in percentage of insurable) with respect to strike level $z^*$defined in percentage of $E_l(\mathbb{Z}_t)$. The reverse of the payout function above thus contractual payout for a contract that protects household when $\mathbb{Z}_t = MD_t,\ ME_t$exceed their expected values.

Table 1 provides statistics of these standardised indices. Figure 4 plots the five indices and their spatial distributions across all rice growing provinces.[38] Overall, provincial averaged, estimated yield indices and CR exhibit lower temporal variations relative to weather indices. Their spatial variations, however, are larger

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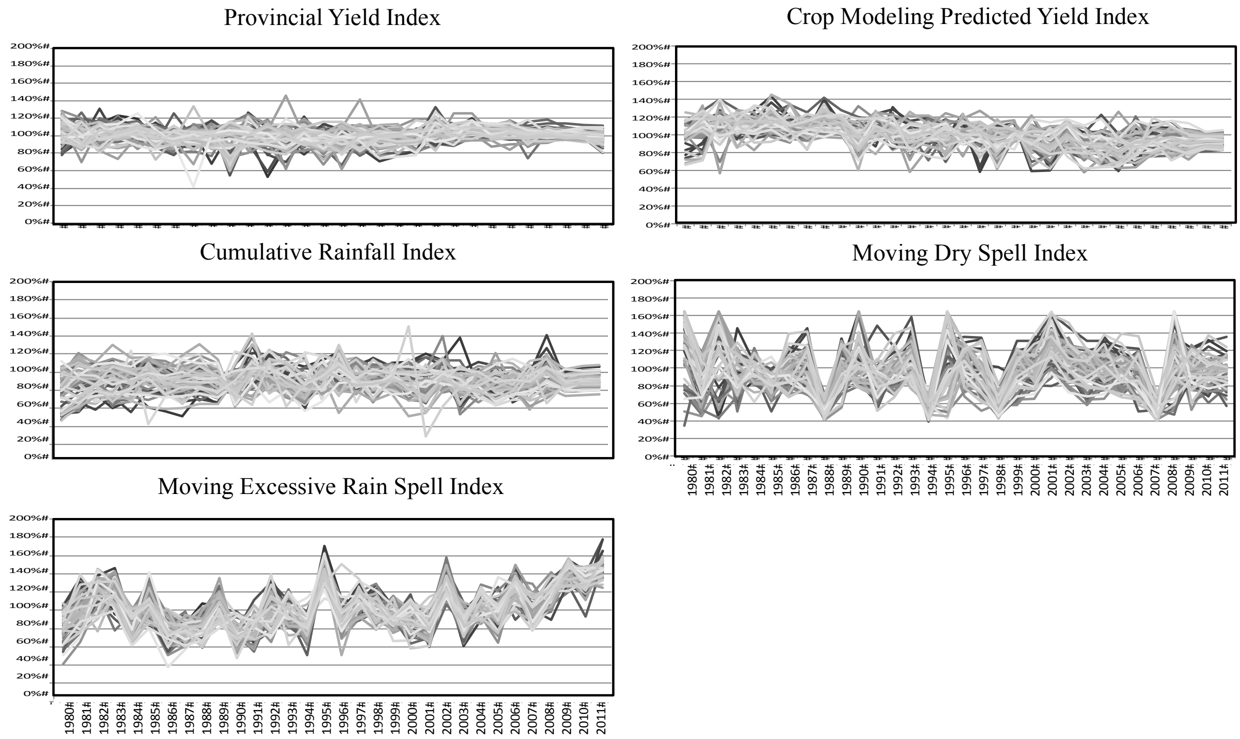
[37] Note that for $y(w_t), CR_t, MD_t, ME_t,$ we standardise at the SMU and pixel first (using SMU and pixel specific moments) before aggregate them into provincial indices. This is different from taking average of index first then dividing by overall long-term average later. The latter case will result in index with lower variations since most the SMU-level variations are already smoothed out in the aggregation process.

[38] There are two values for each of the weather indices in the two-crop zones, one for each crop cycle. Summary in Table 1 and Figure 5 reflect the average of the two values each year.

than the last two weather indices. MD seems to well capture the key covariate drought events in the country especially in 2008, 2001, 1995 and 1990. ME captures the key flood years well especially the catastrophic floods in 1995 and 2010-11.

**Figure 4: Temporal and Spatial Distributions of the Key Indices**




**Basis Risks and Hedging Effectiveness**

How well might these indices explain variations in household's annual crop income per hectare? Household data are merged with these indices at the provincial level in order to estimate (1). Without household panel, we instead use 6-year repeated cross sectional data to estimate, for each index, the following equation[39]

$$lny_{ilt} = X_{ilt}\gamma + D_l\mu + \eta_t + \lambda z_{lt} + \kappa D_l z_{lt} + \varepsilon_{ilt}. \quad (16)$$

The first three terms capture household's long-term expected income with$X_{ilt}$absorbingcharacteristics of households entered in each survey round, $D_l$ absorbing provincial time invariant characteristics especially with respect to rice

[39] We reintroduce provincial subscript $l$ here for clarification. The alternative approach of using pseudo provincial panel in estimating (1) controlling for provincial fixed effect would not take full advantage of these rich household data, as it would not yield household-level variations of basis risks.

production systems (e.g., upland, flooded plain, closure to river basin) and $\eta_t$ absorbing time effect that captures trend in income common across all households. The last three terms reflect stochastic shocks to household income. We also interact $D_l$ with the index in order to capture variations in sensitivity of income to weather shocks across different production systems. The systemic shock thus can be represented by $\beta = \lambda + D_l\kappa$reflecting the sensitivity of household income to provincial index $z_{lt}$. The portion of household income unexplained by the index$\varepsilon_{ilt}$thus represents basis risk associated with the index. This equation is estimated separately for irrigated and rainfed regions using simple linear least squared with standard deviations clustered at provincial level.[40]

Table 2 first presents estimation results. Different regressions explore how different indices can explain variations in farm income of the rice growing households controlling for household and provincial characteristics and time effects that determine household's long-term mean income. The first column shows that these controls explain about 40% and 48% of the income variations for households in the irrigated and rainfed areas respectively, implying a maximum of 60% and 52% of income variations that households are still unable to manage using existing mechanisms. Moving from left to right, we can explore how much of these remaining income variations could be explained using different indices. Except CR, all the indices significantly explain income variations though with different significant level. At 1% significant level, the provincial yield index explains an extra 13% and 11% of income variations in the irrigated and rainfed areas. The estimated yield perform relatively worse, explaining an extra 7% and 9%.

[40] Ideally, we want to estimate provincial-specific $\beta_l$. The temporal observations per province are simply not enough with 6 years in Thai SES data.

**Table 2: Estimation of Farm Income of Rice Growing Households**

| | No Index | Yield index | | Weather index - Fixed Cycles | | | | Weather index - Dynamic Cycles | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yt | Y(wt) | CR | MD | ME | MD+ME | CR | MD | ME | MD+ME |
| Irrigated Areas | | | | | | | | | | | |
| Index 1 | | 4.67*** | 3.63* | 2.43 | -3.39* | -4.17** | -2.11* | 2.54* | -3.22* | -4.02** | -2.87* |
| | | (1.19) | (2.79) | (2.85) | (2.17) | (2.35) | (1.51) | (2.23) | (2.29) | (2.54) | (1.88) |
| Index 2 | | | | | | | -4.01** | | | | -3.89** |
| | | | | | | | (2.23) | | | | (2.26) |
| HH, area and time effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted R-Squared | 0.38 | 0.51 | 0.45 | 0.44 | 0.46 | 0.48 | 0.52 | 0.46 | 0.45 | 0.46 | 0.49 |
| Observations | 4,009 | 4,009 | 4,009 | 4,009 | 4,009 | 4,009 | 4,009 | 4,009 | 4,009 | 4,009 | 4,009 |
| Rainfed Areas | | | | | | | | | | | |
| Index 1 | | 3.91*** | 2.81* | 2.98* | -6.17** | -4.29** | -5.89** | 3.12** | -6.19** | -4.32** | -5.91** |
| | | (1.22) | (2.07) | (2.19) | (3.54) | (2.89) | (2.98) | (2.01) | (3.27) | (2.59) | (3.24) |
| Index 2 | | | | | | | -3.92** | | | | -4.23** |
| | | | | | | | (2.51) | | | | (2.69) |
| HH, area and time effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted R-Squared | 0.45 | 0.56 | 0.54 | 0.53 | 0.58 | 0.55 | 0.67 | 0.54 | 0.59 | 0.55 | 0.67 |
| Observations | 14,206 | 14,206 | 14,206 | 14,206 | 14,206 | 14,206 | 14,206 | 14,206 | 14,206 | 14,206 | 14,206 |

*Note*: Coefficients represent net effect of provincial index $\beta = \lambda + D_K$. Standard errors in parentheses. * significant at 10%, ** at 5% and *** at 1% respectively. Household controls include household size, head age, gender and education, whether household owns land, land size, whether household owns house, number of member working on farm. Provincial control includes upland, flood plain and river basin areas. Time effects are captured by year dummies. Standard errors are clustered at provincial level. The best results for dynamic cycles use the first day in the fixed cycle when the 2-day cumulative rainfall reaches 25 mm as trigger starting point.

Among weather indices constructed based on the fixed 6-zone crop cycles, CR performs the worst among all albeit its relative advantage in simplicity. While explaining only 8% of income in the irrigated areas, MD significantly explain up to 13% of the income variations in the rainfed areas, where cropping rely extensively on rainfall. ME explains only about 10% of income variations in both areas. This raises question if it could serve as appropriate index for insuring flood losses in these areas. Combining MD and ME, we found that the two-peril index combination outperform others and explain 14% and up to 19% of income variations in irrigated and rainfed areas respectively. Despite the added complexity, using dynamic crop cycles in determining index coverage does not add substantial improvement (if at all) to the explanation powers of the constructed weather indices.[41] Overall, the two-peril index combination MD+ME based on fixed zone-specific crop cycle thus strikes us as the potential basis risk-minimising underlying index for Thai rice contract.

How might hedging effectiveness of the optimal contracts based on these indices vary given the observed variations in household-level basis risks? The 6-year household data are limited in temporal variations, and so might under-representthe incidence of extreme events. Using the established relationship and distributions of household-level basis risk estimated in (16), we thus expand our data temporally and spatially by simulating 32-year income dynamics of representative households based on 32-year index data. In specific, for each year $t$ from 1980-2011, 1,000 idiosyncratic shocks are randomly drawn for each province $l$ from the province-specific empirical distributions $f(\varepsilon_{ilt})$ estimated using bootstrapping. Using the 32-year index data, provincial averaged household characteristics and provincial characteristics along with the estimated coefficients in (16), we then simulate 32-year income dynamics of 1,000 households in each province $l$ from 1980-2011. Households' optimal coverage scales for various contracts and strike levels can then be estimated according to (7).[42] These then allow us to compute household-specific certainty equivalent values of consumption with and without various insurance contracts.

Figure 5 presents our results from 32-year income dynamics of 76,000 simulated households with assumed risk aversion $\theta = 3$ and actuarially fair contract prices. The two top panels compare averaged utility-based hedging effectiveness in term of increasing certainty equivalent values gained from obtaining insurance contract relative to no contract.[43] The bottom two compare effectiveness based on simple variance reduction. Contracts are compared at the same level of payout frequency thus controlling for the same level of risk coverage and cost despite varying

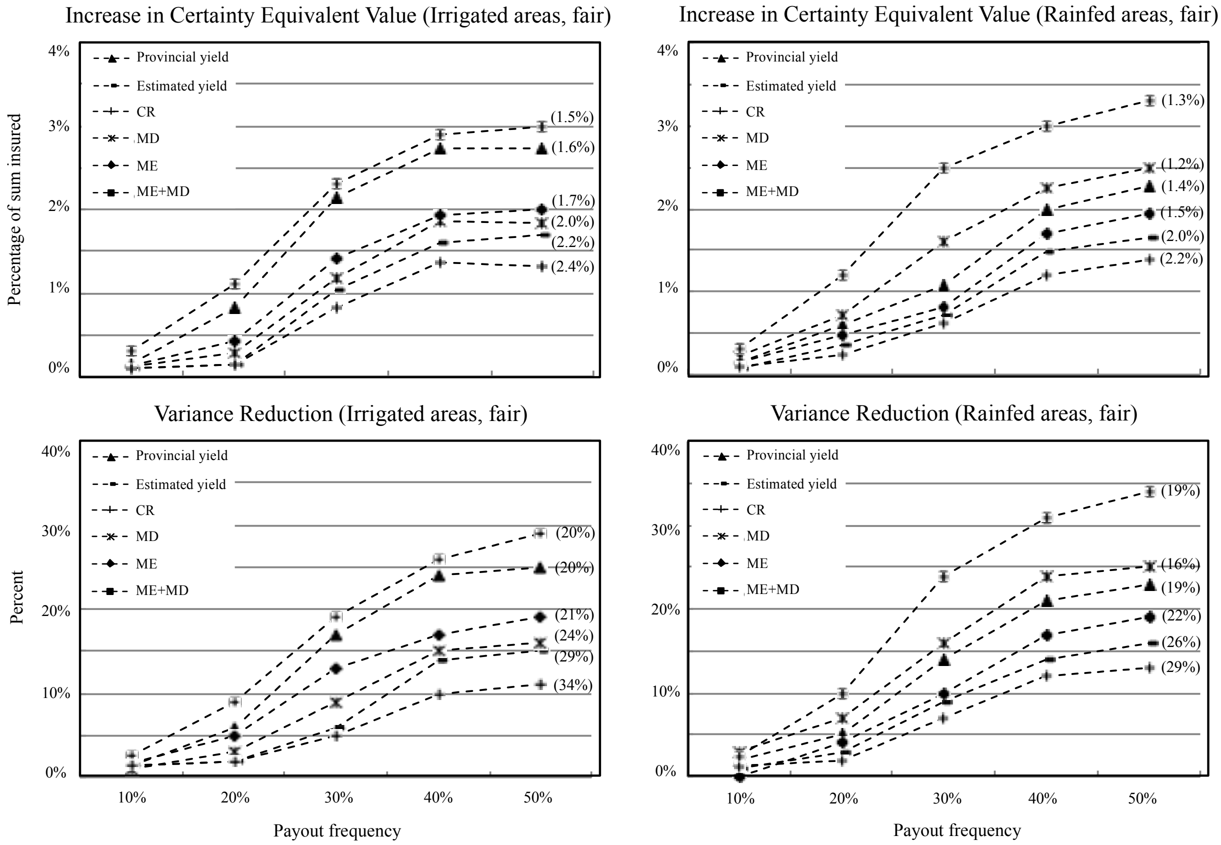
[41] 2-day cumulative rainfall exceeding 25 mm is chosen to trigger the start of each crop cycle, as it provides the best results comparing to others. This chosen trigger might not serve as an appropriate trigger for crop cycle just yet.

[42] As the estimated coefficients are specific at provincial level (not household), the simulated households' optimal coverage scales are specific at provincial level.

[43] We note that these estimated levels of welfare improvement rely extensively on the assumed functional form of utility. Inferences from these results are for comparison of hedging effectiveness across contracts only.

underlying risk distributions across indices and provinces.[44] Overall, both measures of hedging effectiveness of these actuarial fair priced contracts increase at a decreasing rate as payout frequency increases. Hedging effectiveness is very minimal for contracts with low payout frequency, e.g., of less than once every five years. This is due to the nature of systemic shocks on rice production, which tend to be less extreme but occur quite often. Variations of hedging effectiveness across households are high and vary across indices.

**Figure 5: Comparison of Hedging Effectiveness across Optimal Contracts**




*Note*: Plots are averaged across 76,000 simulated households with CARA = 3. Average standard deviations around the estimated series in parentheses.

[44] And so we would expect that specific strike level for each payout frequency to be different across indices and provinces depending on their specific underlying distributions.

The optimal contracts with MD+ME index exhibit the highest hedging effectivenessin both measures. The provincial yield index, which was originally perceived to provide larger coverage for non-weather location systemic shock, performs almost as good as MD+ME in the irrigated zones but worse in the rainfed zones. The simplest contracts based on CR perform the worst in all cases. On average, the optimal MD+ME contractscovering 1-in-3year losses could result in 2.3% and 2.5% increase in households' average certainty equivalent valuesin irrigated and rainfed areas respectively. This could imply that the rates that households are willing to pay for the contracts on top of the fair rates. and up to 20% and 25% reduction in consumption variance in irrigated and rainfed areas respectively. This could imply The MD+ME contract also appears with the lowest variations in contract performance across households. These results are also robust with respect to other underlying risk aversion and premium loading assumptions.

**Optimal Contract Designs**

The two-peril MD+ME contract is thus chosen as appropriate basis risk minimising contracts for Thai rice production in this study. For each cropping season, MD index is constructed for the first 105 days and ME index for the 105-120 days of the cycle. The fixed period of insurable crop cycle for each province is drawn fromthe zone-specific patterns. A seasonal contract payout per insured hectare is thus a combination of payouts from the two indices optimally scaled with $\alpha^*_{MD}$and $\alpha^*_{ME}$ estimated using the risk profiles of 76,000 simulated households. The top panel of Table 3 reports mean provincial scales, actuarial fair premium rates[45] and probable maximum lossesby zones and strike levelsfor seasonal contracts available for the main crop.

[45] Reported pricings are established using burn rate approach. We also price these contracts using Monte Carlo simulations with marginal distribution of the provincial indices are estimated parametrically based on the best-fit distribution (according to chi-square criteria). Because the underlying risk (index) does not exhibit long tail associated with extreme event, our simulation results using best-fit distributions also confirm the same pricing patterns and are available upon request.

## Table 3: Optimal Seasonal Contracts and Actuarial Fair Rates

| | **Strike = 110%** (Avg. payout freq. = 50%) | | | | **Strike = 120%** (Avg. payout freq. = 30%) | | | | **Strike = 130%** (Avg. payout freq. = 20%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Zone** | α*(MD) | α*(ME) | Fair rate | PML | α*(MD) | α*(ME) | Fair rate | PML | α*(MD) | α*(ME) | Fair rate | PML |
| | Contracts available for main crop only | | | | | | | | | | | |
| Irrigated Lower Central | 0.7 | 0.8 | 16% | 68% | 0.8 | 0.9 | 9% | 56% | 0.8 | 0.9 | 5% | 38% |
| Irrigated Upper Central-North | 0.6 | 0.8 | 16% | 65% | 0.7 | 0.8 | 8% | 52% | 0.7 | 0.8 | 4% | 35% |
| Irrigated South | 0.8 | 0.9 | 14% | 59% | 0.8 | 1.0 | 7% | 49% | 0.8 | 1.0 | 3% | 32% |
| Rainfed Lower Central | 1.1 | 0.9 | 15% | 57% | 1.1 | 0.9 | 7% | 46% | 1.1 | 0.9 | 3% | 27% |
| Rainfed Northeast-North | 1.1 | 0.9 | 12% | 48% | 1.1 | 0.9 | 6% | 37% | 1.1 | 0.9 | 2% | 23% |
| Rainfed South | 1.0 | 1.0 | 12% | 46% | 1.0 | 1.0 | 6% | 32% | 1.0 | 1.0 | 2% | 19% |
| **Nationwide** | **0.9** | **0.9** | **14%** | **59%** | **1.0** | **1.0** | **7%** | **47%** | **1.0** | **1.0** | **3%** | **29%** |
| | Contracts available for both main and second crops | | | | | | | | | | | |
| Irrigated Lower Central | 0.7 | 0.8 | 15% | 64% | 0.8 | 0.9 | 8% | 53% | 0.8 | 0.9 | 4% | 33% |
| Irrigated Upper Central-North | 0.6 | 0.8 | 14% | 61% | 0.7 | 0.8 | 7% | 49% | 0.7 | 0.8 | 3% | 31% |
| Irrigated South | 0.8 | 0.9 | 13% | 57% | 0.8 | 1.0 | 6% | 48% | 0.8 | 1.0 | 2% | 28% |
| Rainfed Lower Central | 1.1 | 0.9 | 14% | 57% | 1.1 | 0.9 | 7% | 46% | 1.1 | 0.9 | 3% | 27% |
| Rainfed Northeast-North | 1.1 | 0.9 | 12% | 48% | 1.1 | 0.9 | 6% | 37% | 1.1 | 0.9 | 2% | 23% |
| Rainfed South | 1.0 | 1.0 | 12% | 46% | 1.0 | 1.0 | 6% | 32% | 1.0 | 1.0 | 2% | 19% |
| **Nationwide** | **0.9** | **0.9** | **12%** | **55%** | **1.0** | **1.0** | **6%** | **43%** | **1.0** | **1.0** | **2%** | **27%** |

*Note*: Payout frequencies are for both perils from MD+ME. Optimal scales are estimated at fair rates using annual data. Hence, they are similar for both contracts. Optimal scales, fair rates are averaged across provincial rates. PMLs are maximum provincial values. Prices are based on 1980-2011 historical burn rates. Price estimates from Monte Carlo simulations are comparable so omitted. The nationwide scales is averaged provincial scales weighted by shares of growing areas.

Overall, the optimal coverage scales for the rainfed zones are larger than those of irrigated zones due to their larger income sensitivities to these indices, especially the MD index. Actuarial fair rates are, however, larger at all strike levels for the irrigated zones, especially the irrigated flood prone lower central zone,due to largerindex variations. Mean provincial fair premium rates vary from 12-16% for 1-in-2 year coverage to 6-9% for 1-in-3 year coverage to 2-5% for 1-in-5 year coverage. The variations of mean provincial premium rates across zones also imply spatial variations of the exposures to floods and droughts. The extent of catastrophic risks of the provincial contracts can be shown by estimated MPLs at $VaR_{99\%}$. The PMLs range from as high as 68% of total sum insured for 1-in-2 year coverage to 56% for 1-in-3 year coverage.

**Portfolio Pricing and Potentials for Risk Diversifications**

Making the seasonal contracts available for both main and second crops in the irrigated areas could further allow for temporal risk pooling across seasons within a year. The bottom panel of Table 3 reflects these results. While the optimal coverage choices remain the same (as they are established from an annual model (16)), the fair rates and PMLs reduce slightly for the seasonal contracts available for both crops in the three 2-crop zones. A nationwide portfolio of provincial contracts is then constructed with provincial weights established from combining provincial optimal scales and provincial share of rice growing area. The bottom row in each panel of Table 3 reflects the spatial risk pooling benefits. Catastrophic layers of the insurable risk of the nationwide portfolio reduce for all strikes relative to those of the individual provincial contracts.

These resulting spatial and temporal risk-pooling benefits can be explained in Table 4. In the top panel, the estimated pairwise correlations of the zone portfolios could be as low as -0.12 between the rainfed northeastern and irrigated southern regions. In the middle panel, the estimated pairwise correlations of the main crop portfolio and the second crop portfolio could also be as low as -0.07 in the irrigated southern region. As in (9), pricing provincial contracts as part of a diversifying portfolio could thus result in lower rates through lower catastrophic loads.

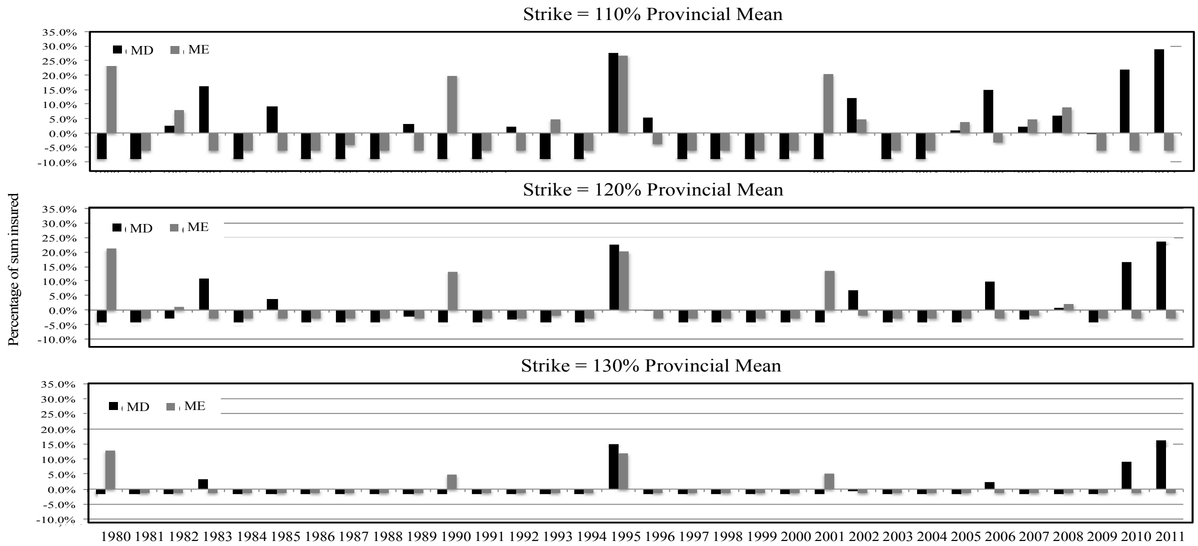
**Table 4: Diversification Potentials of Nationwide Index Insurance Portfolio**

| | Geographical Diversifications | | | | | |
|---|---|---|---|---|---|---|
| Contract Zones | 1 | 2 | 3 | 4 | 5 | 6 |
| 1. Irrigated Lower Central | 1.00 | | | | | |
| 2. Irrigated Upper Central-North | 0.56 | 1.00 | | | | |
| 3. Irrigated South | 0.42 | 0.18 | 1.00 | | | |
| 4. Rainfed Lower Central | 0.78 | 0.57 | 0.21 | 1.00 | | |
| 5. Rainfed Northeast-North | 0.48 | 0.44 | -0.12 | 0.86 | 1.00 | |
| 6. Rainfed South | 0.62 | 0.21 | 0.74 | 0.72 | 0.41 | 1.00 |
| | **Temporal Diversifications** | | | | | |
| Seasonal crop coverage | 1 | 2 | 3 | 4 | 5 | 6 |
| Second crop | 0.23 | 0.11 | -0.07 | | | |
| | **Diversifications with Tradables** | | | | | |
| Tradables | Coeff. | Std.Err. | Adj. R2 | N | | |
| Thai Stock Exchange Index (SET) | 4.60 | 3.60 | 0.07 | 32 | | |
| NASDAQ | 47.90 | 58.80 | 0.04 | 32 | | |
| Corporate bond AAA | -503.50 | 486.86 | 0.02 | 32 | | |
| Food price index | 138.87 | 52.26 | 0.16 | 32 | | |
| Rice future | 512.10 | 250.76 | 0.01 | 16 | | |
| CDD, Florida, U.S. | -14.7* | 5.40 | 0.22 | 28 | | |
| CDD, Calgary, Canada | -11.6*** | 2.90 | 0.31 | 28 | | |
| CDD, Madrid, Spain | -9.6** | 1.73 | 0.14 | 28 | | |
| HDD, Melbourne, Australia | -17.3** | 5.90 | 0.24 | 24 | | |

*Note*: Relationships are estimated from portfolio ne payout at 110% strike. All high frequency tradable returns are converted to annual unit by averaging returns within year. Commodity price indices, futures, weather and other CaTindices are obtained from Chicago Merchantile Exchange (CME).

Figure 6 plots the net payout (payout net fair premium rates as percentage of total sum insured) of the nationwide portfolio of index insurance contracts available for both crops at various strike levels. How might the annual portfolio payouts co-move with annual returns of various tradables in capital, commodity, future and weather markets? Table 4 reports these results. We found no significant pair-wise relationship between the portfolio of Thai rice insurance and the key market indices, e.g., Thai Stock Index (SET), NASDAQ, and securities in commodity or future markets. Our key results are the significant and negative relationships between the portfolio and various actively traded weather indices from around the world. While these results are based on low frequency (aggregated annually) data, they could signal potential diversifying values of Thai rice insurance portfolio in the portfolio of global weather risks.

**Figure 6: Nationwide Index Insurance Portfolio's Net Payouts**




## Risk Financing and Transfer

Figure 6 shows that the net payout position of risk aggregators, e.g., local insurers, appears with great exposures especially during the key catastrophic years. For example, the occurrence of both catastrophic drought and flood in 1995 result in net payoutsof as high as 43% of total sum insured for contracts with 1-in-3 year coverage (120% strike). This signals the importance of international market risk transfers in ensuring the sustainability of the program.

Table 5 reports actuarial fair premium rates and the associated PMLsof various stop-loss reinsurance contracts. Because the underlying risks are not as catastrophic as that of earthquakes, etc., with reasonable PMLs of about 49% sum insured, we assume an optimistic case, where the potential market rates for these reinsurance contracts are established with an additional catastrophic load at 3% of the estimated PMLs. This could reflect the potential costs of capital for reinsurer in holding necessary reserve or obtaining other risk financing instruments. At these potential market rates, we then illustrate some designs of a zero-coupon cat bond with principle payments linked with 100% stop-loss reinsurance contracts for the nationwide portfolios.

**Table 5: Actuarial Fair Stop-Loss Reinsurance**

| | Stop Loss Level (% of Pure Premium) | | | | | |
|---|---|---|---|---|---|---|
| | 100% | | 105% | | 110% | |
| **Strike** | Mean | PML | Mean | PML | Mean | PML |
| 110% | 6% | 49% | 5% | 43% | 5% | 41% |
| 120% | 3% | 39% | 4% | 35% | 3% | 31% |
| 130% | 1% | 25% | 2% | 23% | 2% | 20% |

*Note*: Nationwide seasonal contracts available for both main and second crops. Prices are based on historical burn rates estimated from 1980-2011 distributions

Table 6 reports cat bond prices for various specifications of requiredrate of returns for investor, a cap (% of principle) that limit investor's principle loss if reinsurance contract triggers payouts and strike levels ofnationwide insurance portfolio for the linked 100% stop-loss reinsurance contracts. Cat bond with 100% cap is thus riskier comparing to that with 50% cap since an investor would be exposed to losing all of his/her principle should the catastrophic events triggered reinsurance payout. The required rates of return are set at 4%, 6% and 10% translating into risk premiums between 2.93-8.93% at the current LIBOR rate of about 1.07%.[46] Comparing with other existing cat bonds (with relatively more catastrophic underlying risks) and the Mexican cat bond with as low as 2.35% premium above LIBOR, it seems this chosen range of risk premiums is sufficiently representative of spreads required by investors in the market (Froot, 1999). We note that the total return realised by investors when the bond is not triggered is always higher than the required return used in computing bond prices. The difference between the two presents the added premium associated with the catastrophic risk.[47]

[46]LIBOR rate as of May 30, 2012 from www.global-rate.com.

[47] For example, an investor who purchased a cat bond with required return of 4%, 50% cap with 110% strike at the price = USD0.8823 and received USD1 principle back one year later when reinsurance is not triggered, would realise a total compounded return of 12.4%. The rate can be interpreted as including a risk free LIBOR rate of 1.07%, 2.93% premium associated with bond

The bond prices thus decrease (hence the bond yields increase) with riskiness of the underlying reinsurance contract, the cap value and the required rates of return.

These results are, however, only for illustration of how Thailand's nationwide rice insurance portfolio might be securitised and transferred to international capital market. The actual potential of cat bond will also rely on the costs associated with securitising the contract relative to other means. The key feature that deviates this cat bond from others is its coverage of less extreme shocks relative to other earthquake- or hurricane-linked products in the market.

**Table 6: CAT Bond Linked with Stop-Loss Reinsurance**

| Required Returm | Capped (%) | 100% Stop-Loss Reinsurance on Nationwide Portfolio | | |
|---|---|---|---|---|
| | Principle Losses | 110% | 120% | 130% |
| 4% | 100% | 0.8412 | 0.8729 | 0.8898 |
| | 50% | 0.8823 | 0.8942 | 0.9064 |
| 6% | 100% | 0.8276 | 0.8511 | 0.8688 |
| | 50% | 0.8667 | 0.8818 | 0.8997 |
| 10% | 100% | 0.8096 | 0.8212 | 0.8389 |
| | 50% | 0.8532 | 0.8734 | 0.8935 |

*Note*: Bond prices are calculated assuming market rates of stop-loss reinsurance = fair rates + 3% PML

**How Might This Nationwide Rice Index Insurance Program Work?**

Our results so far imply that (i) the basis risk minimising contract with two-peril MD+ME index could provide up to 35% reduction in the insured's consumption variance, (ii) households are willing to pay between 2-4% of total sum insured on top of the fair rates for contracts with 1-in-2 year to 1-in-3 year payout frequency, (iii) it could be cost effective to price provincial seasonal contracts as part of a pooled nationwide portfolio and (iv) opportunities could exist in transferring portfolio risks to international markets through some forms of illustrated reinsurance and securitisation. We now illustrate the potential market rates, how the designed program and public support can be integrated in the risk financing in order to

default and other risks not associated with the insured reinsurance risk, and an additional 8.4% premium associated with this catastrophic risk associated with the reinsurance.

enhance market viability, and more importantly, how the programcould benefit farmers, agricultural lenders and government.

Table 7 reports potential market rates for the provincial contracts priced as part of the nationwide portfolio under various market arrangements. With a working assumption that the additive catastrophic load for a contract equals to the market rate for 100% stop-loss reinsurance coverage for that contract, our pricing results in an additional 50% mark up from the fair rates.[48] Ascatastrophic loads drive high mark-up rates, insurable risk can then be layered so that complementary public financing of tailed risk beyond some cappedindemnity payouts from insurers could result in reduction of market rates. As shown in Table 7, when insurer's payouts are capped at 30% of total sum insured, market rates for the 1-in-2 year and 1-in-3 year contracts reduce dramatically to their fair rates (and even below their fair rates for a cap of20%).[49]

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[48] This mark up is comparable to other existing index insurance programs in other part of the world. These market rates are comparable to other pilot projects for rice insurance in Thailand. For example, 4.64% rate changed for recently piloted deficit rainfall index insurance covering only drought peril for only the main rice production in Khon Kaen province during July-September.

[49] Because the extreme layers of risk are not so catastrophic, capping at higher level beyond 40% of sum insured will result in more or less the same effects to market premium rates. The market premium rates for 130% strike contract do not change with payout caps, as the contracts' maximum payout rates are already well below the caps.

### Table 7: Potential Market Pricings and Arrangements for Nationwide Index Insurance

| | | Market Arrangements | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Potential Market Rates | | With Public Financing of Tailed Risk beyond Capped Payout at 20% | | 30% | | 40% | |
| Strike | Payout freq. | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| 110% | 50% | 17.8% | (4.6%) | 11.9% | (3.1%) | 14.3% | (3.3%) | 16.9% | (3.7%) |
| 120% | 30% | 8.8% | (3.7%) | **4.2%** | **(2.3%)** | **6.4%** | **(3.1%)** | 8.8% | (3.7%) |
| 130% | 20% | **3.1%** | **(2.1%)** | 3.1% | (2.1%) | 3.1% | (2.1%) | **3.1%** | **(2.1%)** |
| | | **Increase in certainty equivalent value, $CE^{insured}$ - $CE^{uninsured}$(% sum insured per season)** | | | | | | | |
| Low risk aversion (θ=1) | | 0.1% | | 3.6% | | 1.4% | | 0.1% | |
| Med. risk aversion (θ=3) | | 0.2% | | 4.2% | | 2.0% | | 0.2% | |
| High risk aversion (θ=5) | | 0.4% | | 4.9% | | 2.7% | | 0.4% | |
| | | **Simulated impacts of insurance on households, agricultural loans and government (θ=3)** | | | | | | | |
| Net income for consumption | | 24,275 | | 33,052 | | 31,278 | | 24,275 | |
| *(No I = 25,314 baht/year)* | | (28,978) | | (24,464) | | (26,464) | | (28,978) | |
| 5-yr loan outstanding | | 39% | | 0% | | 9% | | 39% | |
| *(No I = 90% 1-yr income)* | | (57%) | | (0%) | | (17%) | | (57%) | |
| Input loan default rate | | 21% | | 0% | | 8% | | 21% | |
| *(No I = 47% per year)* | | (12%) | | (0%) | | (4%) | | (12%) | |
| Government spending | | 0 | | 843 | | 297 | | 0 | |
| *(No I = 0 million baht)* | | (0) | | (3,249) | | (1,580) | | (0) | |

*Note*: The potential market rates = fair rates + market rates for 100% stop-loss reinsurance. Reinsurance market rates = fair rates + 3% PML. Payouts are capped as % of total sum insured. Those in bold are welfare maximising contract strike for each market arrangement. CE and impacts of insurance are for the welfare maximising coverage. Results vary across provinces. Mean reported with standard deviations in parentheses.

Based on 32-year income dynamics of 76,000 simulated households, welfare maximising contract strike levelunder each market arrangement is then marked in bold in Table 7. The associated increases in certainty equivalent consumption are also reported for farmers with low, medium and high levels of risk aversion. The 1-in-5 year contract appears optimal under fully market-based index insurance program. But with low risk coverage, its utility-based hedging effectiveness is low but still positive, implying that on average households are willing to buy this contract at the market rate and contribute up to 0.4% of total sum insured on top of the current rate. With government financing indemnity payouts beyond 20-30% caps, the welfare maximising strike shifts to 1-in-3 year contract. These market arrangements also result in larger hedging effectiveness through lower insurance prices and larger resulting optimal risk coverage.

Which market arrangement is appropriate for this nationwide index insurance program? We explore this further by simulating the potentialimpacts on farmers, agricultural loan portfolios and government of these market arrangements for the nationwide index insurance program, as well as theexisting program. To do so, several assumptions are made. First, we assume that all 76,000 simulated farmers areclienteles of BAAC. Each year, they take out a loan to finance total input cost and to obtain insurance coverage for income from all cultivated rice crops (one or two). Total production income is then used to pay back the loan. From SES data, total input cost is assumed to be49% of averaged provincial crop production income, which also vary across provinces. Household is assumed to pay back their loan as much as is feasible – the maximum repayment is reached when net income available for consumption drop to zero.

With these assumptions, household's production income available for consumption per hectare per year thus reflects totalincome after receiving insurance payout and netting out all the accumulated loans outstanding up to that year:

$$c_{it} = \max\left(0, y_{it} + \alpha^* \pi(z_t, z^*) - \sum_{\tau=1}^{t} (1+r)^{t-\tau+1} L_\tau\right) \qquad (17)$$

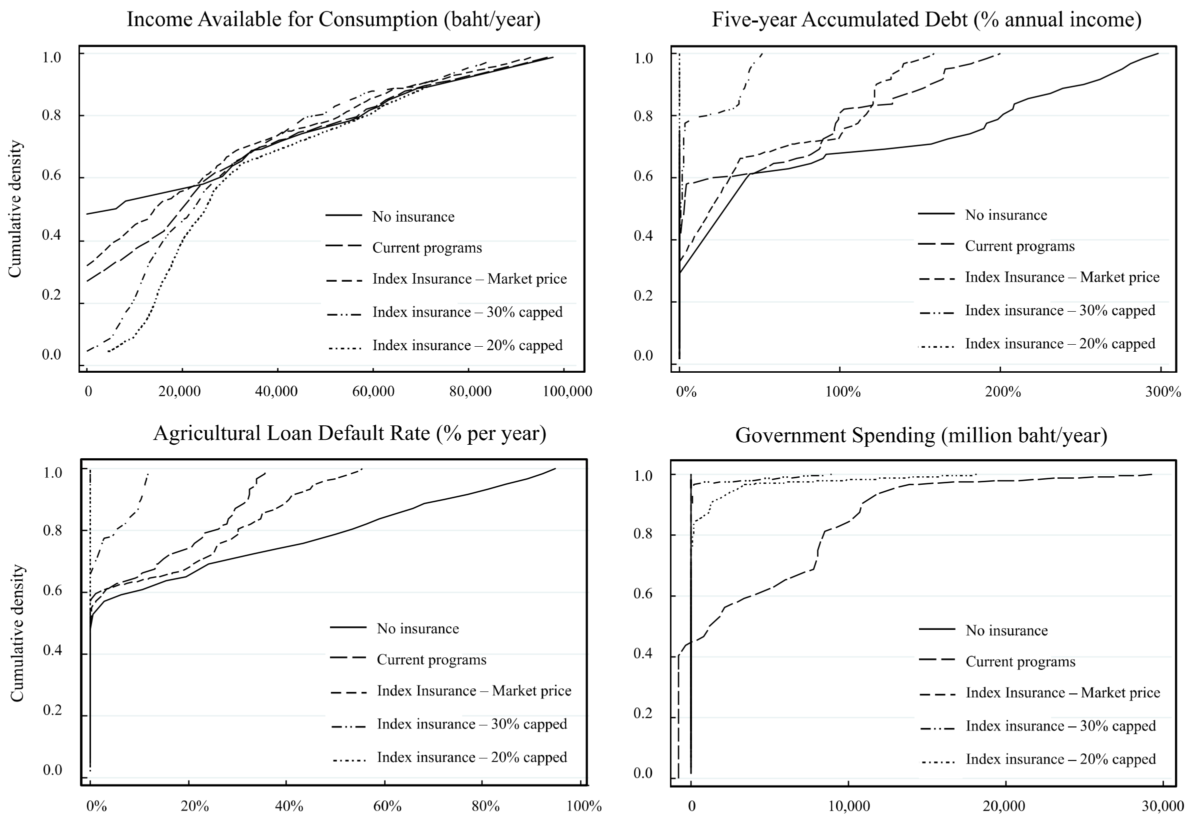
where insurance payout reflects summation of the two potential payouts for each index$\pi(z_t, z^*) = max\{\mathbb{Z}_t / E_l(\mathbb{Z}_t) - z^*, 0\} \times \bar{y}$with$\mathbb{Z}_t = MD_t, ME_t$ and $\bar{y}$ is the provincial averaged production income per hectare. The optimal coverage scale$\alpha^* = (\alpha^*_{MD}, \alpha^*_{ME})$. The nominal interest rate$r$ is at 6.75% per year. Total loan taken per hectare$L_t = 49\%\bar{y} + \delta E\pi(z_t, z^*)$.From SES data, we assume that household cultivates 1.92 hectare of rice paddy each year.

Based on 32-year dynamic data of 76,000 simulated households, Figure 7 plots cumulative densities of income available for household consumption, five-year accumulated debt position realised at any given year, BAAC'sannual loan default rates and annual government spending[50] under various schemes. The bottom panel of Table 7 also reports means and SDs of these impacts. With no disaster insurance market andgovernment support, there is about 50% probabilities that income available for consumption of Thai rice farming households could collapse to zero. Household's five-year accumulated debt realised in any given year is almost always positive with an average of 90% of annual production income. This outstanding debt could be as high as 300% of averaged annual income in any given year. And BAAC's loan default rate is estimated at 47% per year on average. The existing program with a combination of government's disaster relief and subsidised insurance[51] results in favourable distributional impacts that almost always first order stochastically dominate those of the baseline. The key drawback, however, is the tremendous government budget exposure, which stands at an average of 8,890 million baht per year, and could reach 29,930 million baht in some key years.

[50]We rescale the simulated representative sample to represent the current 9.2 hectares of growing areas nationwide. The current sample represents 63 similar households (9,200,000/(76,000×1.92)).

[51] Without actual payout statistics, we assume that under the existing program, if household's actual crop income falls below its 1-in-3 year trigger level, they will be paid 3,787 baht per hectare (606 bath/rai) under disaster relief program and an extra 6,944 baht per hectare (1,111 baht/rai) if they pay for disaster insurance coverage at a subsidised price of 375 baht per hectare (60 baht/rai). We believe this assumption is reasonable, as (i) the program covers larger sets of disasters and (ii) it makes payout conditional on government's declaration of disasters at very local levels with required actual loss verification. Because government disaster insurance is offered at highly subsidised price, our welfare optimisation implies that all representative risk-averse households will purchase full coverage. Hence 100% insurance penetration rate is used. Note that we abstract from all the incentive problems associated with existing program that could result in larger exposure on government spending.

**Figure 7: Simulated Impacts of Various Nationwide Index Insurance Arrangements**




*Note*: Cumulative densities based on 32-year dynamic data of 76,000 simulated households in 76 provinces nationwide

The market driven index insurance program without government support could also result in dramatically improvement in distributional impacts relative to the baseline case ofno market and government support. The probabilities of zero income available for consumption, the averaged long-term debt accumulation and BAAC'sloan default rates reduce by half and also with great reduction in variations. These distributional impacts are, however, relatively smaller on average but not necessarily first order stochastically dominated by those of the existing program. This is because, on the one hand, farmers pay higher market prices for market-based index insurance product that covers smaller sets of disasters relative to the existing product. On the other hand, compensations from index insurance (based on provincial averaged income)tend to be larger than those of the existing program (based on 30% of input cost) when the contract is triggered. With comparable impacts but no cost to the government, this purely market driven index insurance product could be appealing as one of the risk management tools for Thai rice farmers.

These distributional impacts further improve substantially for the index insurance program withintegrated public financing of tailed riskbeyond insurer's payout caps. At 30% (20%) payout cap, the resulting lower insurance prices and larger optimal risk coverage lead to more than 80% (almost 100%) reduction in probabilities of zero income available for consumption, long-term accumulated debt and BAAC's loan default ratesrelative to the baseline. The required public financing of these tailed risks are also substantially smaller in means and variations comparing to those required in the existing program. A case for public financing of tailed risk for Thailand's nationwide index insurance program thus could be strong. First, these public-private market arrangements are no doubt superior in both potential impacts on households and BAAC loan and on government's budget exposure relative to the existing program. And second, their distributional impacts are substantially larger than those under purely market-driven program.

## 4. Conclusions and Implications for the Rest of Asia

This chapter laid out why index based risk transfer products could be attractive as a means to address important insurance market imperfections that have precluded the emergence and sustainability of formal insurance marketsin developing countries. It then provides analytical framework for designing and evaluating optimal index insurance contracts using disaggregated data, and for analysing the potentials for these insurable risk to be diversified, transferred and financed in order to enhance sustainability of the program. It then illustrates how disaggregated and spatiotemporal rich sets of household and disaster data, commonly available in developing countries, could be used to design and analyse nationwide, scalable disaster index insurance program for rice farmers in Thailand.

Relative to the direct measures of provincial yield andthe estimated yield based on climate-crop modelling, we found that objectively measured weather data could be carefully constructed as basis risk minimising indices for index insurance contract. Objectively measured remote sensing data also proved to be useful in controlling for heterogeneous cropping patterns across larger geographical areas nationwide. The transparency of these weather indices and control measures along with their spatiotemporal availability could hold further advantages in scaling up contract designs to wider settings.

Using household level data in estimating basis risk and so in simulating contracts' hedging effectiveness, we found the resulting contract performance, optimal contract scales and pricings to vary largely across provinces and households. Contract designed at the provincial level – the most micro level given our representative data – was thus considered. Overall, the optimal provincial contract based on basis risk minimising combination of moving dry spell and moving excessive rain spell indices could result in up to 25% reduction in the variations of household's income available for consumption. Simple cumulative rainfall, widely used in marketable contracts worldwide, however, appeared with the lowest performance. This raised concerns on the extent of basis risk associated with currently available contracts.

We found evidence of temporal and spatial diversification benefits, as we scaled insurance portfolio to cover all provinces nationwide and to cover the second crop grown among farmers in the irrigated areas each year. Thus return to scale in term of cost effective portfolio pricing can thus be achieved as part of nationwide, multi-seasonal coverage insurance program. Spatiotemporal availability of weather data further allowed us to show using simple correlation exercise that nationwide index insurance portfolio of Thai rice could be diversifiable with other weather indices worldwide in the global portfolios. This could imply, on the one hand, that local risk aggregators could diversify their portfolio risk with appropriate hedging portfolio of global weather indices. On the other hand, tradable security linked with Thai nationwide insurance portfolio, e.g., cat bond, could be appealing in the international market as diversifiable security in various diversifying global portfolios.

The transparency of these weather indices and control measures in fact could further promote the possibility of cost effective risk transfers in the international market. We thus designed the corresponding reinsurance contracts and cat bonds, and illustrated their potentials and how these might be useful as risk transfer instruments. The key distinction of our cat bonds from others is the coverage of relatively higher frequency but lower impact losses from floods and droughts, comparing to other earthquake- or hurricane-linked products. Skees, *et al*. (2008) also discussed the potentials of micro-cat bond in transferring covariate but less extreme risks out of developing countries.

Bringing all the results together, we asked what might appropriate market arrangement be to ensure sustainable implementation of this nationwide insurance program? Using disaggregated spatiotemporal rich data, we simulated the potential impacts on household welfare, agricultural loan portfolio and government of this nationwide program under various market arrangements relative to the current program. The purely market driven program was found to result in more than 50% reductions in probabilities that household consumption collapsing to zero, in means and variations of five-year accumulated debt and BAAC's annual loan default rates. As these impacts are comparable to those of the current program, albeit no budget exposure to the government, the market-driven program thus already proved as one of the effective disaster risk management tools for the setting. Properly layering insurable nationwide risk, we further found public financing of tailed risk beyond the 20-30% capped to insurer's payout rates to result in substantial reduction in market premium rates. These in turn resulted in up to twice the impacts of the purely market-driven program, though with substantial smaller budget exposures to the government relative to the current government program. There could thus be a strong case for public financing of tailed risk in enhancing development values and market viability of Thailand's nationwide index insurance program.

How might this nationwide insurance program be implemented? An insurance indemnity pool of the nationwide index insurance contract could be created to allow local insurers to diversify their risks and contribute capital to the reserve pool, from where indemnity payments can be drawn. Reinsurance could potentially be acquired when indemnity payments exceed the pool but for the risk up to some appropriate capped level. Government could then finance the low frequency but catastrophic tailed risk through various options, e.g., offering complementary disaster insurance coverage for this tailed risk, providing the insurers direct coverage or financing of the transfers of this tailed risk. Government could also maintain some necessary reserve and use some forms of IBRTPs to hedge their exposures in the international market.

The design and market arrangement of this nationwide index insurance for Thai rice farmers thus deviate largely from the current program. First, unlike direct premium subsidisation, public financing of the tailed risk does not distort market prices. The capped commercialized contracts are still sold at their market rates and the rates differ across provinces with different risk profiles. This prevents the potential adverse selection problem, likely to occur under the current scheme with one price for all. Second, the public financing of the tailed risk provides complementary, rather than substituting, coverage. This thus would not crowd out private demand for insurance, especially for the risk layer that should appropriately be absorbed by the households and market. Third, the government's budget exposure to financing of the tailed risk could be insured through some forms of IBRTPs. This, in turn, could enhance sustainability of the program. And more importantly, the key advantages of these index insurance design relative to the current loss-based insurance program are (i) relatively lower transaction cost, especially in loss verifications, (ii) relatively lower adverse selection and moral hazard, (iii) the contract still preserves insured household's incentive to take good care of their farms and so to adjust their cropping patterns to avoid risk since the indemnity is regardless of their actions and (iv) contract could potentially make timely payout as verification of these indices are in near real time.

Various limitations of the current study are worth noting with the goal to stimulate future required research ideas. First, our analyses are based on simulated rainfall data, not the actual data observed at various stations. Despite its relative advantage in the relatively richer spatial distribution, simulated data need to be verified with actual weather experienced at the micro level. Efforts are also underway in many developing countries, including Thailand, in constructing appropriate gridded data from observed station data in order to improve spatial distribution of the station data. Second, the current analysis mapped the relatively higher spatial resolution weather data with household data at provincial level, due to the lack of sub-district locators in the SES data. Efforts should be made in matching weather or disaster variables at the most micro level possible. Third, various spatiotemporal available remote sensing products, could have high potential in improving the measures and performance of the underlying indices. Efforts are underway in using these products to detect inter and intra year variations of rice growing areas, stage of crop growth, paddy losses and the extent of natural disasters (see Rakwatin, *et al*. 2012, for example). And fourth, the observed increases in frequency and intensity of natural disasters imply the need for incorporating simulated impacts of climate change in the modelling and pricing of insurable risks. The ECHAM4-PRECISE simulated climate data used in this analysis could allow us to do so. Alternatively, various available hazard modellings that allow for risk simulations under various extreme scenarios could also be used.

The analytical framework as well as the empirical methodology proposed in this chapter should be replicable in other settings and in other developing Asian countries, where exposures to covariate natural disaster risks remain uninsured. The data sets used in this chapter should well be available in other Asian countries. The extended time series of spatiotemporal rich weather data as well as remotely sensed data are available worldwide at high quality and low cost.[52] And the high quality, national representative household dynamic welfare data similar to Thai SES data should well be available in the key Asian countries. Some examples include repeated cross-sectional household data

[52] Gridded weather data from WMO stations across Asia are available online at NOAA Global Daily Climatology Network (daily, 1900-present). Various satellite imagery Normalised Difference Vegetation Index (NDVI) available from NASA MODIS at 250m resolution (15-day; 2000-present) and from NOAA AVHRR at 8km resolution (10-day; 1982-2000). RADARSAT-1 and RADARDAT-2 with cloud-penetrating SAR sensor at 25m resolution (every 15 day, 1995-present) have been increasingly used for flood monitoring.

from Indonesia National Socioeconomic Survey (SUSENAS), available every year from 1990-2010, from Vietnam Household Living Standards Survey (VHLSS), available every 2 years from 2002 to 2010.

This chapter offers an optimistic view of the potentially optimal designs, market viability and impacts of IBRTPs designed at a large nationwide scale. These results could deviate largely from actual implementation in the real world. At least, four key implementation challenges are worth noting. First, it could be difficult to establish informed effective demand among clientele with relatively low financial literacy in developing countries. Second, the presence of large basis risk could still be possible in some coverage areas. Third, cost of marketing and delivery mechanisms of the contract could still be high in developing countries. And fourth, the targeted clientele could have financial constraints in paying insurance premium.

These key challenges thus place significant implications on how index insurance program should be implemented in developing country settings. Should the insurance contracts be offered as a stand alone or linked with other financial products? Linking with other existing financial products might resolve high implementation costs and relax some financial constraints among targeted clientele. Should the program be established at the micro, meso or macro levels? Extended investment in education, training and extension tools are thus critical if contracts are sold directly to households. At the meso level, rural banks like BAAC could obtain insurance contract to insure their loan portfolio, so that they can then lend insured loans to households. Groups and cooperatives can obtain coverage for their group saving or credit schemes. One testable assumption is that group-sharing network could potentially smooth out individual basis risk associated with index insurance contracts. Necessary randomised impact evaluation research has been launched around the world in attempt to address these questions. Extended discussion of key implementation challenges of IBRTPs in developing countries to data are summarised in Miranda, *et al*. (2012) and IFAD and WFP (2010). Overall, the challenges are significant, but the considerable prospective gains associated with IBRTPs for enhancing development of sustainable disaster insurance programs in developing countries would seem to justify considerable new effort in this area.

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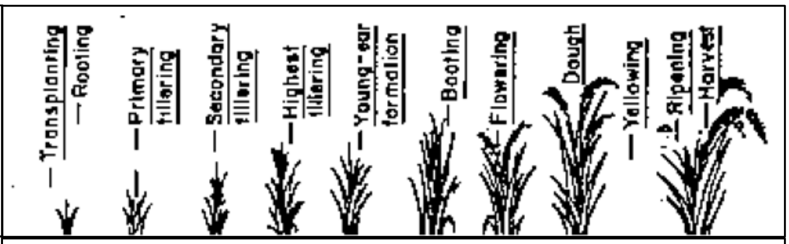
## APPENDIX

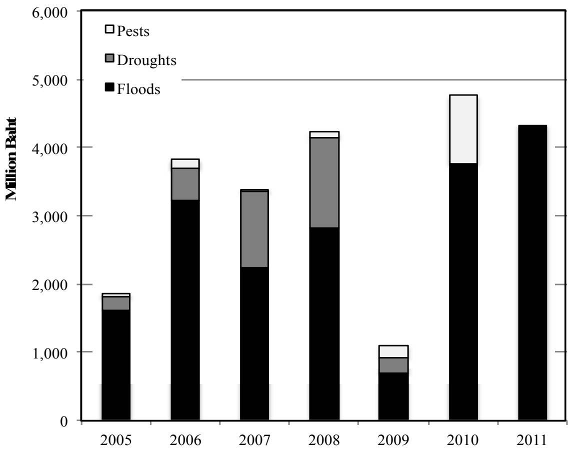
## Figure A1: Growth Stages of Rice Plants and Key Variables

| Rice growth stage (Yukawa (1989) and Murphy (1998)) |  | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Days after seeding | 20 | 28 | 35 | 45 | 58 | 75 | 86 | 105 | 120 |
| Height (cm) | 5 | 25 | 35-55 | 35-55 | 60-65 | 80-95 | 80-95 | 80-95 | 80-95 |
| Crop water requirement | 25.4 | 39.6 | 35.9 | 35.2 | 43.1 | 47.4 | 42.8 | 0 | 0 |
| Critical rainfall level (mm/10-day) | 25 | 30 | 30 | 30 | 40 | 35 | 0 | 0 | 0 |



*Note*: Data are obtained from World Bank (2006)

## Figure A2: Government Budget Spent on Disaster Reliefs for Rice Farmers (2005-2011)




*Note*: Data are obtained from Thailand Ministry of Agriculture

## Table A1: Summary of Existing Pilot Projects of IBRTPs in Asia

| Country/Product | Type | Targeted users | Risk | Index | No. latest beneficiaries | Risk financing | Progress |
|---|---|---|---|---|---|---|---|
| **Bangladesh**<br><br>**Weather index insurance** | Micro level, standalone, group-based contracts, linked with loans | Farmers, farmer's groups | Drought and flood | Simple weather parameters | - | - | Under development |
| **India**<br><br>**Public and private weather index insurance** | Micro level, standalone, linked with loans, seed sales, contract farming | Farmers (small, medium, large) | Various weather-related shocks (excess and deficit rainfall, humidity and frost) | Station rainfall, temperatures, weather-linked crop diseases, fog, humidity, satellite weather index | > 700,000 across the country | Public agricultural insurer (AIC), ICICI Lombard, IFCCO-Tokio, Swiss Re, Tokio Marie, Endurance Re, SIRIUS Re | First piloted in 2003, expand largely Mostly unsubsidized except some small numbers of states |
| **Mongolia**<br><br>**Index-based livestock insurance** | Micro level, private-public partnership in risk financing | Nomadic herders | Severe weather, especially winter storm | District census of aggregate livestock mortality rate | 4100 in 4 provinces | Insurance pool of local insurers with government providing stop-loss reinsurance, WB contingent loan for catastrophe loss through risk layering | First piloted in 2006; expand gradually |
| **Thailand**<br><br>**Drought insurance for maize and rice** | Micro level, distributed by Bank of agricultural & agricultural coop. | Maize and rice farmers | Droughts | Cumulative rainfall during growing season | 817 in 11 provinces | Consortium of nine local insurers<br><br>Sompo Japan | Product for maize first piloted in 2007, government supports to expand. For rice first piloted in 2011 |

## Cont. Table A1

| Country/Product | Type | Targeted users | Risk | Index | No. latest beneficiaries | Risk financing | Progress |
|---|---|---|---|---|---|---|---|
| **Vietnam**<br><br>**Area-yield index insurance for rice** | Micro level, cover loans to rice farmers | Rice farmers | Covariate shocks that affect area yield | Area yield indexbased on data from the Vietnam's Bureau of Statistics | 10 provinces | Agribank Insurance Joint Stock Company (ABIC) as insurer, reinsurer using Swiss Re and Vietnan National Reinsurance Corpopration (Vina Re) | Sold since 2011 |
| **The Philippines**<br><br>**Area-yield index insurance for rice** | Micro level, supported by the German GTZ | Rice farmers | Covariate shocks that affect area yield | Area yield index triggers relative to 15-year average yield | 17 irrigated municipalities | Local insurer | Piloted in 2012 |
| **Vietnam**<br><br>**Flood insurance for** | Meso level protecting bank from loan defaults | Vietnam Bank of Agri.and Rural | Early flooding of rice fields during rice harvest | River level measured at the upper Mekong river during early rice | - | - | First designed in 2008 but has not been |

# CHAPTER 5

# Social Capital in Post Disaster Recovery: Towards a Resilient and Compassionate East Asian Community

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*Standard approaches to disaster mitigation and recovery have, until recently, tended to overlook the role of social resources. This chapter investigates the mechanisms through which social capital and networks assist with disaster management, including modifying the responses of exit and voice, overcoming barriers to collective action, and providing informal insurance and mutual aid. Through examples such as the 1923 Tokyo earthquake, the 1995 Kobe earthquake, the 2004 Indian Ocean tsunami, and the 2011 compounded disaster in Tohoku, Japan, this piece seeks to underscore a potentially efficient and cost effective response to crises.*

***Keywords***: Social capital, Resilience, Disaster recovery

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After any major disaster, survivors must decide if they want to return to a destroyed home in a wrecked town with no viable infrastructure and few fellow residents. In the town of Rikuzentakata, Japan where 10% of the population was killed and 80% of the businesses were washed away by the Tohoku tsunami in March 2011, one resident - a baker named Masayuki Kimura - has been willing to return to the destroyed area to bake sweets, breads, and snacks for his community. He returned, cognizant of the fact that turning a profit was unlikely and that his start up costs would be high. Rather than returning because of his love for business or because he had no other options, he moved back to his hometown because of his personal ties to the area. Kimura had saved his own life, and that of his mother, by evacuating to higher ground soon after the 8.9 magnitude earthquake struck off Japan's northeastern shore at 2:46 pm on the 11th of March. From a hilltop nearby they watched as their home and bakery shop was destroyed; the tsunami, as high as 46 feet in some places, swallowed much of coastal Rikuzentakata.

The USD 370,000 worth of business loans which Kimura had taken on before the disaster remained, though, and he considered leaving the area to start afresh elsewhere. Had he left, he would have been among many making similar choices; more than 1200 people had left the city to move elsewhere by the end of 2011 (Barta, *et al.* 2011). But the baking business was started by his grandfather in 1926 and he had specifically brought Kimura's father into the family to keep the enterprise going. Even while sitting in temporary housing following their evacuation, Kimura's mother soon began telling reporters that she wanted to rebuild and begin making sweets for the community again. Pushed by her words, Kimura found second hand baking gear and moved into a temporary location, discovering that many of his suppliers of equipment and foodstuffs refused to take his money when they found out where he was living. While distributing supplies at evacuation centers, he heard from many people discussing their nostalgia for the flavors of normal life: "People are longing for our local taste." Recognizing his personal connections to his community and the ways in which his sweets can help others rebuild their lives, Kimura has committed to rebuild whatever the costs (Wakabayashi, 2011).

The story of Masayuki Kimura provides us with critical insights into the role of social capital and social networks in the process of disaster recovery. As the tsunami approached, many people survived the wave because of the actions of others; among them was Kimura's mother, who was saved by her son. For the elderly and infirm, the only hope of living through the event came from the assistance of caregivers, neighbors, and family. These connections were able to assist the bedridden into cars and vans and then out of the plain in which many homes were located. Once the waters had receded, Kimura, like other survivors, had to decide whether or not to return to his damaged home and community.

His personal ties to the town helped him to move back to the wasteland that was Rikuzentakata even though he understood the process would be costly and slow. In the process of rebuilding his business, aid from and ties to colleagues and acquaintances proved critical; financial and emotional support from network members cemented his desire to move forward. His story matches that of many other survivors and towns around the world who have displayed resilience in their recoveries. Individuals and localities bounced back from tragedy and hardship not solely through wealth, government aid, or top-down leadership, but through their neighbors, connections and social networks.

The 3/11 Tohoku compound disaster sits as one in a dizzying list of high profile disasters, including the Indian Ocean tsunami in 2004, Hurricane Katrina in 2005, and the 2010 Haiti earthquake. The last two decades of disasters have seen a clear trend of increasing casualties and higher amounts of damage (Guha-Sapir, *et al.* 2011). Because of wide scale migration towards vulnerable coastal locations and increasing urbanization around the world, floods and water-related disasters have contributed to the increasing toll on human life. With anthropogenic global warming speeding up the rise of ocean levels and increasing the frequency of extreme weather events, disasters will continue to be part of the human condition. Under these conditions, scholars and policy makers alike should recognize the importance of providing usable knowledge about disaster recovery.

Much folk wisdom about disaster recovery remains focused on variables assumed to influence the efficiency and effectiveness of the process. Standard variables include damage from the disaster, quality of governance, the socioeconomic status of the individuals and communities affected, and the amount of aid provided by national governments and aid organizations. However, a great deal of research has shown that in a variety of important policy fields such as health, civic engagement, and livelihood searches, social networks strongly influence behavior and outcomes. One randomized experiment using five trials over seven weeks which engaged more than 700 participants demonstrated that individuals were heavily influenced by the behavior of actors similar to them to take on new behaviors. Hence early adopters of diet diaries which recorded what foods each subject had eaten soon passed on their behaviors to fellow network members (Centola, 2011). Other research has demonstrated that if our friends and acquaintances start going to the gym, we're likely to follow suit (Christakis and Fowler 2009). We've known since the 1970s that "weak ties" – the people whom we meet through our friends and acquaintances – are the ones who help us find new jobs (Granovetter, 1973). This chapter draws on research from a variety of scholars and disciplines to emphasize the role played by social capital and networks in disaster mitigation and recovery. It begins with a review of the standard literature on recovery, moves into a discussion of the mechanisms by which social capital influence rebuilding, and then brings evidence from a variety of studies to back up its approach. I end with a discussion of broader lessons from these studies and conclude with a focus on future research agendas and directions for scholarship.

## 1. Standard Literature on Disaster Recovery

Typical approaches to disaster recovery focus on the role of standard variables such as damage, governance, socioeconomic status, and aid. The concept that the level of damage from the crisis would influence the path of recovery is intuitive and was highlighted by Douglas Dacy and Howard Kunreuther's pioneering work on the process of recovery and the role of the federal government in hazard mitigation following the 1964 Alaskan earthquake. In their book they argued that "it just seems reasonable to assume that the speed of recovery following a disaster will be determined primarily by the magnitude of the physical damage" (1969: 72). Given the tremendous damage from Hurricane Katrina, for example, which flooded roughly 80 % of New Orleans, many observers believe that the road to recovery will be a long one. This would be in contrast to smaller scale disasters in North America, such as tornadoes, which may touch down and strike only a few homes; in such cases, it may be a matter of weeks or months before lives of residents return to normalcy.

Other scholars and journalists have argued instead that the quality of governance matters, as they envision local mayors, governors, and even national decision makers speeding up or impeding the broader recovery process. Political scientists have called the rush to judgment after disasters the "blame game" and it can be found in developing and developed nations alike. After the 1995 Kobe earthquake, many blamed the Japanese national government for not bringing in the Self Defense Forces quickly enough to assist with fire fighting, search, and rescue. After Hurricane Katrina in the summer of 2005 many openly blamed Mayor Ray Nagin, Governor Kathleen Blanco, and President George Bush for failing to put sufficient disaster preparation and mitigation in place despite the widespread knowledge of the weakness of New Orleans' levee system. Similarly, after the Tohoku disaster in March 2011, observers were quick to argue that ties between Tokyo Electric Power Company (TEPCO) executives and the long ruling Liberal Democratic Party (LDP) in Japan resulted in less than sufficient safety standards at nuclear power plants (with one critic tweeting "amakudari kills" in reference to the practice of regulators descending from heaven into paid positions in the industries they have regulated while in government).

Sociologists and economists have focused on the socioeconomic status of victims and have tried to link their recovery processes to their wealth and private resources. In studies of recovery from the early 20$^{th}$ century earthquake and fires in San Francisco, California, for example, researchers argued that lower class individuals had to move multiple times in their search for post-quake shelter. Such actions made it more difficult for them to effectively restart their lives. Other studies have underscored that many of the victims of Hurricane Katrina in New Orleans were individuals with low incomes and little education, and that their livelihoods suffered more than survivors of higher status. Many of the communities struck hardest by the 2011 Tohoku earthquake and tsunami were older, retired residents with little savings and no home or earthquake insurance. Government officials in

Japan worry whether these residents will be able to carry out effective recoveries given their limited reserves of financial capital.

Finally, many researchers and policy makers have argued that the amount of aid provided from outside institutions, whether national governments, NGOs, or international organizations such as the United Nations or the United States Agency for International Development (USAID). After the eruption of Mount St. Helens in the state of Washington, the governor was asked what she needed. In her response, she spelled out the word “money.” International observers have worried when autocratic regimes have refused to accept international aid offers, such as the government of Myanmar following its typhoon. Their core concern has been that a lack of aid for survivors will result in slower recovery overall.

## 2. A New Approach: Social Capital

Traditional approaches have focused primarily on factors external to disaster-affected communities, and have paid little attention to the ways in which social relationships within the community may drive or inhibit the process of rebuilding. New research on the role of social capital - the ties that bind us together and provide useless data and information on trustworthiness - has illuminated three mechanisms through which networks and relationships can influence the process of disaster recovery.

The first - illustrated well by the vignette about the baker in the town of Rikuzentaka - is known by economists as the choice between “exit” and “voice” (Hirschman, 1970). Exit refers to the process of uprooting from one’s initial community and starting life over again in a new one. Survivors of disaster may exercise exit early on - when they realize that their homes are damaged or destroyed - or later in the recovery process, when they see that their community is not recovering effectively. Following the Diaspora from New Orleans after Hurricane Katrina, many survivors decided to start their lives over again in communities in Houston, Dallas, Memphis, and so on. They did so because they believed that their new communities provided better livelihoods, or because they feared that their own recoveries in New Orleans might be stalled. Alternatively, survivors may choose to return to wrecked houses and rebuild their lives no matter how much damage has been done to them. When residents return and begin to work collectively, letting authorities in the area know their preferences and working to make themselves heard in the planning process, economists call this "voice." Research on the process of return has underscored that individuals with more ties to their old communities - whether through family, friends, a sense of belonging or place, or jobs - are more likely to return and exercise voice. Those who feel less connected to their neighbors, or who feel that their networks are not returning, will be more likely to select exit.

The second mechanism by which social capital can assist following disaster is with the overcoming of barriers to collective action. Around the world, people often have strong beliefs and deeply rooted ideals, but they may not actually work to see these put into practice. This may be because they lack the time, energy, or ability, but it can also because they assume that someone else will do the "heavy lifting" involved. Social scientists call this phenomenon free-riding, and because of it many are content to remain in their homes or offices while others go out and march, vote, sign petitions, blockade doors, and actually mobilize. Post-disaster situations often have collective action problems that require maximum participation. To deter looting, for example, everyone in the neighborhood has to chip in and give up us some of their sleep or free time to walk on patrol. If people opt out or decide to shirk their responsibilities, they may open up the area to potential thieves. To ensure that authorities will turn power back on to damaged areas, everyone has to ensure that they sign up through online or paper forms indicating their return. Some communities, such as Village de L'est in northeastern New Orleans overcame their collective action problems (they convinced the local utility to restart their power) while other areas, such as the condominium owners in Kobe did not (they were unable to fully take advantage of an offer from the city government to remove debris if all owners signed onto the plan) (Aldrich, 2012a). Areas with higher levels of trust and social capital can better overcome the barriers to collective action and mobilize their residents to participate; communities where people lack trust and believe that others will not come to their aid will find themselves mobilizing only a small fraction of the returnees.

The final mechanism by which social capital assists post-disaster is through the provision of mutual aid and informal insurance. An example may help illustrate the ways in which social capital provides information, fellowship, and support during times of crisis. After the Tohoku tsunami struck the town of Shichigahama (literally "Seven beaches") in Miyagi Prefecture and destroyed roughly 1000 homes there, a knitting club named *Keito Iki-Iki* (Yarn Alive) has emerged to provide social support for its 20 or so mostly elderly neighbors. "It cheers me up so much that I don't even feel lonely at night, I just feel like knitting some more," reported one member whose home and store were washed away by the tsunami. Later, when the same resident missed a club meeting to attend an athletic event, her fellow knitters called to check up on her (Ono 2012). Informal insurance means that network members provide necessary resources at a time when standard suppliers of those resources - such as the government, private sector companies, and so forth - are unable to do so. Similarly, after Hurricane Katrina suppliers such as Wal-Mart, gas stations, and hotels were closed, so neighbors borrowed power tools, gasoline, and places to stay in order to work on their damaged homes.

## 3. Review of Literature on Social Capital

Research on social capital's role in post-disaster recovery has been building up gradually into a strong component of the broader field of disaster research. One of the earliest works on this topic came from sociologists who recognized that people in need of resources go to formal service providers, such as government welfare agencies, only as a last resort. Instead, many people prefer to use their friends, family, and network connections for support during crises. Using data on survivors of Hurricane Andrew in 1992, one team of scholars established the importance of network ties in the recovery process. At a time when normal sources of support were closed due to the damage wrought by the hurricane, survivors sought support from network members through formal and informal channels (Beggs, *et al.* 1996).

Through a separate investigation of how three rural communities in Manitoba, Canada handled the 1997 Red River Flood, researchers soon confirmed the role of stronger social capital in the recovery process (Buckland and Rahman 1999). In their focus on how the communities prepared for and then handled the disaster, they found that the social ties among residents profoundly influenced the trajectory of disaster response. In the communities of Roseau River, Rosenort, and St Jean Baptiste, Rosenort had the highest levels of civic engagement as measured through both the number of organizations and the number of meetings. "Rosenort in particular demonstrated a vigorous response to the flood, which was made possible through intense social capital formation, reflecting the community's unique historic, cultural and religious background" (*ibid*. p.188).

Data from the Gujarat and Kobe earthquakes in India and Japan, respectively, further demonstrated the importance of bonding, bridging, and linking social capital in furthering recovery and rehabilitation efforts (Nakagawa and Shaw 2004). This comparative study used both qualitative and quantitative methods to better understand the factors responsible for speedier and more efficient recoveries. While the two areas struck by earthquakes had very different cultures and levels of socioeconomic development, "At every stage of the disaster cycle (rescue, relief and rehabilitation), the communities played the most important roles among other concerned stakeholders" (*ibid*. p.27). Further, individuals in more civically active and engaged communities expressed higher levels of satisfaction with the process of planning and recovery than survivors from more fragmented and less involved areas.

A number of recent studies have underscored the role of social networks in broader processes of adaptation and resilience. One highly-cited study in *Science* magazine argued that local institutions and social networks provided the basis for both local and international action in response to increasing vulnerability. The article brought examples from the 2004 Indian Ocean tsunami and the 2004 Hurricane Ivan to show how well-connected communities learned from previous hazards and used social connections to strengthen their resilience. The authors emphasized that "Networks and institutions that promote resilience to present-day hazards also buffer against future risks, such as those associated with climate change" (Adger, *et al.* 2005).

One researcher set up in-depth, process-tracing case studies of how two communities in Nagata ward of Kobe, Japan handled the 1995 earthquake which devastated the city's urban center and killed more than 6400 people (Yasui 2007). "Both communities were characterized by population decline, aging population, fragile old wooden housing, high building density, narrow streets and mixed residential and industrial land uses located near to each other" (*ibid*. p.15). Despite these similarities, Mano has been known since the early post-War II days as a well-organized community with high levels of civic engagement and participation. Beginning with greening and anti-pollution movements, the community has been a locus for activism and involvement with strong, interconnected networks. It further demonstrated its ability to overcome collective action problems when handling the fires that broke out after the 1995 earthquake. As one local leader recalled, "when fire erupted after the earthquake, people started lining up and handing buckets full of water to the next person to put out the fire because the water pressure was too low to use the fire hydrant properly (*ibid* p.186). In contrast, Mikura has little history of past activism, and residents were hard pressed to remember community development activities in the past. When fires broke out following the quake, "the residents of Mikura community passively watched as their homes burnt to ashes" (*ibid* p.227). While Mikura developed its capacity post-disaster, many of its residents did not return, and much of the work done in the area was carried out through outsiders.

Another study of the 1995 Kobe earthquake recovery process looked less at communities and neighborhoods and more at the recoveries of individual survivors (Tatsuki, 2007). Through four waves of surveys with roughly 1000 respondents, the Hyogo Life Recovery Survey Project designed a life recovery scale based on 14 different factors. The author then categorized responses into fields of self governance and solidarity, and found that there were statistically significant differences in the same respondents before and after the quake.[1] Many survivors moved from more self-focused approaches to communitarian approaches, shifting their field of focus from themselves and their families onto the broader neighborhood and society. Individuals who reported higher levels of solidarity and civic-mindedness tended to have stronger recoveries than more isolated individuals. Through focus groups and interviews Tatsuki showed how social ties helped

[1]Supporting these findings, Cassar, *et al.* (2012) provide experimental evidence that victims of disaster are more trusting of others and simultaneously moderately more trustworthy.

survivors to rebuild communities and then to retell the story of the disaster as one of recovery and engagement as opposed to one based solely on loss.

After the 2005 Hurricane Katrina which resulted in the collapse of the levees in New Orleans, Louisiana, a scholar showed how local community ties and the accompanying narratives of recovery strongly predicted levels of community recovery (Chamlee-Wright, 2010). Chamlee-Wright saw post-disaster situations as ones in which many people have strong disincentives from expending time and energy on recovery, preferring to free ride on the efforts of others. Given that communities provide the associational worlds which govern norms and behavior, she "recognizes a reciprocal relationship between the institutional rules of the game and cultural processes" (Chamlee-Wright 2010: 16). Using this focus on social capital and community ties as a start, she used interviews and case studies to document the different levels of recovery across four neighborhoods in the city: Lower Ninth Ward, Mary Queen of Vietnam, Broadmoor, and St. Bernard Parish. Her approach showed how important the cultural tool kits and levels of solidarity are in the process of recovering after crisis.

Similarly, scholars researched the ways in which different types of social capital created different capacities in two neighborhoods devastated by Hurricane Katrina (Elliott, *et al.* 2010). One neighborhood, the Lower Ninth Ward, was made up primarily of African-Americans who lived below the poverty line, while the other, Lakeview, was a neighborhood made up primarily of affluent whites. Interviewing 100 residents from each of the neighborhoods, the authors sought to understand how networks - especially bonding and linking social capital - played a role in recovery after the storm. Overall, it took more than twice as long for residents of the Lower Ninth Ward to return to their homes as their counterparts in Lakeview, and they also were about one-seventh as likely to contact a neighbor. In the Lower Ninth Ward, individuals were less likely to connect to their geographically proximal neighbors and friends and also less likely to be able to call on the help of outsiders who lived beyond the ruined area. "As a result, relative declines in translocal assistance dovetailed with a relative inability to re-establish local residential networks to undercut the reconstitution of local sources of social support for Lower Ninth Ward residents" (*ibid*. p.643).[2]

One final book drives home the power of social networks in rebuilding after crisis and hints at the potential for positive interaction between social networks and the state. Rieko Kage used the wide variation in reconstruction rates among Japan's 47 prefectures after World War II to reject explanations for post-crisis recovery based on economic or state-centric hypotheses which posit that higher levels of economic resources or the presence of a cohesive and autonomous state are sufficient conditions for better recovery (Kage, 2011: 143). Through side-by-side process tracing of YMCAs in Kobe and Sapporo along with cases of judo clubs in Fukuoka and Yokohama, Kage showed how some areas in pre-war Japan had greater citizen enthusiasm for and involvement in voluntary activities while others withered, especially as war time conditions deteriorated and top-down, government coercion intensified.

## 4. Additional Evidence of Social Capital's Role

To further illustrate the role of social capital in post-disaster recovery, three "megacatastrophes" over the past century show how networks strongly influenced the trajectories of rehabilitation across time and space. The three disasters under review are the 1923 Tokyo earthquake, the 2004 Indian Ocean tsunami, and the 2005 Hurricane Katrina All resulted in the deaths of more than 1,000 people and caused tremendous amounts of property damage.

On 1 September 1923 at approximately noon a tremendous earthquake struck the capital of Japan, collapsing buildings and setting off fires which raged for several days. When the smoke cleared, the earthquake had caused more than 140,000 deaths and leveled roughly 40 % of Tokyo. Roughly two-thirds of the population became homeless and more than 345,000 homes were lost to fire and shaking. Residents began seeking to rebuild within days, constructing "barrack" type temporary housing

[2] The researchers are referring to the ability of individuals living outside the affected area - hence the term "translocal" – to provide resources at a critical moment.

units using debris and scrap metal in whatever land they could claim. Images from the town show popular parks filled with ramshackle cabin-like structures, often with carts filled with materials parked just outside.[3] However, even though the drive to rebuild was strong, some neighborhoods seemed to display more resilience than others, drawing back in old residents and attracting new immigrants, while other communities seemed to lose population. To better understand why some areas revitalized at the same time that similar communities became ghost towns, I used detailed police records from the 1920s and the 1930s to understand the conditions of recovery (Aldrich, 2012b).

The Tokyo Metropolitan police operated out of neighborhood police boxes called *kōban*, and their records of daily life in their communities were extensive and well maintained. From their surveys, I extracted neighborhood level measures of population density (measured as individuals per square kilometer), the number of factory workers per capita (who, on the whole, were uneducated migrants from the countryside) along with the number of commercial cars per capita in the neighborhood. I also have information the number of trucks and cars, the per capita cost of crime in the area, and the percentage of local residents killed in the earthquake. To understand the financial resources available to local residents, I include observations of per capita pawnbroker lending rates; pawnshops were seen as such important sources of credit that the Tokyo municipal government itself sought to rebuild pawnshops to replace those that had been destroyed in the earthquake. To measure the ability of local residents to overcome collective action problems and to work cooperatively, I recorded the number of demonstrations per year (in each neighborhood) along with voter turnout in municipal elections (for which universal male suffrage had just been granted).

To check to see which of these potential factors - economic capital, population density, damage from the earthquake, and so on - had the strongest impact on the process of population recovery, I ran three different types of analyses. I first used a simple bivariate analysis, dividing the neighborhoods into those with high levels of social capital (above average levels of voter turnout and demonstrations) and those

[3]The Reynolds collection (http://library.brown.edu/cds/kanto/about.html) has over 100 photographs taken in Japan immediately following the earthquake.

with lower levels of social capital (average or below average levels of these activities), and looked at their average population growth rates. The chi-squared value for a tab test of below-average/above-average social capital with below-average/above-average growth rates was 0.001, indicating a statistically significant difference between these two types of communities. Then, I used a method called propensity score matching to try to build a dataset which mirrors the "twin studies" often carried out by medical scientists looking to establish a causal relationship. This approach creates a dataset of observations which are quite similar, in which all of the observations had a similar propensity to receive the treatment (in this case, high or low levels of social capital) but only some did. In doing so we can better create causal inference about our variables of interest. Using this method, I found that neighborhoods with higher-than-average numbers of political demonstrations had a 2 % higher level of population return than very similar neighborhoods (in terms of earthquake damage, economic and human capital, area, and so forth), with lower-than-average numbers of rallies, marches, and protests.

My final analysis of the data from Tokyo used time-series, cross-sectional, panel-corrected models to hold all of the control variables (damage from the earthquake, pawn broker lending, population density, and so on) at their means while allowing voter turnout to vary. Using the simulation program known as "Clarify" I generated predictions for the population growth rate along with 95 % confidence intervals around this prediction. The result showed a very strong, positive relationship between voter turnout and population growth, holding constant the values of the other factors. Communities in which the people turned out to vote had a far higher population growth rate than areas in which people voted in smaller proportion. Even a century ago, the impact of social capital on post disaster recovery is measurable and statistically significant. Some hundred years later, though, social capital proved equally important.

A great deal of work on the 2004 Indian Ocean tsunami has shown the power of social networks in the process of recovery. On the 26 December 2004 a "megathrust" earthquake of at least a 9.0 magnitude struck off the west coast of Sumatra, Indonesia and set off tsunami as tall as 100 feet in some areas. The tsunami devastated coastlines in India, Sri Lanka, and Indonesia, killing close to 200,000 people across these areas, with 35,000 killed in Sri Lanka. Seventy thousand (70,000) houses in Sri Lanka were destroyed completely with another 30,000 damaged. Many of the villages struck by the tsunami were coastal fishing villages with homes and livelihood locations directly next to the ocean. Recovery across villages has varied; some have recovered population and put their fisher people back to work, while others languished for months, if not years.

Minamoto (2010) carried out surveys of 187 households in eastern Sri Lanka located in areas which had suffered damage from the tsunami. To measure levels of social capital, the author looked at "(1) the social norms, people's behaviors and attitudes during reconstruction; (2) changes in networks during reconstruction; and (3) characteristics of the community-based organizations to which our respondents belonged" (*ibid*. p.551). The results of the quantitative analysis showed that linking social capital - that is, connections between survivors and national and international nongovernmental organizations (NGOs) proved critical at helping to secure necessities such as food, shelter, water, and education. Trust among the members of community-based organizations along with formal community networks had strong, positive relationships with livelihood recovery, while more bonding social capital - focused on the family and kin - occasionally contributed to negative perceptions of recovery.

The recognition of the role of social capital in Sri Lankan recovery pushed international aid organizations, such as UN HABITAT to help affected communities to rebuild not only their homes but their social networks as well (see details on the intervention at http://www.fukuoka.unhabitat.org/projects/sri_lanka/detail10_en.html). In their study of five affected districts in Sri Lanka, DeSilva and Yamao (2007) argued that "poor social capital status makes communities more vulnerable and highly dependent on donors" (*ibid*. p.45) while "high levels of social capital facilitate the entrepreneurial ventures among farmers" (*ibid*. p.46). The higher levels of trust and coordination among well integrated communities provided them with opportunities for risk-taking and entrepreneurial ventures which could, over the long term, secure their livelihoods and increase their income. In contrast, communities with lower levels of trust who were unable to coordinate their activities found themselves most dependent on the generosity and activities of the international aid community.

Another example came one year after the Boxing Day Tsunami –in late August, less than a year later, Hurricane Katrina arrived on the Gulf Coast of North America.

The collapse of the levees after the landfall of Hurricane Katrina on 29 August 2005 submerged some 80 % of New Orleans; it was almost two months before the water was pumped out of some neighborhoods. While many neighborhoods in the city remain under populated and filled with debris and weeds, others quickly rebounded from the flooding and began renovating their homes and businesses. Observers suggested a number of potential explanations for the variation in recovery speeds. Some argued that economic resources held by survivors best predicted who would return and begin rebuilding, and who would stay away. Others argued that race - long a divisive issue in the city - would influence the recovery process. But one scholar has focused on the ways in which communities create their own narratives and norms of independence, hard work, and collective responsibility.

Emily Chamlee-Wright's book on the recovery process focused on the cultural toolkits held by residents of neighborhoods across the city. One area has stood out as a paradigm of independence, solidarity, and rapid rebuilding: the primarily Vietnamese and Vietnamese-American community centered around Mary Queen of Viet Nam (MQVN) church. "By spring 2007 over 90 % of the Vietnamese American residents but fewer than 50 % of the African Americans had returned to Village de L'Est" (Leong, *et al*. 2007). Located in the northeastern, Village de L'Est area of the city, the community returned within months of the flooding and demonstrated its ability to influence broader public policy when it successfully shut down the Chef Menteur Landfill which had been reopened to accept storm debris. MQVN's residents comprise both older residents who came over from Vietnam at the height of its war in the mid 1970s along with a younger generation which has grown up with the norms and teachings of the community.

Interviews with local residents underscored their norms of collective responsibility and a belief in the value of hard work. One resident, when asked about concerns that the city was not up and running when they returned, argued that "it didn't really matter that we didn't have [municipal] services up" (quoted in Chamlee-

Wright 2010: 69). Rather than waiting for the city to provide social services, or local businesses to restart and sell necessary materials for rebuilding, the community self-organized before returning, dividing up responsibilities and ensuring that they would be self sufficient upon their return. Further, because of their historical experiences and insular culture, the community saw the widespread damage from the storm as a relatively minor nuisance compared with their previous struggles during the Vietnam war. As one interviewee pointed out, "thirty years ago [we came] with empty hands...thirty years later we already have the tools for everything, strategies, [and] the understanding [that] we can rebuild that" (quoted in Chamlee-Wright, 2010: 70)

The bonding, bridging, and linking social capital in the area allowed residents to not only coordinate their rebuilding processes internally but to ensure that their voices were heard by the city government and other relevant institutions. "In Village de L'Est, under the leadership of the Mary Queen of Vietnam Church and its new Community Development Corporation, residents have rebuilt most of the community's single-family homes; an unsafe landfill has been shut down; new senior housing and urban farms are under development; businesses have returned to the two main commercial districts; and a new health center and charter school are being planned" (Brand and Seidman, n.d.). Few other neighborhoods in the city of New Orleans have been able to replicate the success demonstrated by MQVN after Katrina.

## 5. Discussion

In this chapter I have tried to underscore the ways in which social capital serves as a critical part of disaster recovery by bringing evidence from a variety of disasters and catastrophes in different nations and time periods. I believe that the growing body of evidence on social capital suggests three broader lessons. First, it hints at the importance of thoughtful and sustained interaction between government and local social networks. Next, some standard recovery strategies may in fact harm the social infrastructure so critical for the processes of rebuilding and hence should be planned carefully. Planners should be careful to think through and avoid these potential barriers to effective recovery. Finally, should these studies indeed capture the essence of social capital's role, the findings suggest next steps for both governments and NGOs which seek to improve the recovery process after crisis.

This chapter has shown how social capital - the ties that bind neighbors, friends, and acquaintances together, deepening their trust and making their collective action more likely - works in ways often guided by geography and distance. As local-level networks and community based organizations can coordinate group actions and deepen trust, governments should recognize their role in broader emergency management and disaster recovery planning. Rieko Kage (2011) showed how local civil society organizations interacted with government resources to further the process of recovery after World War II in Japan. National and regional governments have deep resources but can easily direct them to useless or damaging projects. Through strong coordination with local social networks and community groups, valuable resources from the state can be used more effectively and efficiently. For example, while national planners may envision a bridge or road as critical, local residents may understand that restarting a school or local church will form a critical "anchor" in the recovery process. Governments able to tap into the local knowledge and mobilization potential of well-connected neighborhoods could use social capital as a "force multiplier" and extend the scope of their programs. Future quantitative and qualitative research should look closely at the ways that local social networks interact with government mitigation and recovery policies.

In a related way, standard recovery plans may actually harm reservoirs of social capital. For example, after large-scale disasters government agencies usually seek to rush survivors out of temporary emergency dwellings into long term shelters. This strategy, carried out in good faith, can easily harm existing networks by placing vulnerable individuals, such as the elderly and infirm, in areas far from their friends, family, and networks. Following the 1995 Kobe earthquake, for example, many older survivors were rushed into long term housing, but the tragedy that followed was unexpected: more than 240 survivors died "lonely deaths" in their new apartments. Without friends, family, and networks, these survivors had little to live for. New recovery plans should build instead on bottom up strategies which integrate a deep knowledge of the needs of the community with its own voice.

One example of a program to activate and sustain local community involvement in recovery efforts comes from the Tohoku disaster. The Hobo Nikkan Itoi Shimbun has documented the stories of a number of local residents whose homes and livelihoods were disrupted by the tsunami (http://www.1101.com/yamamotocho/english/2011-10-20.html). In telling the story of their activities - cleaning up debris, sorting out the relief supplies and sharing them among themselves - at the early stage in their life as evacuees, these narratives underscore the power of the group in both accomplishing measurable outcomes (e.g. making a mud-filled home livable again) and in creating a new identity. Through their group activities in the community, residents move from victims to active agents with dignity.

Finally, should these studies capture the reality of recovery, the next stage of work should be pursuit of research on increasing levels of social capital in vulnerable areas through public policy. Several studies have shown that tactics such as community focus groups (Brune and Bossert, 2009; Pronyk, *et al.* 2008) and community currency or "scrip" (Doteuchi, 2002; Richey, 2007) can deepen trust among participants and increase their civic engagement. Governments around the world should consider investing fewer funds in often misused or underutilized physical infrastructure and consider the ways that deepening their social infrastructure can improve recovery outcomes. Social capital-focused programs may not only be cheaper than interventions focused on physical infrastructure, but their impact will be felt for a longer period of time as well.

## 6. Conclusion

This chapter has suggested a new paradigm for thinking about disaster recovery and for designing emergency management responses. Moving beyond "brick and mortar" approaches to recovery, it has stressed that the ties between residents may serve as a critical engine during what may be a long and difficult recovery process. Ongoing research in related fields continues to support this approach. Coppock, *et al*. (2011), for example, demonstrated that the establishment of collective action groups in rural Ethiopia, along with the creation of social safety nets, had led to measurable improvements in quality of life and to reduction in hunger. Working with more than 2300 women in 59 collective-action groups on the Borana Plateau, researchers demonstrated that low cost (USD1 per month per person over 3 years), peer networking and participatory education programs improved lives and strengthened human development. These sorts of new public policies suggest a new wave of government and NGO action which move beyond the traditional sorts of interventions that have been the norm since the 1950s.

East Asia has suffered from a number of disasters over the past decades, and as nations like China, India, Indonesia, and Vietnam modernize and urbanize, their populations will be increasingly vulnerable to natural and man-made crises. Rather than merely responding to disasters as they occur in the future, visionary decision makers in these and other countries should move to embrace a social-capital based approach to policy making. Bringing residents to the forefront and increasing community based planning will ensure a strong future for these important countries.

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# CHAPTER 6

# Impact of Disasters and Role of Social Protection in Natural Disaster Risk Management in Cambodia*


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*The pattern of risks faced by the poor and vulnerable in rural areas of Cambodia, as a consequence of natural disaster, is posing an increasing threat to their livelihoods. One third of the past three years has been taken up either with flooding or with drought, and the drought periods were more prolonged than the floods. The damage caused by flood and drought was comparable, although the flood of 2011 was the most extensive of the disasters. This chapter presents impacts of disasters on household welfare and the linking of social protection interventions to address the entitlement failure of poor and vulnerable people suffering from the impacts of flood and drought. There is a strong need at the policy level to design social protection interventions to emphasize ex-ante instruments rather than the ex post response to natural disasters as focusing on emergency assistance and relief. Cash transfers programs provide direct assistance in the form of cash to the poor. Ex-ante cash transfer programs can play a crucial role in encouraging poor households to invest in business rather than spending on food. Microfinance schemes can also help ex-ante income diversification that can bolster households against widespread natural disasters.*



***Keywords*****:** Natural disaster, Entitlement failure, Social protection


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## 1. Introduction

The pattern of risks faced by poor and vulnerable people in rural areas, particularly those involved in agriculture and other ecosystem-dependent livelihoods, is becoming a major cause of chronic poverty. Dependency on subsistence agriculture, in particular for the rural poor in Cambodia, accumulates the impact of stresses and shocks (such as droughts or floods). This has profound implications for the security of their livelihoods and for their welfare. Such stresses and shocks, on the other hand, will not necessarily always lead to negative impacts, as risks and uncertainties that are often associated with seasonality are embedded in the practice of agriculture, and there is considerable experience of coping and risk management strategies among people working in this sector. However, in the face of climate change, the magnitude and frequency of stresses and shocks is changing and, therefore, approaches such as social protection, disaster risk management and climate change adaptation will be needed to bolster local resilience and supplement people's experience.

The basic nature of disaster impact in Cambodia seems to be the occurrence of relatively moderate flood and drought events combined with a high level of vulnerability and major limitations in the ability of rural people to cope with the impact of these events on their livelihoods. Cambodia does not face flood risks of the magnitude and intensity of Bangladesh, nor does it face droughts of the magnitude and intensity of countries in the African Sahel. Yet the more moderate magnitude and intensity of droughts and floods that are encountered in Cambodia are enough to threaten livelihoods and to cause widespread suffering among rural people. By understanding that natural disasters have a huge impact on social and economic welfare, policies to manage them need to be integrated and well grounded to the specificities of natural hazards as well as local capacities in terms of fiscal, administrative and economic capabilities.

In Cambodia as well as in many other countries, social protection responses to natural disaster have been ad-hoc mechanisms. Social protection, including support payments and insurance against risk, does not reduce disaster risk in itself. Nor is it an alternative to development investments in public infrastructure and services, but there are compelling reasons why social protection should be part of strategic disaster risk management. The main approach of this chapter, therefore, is to integrate natural hazards into the design and implementation process of social protection, particularly as an ex-ante intervention, and to see such shocks as not being exogenous to it.

This chapter makes the case for social protection being an important tool for managing the risk of natural hazards. Social safety nets and other components of social protection will be presented to show both ex-ante, to prevent and mitigate the impact of natural disaster, and ex-post, to cope with the impacts of natural shocks. The case study on understanding the impact of the 2011 flood on Cambodia's rural poor, who require this comprehensive linkage between social protection and disaster management, will be discussed. The specific aims of this chapter include: (i) to conduct ex-post and ex-ante analysis of the past and potential socioeconomic impacts of disasters on the livelihoods of the rural poor in Cambodia, (ii) to assess risk-coping strategies of households, and (iii) to highlight disaster management system, focusing on the role of social protection.

The rest of the chapter is organized as follows. Section 2 briefly presents definitions of disasters and our research methodologies. Sections following deal with climate-related vulnerability in Cambodia, particularly the series of floods and droughts resulting from the unique hydrologic regime and agrarian system, and their impacts on people's livelihoods. Subsequently, the chapter presents the role of social protection for natural disaster management, and mechanism to address the entitlement failures resulting from the impact of flood and drought, before concluding the chapter.

## 2. Research Methodologies

### 2.1. Definition of Disasters and Disaster Risk Management

Following Sawada (2007), disasters can be classified into three major groups. The first type is the natural disaster, which includes hydrological disaster (flood), a meteorological disaster (storm or typhoon), a climatologically disaster (drought), a geophysical disaster (earthquake, tsunami and volcanic eruptions), or biological disaster (epidemic and insect infestation). The second type of disaster comprises technological disasters, i.e., industrial accidents (chemical spills, collapses of industrial infrastructures) and transport accidents (by air, rail, road or water). The final group of disasters is manmade, and includes economic crises (hyperinflation, banking or currency crisis) and violence (terrorism, civil strife, riots, and war).

Disaster risk management (DRM) describes the sets of policies, strategies and practices that reduce vulnerabilities, hazards and unfolding disaster impacts throughout a society. Disasters can have a huge impact on livelihood opportunities and on people's ability to cope with further stresses. Impacts such as loss of assets can lead to increased vulnerability of poor people and a "downward spiral of deepening poverty and increasing risk" (Davies, *et al*. 2008). DRM aims to make livelihoods more resilient to the impacts of disasters, hazards and shocks before the event. Programs include early warning systems, infrastructure investment, social protection measures, risk awareness and assessment, education and training, and environmental management.

In the Cambodian context, disaster risk management should put more emphasis on social protection measures to help people cope with major sources of poverty and vulnerability, while at the same time promoting human development. It consists of a broad set of arrangements and instruments designed to protect individuals, households and communities against the financial, economic and social consequences of various risks, shocks and impoverishing situations, and to bring them out of poverty. Social protection interventions include, at a minimum, social insurance, labor market policies, social safety nets and social welfare services.

### 2.2. Methodologies and Data Sources

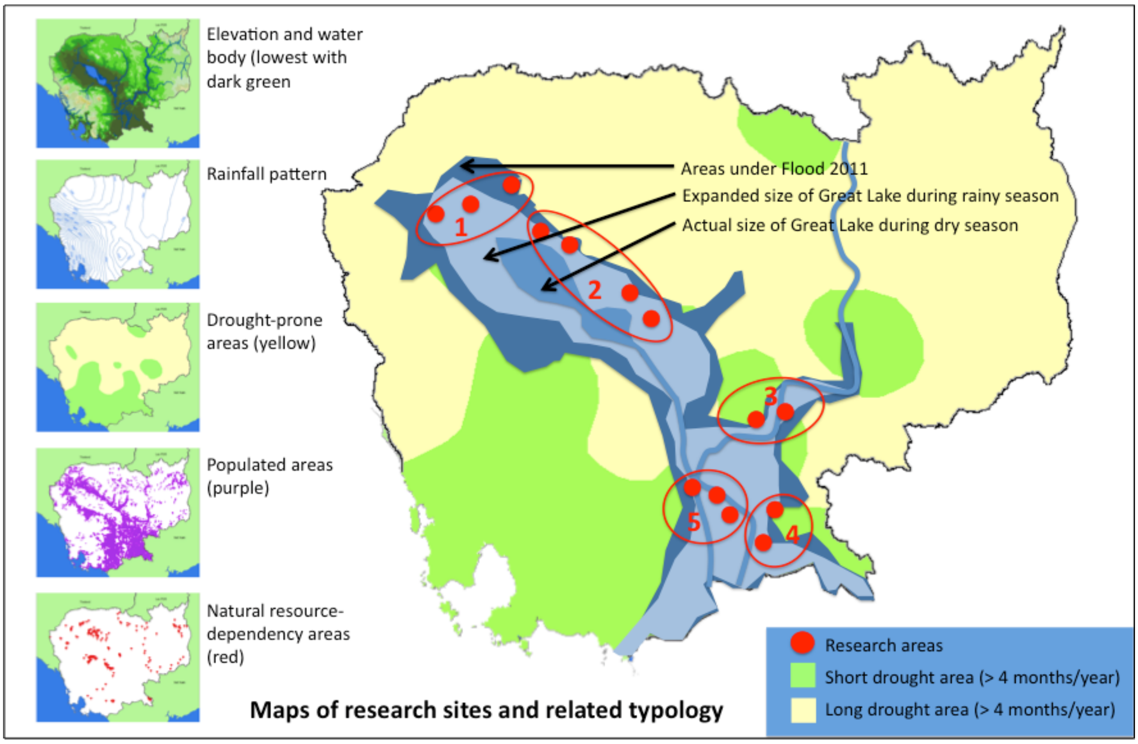
The chapter utilizes existing socioeconomic survey data from 2004 and 2009 and a unique questionnaire survey in 2012 for empirical analyses.

The field research, carried out during February to April 2012, took place in 7 provinces (22 communes of 15 districts), which were selected to represent the major and sub-components of Cambodia's agrarian landscape (Figure 1). These 7 provinces were later categorized into 5 clusters of research areas based on an agro-ecological typology:

Cluster 1: Areas with inundated plains, prone to secondary river flooding and prolonged drought (Preah Net Preah and Serei Sophorn District of Banteay Meanchey

Province and Banteay Srey District of Siem Reap Province). The majority of crops are large scale cash crops (cassava and maize).

**Figure 1: Map of Research Areas showing 5 Clusters of Districts in 7 Provinces according to the Agro-ecological Typology of the Areas**




*Source:* Authors

Cluster 2: Areas with undulated plains, prone to flooding from Great Lake during the rainy season (Tonle Sap) but reliant on the delayed recession of floodwater during the dry season (Siem Reap and Chikreng District of Siem Reap Province and Kampong Svay and Baray District of Kampong Thom Province). Receding rice and occasionally floating rice are the major crops.

Cluster 3: Areas of riverbank, prone to Upper Mekong flooding during the rainy season but reliant on the fast recession of floodwater during the dry season (Cheung Prey and Batheay District of Kampong Cham Province). Diversified vegetables and cash crops can be found.

Cluster 4: Areas with extreme undulated plains, prone to Lower Mekong flooding and vulnerable to the speed of flooding and prolonged drought (Prey Veng and Svay Antor District of Prey Veng Province). The area is used mainly for rain-fed rice production.

Cluster 5: Areas of riverbank with secondary swamp lakes, prone to Lower Mekong flooding during the rainy season but reliant on the fast recession of floodwater during the dry season (Muk Kampoul and Khsach Kandal District of Kandal Province and Russey Keo District of Phnom Penh). The area is used mainly for vegetable production.

In total, 239 households randomly selected with the help of Village Chiefs were interviewed. Based on the proxy mean test procedure of the ID-Poor Database[1] (Ministry of Planning, 2011) including characteristics of housing, household properties, land sizes etc. The interviewed households were divided into 3 categories, namely the Poor, Near-Poor, and Non-Poor.

These 5 clusters are used to identify areas and locations of household in the sample of the Cambodian Socio-Economic Survey in 2004 and 2009[2] to analyze the impact of droughts and floods on household welfare. Households were also categorized based the size of land ownership into small (0 - 0.5 ha), medium (0.5 - 3 ha), and large (more than 3 ha).

## 3. Vulnerability to Climate in Cambodia

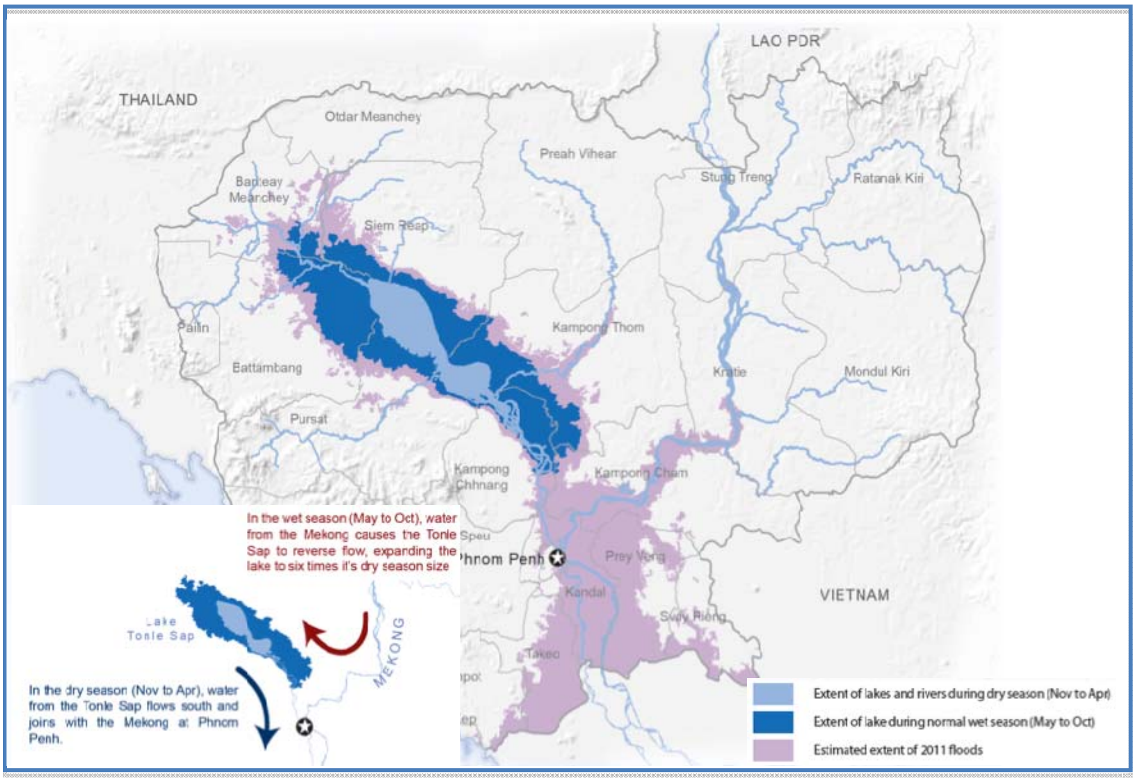
Cambodia's unique hydrological regime and low coverage of water control infrastructure makes it vulnerable to climatic and natural disasters (Figure 2). Most rural households rely heavily on subsistence agriculture for their livelihoods, especially rice cultivation, which accounts for 90% of the country's total cultivated area and 80% of agricultural labor input (World Bank, 2006a). Agricultural production (and thus households' food security) is heavily dependent on weather conditions and can fluctuate significantly from year to year.

[1] ID-Poor Database, an almost nationwide database of the "Identification of Poor Household Program" which divided the livelihood of people into 3 categories (very poor or ID-Poor I, poor or ID-Poor II, and non-poor) based on a set of proxy mean tests of household properties.

[2] CSES (Cambodian Socio-Economic Survey), last conducted in 2009, is a nationwide representative sample of 12,000 households focusing on livelihood and socio-economic characteristic at household level.

Accordingly, the growth rate of the crop sub-sector is highly variable, reflecting high reliance on adequate rainfall and susceptibility to the weather (Cambodian Development Resource Institute (CDRI), 2008). Livelihoods and sources of income for the rural population may therefore be compromised, leaving them reliant on social protection from the state and development partners – in particular in the case of natural disasters.

**Figure 2: Detailed Extension of Actual Size of Great Lake (during Dry season), Expanded Size (during Rainy Season), and the Areas Flooded in 2011**




*Source:* Authors.

Poor households also rely on use of natural resources such as water and forests to generate income. Access to common property provides an important safety net for the rural poor in bad harvest years. The 2006 Poverty Assessment found that one-quarter of the poor depended only on fishery and forest products for over half their income in 2004 and, on average, fishery and forest products accounted for 25% of household income among the poor (World Bank, 2006b). However, access to this common property is becoming increasingly limited. As captured in the qualitative Participatory Poverty Assessment (Ballard, *et al*. 2007), many of the extractive activities in the forest do not comply with rules and regulations. Rising population numbers have also contributed to overexploitation and a decline in resource availability. In addition, leasing of water bodies to business interests and increasing restrictions on free access to fisheries are already evident in places where the poorest depend on hunting and gathering for their livelihoods.

Rural households' vulnerability to climate and economic shocks is exacerbated by the low productivity and low diversification of their income-generating activities. Most rural households rely heavily on subsistence agriculture for their livelihoods: an estimated 72 % of Cambodians are dependent on fishing and agriculture (Cambodian National System for Disaster Management (CNCDM), 2010). In addition, household-level agricultural productivity remains low: rice yields, for instance, remain among the lowest in the region, owing to limited and poor use of improved seed, fertilizer, tillage and water management (CARD, *et al*. 2009).

**Table 1: The Total Number of Months in the Last 3 years in which Flood and Drought were Experienced, and the Degree of Severity by Different Agro-ecological Zones**

| Areas | Total number of months | | Total level of severity | | Flood 2011 severity |
|---|---|---|---|---|---|
| | Flood | Drought | Flood | Drought | |
| 1 | 4.51 | 8.32 | 14.84 | 13.14 | 6.89 |
| 2 | 5.95 | 6.04 | 14.36 | 12.63 | 7.37 |
| 3 | 5.89 | 4.13 | 13.87 | 12.28 | 9.43 |
| 4 | 6.05 | 9.49 | 14.24 | 10.66 | 8.98 |
| 5 | 4.97 | 5.32 | 13.53 | 10.97 | 7.08 |
| Total | 5.58 | 6.49 | 14.18 | 12.04 | 7.93 |

*Source:* Authors' calculation from the surveyed data

In the current research, interviewees were asked to range the severity of flood and drought from "no-impact at all = 0" to "significant damage to harvest, livelihood and income = 10" in 2009, 2010, and 2011. In Table 1, the total number of months in the last 3 years that the interviewees experienced flood and drought and the degree of severity by different agro-ecological zones is presented. In total, drought periods were more prolonged than floods especially in Area Cluster 1 (lands used for cash crops) and 4 (lands used for rain-fed rice). The total duration of flood and drought accounted for one third of the last 3 years. The damage caused by flood and drought was comparable overall, even though the 2011 flood was the most damaging event.

It was observed that different typologies of severity were experienced as a result of drought and flood among households with different poverty levels and land size. The detail of the total number of months in the last 3 years in which flood and drought were experienced, and the degree of severity, by different poverty levels and land sizes is presented in Table 2. Large-scale farmlands were mostly owned by non-poor in both figures. However, severe impacts from flood and drought were experienced extensively in large, medium and small-scale farmlands.

**Table 2. The Total Number of Months in the Last 3 years in which Flood and Drought were Experienced, and the Degree of Severity by Different Poverty Levels and Land Sizes**

| | | Total number of months | | Total level of severity | | Flood 2011 |
|---|---|---|---|---|---|---|
| Poverty | Land size | Flood | Drought | Flood | Drought | severity |
| Poor | Small | 5.28 | 6.60 | 13.28 | 8.80 | 7.44 |
| | Medium | 5.55 | 6.51 | 13.38 | 13.02 | 7.45 |
| | Large | 5.33 | 6.67 | 14.08 | 11.67 | 7.58 |
| | Total | 5.44 | 6.56 | 13.45 | 11.57 | 7.46 |
| Near-poor | Small | 5.93 | 6.62 | 14.89 | 12.82 | 7.71 |
| | Medium | 5.79 | 5.84 | 13.72 | 11.36 | 9.09 |
| | Large | 5.72 | 5.89 | 13.83 | 14.83 | 6.33 |
| | Total | 5.83 | 6.14 | 14.17 | 12.42 | 8.17 |
| Non-poor | Small | 5.50 | 7.75 | 18.00 | 12.75 | 8.00 |
| | Medium | 4.79 | 7.21 | 15.71 | 11.14 | 8.43 |
| | Large | 4.63 | 8.00 | 13.63 | 11.63 | 8.25 |
| | Total | 5.00 | 7.59 | 16.03 | 11.82 | 8.24 |
| Total | Small | 5.67 | 6.78 | 14.85 | 11.59 | 7.67 |
| | Medium | 5.58 | 6.27 | 13.82 | 11.99 | 8.36 |
| | Large | 5.37 | 6.58 | 13.87 | 13.16 | 7.13 |
| | Total | 5.58 | 6.49 | 14.18 | 12.04 | 7.93 |

*Source:* Authors' calculation from the surveyed data

The severity of drought is quite diverse. Poor and small farm-land holders were mostly at the lower level of severity whereas as near-poor and medium farm-land holders were concentrated in the high severity zone, and the non-poor and large-scale holders experienced medium severity.

In contrast to the degree of drought severity, the severity of flooding is more concentrated. It is observed that poor and small farmlands and near-poor and medium farmlands were located in the lower zone of severity whereas the non-poor and large farmlands were concentrated in the higher division of severity.

The results presented in Table 2 indicated the extensive impact of drought on small and medium-scale farmlands and the high level of damage from flood (mostly sudden and prolonged) to the large-scale farmlands.

On the other hand, the non-diversification of household economies exacerbates the vulnerability of rural Cambodians. Most rural households rely heavily on subsistence agriculture for their livelihoods, with rice cultivation accounting for 90 % of total cultivated area and 80% of agricultural labor input. Rice yields remain among the lowest in the region due to limited and poor use of improved seed, fertilizer, tillage, and water management. Because productive off-farm opportunities are limited, rural households lack alternatives that would allow them to maintain stable incomes or cope in times of poor harvest (Council for Agricultural and Rural Development (CARD), 2010).

## 4. The Impacts of Natural Disasters

### 4.1. The Socio-economic Impacts of Natural Disasters

According to the World Disasters Report (2010), Asia is the continent most prone to disasters (Table 3). During the past decade, Asia experienced more than 2,900 disasters (40% of the world total); affecting more than 2 million people (85%); killed more than 900,000 people (84%); and caused more than USD 386 billion damage (39%). Swiss Re (2011) reported that the total property losses arising from the Japanese earthquake tragedy in Fukushima caused more than USD 200 billion of damage, but that only USD 30 billion was covered by private insurance, compared with about USD 9 billion of the USD 12 billion in total property losses that was covered by private insurance in the case of the recent Christchurch, New Zealand earthquake[3].

Obviously, the costs of disasters pose threats to both short and longer term development in the region, by disrupting production and flows of goods and services, worsening the balances of payments and government budgets, derailing economic growth, income distribution, and poverty reduction. Disasters also pose negative effects on social structures and the environment.

**Table 3: Distribution of Disasters by Continent, Total Number of Disasters, People affected, Deaths, and Damage from 2000 – 2009**

| | Total Number of reported disasters | Number of people affected | Number of people killed | Estimated damage (in millions of USD (2009 prices)) |
|---|---|---|---|---|
| Africa | 1,782 | 306,595 | 46,806 | 12,947 |
| Americas | 1,334 | 73,161 | 32,577 | 428,616 |
| **Asia** | **2,903** | **2,159,715** | **933,250** | **386,102** |
| Europe | 996 | 10,144 | 91,054 | 146,414 |
| Oceania | 169 | 658 | 1,665 | 12,612 |
| Total | 7,184 | 2,550,273 | 1,105,352 | 986,691 |

*Source:* The International Federation of Red Cross and Red Crescent societies (2010), "World disasters report: focus on urban risk"

In Cambodia, extreme floods and droughts are among the most damaging shocks afflicting rural households, and climate change will heighten their severity. In the past decade, unusual floods and droughts have severely affected large parts of the countryside, resulting in three years of negative agricultural growth (Table 4).

**Table 4: Estimated Impact of Extreme Floods and Droughts, 2000-2005**

| Year | Event | Affected pop. (m) | Deaths | Damaged (USDm) | Affected crop (ha) | | Agr. growth |
|---|---|---|---|---|---|---|---|
| | | | | | Damaged | Destroyed | |
| 2000-01 | Flood | 3.4 | 347 | 157 | | 374,174 | -0.4% |
| 2001-02 | Flood | 2.1 | 62 | 36 | 250,000 | | +3.6% |
| | Drought | 0.5 | | | | | |
| 2002-03 | Drought | 2 | | 22 | 134,926 | | -2.5% |
| | Flood | 1.5 | 29 | 12 | | 40,027 | |
| 2004-05 | Drought | 2 | | 21 | 62,702 | | -0.9% |

*Source:* ADI (2007)

[3] http://www.swissre.com/publications/ accessed on September 8, 2011.

In 2009, Typhoon Ketsana left 43 people dead and 67 severely injured and destroyed the homes and livelihoods of some 49,000 families or 180,000 people directly or indirectly (equivalent to 1.4 % of the population). Most of the affected districts were among the poorest in the country. The widespread damage to property and public infrastructure will have a long-term impact on these communities' livelihoods (CNCDM, 2010). Looking ahead, although many regions in Cambodia are shielded geographically from climate hazards, almost all provinces are considered vulnerable to the impact of climate change, owing to their low adaptive capacity resulting from financial, technological, infrastructural and institutional constraints (UNDP, 2009).

Poor households are less able to cope than the non-poor, even though empirical studies showed that households are partially able to smooth consumption after a natural disaster (Vakis, *et al*. 2004). The poor are more vulnerable since they are typically more exposed to risks and have access to fewer coping mechanisms that can permit them to deal with the natural disasters. Many households use sub- optimal or even harmful coping options such as reducing consumption expenditures on food, health and education services, and trying to increase incomes by sending children to work. In addition, as the poor are more likely to reside in hazardous locations and in substandard housing, they are more susceptible to natural disasters. Finally, exposure to natural hazards (and to that extent to natural disasters) affects income-generating decisions, which can have long-term implications in the form of lower future income streams, longer recovery periods and poverty traps.

**Table 5: Specific Case of the Impact of Flood 2011 in Different Provinces**

| Province | Impact at HH level (thousand) | | | Damaged rice (ha) | Affected infrastructure | |
|---|---|---|---|---|---|---|
| | Household | Resettlement | Houses | | Road (km) | School |
| Country | 354 | 52 | 267 | 284,000 | 925 | 1360 |
| Kampong Thom | 55 | 2 | 8 | 65,000 | 28 | 189 |
| Prey Veng | 41 | 10 | 60 | 50,000 | 81 | 248 |
| Siem Reap | 27 | | 18 | 19,000 | 101 | |
| Kampong Cham | 33 | 6 | 33 | 23,000 | 57 | 230 |

*Source:* NCDM (2012) compiled from MAFF (2012), MoWRAM (2012), MRD (2012)

Table 5 above summarizes the impact of the 2011 flood at the macro level on livelihoods, rice production, and physical infrastructure in several provinces including Kampong Thom and Siem Reap (Area Cluster 2), Kampong Cham (Area Cluster 3), and Prey Veng (Area Cluster 4). While the impact of the flooding in 2011 was extremely high at the household level (affected households and resettlement), the damage to rice and agricultural activities, together with the effect on physical infrastructure (roads and schools) will have a long-term impact.

### 4.2. Impact of Natural Disasters on Household Welfare

In assessing the impact of natural disasters on household welfare in Cambodia, we follow the framework of "entitlement failures" proposed by Sen (1981) and elaborated by Devereux (2007). In rain-fed agricultural systems as Cambodia, erratic rainfall can have comprehensive and devastating impact on affected livelihoods and local economies. Addressing the sequence of entitlement failures caused by droughts or floods can prevent them from evolving into a food crisis, and can keep people out of poverty.

**Table 6: Entitlement Failure as the Results of Natural Disasters**

| Entitlement category | Impacts of drought & flood | Policy response |
|---|---|---|
| Production based | - Harvest failure | - Productivity-enhancing safety nets' (Starter Packs) |
| Labor based | - Employment opportunities decline<br>- Real wage rates fall | - Public work program |
| Trade based | - Market failure<br>- 'Failure of exchange entitlements' (terms of trade decline) | - Open market operations<br>- Food price subsidies<br>- Pricing policies |
| Transfer based | - Failure of informal safety nets<br>- Food aid failure<br>- "Priority regimes" | - Food aid<br>- Cash transfers<br>- Weather insurance |

*Source:* Adapted from Devereux (2007)

According to Devereux (2007), entitlement failures can occur sequentially. The production failure would first lead to labor market failure, then commodity market (trade-based entitlements), and finally transfer failures. Table 6 illustrates that droughts and floods cause not only crop failures but a sequence of knock-on shocks to local economies and societies, where effective intervention, or lack of it, could mitigate or exacerbate the shock. Some of these policy responses will be discussed later in the context of the risk management system.

Using our household data from socioeconomic survey data collected in 2004 and 2009, the chapter tests whether droughts or floods can lead to one of the entitlement failures: production, labor markets, commodity markets (trade-based entitlements), or transfer failures. However, due to the limitation of the data, the specific failure cannot be identified. Only the consequence of these failures, i.e. low income or consumption is available in the data set.

The dependent variables (consumption) are examined by way of statistical regression. The statistical model in its general form is given as follows:

$$Y_i = \gamma_0 + \Gamma' X_i + \varepsilon_i \qquad (1)$$

Where (1) is the equation for dependent variables $Y_i$ (income or consumption), *i* represents household *i* and $X_i$ is a set of explanatory variables that captures household characteristics and concerned variables (drought or flood-prone areas).

Controlling for other household characteristics, we expect that households in the drought or flood-prone areas will have lower consumption than otherwise. All variable and summary statistics are given in table 7.

**Table 7: Summary of Household Characteristics**

| **Variables** | **Unaffected Area** | | | **Affected Area** | | |
|---|---|---|---|---|---|---|
| | N | Mean | S.D | N | Mean | S.D |
| Logarithm of household consumption | 40 | 8.73 | 0.64 | 120 | 8.37 | 0.68 |
| Logarithm age of household head | 40 | 3.75 | 0.31 | 120 | 3.72 | 0.33 |
| Dummy for gender of household head | 40 | 0.88 | 0.33 | 120 | 0.78 | 0.41 |
| Dummy for marital status of household head | 40 | 0.80 | 0.41 | 120 | 0.76 | 0.43 |
| Dummy for literacy of household head | 40 | 0.75 | 0.44 | 120 | 0.72 | 0.45 |
| Size of household irrigated land | 40 | 0.18 | 0.54 | 120 | 0.30 | 2.13 |
| Logarithm size of household | 40 | 1.42 | 0.51 | 120 | 1.45 | 0.48 |

*Source:* Authors' results computed from socioeconomic survey data from 2004 and 2009

Table 7 summarizes key characteristics of the selected households in the socioeconomic survey data in 2004 and 2009, corresponding to some sites in the 7 provinces and 5 clusters of the surveyed areas in April 2012. A total of 160 households were identified, living in the same commune, out of which 120 households resided in the affected villages. Age, gender, marital status, literacy of household head, household size, and irrigated land area are used as controlled variables.

We conduct a simple regression and check the impacts of the drought or floods on households' welfare, proxied by their consumption. The regression results are presented in Table 8.

**Table 8: Impact of Natural Disaster on Household Welfare**

| Independent variable | Dependent variable: Logarithm of Household Consumption |
|---|---|
| Logarithm age of household head | 0.292 |
| | (0.184) |
| Dummy for gender of household head | -0.299 |
| | (0.189) |
| Dummy for literacy of household head | 0.508*** |
| | (0.123) |
| Dummy for marital status of household head | 0.162 |
| | (0.174) |
| Logarithm size of household | -0.458*** |
| | (0.149) |
| Size of household irrigated land | -0.0380*** |
| | (0.0138) |
| **Dummy for disaster-prone Area** | **-0.446*** ** |
| | (0.112) |
| Constant | 8.128*** |
| | (0.671) |
| Observations | 160 |
| R-squared | 0.244 |

*Note*: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Results from the regression show that household consumption is dependent on literacy, size, and irrigated land area at the 1% level of statistical significance. More importantly, the consumption level of households in drought or flood-prone areas is significantly lower than otherwise, confirming the negative impact of natural disasters on their livelihood. The negative sign of the coefficient of irrigated land area suggest that drought or flood compounds the impact on those households with larger holdings of cultivated land dependent on irrigation.

Using our unique survey data from 2012, we compiled information on the impacts of the aftermath of the flood in 2011 on households' consumption, crops, livestock, houses, and health. Table 9 summarize the data on households who reported severe impacts from the flood in terms of damage to crops, livestock and houses, and health problems, differentiated by whether or not they reported a reduction in their consumption.

**Table 9: Summary of Household Characteristics**

| **Variables** | **Reported Reduction in Consumption** | | | **Reported No Change in Consumption** | | |
|---|---|---|---|---|---|---|
| | N | Mean | S.D | N | Mean | S.D |
| Dummy of household status (poor) | 48 | 0.583 | 0.498 | 191 | 0.524 | 0.501 |
| Logarithm size of household | 48 | 1.704 | 0.314 | 190 | 1.556 | 0.428 |
| Severity of flood | 48 | 2.091 | 0.291 | 190 | 1.926 | 0.509 |
| Dummy for crop damage | 48 | 0.688 | 0.468 | 191 | 0.565 | 0.497 |
| Dummy for livestock damage | 48 | 0.667 | 0.476 | 191 | 0.482 | 0.501 |
| Dummy for house damage | 48 | 0.500 | 0.505 | 191 | 0.319 | 0.467 |
| Dummy for sickness | 48 | 0.646 | 0.483 | 191 | 0.508 | 0.501 |

*Source:* Authors' computed from survey data 2012

The empirical results shown in Table 10 suggest that the larger the size of household reporting severe flooding, resulting in house damage, the greater the likelihood of a reduction in their consumption in the aftermath of the flood in 2011, at the 1% to 5% level of statistical significance.

**Table 10: Impact of Natural Disaster on Household Welfare**

| Independent variable | Dependent variable<br>Reduction in Household Consumption |
|---|---|
| Logarithm size of household | 0.655** |
| | (0.272) |
| Dummy of household status (poor) | 0.286 |
| | (0.209) |
| Severity of flood | 0.579** |
| | (0.270) |
| Dummy for crop damage | 0.327 |
| | (0.203) |
| Dummy for livestock damage | 0.279 |
| | (0.202) |
| Dummy for house damage | 0.542*** |
| | (0.206) |
| Dummy for sickness | 0.278 |
| | (0.206) |
| Constant | -3.967*** |
| | (0.739) |
| Observations | 237 |

Note: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

# 5. Household Risk-coping Strategies and Role of Social Protection in Natural Disaster Risk Management

## 5.1. Household Risk-coping Strategies

Natural disasters can fit within the Social Risk Management (SRM) framework. SRM aims at providing instruments that allow the poor (but also the non-poor) to minimize the impact of exposure to risk and to change their behavior in a way that helps them exit poverty and reduce vulnerability (Vakis, 2006, Holzmann & Jorgensen, 2000 and Holzmann, 2001).

SRM instruments can be used at different moments in the risk cycle: there are ex-ante and ex-post coping strategies. Ex-ante measures aim to prevent the risk from occurring (risk prevention), or to reduce its impact (risk mitigation). Prevention strategies include measures designed to reduce risks in the labor market (the risk of unemployment), in health care (the risk of preventable diseases) or in standards (the risk of building collapse in areas prone to earthquakes). Mitigation strategies help individuals reduce the impact of a future risky event. For example, households may pool uncorrelated risks through informal or formal insurance mechanisms.

Ex-post coping strategies are designed to relieve the impact of the risk once it has occurred. Some examples of coping are drawing from individual savings or borrowing. Similarly, the government may also provide ex-post support in cases of catastrophic events or in the aftermath of an economic shock.

In general, household risk-coping mechanisms include: reduction in consumption expenditure while maintaining total caloric intakes, borrowing (credit), accumulation of financial and physical assets, and receiving assistance or remittances, (Sawada, 2007).

**Table 11: Household Risk-coping Strategies**

| Independent variable | Dependent variable | | | |
|---|---|---|---|---|
| | Crop damage | Livestock | House | Sickness |
| Logarithm size of household | 0.0812 | 0.329 | -0.250 | 0.0244 |
| | (0.207) | (0.216) | (0.211) | (0.208) |
| Dummy of household status (poor) | 0.395** | -0.0673 | -0.266 | 0.297* |
| | (0.176) | (0.172) | (0.176) | (0.173) |
| Dummy for using saving | 0.450** | -0.0301 | 0.102 | 0.0537 |
| | (0.224) | (0.213) | (0.213) | (0.217) |
| Dummy for borrowing | 0.126 | 0.689*** | 0.454*** | 0.673*** |
| | (0.177) | (0.173) | (0.173) | (0.178) |
| Dummy for changing crops | 0.792*** | -0.255 | -0.193 | -0.434** |
| | (0.186) | (0.182) | (0.183) | (0.186) |
| Dummy for receiving supports from Government/NGOs | -0.472** | -0.213 | 0.162 | 0.322* |
| | (0.189) | (0.179) | (0.183) | (0.181) |
| Dummy for migration | -0.00448 | 0.0406 | 0.0642 | -0.111 |
| | (0.127) | (0.116) | (0.129) | (0.129) |
| Constant | -0.454 | -0.397 | -0.0518 | -0.269 |
| | (0.366) | (0.375) | (0.372) | (0.374) |
| Observations | 238 | 238 | 238 | 238 |

Note: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

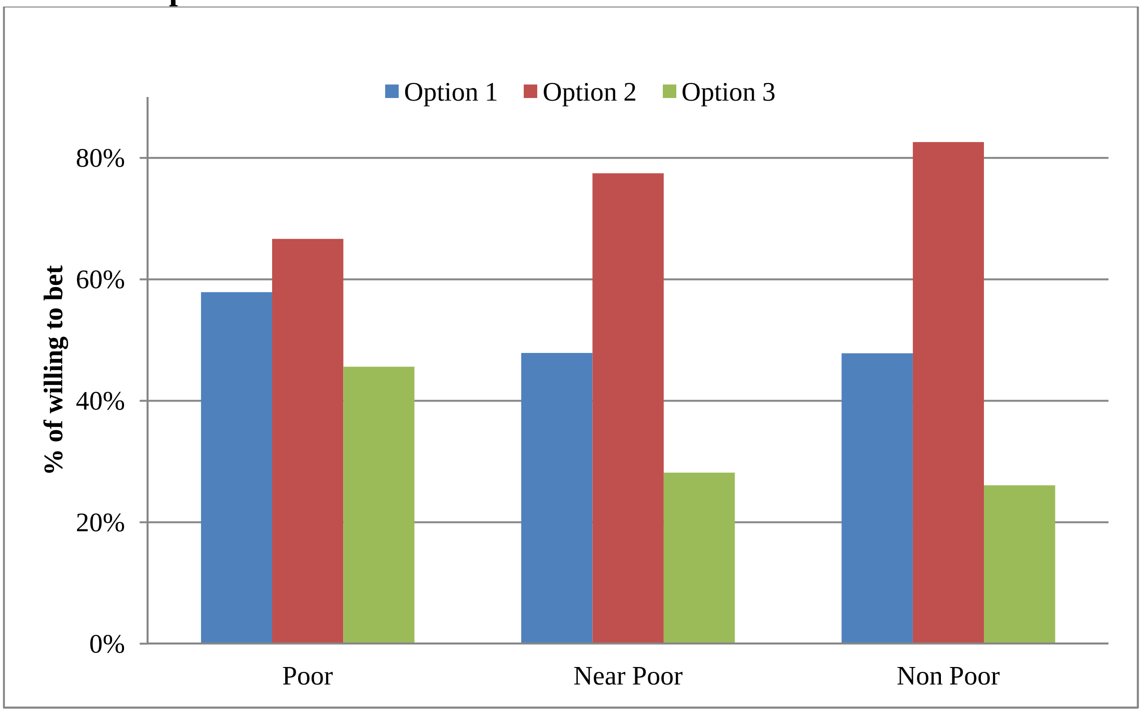
We conduct simple regressions to see how the affected households utilize each of these risk-coping mechanisms. The results from Table 11 suggest that poor households suffering from crop damage would heavily rely on changing crops, using (dis)saving, and tend not to received support from the government or NGOs.

Those who suffer damage affecting livestock, houses, and health would borrow more money from either relatives or micro-financing institutions. Moreover, poor sick households seem not to be able to change crops but do receive some assistance from the government or NGOs.

### 5.2. Household Risk-taking Behavior and Subjective Probability of Loss from Disasters

In this current study, to assess the attitude toward risks, interviewees were asked to bet in three coin-flipping games ranging from the very secure behavior (if not bet, receive USD60. If bet, lose 60 for unlucky, lucky to receive 120 for option 1 and 240 for option 2) to riskier betting options. The last game, the riskiest, if not bet lose USD60, and when betting, interviewee would either keep their money if lucky or lose USD120 otherwise.

**Figure 3: Attitude toward Risk as Indicated by Willingness to Bet for Different Options**




*Source:* Authors' calculation from the surveyed data

As shown in Figure 3, most households in all three groups were willing to bet in the second game where they might lose USD 60 or gain USD 240. This game sought to show the willingness of households to invest in measures designed to reduce risks (for example, innovative technology).

To assess the relationship between risk-taking behavior and the subjective probability of loss, we conduct a simple ordered logit regression to capture the willingness of household taking riskier bets against their subjective probability of loss from natural disasters.

**Table 12: Relationship between Risk-taking Behavior and Subjective Probability of Loss from Disasters**

| Independent variable | Dependent variable |
|---|---|
| | Risk-taking behaviour |
| Logarithm size of household | 0.730* |
| | (0.397) |
| Dummy of household status (poor) | -0.799*** |
| | (0.257) |
| Subjective probability of loss from disasters | 0.775** |
| | (0.350) |
| Observations | 231 |

Note: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The empirical results from Table 12 confirm the risk-averse behavior of the poor households, and also that households will only be take higher risks when they believe that the likelihood of disaster occurrence is higher. Subjective probability beliefs and a high degree of risk-averse behavior among the poor would make the demand for catastrophe insurance a potential option.

### 5.3. Role of Social Protection in Disaster Risk Management

In the absence of an integrated risk management system, it is important to incorporate social protection into the "natural" disaster management system to address the entitlement failures discussed above. Understandably, social protection, including support payments and insurance against risk, does not reduce disaster risk in itself. Nor is it an alternative to development investments in public infrastructure and services, but there are three compelling reasons why social protection can be part of strategic DRM, Vakis (2006).

First, social protection instruments should be considered as part of a larger set of risk management arrangements, to complement and strengthen existing mechanisms and systems. They should not crowd out other risk management arrangements (informal, market-based or public) but instead be evaluated with other options, based on existing capacities, resources and the potential benefits of each arrangement.

Second, an emphasis on ex-ante instruments (risk mitigation or risk prevention aspects) is more crucial than ex-post, focusing on emergency aid and relief. Taking into consideration a country's limited resources, capacities and other short-term development priorities, the long term costs (and forgone benefits) from an emphasis on ex-ante instruments are large.

Finally, an effective natural disaster system requires certain pre-requisites, such as flexibility to adjust and scale up easily, appropriate capacity and effective coordination efforts among government, non-government, private sector and other actors.

Existing schemes draw from informal arrangements, public support from the government and development partners, and civil society and non-governmental organizations (CSOs and NGOs). All these play an important role by complementing one another. It remains clear, however, that even together they do not manage to adequately protect the most poor and vulnerable. A strong case remains for expanding social protection coverage for the poor. A number of initiatives such as cash and food transfer, public works, service fee waiver programs, and microfinance are discussed below by Vakis (2006).

Cash transfers programs provide direct assistance in the form of cash to the poor with low cost of operating and inherent flexibility to scale up during emergencies. This kind of program seeks to address both short-term structural poverty objectives via the income support and also to break intergenerational transmission of poverty through the long-term accumulation of human capital. In the context of natural disasters, cash transfers can provide households with the highest flexibility in terms of how to deal with their problems. In the case of conditional cash transfers, they can deter the use of harmful coping strategies that often occurs after shocks like natural disasters, for example increases in the incidence of child labor, or reductions in food consumption (de Janvry, *et al*. 2006).

Table 13 presents the purpose for which cash transfers of USD 10, 20, and 30 would be used by households at different poverty levels. In the cases of transfers both before and after a flood, the poor and near-poor households would allocate the first USD 10 and 20 of any transfer for domestic use. The allocations of USD 10 and 20 for domestic use rather than for business can be observed more clearly after a flood. However, the allocation for business purpose is higher when the transfer is USD 30.

Public works programs are an important counter-cyclical instrument in a country's programmatic portfolio, as they typically provide unskilled manual workers with short-term employment on projects such as road and irrigation infrastructure construction and maintenance, reforestation, and soil conservation. After natural disasters, public works programs can provide direct income transfers to affected households, which can allow households to meet consumption shortfalls and other immediate needs.

A number of additional social protection instruments can also be used to address natural disasters. For example, service fee waivers, which allow poor households to access a variety of health, sanitation and education services, can be used to reduce the costs of health care and education for affected areas. Food transfer related programs can also address natural disasters. They can take a variety of delivery forms such as direct food relief, food vouchers or food for work (Del Ninno & Dorosh, 2003).

Particular attention should be paid to vulnerable groups in the context of natural disasters such as disabled people. Assisting people with disabilities in the aftermath of natural disasters may require additional efforts and complications. Any new construction to replace buildings including a country's health infrastructure needs to take advantage of the opportunity to introduce cost-effective, accessible designs, both for the new contingent of disabled people and for the pre-existing disabled population.

**Table 13: Primary Purposes of Using Cash Transferred at Different Levels**

| Poverty | Purposes | Amount of cash transferred ($) | | |
|---|---|---|---|---|
| | | 10 | 20 | 30 |
| | | If transferred before the Flood 2011 | | |
| Poor | Domestic | 57.32 | 53.66 | 41.46 |
| | Business | 36.59 | 42.68 | 51.22 |
| | Health | 2.44 | 1.22 | 2.44 |
| | Other | 3.66 | 2.44 | 4.88 |
| Near-poor | Domestic | 71.43 | 52.1 | 34.45 |
| | Business | 20.17 | 38.66 | 52.94 |
| | Health | 5.04 | 3.36 | 5.04 |
| | Other | 3.36 | 5.88 | 7.56 |
| Non-poor | Domestic | 50 | 47.37 | 44.74 |
| | Business | 28.95 | 36.84 | 39.47 |
| | Health | 10.53 | 10.53 | 10.53 |
| | Other | 10.53 | 5.26 | 5.26 |
| Poor | Domestic | 58.54 | 57.32 | 47.56 |
| | Business | 23.17 | 39.02 | 46.34 |
| | Health | 14.63 | 3.66 | 3.66 |
| | Other | 3.66 | 0 | 2.44 |
| Near-poor | Domestic | 68.91 | 64.71 | 48.74 |
| | Business | 17.65 | 32.77 | 41.18 |
| | Health | 10.08 | 1.68 | 6.72 |
| | Other | 3.36 | 0.84 | 3.36 |
| Non-poor | Domestic | 57.89 | 55.26 | 52.63 |
| | Business | 26.32 | 34.21 | 39.47 |
| | Health | 7.89 | 7.89 | 5.26 |
| | Other | 7.89 | 2.63 | 2.63 |

*Source:* Authors' calculation from the surveyed data

Government should promote and strengthen microfinance schemes to help households diversify their incomes, which can mitigate against widespread natural disasters and can promote participation in civic and political organizations to invest in preventive measures such as drainage, emergency warning systems, and food storage.

## 6. Conclusion and Recommendation

The patterns of risk and vulnerability faced by poor and vulnerable people in rural areas, particularly those involved in agriculture and other ecosystem-dependent livelihoods, are becoming major cause of chronic poverty. Dependency on subsistence agriculture, in particular for the rural poor in Cambodia, accumulates the impact of stresses and shocks (such as droughts or floods). Cambodia's unique hydrological regime and low coverage of water control infrastructure makes it vulnerable to climatic and natural disasters. Over the past three years flooding and prolonged drought have accounted for almost one third of the elapsed time. The levels of flood and drought damage were comparable, even though the severe flood of 2011 was the most extensive disaster.

The above theoretical and field study provides evidence for policy decisions on linking the mechanism of disaster management to social risk management and social protection instruments that best fit the context of the series of flood and drought disasters in Cambodia. Households perceive social risk management instruments differently. Preventive strategies to reduce the probability of the risk occurring are not well understood by poor households.

There is a strong need at policy level to design social protection interventions to emphasize ex-ante instruments rather than focus the response to natural disasters as ex-post actions, concentrating on emergency measures and relief. Cash transfer programs provide direct assistance in the form of cash to the poor. Ex-ante cash transfer programs can play a crucial role in encouraging poor households to invest in business rather than spending on food. Microfinance schemes can also help ex-ante income diversification to help households cope with a wide range of natural disasters.

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# CHAPTER 7

# Economic and Welfare Impacts of Disasters in East Asia and Policy Responses: The Case of Vietnam


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*Although Vietnam has seen remarkable economic achievements over the last twenty-five years, the country is still one of the poorest countries in the world. Unfortunately, the country is prone to many natural hazards. Vietnam is located in one of the five cyclone centers on the planet. It is estimated that Vietnam is hit by 4.3 storms and more than 3 floods per year.*

*Though the aftermaths of natural hazards are sizable, estimating their impacts is challenging, yet crucial for policy development. This chapter aims to conduct a scientific assessment of the impact of a natural catastrophe to help understand the multidimensional costs of disasters, and to draw lessons on how the impacts of natural disasters can be properly assessed. In addition, it provides an overview of the management of natural disasters and climate change in Vietnam, to see how the policy system has been working to deal with the risk of natural disasters and climate change. Finally, it identifies possible options for Vietnam to move forward to an effective disaster risk management system.*



***Keywords**:* Natural hazards, Storms, Floods, Impact evaluation, Matched sampling, Disaster management.

# 1. Introduction

Although Vietnam has seen remarkable economic achievements over the last twenty-five years, the country is still among the poorest countries in the world. The economic growth rate had been nearly 8% per annum for the period from 1990 to 2008 but it started to slow down 5 years ago. The GDP annual growth rate was 5.3%, 6.8% and 5.9% in 2009, 2010 and 2011, respectively. The global financial and economic crises and domestic macro-economic policies are cited as the main sources of the economic growth decrease. Currently, GDP per capita of Vietnam is reported at USD 722.8 at 2000 constant prices. It is estimated that more than 13 million people are living with less than USD1.25 per day.[1]

The economy is heavily dependent on agriculture, with 70 % of the population living in rural areas. The share of rural population has been shrinking due to a rapid urbanization process in recent years. Nevertheless, the rate of decrease is steady and low. The share of rural population was 69.83% in 2010, decreased from 72.9% in 2005. The contribution of agriculture to GDP has been decreasing rapidly over the last two decades. In 1990, agriculture contributed 39% to total GDP. In 2000, the share of agriculture was down to 20.5%.

The World Bank has recently affirmed that Vietnam stands at the top in the list of countries most vulnerable to climate change in the world (Dasgupta, *et al.* 2009). According to this research, Vietnam is ranked number 2 by the percentage increase in storm surge zones when compared to current surge zones. By absolute impacts of sea level rise and intensified storm surges, Vietnam is number 3 on the list after Indonesia and China. At the city level, Vietnam is also dominant in the list of cities at risk from storm surges.

While the risk of climate change is potentially dangerous, natural disasters have always been disastrous and deadly. Vietnam is located in one of the five storm centers on the planet. It is estimated that Vietnam is hit by 4.3 storms per year. Vietnam is also prone to floods and other natural disasters. The government's official data show that between 1990 and 2010 Vietnam experienced 74 flood catastrophes. Storms and floods almost always come with severe aftermaths. For

[1]The World Bank's Poverty and Population estimates are available at: http://data.worldbank.org

instance, Typhoon Damrey, whose impact will be assessed in section 2.2, caused 68 human deaths, devastated 118,000 houses and destroyed 244,000 hectares of rice. The aftermath statistics might, moreover, just reflect the shot-term impacts of such disasters. Natural catastrophes can cause long-term and persistent impacts on households and the economy if, for instance, they destroy investment and lock people into a poverty trap and chronic poverty.

This research has several goals. Its first aim is to provide a thorough review of the circumstances of natural disasters in Vietnam by bringing together the existing research literature and utilizing the best data available to date. Section 2.1 addresses this goal. Its second goal is to conduct a scientific assessment of the impact of a natural catastrophe in order to help understand the multidimensional costs of disasters and draw lessons on how the impacts of natural disasters can be properly assessed. This goal is in the subject of section 2.2. The third goal of this chapter is to present an overview of the management of natural disasters and climate change in Vietnam, to see how the policy system has been working to deal with the risk of natural disasters and climate change, and identify possible options for Vietnam to move forward to an effective disaster risk management system. Section 3 is dedicated to this third goal. Based on the analyses of the previous sections, together with lessons learnt from other countries, Section 4 is written for the purpose of providing recommendations, at the national level as well as in the context of regional collaboration, for Vietnam to move forward. Section 5 concludes.

## 2. Impact of Disasters on Households and Poverty Reduction in Vietnam

### 2.1.Overview of Natural Disasters in Vietnam

Vietnam lies between the latitudes 8°27’ and 23°23’ North, and the longitudes 102°8’ and 109°27’ East on the Indochinese Peninsula. The terrain is flat in coastal areas but relatively elevated in the midland and the mountainous regions of the Central Highlands, North East and North West. Vietnam can also be recognized as having an S-shape on maps, with narrow parts in the middle and wide parts in the two tails, in particular the upper tail of the land. Its climate is characterized by monsoon winds, blowing northeast and carrying considerable moisture is the climate is, however, diversified across regions. Based on climatic characteristics, Vietnamese meteorologists classify the country into seven regions, namely; Red River Delta, Northern Uplands, North Central Coast, South Central Coast, Central Highlands, South East and Mekong River Delta.

Being located in the center of the South China Sea, one of the Earth's 5 typhoon centers, Vietnam is prone to natural disasters. To briefly describe the context of natural disasters in Vietnam, Shaw (2006) has written:

> Due to the co-occurrence of the typhoon and rainy season in the narrow and low plains, high mountains, floods and typhoons have been very frequent during the past three decades, and seem to have a greater severity. Floods and typhoons have been a constant threat to the life and productivity of the Vietnamese people. Currently, 70% of the 73 million people of Vietnam live in disaster-prone areas, with the majority of the people residing in the Central region. These people's lives and livelihoods very much depend on the country's natural resources. Losing crops and homes in floods and storms keeps many rural Vietnamese trapped in a cycle of poverty. This has been intensified in the recent years with major floods occurring more frequently.

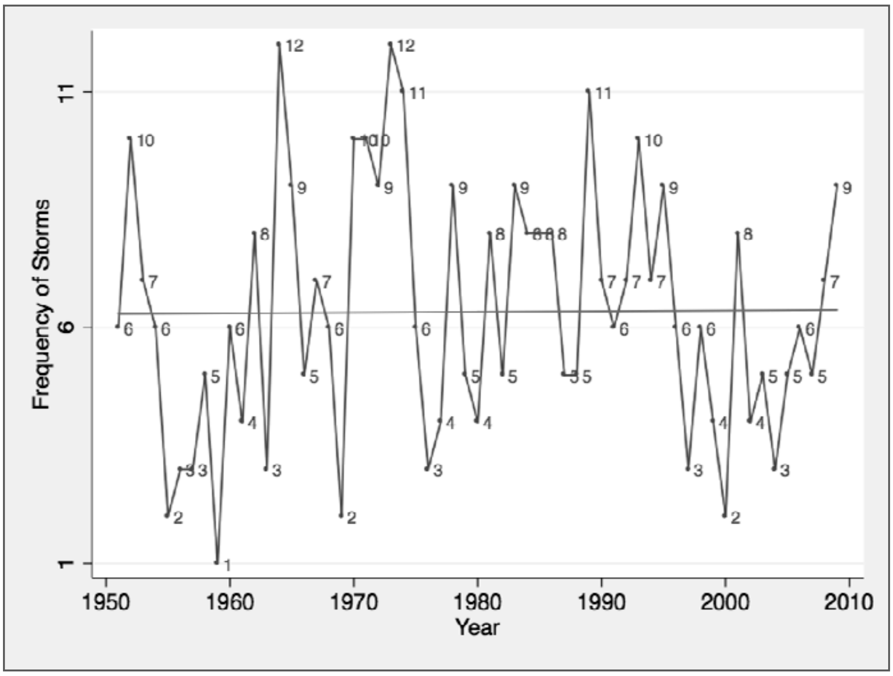
Utilizing a unique comprehensive database on natural disasters occurring since 1989 as well as complete storm archive since 1951 we will describe the situation of natural disasters in Vietnam in the rest of this section. The comprehensive database has been maintained by the Central Committee for Flood and Storm Control (CCFSC) of the Government of Vietnam for the last two decades. It collects a wide range of information on the identification of disasters and their aftermaths and impacts. The data is available at the provincial level. The storm archive contains information on every storm that occurred since 1951. The archive has been maintained and provided free of charge by Japan Meteorological Agency.

## Tropical storms and typhoons

Tropical storms are the most frequent and disastrous natural disaster in Vietnam. In Figure 1 we show the yearly frequency of storms that made landfall in the boundary of Vietnam for the period from 1951 to 2009. A scary observation is that over the period, Vietnam was hit by at least one storm every year. There are several years in which the number of storms exceeded ten, making almost a storm per month. On average, Vietnam was hit by 4.3 storms annually.

A number of research papers have suggested that climate change may result in an increase in the frequency of storms in Vietnam (Hoang Tri, *et al.* 1998; Pham and Furukawa, 2007). Fortunately, our regression analysis indicates that the increase has not yet taken place in Vietnam. The line in Figure 1 visualizes the fitted values of the regression of the number of storms on a time trend. The fact that it is a flat line suggests that the effect of the time trend is not significantly different from zero. Strikingly, if we run a regression of the number of storms on the time trend for the period from 1980 to present, the coefficient is -0.016 and statistically significant at 10%, meaning that the frequency is even lower since 1980, although the size of decrease is marginally meaningful.

**Figure 1: Storm Frequencies in Vietnam**

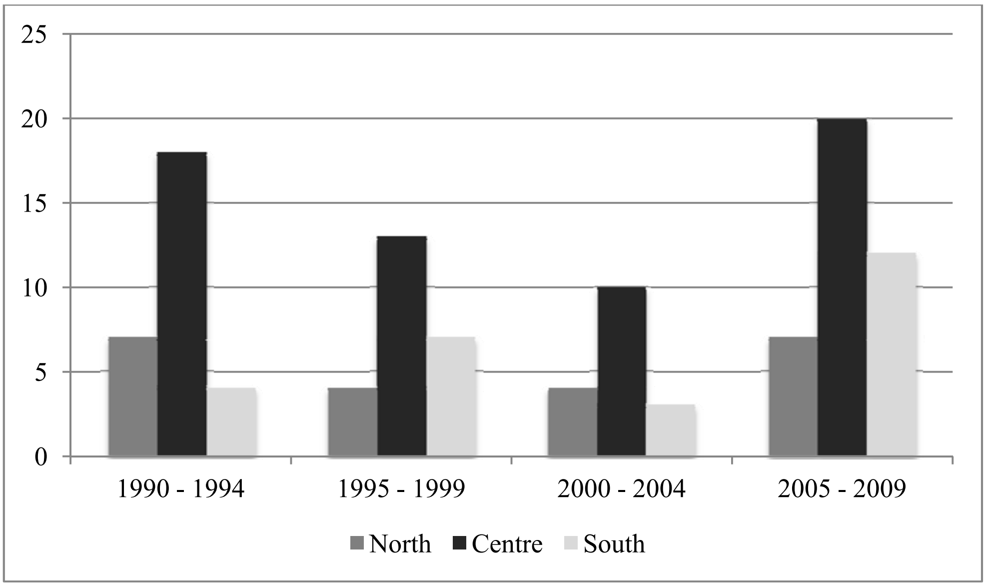



*Source:* Author's calculations using Japan Meteorological Agency's Storm Archives

There is, however, enormous heterogeneity in terms of storm frequencies and exposure across regions of Vietnam. As clearly shown in Figure 2, which presents the distribution of storms in three regions of Vietnam, the Centre is more frequently hit by storms in all the four periods. In the first period, the northern part appeared to be hit more frequently than the south but in the last period, the comparison has been reversed although both the two regions were hit more frequently than in the previous period.

The aftermaths of tropical storms in Vietnam are enormous, both in terms of human losses and economic impacts. Table 1 summarizes the losses due to tropical storms in Vietnam for the period from 1990 to 2010 using the data from the CCFSC database. In two decades, storms killed more than 5,700 people and caused an additional 7,000 injuries. Moreover, many households have become homeless due to storms. The period from 1995 to 1999 is remarkable in terms of losses. This single period accounts for nearly 65% of human lives lost, 36% of houses destroyed and 55% of bridges damaged. It is worth noting that in this period, the frequency of storms seems lower than the previous and the latest period. It indicates that the intensity of storms in the 1995-1999 period must have been considerable.

**Figure 2: Typhoon Frequencies across Regions of Vietnam**




*Source:* Author's own calculation using CCSFC's disaster database

**Table 1: Impacts of Typhoons in Vietnam, 1990 – 2009**

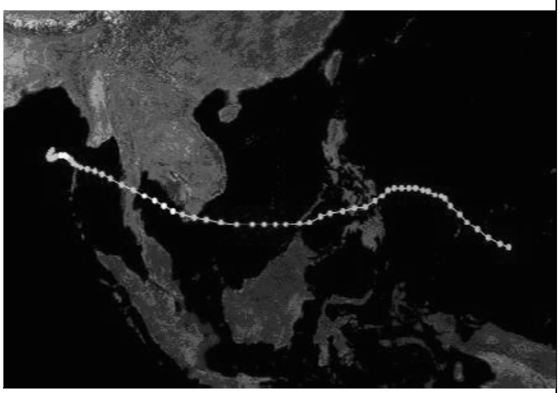
| Time | People killed | People injured | Houses destroyed | Houses damaged | Bridges damaged | Tel poles damaged |
|---|---|---|---|---|---|---|
| 1990 - 1994 | 710 | 1219 | 117912 | 5581 | 1892 | 4572 |
| 1995 - 1999 | 3670 | 2031 | 153148 | 272 | 5652 | 11359 |
| 2000 - 2004 | 200 | 350 | 9945 | 4750 | 738 | 3187 |
| 2005 - 2009 | 1134 | 3439 | 145214 | 157080 | 2126 | 16941 |

*Source:* Author's own calculations using CCFSC's database

The frequency of being hit by storms alters the expectations and awareness of the local people. Exposure to very few disasters causes people to have low expectations about being hit by disasters. Consequently, this behavior lowers the awareness and preparedness required for dealing with disasters, both in terms of formal and self-insurance. Wang, *et al*. (2012) point out that the level of risk closely relates to the acceptance of insurance against disasters. Awareness and preparedness also affect how well people mitigate the effects once disasters happen and thus affect the aftermaths of disasters. As an example, storms are very rare in the Mekong River Delta region of Vietnam. Local residents have almost no expectation of having a storm in this region. Unfortunately, in early November 1997, a storm, called Linda, swept through the farthest south communes causing historical losses, both in terms of human lives and asset losses, although Linda was not an extremely powerful storm in relative terms, as highlighted in Box 1.

**Box 1: Tropical Storm Linda (1997)**

Severe Tropical Storm Linda was the worst typhoon in southern Vietnam in at least 100 years, killing thousands of people and leaving extensive damage. It formed on October 31 in the South China Sea, between Indochina and the Philippines. Strengthening as it moved westward, Linda struck extreme southern Vietnam on November 2 with winds of 65 mph (100km/h), dropping heavy rainfall. Once in the Gulf of Thailand it strengthened further to minimal typhoon status, but weakened to tropical storm



strength before crossing the Malay Peninsula into the Bay of Bengal, the first storm to do so in five years. It re-strengthened in the Indian Ocean to typhoon status, but increasing wind shear and weakened steering currents caused Linda to dissipate on November 9.

The worst of Linda's impact was in Vietnam, where 3,111 people were killed, and damage totaled USD385 million (USD). Heavy rainfall caused flooding, which damaged or destroyed about 200,000 houses and left about 383,000 people homeless.

**(Excerpt from Wikipedia)**

**Rainfall and runoff floods**

Vietnam is also prone to rainfall and river-runoff floods as well as to flash floods. The CCFSC's data reveal that, over the last two decades, Vietnam has experienced more than 70 floods. Figure 3 visualizes the annual distribution of flooding and the trend of change overtime. The figure clearly indicates a five-year cyclical peak and it may well be aligned with La Niña effects.

On average, Vietnam experienced 3.4 flood events annually in the period from 1990 to 2009. More importantly, it seems that the number of floods annually has been increasing overtime. The positively sloping fitted line in Figure 3 implies an increasing trend. Fortunately, the marginal increase is neither big, nor statistically significant.

Floods are widely disastrous natural events and ranked second to storms and typhoons in Vietnam. We summarize floods' aftermaths in Table 2. Over the same period, there were 5,024 people killed by floods, and an additional 1,641 people reported missing. Floods destroyed or damaged more than 220,000 houses. There is a clear separation in terms of losses between the 1990-1009 and 2000-2009 periods. Human losses tripled in the later period and house losses doubled. The increase in the magnitude of losses may be due to increases in the intensity of floods as well as the number of the floods.

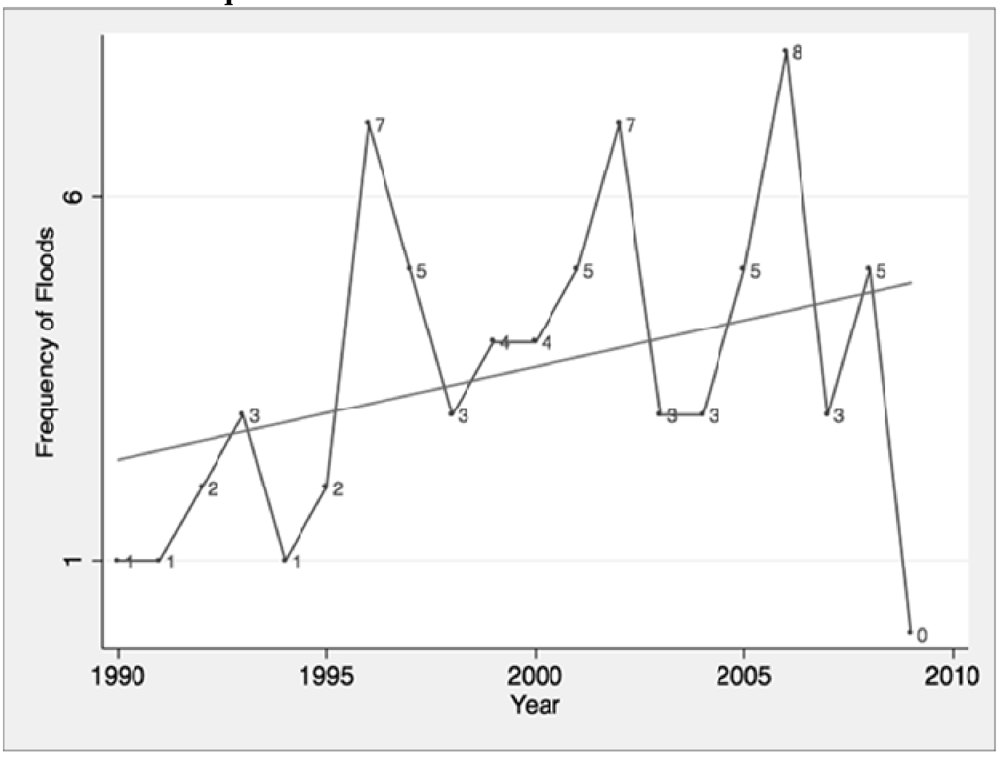
**Table 2: Impacts of Floods in Vietnam, 1990 – 2009**

| Time | People killed | People injured | Houses destroyed | Houses damaged | Bridges damaged | Tel poles damaged |
|---|---|---|---|---|---|---|
| 1990 - 1994 | 767 | 369 | 23154 | 510 | 3658 | 6468 |
| 1995 - 1999 | 757 | 162 | 48307 | 0 | 26156 | 239 |
| 2000 - 2004 | 2279 | 644 | 132332 | 33 | 14210 | 3228 |
| 2005 - 2009 | 1221 | 466 | 18246 | 369 | 2900 | 944 |

*Source:* Author's own calculations using CCFSC's database

Although regional distribution of floods is more even than that of storms and typhoons, the determinants of floods are still associated with regional characteristics. In the Mekong River Delta, floods are generally caused by runoff water along the Mekong River. Since this delta area is relatively flat and low-lying, runoff floods tend to stay for a very long time. In the central region, however, floods happen more often in the form of flash floods, resulting from intense rainfall, short and steep watersheds, and relatively little water storage capacity. In the Red River Delta, floods are characterized by intense rains, exacerbated by tidal effects (Pilarczyk and Nuoi, 2005).

**Figure 3: Flood Frequencies in Vietnam**




*Source:* Author’s own calculation using CCSFC’s disaster database

**Box 2: Flood in the Central Region, October 2010: A Double Catastrophe**

From 1 to 6 October 2010, flooding in Viet Nam caused severe loss and damage, particularly in the most isolated communes. According to VNRC damage reports to date, the floods have affected a total of 25 districts in the five provinces of Quang Binh, Ha Tinh, Quang Tri, Nghe An and Thua Thien Hue in central Viet Nam.

According to the latest reports from the Vietnamese government's central committee for flood and storm control (CCFSC), flash floods and collapsing houses have killed 66 people, and injured 86, with 18 reported missing. In these five provinces, more than 155,293 houses have been flooded, damaged or unroofed, while some 2,133 have been completely destroyed. Up to 14,395 families (57,580 people) have been evacuated to safer places.

Quang Binh and Ha Tinh are by far the two provinces most affected. In Quang Binh, all seven districts and 90 per cent of the communes have been flooded.

| **Province** | **Damage to houses** | | **Agricultural losses** | | **Estimated total losses (VND billion)** |
|---|---|---|---|---|---|
| | Destroyed | Flooded/ damaged | Food/seeds (tones) | Rice/crops (hectares) | |
| Ha Tinh | 1,882 | 26,350 | 30,000 | 10,400 | 845 |
| Quang Binh | 250 | 109,600 | 41,400 | 4,800 | 1,588 |
| **TOTAL** | **2,132** | **135,950** | **71,400** | **15,200** | **2,433** |

In these two provinces alone, more than 21,000 hectares of agricultural land (winter rice crop, winter corn, sweet potatoes, and peanuts) have been destroyed and more than 71,000 tons of food and seeds have been lost.

In total, the estimated loss caused by the present floods is about VND 2,758 billion (CHF 136.2 million or USD 142.5 million or EUR 101.5 million), with VND 2,433 billion of this sustained by Ha Tinh and Quang Binh provinces alone.

In Ha Tinh, the possibility of the Ho Lo hydro-power plant reservoir embankment being breached threatened some 28,000 families living in the downstream areas. VNRC assisted in the urgent evacuation of these families while flood mitigation measures were taken whereby water was released from the power plant's reservoirs through designated spillways. This action greatly contributed toward the mitigating the threat of flooding in both the Huong Khe and Cam Xuyen districts.

With official figures stating more than 152,200 houses being flooded or damaged with 2,133 completely destroyed, it is estimated that around 660,000 people (157,000 households) have been directly affected by the flood. This emergency appeal operation targets assistance to 28,500 of the most vulnerable households, representing 18 per cent of the total population affected. As described below, VNRC together with its partners in-country and other NGOs and UN agencies carried out more in-depth assessments in all five affected provinces to obtain a more clear comprehensive picture of both people affected and needs existing.

Other fundamental elements need to be taken into consideration for a thorough understanding of the situation in Vietnam. Due to the severe situation in Quang Binh and Ha Tinh in particular, the People's Aid Coordinating Committee (PACCOM) officially called for emergency assistance from international organizations for food and non-food relief items, livelihoods, health and educational materials on 13 October 2010.

The situation in this area continues to worsen as very heavy rainfall in central Viet Nam since 14 October has caused additional flooding in the provinces of Nghe An, Ha Tinh and Quang Binh.

According to the latest data from the Vietnamese government, 20 people have died and one reported missing, while some 152,200 houses have been flooded. Up to 17 October, 116,000 people have been evacuated in Quang Binh and Ha Tinh by the government with support from VNRC chapters.

Finally, with tropical storm Megi presently heading for the Philippines and gauged to make landfall there as a severe category 5 super typhoon on 18 October, there is the possibility of it affecting Viet Nam afterwards and subsequently, exacerbating the serious flood situation that already exists.

Taking into consideration the current severe situation in Quang Binh and Ha Tinh, the call by PACCOM for international assistance and the ominous weather forecast, VNRC has requested that IFRC launch an emergency appeal to assist 120,000 of the most vulnerable people (28,500 households or 18 per cent of the total affected population) through provision of food, safe water, non-food relief items, livelihood assistance and psychosocial support.

This current context based on the present disaster situation of two consecutive floods in central Viet Nam and the possibility of Megi striking Viet Nam significantly increases the probability of a greater disaster taking place in Viet Nam. Should this happen, an extension of this appeal will be made in lieu of launching a new one.

**(Excerpt from IFRC's Emergency appeal MDRVN007)**

**Other Hazards**

In addition to storms and floods, Vietnam is prone to several other types of natural disaster. The CCFSC's disaster database has documented five other disasters, namely drought, cold wave, land collapse, flood-tide and tornado/hailstorm. Of these disasters, drought is also an awful natural event that several provinces, particularly in the southern part of Vietnam, have experienced. Fortunately, the frequency and intensity of the disasters mentioned above are not as substantial as those of storms and floods. Accordingly, the consequences of these disaster types are less when compared to the consequences of floods and storms, although they are clearly visible. As seen in Table 3, over the 20-year period from 1990 to 2009, 2253 people had been killed by cold wave, land collapse, flood-tide and tornado/hailstorm.

**Table 3: Impacts of Other Natural Hazards in Vietnam, 1990 – 2009**

| Time | People killed | People injured | Houses destroyed | Houses damaged | Bridges damaged | Tel poles damaged |
|---|---|---|---|---|---|---|
| 1990 - 1994 | 783 | 90851 | 7211 | 23692 | 350 | 201 |
| 1995 - 1999 | 373 | 575 | 5277 | 19620 | 600 | 10 |
| 2000 - 2004 | 548 | 708 | 15286 | 133379 | 1599 | 606 |
| 2005 - 2009 | 549 | 558 | 3285 | 75364 | 814 | 988 |

*Source:* Author's own calculations using CCFSC's database

## 2.2. Impact of Disasters on Households and Poverty Reduction in Vietnam

The analysis using the CCFSC data is informative and useful but it must be subject to several caveats. First, measurement errors can be huge due to the way the data collection system was organized. Secondly, there is a likely possibility that respondents or victims might exaggerate the impact and aftermath of a disaster because they have learnt that they might be given more support from donors or charity organizations. Thirdly, the aftermath statistics might not reflect the medium- and long-term impacts of disasters. To investigate the extent to which disasters affect households' welfare and livelihoods in a causal manner, we conduct below an impact evaluation of a disastrous tropical storm that hit Vietnam in September 2005. The typhoon was named Damrey by the World Meteorological Organization.

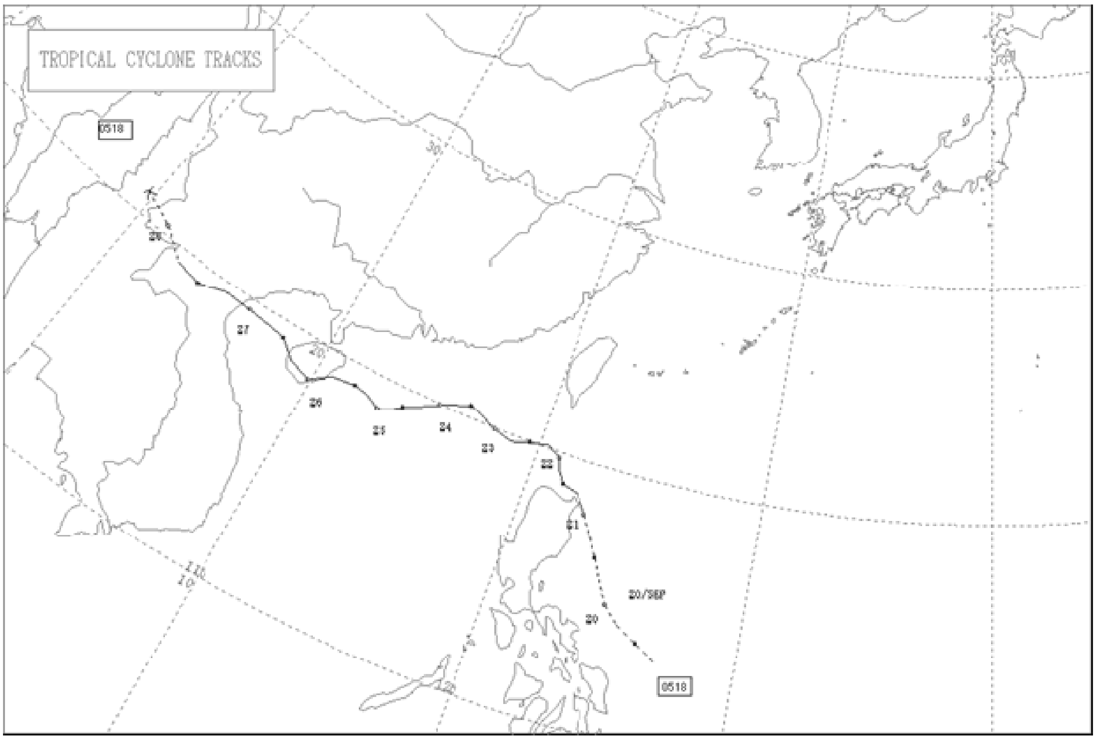
### *2.2.1. Typhoon Damrey*

Damrey was the international name of tropical storm number 7 in 2005 in Vietnam. Damrey was born from Tropical Depression 17W (named by the Joint Typhoon Warning Center) on September 20, 2005. At 0:00 on that day, Damrey's eye was centered at latitude 18.7N and longitude 122.2E with a maximum wind speed of 34 knots. It became stronger in the following days and made landfall at Wanning, in the Hainan province of China at 4:00am on September 26 local time, with a sustained maximum wind speed of 75 knots. Damrey kept moving west towards Vietnam with somewhat lower intensity. In the early morning of September 27$^{th}$, Damrey made landfall in coastal areas of Thai Binh, Nam Dinh, Thanh Hoa and Hai Phong provinces with a wind speed of 60 knots. After about 15 hours devastating a large area of Vietnam, Damrey attenuated and disappeared in Laos on the following day. The path of Damrey's motion is depicted in Figure 4.

According to meteorological specialists, Typhoon Damrey was the most powerful storm in Vietnam over the period 1996 to 2005. CCFSC statistics on the aftermath of Damrey, summarized in Table 4, reveal horrific human and asset losses. In less than a day of its life, Damrey killed 68 people and caused 28 others to be injured. To mitigate the aftermath of Damrey, more than 38,000 households, or more than 150,000 people, had to evacuate. In addition, Typhoon Damrey completely destroyed or badly damaged a wide range of physical assets and investments, such as agricultural crops, irrigation dykes, schools and hospitals.

Although the aftermath statistics might be subject to measurement errors, the losses are undeniably huge.

**Figure 4: Path of the Motion of Damrey's Eye**




*Source:* Japan Meteorological Agency. Time is in UTC

**Table 4: Summary of Aftermath of Typhoon Damrey**

| Loss | Unit | Number |
|---|---|---|
| Human deaths | Person | 68 |
| Human injured | Person | 28 |
| Households evacuated | Household | 38,317 |
| Houses collapsed or swept away | House | 4,746 |
| Houses damaged | House | 113,523 |
| Schools collapsed, swept away or damaged | School | 4,080 |
| Hospital collapsed or swept away | Hospital | 197 |
| Paddy areas submerged or damaged | Hectare | 244,619 |
| Vegetable areas submerged or damaged | Hectare | 62,507 |
| Trees collapsed | Tree | 1,106,263 |
| Dykes collapsed, swept away or damaged | Meter | 88,950 |
| Length of roads damaged | Kilometer | 267 |

*Source:* CCFSC Disaster Database

### *2.2.2. Evaluation Methodology*

Although responsible organizations in Vietnam made detailed records in the aftermath of the typhoon, the statistics provided do not necessarily show the true impact of the typhoon, for a number of reasons. First, the data might be subject to enormous measurement errors. The responsible organizations acquire the aftermath statistics via a reporting system, starting from commune to district and finally to the province's level of authority. It is really difficult to imagine that such a complicated system as this has no problems during the data collection process. In addition, victims of the disasters, or relief agencies, have a tendency to exaggerate the effects of disasters in order to get more aid and support. This is a well-known problem in the literature (Taylor, 1979; Pelling, 2003; Guha-Sapir, *et al.* 2004).

Secondly, the statistics may only reflect the short-term aftermath of disaster, while the disasters can cause long-term negative impacts on livelihood and poverty. In the worst cases, disasters can trap people into persistent poverty (Carter, *et al.* 2007).

Evaluating the impact of such an event as Typhoon Damrey is very challenging. The first challenge is to identify the affected areas. One solution might be to rely on the media or storm tracking agencies. As storms are deadly and highly frequent disasters, a number of meteorological agencies have been paying attention to capturing, tracking and archiving the data for both forecasting and analysis purposes. The tracking data are very good in terms of providing the maximum wind speed and the path of the eye. Nevertheless, they do not identify affected localities precisely enough to link with micro data such as household surveys.

Another way to identify affected areas is through interviews with respondents in a household survey. This technique has long been employed to evaluate the impact of natural disasters (Morris, *et al.* 2002; Alvi and Dendir, 2011; Patt and Schröter, 2008). Unfortunately, this approach is not always feasible because it is very expensive to conduct household surveys with adequate sampling characteristics and observations to capture the information. In addition, such an identification strategy can be subjectively biased by respondents due to forgetting and a tendency to self-interest.

**Figure 5: Typhoon Damrey, September – October, 2005**

*Source*: Author's estimation

The second challenge we have to face when evaluating the impact of storms is that natural disasters are surprisingly not random events. As we have seen in the review above, storm frequencies are very much different from place to place, which lead to differences in the likelihood of being hit by a storm, expectations of storms and awareness and preparedness for dealing with them. All of these factors accumulate overtime to cause the economic background of the places to alter. In other words, there is selection endogeneity in the types of intervention made in storm-affected areas.

Our method of evaluating the impact of Typhoon Damrey aims at overcoming both these two challenges. For the first challenge, which is to identify the areas affected by Damrey, we have successfully developed a method that allows us objectively to identify communes (the smallest administrative division in Vietnam) hit by Typhoon Damrey with the minimum wind speed of 35 knots. The result is shown in Figure 5 and the algorithm is summarized as follows.

The core activity is to construct a trail following the path of the Typhoon's eye in which the wind speed is no less than 35 knots. An attempt to do this was made at the Division of Early Warning and Assessment of the United Nations Environment Program (Mouton and Nordbeck, 2005). This work utilizes the wind prediction model suggested by Holland (1980) but improves it further by taking into account the asymmetric nature of storm winds. Holland's model allows us to estimate the distance from the eye of a cyclone given a level wind speed. This model, however, assumes that the wind profile is symmetric, which is never the case (Australian Bureau of Meteorology). In really, in the Northern Hemisphere, wind speed on the right side of the eye is higher than wind speed on the left side. In the Southern Hemisphere, this relationship is reversed (Mouton and Nordbeck, 2005).

We follow the routine described in Mouton and Nordbeck (2005) with special concentration on preparing the data from storm archives for the best identification of the trail. The output of this routine is a geo-referenced shape-file that can be over-laid with a commune shape-file to identify affected communes.

It is worth noting that the process has been done for every severe storm that hit Vietnam between 1955 and 2010, rather than just for Typhoon Damrey. This is necessary because we need to obtain a measure of the long-term likelihood of being hit by storms to address potential selection biases.

In addition, to eliminate the potential selection biases, we employ a "matched-sample regression" strategy when estimating the impact of Damrey. This method involves two steps. First, we construct a better sample by selecting the most comparable households in the unaffected households using a propensity score matching, as pioneered by Rosenbaum and Rubin (1985).

Secondly, once the most relevant control group has been identified, we employ the following specification to estimate the impact of Damrey:

$$Y_{ci} = \alpha + \beta D_c + \gamma PS_c + \delta X_{ci} + \varepsilon_{ci} \quad (1)$$

where:

- $Y_{ci}$ is an outcome indicator of household $i$ in commune $c$. Outcome indicators include food expenditure, total expenditure, total income, house repair expenses, and rice production.
- $D_c$ is a dummy variable which takes a value of unity of commune $c$ was hit by Typhoon Damrey and zero otherwise.
- $PS_c$ is the propensity score used to construct the matched sample.

- $X_{ci}$ is a set of control variables of household $i$ in commune $c$, including demographic variables, education and employment variables.

The coefficient $\beta$ captures the impact of Damrey. Since we will be fitting the model with the matched sample as well as controlling for the propensity score to being hit by Damrey, we are strongly convinced that biases will be eliminated to make $\beta$ an unbiased estimate of the impact of Damrey.

*2.2.3. Data and Empirical Results*

Data used to fit the model above come from the Vietnam Household Living Standard Survey (VHLSS) 2006. The VHLSSs have been conducted by the General Statistics Office (GSO) of Vietnam since 2002 with technical and financial supports from the World Bank. The survey's questionnaire follows the structure employed by the Living Standards Measurement Study (LSMS) advocated by the World Bank since the early 1990s, and been conducted in a number of developing economies. The VHLSSs have been considered one of the highest quality surveys and are used in several research papers (Katsushi, *et al.* 2011; Nguyen Viet, 2011; Nguyen and Winters, 2011; Sepehri, *et al*. 2011; Mergenthaler, *et al.* 2009).

The VHLSS 2006, like the other VHLSSs, collected information on various aspects of households such as demographics, education, health, expenditure, economic activities and income sources. The VHLSS 2006 interviewed 9189 households in 3063 communes, which account for approximately one third of all the communes in Vietnam. The survey covered both rural and urban communities. The ratio of rural communes to urban communes is 2294/769, unsurprisingly close to the corresponding population ratio.

In this chapter we focus on the rural household sample. The rural households are much more vulnerable to natural disasters, both in terms of self-defense capacity and in terms of livelihood. The main livelihood of the rural households is agricultural activity, which is substantially fragile to storms. The rural sample comprises 6,882 households in 2,294 communes.

This sample is then merged with the commune-level data set containing a measure of Damrey and the long-term likelihood of being hit by a storm in a one-year period that we have described earlier. We are unable to match all of the communes in the two data sets, however, although most of them can be perfectly matched. Out of the 6,882 households in the rural sample, we can merge up to 6,831 households in 2,277 communes. This is the sample we will be working on.

There are 816 households in the sample, from 272 communes hit by Typhoon Damrey. The remaining 6,015 households were unaffected by Typhoon Damrey.[2] The 6,015 unaffected households were located in 2,005 communes. The sample of 275 Damrey communes and 2,005 non-Damrey communes form the sample (hereafter referred to as the Damrey dataset) that we will rely on to identify a "matched sample", used tomeasure the effects of Damrey at the commune level. We employ the propensity score method pioneered by Rosenbaum and Rubin (1985) and later adopted and developed further by many researchers ((Rubin and Thomas, 1996), (Smith and Todd, 2001), (Jalan and Ravallion, 2003)). The estimation of a propensity score has been officially supported by Stata Software since 2002 thanks to (Becker and Ichino, 2002).[3]

Table 5 presents basic statistics of several variables we have in the Damrey dataset. The variable "Probability of being hit by storm" measures the long-term likelihood that the commune is hit a storm with wind speeds at least 34 knots. It is constructed using the following formula:

$$Pstorm = 1 - e^{-\lambda} \quad (2)$$

where $\lambda$ is the expected number of storms that hit the commune annually.

The parameter $\lambda$ is the mean of yearly storms calculated over the last 30-year period. In fact, it is the key variable, and we are convinced that once we control for it we can eliminate most (if not all) of the potential biases. This is because this variable actually captures a many factors affecting storm exposure. For instance, coastal areas are subject to many more storms than inland areas, since storms will quickly lose their strength once they make landfall; the "long-term probability of being hit by a storm" variable also reflects very well the north/south regional divide

[2] Unaffected households are households in communes in which wind speeds due to Damrey were lower than 34 knots.
[3] The Stata command is pscore.

since, as we have seen earlier, storms do not happen frequently in the southern part of Vietnam.

We estimate the Propensity Score of impact by Damrey using the "pscore" routine in Stata. Basically, the score is the series of fitted values of the following logistic model:

$$Damrey_c = \alpha_0 + \alpha_1 Pstorm_c + \alpha_2 X_c + \varepsilon_c \quad (3)$$

where:

- $Damrey_c$ is a dummy variable which takes a value of unity if commune *c* were hit by Damrey and zero otherwise.
- $Pstorm_c$ is the long-term likelihood of being hit by a storm in a one-year period of commune *c*, estimated using the data on all storms in the last 30 years.
- $X_c$ is a set of control variables for commune *c*.
- $\varepsilon_c$ is the error term.

We have estimated Model **(3)** with several sets of control variables, such as distance to coast, and elevation, so as to seek for the specification that gives us the best matching result. The model is then determined to include no control X. This result does not surprise us, however. In fact, as we discussed above, the $Pstorm$ variable has already captured the information of elevation and distance to the coast, and it captures the information in a better way. Other infrastructure measures play insignificant roles because most of the communes have the infrastructure. In the end, '*pscore*' determines that 6 is the optimal number of blocks of the propensity score, so that the balancing property is satisfied (within each block).

**Table 5: Summary Statistics of Damrey Dataset**

| **Variable** | **Mean** | **N** | **SD** | **Min** | **Max** |
|---|---|---|---|---|---|
| Probability of being hit by a storm | 0.27 | 2226 | 0.15 | 0.00 | 0.58 |
| Distance to coast | 79627.89 | 2226 | 79543.66 | 78.92 | 453339.80 |
| Elevation | 136.32 | 2226 | 261.12 | -6.93 | 1844.85 |
| Coastal commune | 0.07 | 2280 | 0.26 | 0.00 | 1.00 |
| Delta commune | 0.53 | 2280 | 0.50 | 0.00 | 1.00 |
| Commune has car road | 0.87 | 2280 | 0.33 | 0.00 | 1.00 |
| Commune has market | 0.64 | 2280 | 0.48 | 0.00 | 1.00 |
| Commune has post office | 0.87 | 2280 | 0.34 | 0.00 | 1.00 |

*Source:* Author's Calculations

Table 6 shows a summary of the two samples: the Unmatched sample (Damrey sample) and the matched sample. The matched sampling proves to be highly significant in terms of finding a more comparable control group. The gaps in $Pscore$ and $Pstorm$ between Damrey communes and non-Damrey communes in the unmatched sample are very high.

As we expect, Damrey communes have much higher scores for both two variables because Damrey communes are located in storm-prone areas. The matched sampling has narrowed down the gaps significantly. The average $Pscore$ in Damrey communes is 0.249 and 0.229 in the non-Damrey communes in the matched sample.

**Table 6: Mean Comparison of Damrey versus Non-Damrey Communes**

| | Pscore | Pstorm | Distance to Coast | Elevation |
|---|---|---|---|---|
| **Unmatched sample** | | | | |
| Non-Damrey communes | 0.102 | 0.251 | 86596.528 | 149.723 |
| Damrey communes | 0.249 | 0.420 | 28498.465 | 37.999 |
| *All communes* | *0.120* | *0.271* | *79627.892* | *136.322* |
| **Matched sample** | | | | |
| Non-Damrey communes | 0.229 | 0.408 | 69863.744 | 79.899 |
| Damrey communes | 0.249 | 0.420 | 28498.465 | 37.999 |
| *All communes* | *0.234* | *0.411* | *59254.205* | *69.152* |

*Source:* Author's own calculations

The matched sample contains 3,123 households in 1,041 communes, of which 801 households in 267 communes were hit by Damrey. Table 7 presents summary statistics of the variables we will use in the model used to estimate the impact of Damrey (Model **(1)**). We will estimate the impact of Damrey on 6 outcome measures, namely i) household expenditure measured in log, ii) household food expenditure measured in log, iii) household total income measured in log, iv) percentage of house repair expenses in total household expenditure and v) the quantity of rice harvested in the summer-autumn season. It is worth noting that the number of observations for house repair expenses and rice production variables are smaller because those households who did not repair houses or did not grow rice were not included in the summary.[4] Table 8 summarizes the results of the mean-difference tests of the key variables between Damrey-affected hosueholds and Damrey-unaffected households in the matched sample.

**Table 7: Summary Statistics of the Matched Sample**

| Variable | Mean | N | SD | Min | Max |
|---|---|---|---|---|---|
| Log household expenditure | 9.64 | 3123 | 0.55 | 7.44 | 11.53 |
| Log food expenditure | 8.94 | 3123 | 0.51 | 6.45 | 10.68 |
| Log household income | 9.80 | 3123 | 0.71 | 7.10 | 12.59 |
| % house repair expenses in total household expenditure | 0.25 | 492 | 0.47 | 0.00 | 4.59 |
| Summer paddy production | 987.62 | 379 | 1192.56 | 60.00 | 20000.00 |
| Log head's age | 3.86 | 3123 | 0.27 | 2.83 | 4.57 |
| Head's gender | 0.80 | 3123 | 0.40 | 0.00 | 1.00 |
| Minority ethnicity | 0.14 | 3123 | 0.35 | 0.00 | 1.00 |
| Head's education is college | 0.20 | 3123 | 0.40 | 0.00 | 1.00 |
| Head worked for firms | 0.08 | 3123 | 0.28 | 0.00 | 1.00 |
| Household size | 4.08 | 3123 | 1.55 | 1.00 | 15.00 |
| % of children | 0.21 | 3123 | 0.21 | 0.00 | 0.80 |
| % of elderly | 0.14 | 3123 | 0.29 | 0.00 | 1.00 |
| % of members with college degree | 0.17 | 3123 | 0.24 | 0.00 | 1.00 |
| % of members working for wages | 0.20 | 3123 | 0.22 | 0.00 | 1.00 |

*Source:* Author's Calculations

**Table 8: Comparison of Control Variables**

| Control variable | Non Damrey | Damrey |
|---|---|---|
| Log head's age | 3.848*** | 3.880*** |
| Head's gender | 0.793** | 0.828** |
| Minority ethnicity | 0.152*** | 0.102*** |
| Head's education is college | 0.202 | 0.186 |
| Head worked for firms | 0.086 | 0.076 |
| Household size | 4.117** | 3.973** |
| % of children | 0.214 | 0.210 |
| % of elderly | 0.142 | 0.154 |
| % of members with college degree | 0.179*** | 0.151*** |
| % of members working for wages | 0.206 | 0.197 |

*Source:* Author's calculations; Asterisks for mean-difference test: * significant at 10%; ** significant at 5%; *** significant at 1%.

[4] Actually, these household should have a value of zero for the variables.

A conventional approach to estimating the impacts of Typhoon Damrey using the matched sample is to simply compare the mean of the affected households with that of the unaffected households. However, one can make use of the propensity score as a regressor in regressions that estimate the impacts (Imbens, 2004). This way of exploiting the propensity score is relevant for our case since Damrey is identified in the same way to all the households in a commune and is exogenous to all household characteristics. In other words, household characteristics are still useful in explaining the outcome indicators of interest and thus should be controlled for.

We present results of the regressions that estimate the impacts of Damrey on rice production, household income, food expenditure, household expenditure and house repairs in Table 9, Table 10, Table 11 Table 12, and Table 13, respectively. In these tables, the first column shows the estimate of $\beta$ with no controls. It can be considered the treatment effects estimated by the conventional matching method. In the subsequent columns, we gradually add more controls to see how robust the estimates of $\beta$ are to the controls included.

### Impact of Damrey on Rice Production

Typhoon Damrey was active during the last days of September 2005. This period overlapped with the Summer-Autumn rice season in Vietnam. The CCFSC data shows that 244,619 hectares of rice were damaged due to Damrey. Our analysis allows us to quantify the impact of Damrey in terms of the quantity of rice loss which is a much more precise measure of the aftermath.

**Table 9: Dependent Variable: Summer-Autumn Rice Production**

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Damrey | -1,343.60*** | -1,168.62*** | -1,207.04*** | -1,711.54*** |
| | (364.038) | (357.570) | (360.757) | (433.152) |
| Pscore | | -8,970.23*** | -9,055.49*** | 828.48 |
| | | (1,547.068) | (1,574.033) | (1,463.447) |
| Log head's age | | 373.27* | 1,304.52*** | 621.08** |
| | | (201.343) | (404.086) | (289.664) |
| Head's gender | | 220.25 | 272.32* | 214.95 |
| | | (151.293) | (161.255) | (149.368) |
| Head's education is college or above | | -3,396.41*** | -3,420.08*** | -1,237.18** |

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | | (793.076) | (779.195) | (488.526) |
| Head works for firms | | -141.54 | -49.75 | -214.26 |
| | | (188.028) | (224.493) | (216.671) |
| Household size | | 53.52 | 328.23 | -109.82 |
| | | (220.198) | (218.820) | (217.167) |
| Head's ethnicity is minority | | 185.19*** | 106.65** | 98.32** |
| | | (55.029) | (49.958) | (45.253) |
| % of children | | | 521.02 | -18.69 |
| | | | (485.834) | (438.259) |
| % of elderly | | | -1,371.38*** | -1,093.10*** |
| | | | (380.293) | (317.818) |
| % with college or higher degree | | | -442.71 | 185.67 |
| | | | (368.853) | (335.849) |
| % wage workers | | | -1,395.14*** | -331.51 |
| | | | (448.595) | (316.009) |
| Region fixed-effects | N | N | N | Y |
| Constant | -2,345.20*** | -2,373.43** | -5,269.23*** | -6,889.82*** |
| | (455.579) | (932.213) | (1,707.959) | (1,988.132) |
| Observations | 3,123 | 3,123 | 3,123 | 3,123 |
| Pseudo R-squared | 0.00777 | 0.0438 | 0.0481 | 0.134 |

*Note: Robust standard errors in parentheses, clustered at commune level;*
*Meaning of asterisks: *** p<0.01, ** p<0.05, * p<0.1*

Table 9 presents the regression results that show the impact of Damrey on rice production. These results come from the Tobit version of Model **(1)** because for those households who do not grow Summer-Autumn rice the dependent variable will have a value of zero. This means that the variable is left-censored at zero. The coefficient of Damrey is highly significant and robust. Its sign is negative suggesting that Damrey negatively affected rice production. Specifically, Damrey caused a loss of about 1.5 tons of rice for the affected households. This amount of rice loss is 60% of the average Summer-Autumn rice harvested by Summer-Autumn rice farmers.

**Impact of Damrey on Total Household Income**

Damrey caused impacts on household income via rice losses and through other channels. We investigate the impact by fitting Model **(1)** with the OLS procedure since the dependent variable is uncensored. The regression result is shown in Table 10. The coefficient of Damrey is negative and strongly significant in all the specifications of the regression. In terms of the order of magnitude, the coefficient ranges from 0.05 to 0.16, meaning that Damrey-affected households experienced from 5% to 17% reduction in income compared with unaffected households.

**Table 10: Dependent Variable: Log Household Income**

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Damrey | -0.163*** | -0.146*** | -0.129*** | -0.053* |
| | (0.031) | (0.028) | (0.027) | (0.028) |
| Pscore | | 0.574*** | 0.515*** | 0.335** |
| | | (0.132) | (0.125) | (0.147) |
| Log head's age | | -0.192*** | -0.140** | -0.110** |
| | | (0.047) | (0.056) | (0.055) |
| Head's gender | | 0.087** | 0.134*** | 0.136*** |
| | | (0.034) | (0.032) | (0.032) |
| Head's education is college or above | | -0.298*** | -0.275*** | -0.306*** |
| | | (0.038) | (0.035) | (0.044) |
| Head works for firms | | 0.364*** | 0.053 | 0.062 |
| | | (0.031) | (0.038) | (0.038) |
| Household size | | 0.202*** | 0.093** | 0.087** |
| | | (0.039) | (0.036) | (0.036) |
| Head's ethnicity is minority | | 0.202*** | 0.186*** | 0.188*** |
| | | (0.010) | (0.011) | (0.010) |
| % of children | | | -0.278*** | -0.251*** |
| | | | (0.073) | (0.072) |
| % of elderly | | | -0.369*** | -0.394*** |
| | | | (0.057) | (0.057) |
| % with college or higher degree | | | 0.749*** | 0.741*** |
| | | | (0.064) | (0.063) |
| % wage workers | | | 0.196*** | 0.146*** |
| | | | (0.053) | (0.053) |
| Region fixed-effects | N | N | N | Y |
| Constant | 9.847*** | 9.500*** | 9.348*** | 9.295*** |
| | (0.018) | (0.191) | (0.221) | (0.224) |
| Observations | 3,123 | 3,123 | 3,123 | 3,123 |
| R-squared | 0.011 | 0.301 | 0.382 | 0.399 |

*Note:* Robust standard errors in parentheses, clustered at commune level;
Meaning of asterisks: *** p<0.01, ** p<0.05, * p<0.1

### Impact of Damrey on Food Expenditure

We also rely on the OLS procedure to estimate the impact of Damrey on the food expenditure of the households (measured in log). The regression results are presented in Table 11. In all the specifications, the coefficient of Damrey is always strongly significant and negative, suggesting a negative impact of Damrey on food expenditure. The size of the coefficient ranges from 0.038 to 0.104 showing that food expenditure in the affected households was 3.9% to 11% lower than in the unaffected households.

**Table 11: Dependent Variable: Log Household Food Expenditure**

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Damrey | -0.104*** | -0.095*** | -0.086*** | -0.038* |
| | (0.023) | (0.020) | (0.019) | (0.020) |
| Pscore | | 0.582*** | 0.550*** | 0.210** |
| | | (0.086) | (0.080) | (0.102) |
| Log head's age | | -0.135*** | -0.053 | -0.035 |
| | | (0.029) | (0.037) | (0.037) |
| Head's gender | | 0.118*** | 0.149*** | 0.151*** |
| | | (0.022) | (0.020) | (0.020) |
| Head's education is college or above | | -0.140*** | -0.124*** | -0.138*** |
| | | (0.027) | (0.025) | (0.030) |
| Head works for firms | | 0.196*** | 0.008 | 0.014 |
| | | (0.019) | (0.023) | (0.023) |
| Household size | | 0.145*** | 0.075*** | 0.081*** |
| | | (0.027) | (0.027) | (0.026) |
| Head's ethnicity is minority | | 0.191*** | 0.176*** | 0.179*** |
| | | (0.007) | (0.008) | (0.007) |
| % of children | | | -0.206*** | -0.186*** |
| | | | (0.044) | (0.043) |
| % of elderly | | | -0.336*** | -0.347*** |
| | | | (0.037) | (0.036) |
| % with college or higher degree | | | 0.441*** | 0.428*** |
| | | | (0.045) | (0.044) |
| % wage workers | | | 0.098*** | 0.061* |
| | | | (0.035) | (0.035) |
| Region fixed-effects | N | N | N | Y |
| Constant | 8.965*** | 8.437*** | 8.200*** | 8.249*** |
| | (0.013) | (0.116) | (0.144) | (0.145) |
| Observations | 3,123 | 3,123 | 3,123 | 3,123 |
| R-squared | 0.009 | 0.436 | 0.509 | 0.528 |

*Note:* Robust standard errors in parentheses, clustered at commune level;
Meaning of asterisks: *** p<0.01, ** p<0.05, * p<0.1

**Impact of Damrey on Total Expenditure**

According to Table 12, which summarizes the results of regressions used to investigate the impact of Damrey on total expenditure, Typhoon Damrey caused significant welfare losses to the affected households. The impact coefficient ranges from -.0147 to -0.074 suggesting that, due to Damrey, the affected households expenditure levels lower than unaffected ones by 7.4% to 15.8%.

**Table 12: Dependent Variable: Log household Expenditure**

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Damrey | -0.147*** | -0.134*** | -0.117*** | -0.074*** |
| | (0.025) | (0.022) | (0.020) | (0.022) |
| Pscore | | 0.600*** | 0.560*** | 0.244** |
| | | (0.105) | (0.096) | (0.118) |
| Log head's age | | -0.107*** | -0.079* | -0.064 |
| | | (0.035) | (0.045) | (0.044) |
| Head's gender | | 0.094*** | 0.130*** | 0.132*** |
| | | (0.025) | (0.022) | (0.022) |
| Head's education is college or above | | -0.243*** | -0.228*** | -0.213*** |
| | | (0.033) | (0.031) | (0.039) |
| Head works for firms | | 0.262*** | -0.030 | -0.022 |
| | | (0.024) | (0.026) | (0.026) |
| Household size | | 0.238*** | 0.169*** | 0.172*** |
| | | (0.034) | (0.033) | (0.033) |
| Head's ethnicity is minority | | 0.181*** | 0.168*** | 0.170*** |
| | | (0.009) | (0.009) | (0.009) |
| % of children | | | -0.300*** | -0.285*** |
| | | | (0.053) | (0.052) |
| % of elderly | | | -0.369*** | -0.383*** |
| | | | (0.043) | (0.042) |
| % with college or higher degree | | | 0.692*** | 0.680*** |
| | | | (0.053) | (0.052) |
| % wage workers | | | 0.004 | -0.035 |
| | | | (0.041) | (0.041) |
| Region fixed-effects | N | N | N | Y |
| Constant | 9.647*** | 9.057*** | 9.033*** | 9.099*** |
| | (0.015) | (0.143) | (0.176) | (0.175) |
| Observations | 3,099 | 3,099 | 3,099 | 3,099 |
| R-squared | 0.014 | 0.358 | 0.460 | 0.476 |

*Note:* Robust standard errors in parentheses, clustered at commune level;
Meaning of asterisks: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

**Impact of Damrey on House Repair Expenses**

The aftermath in the form of shelter damage is particularly interesting to look at. Although households in storm-prone areas have a tendency to invest in more durable shelters, huge damage can easily occur during severe storms. To investigate whether this was the case with Damrey, we estimate Model **(1)** with the dependent variable being the expense incurred in house repairs. Since there are households who happened to have no spending on house repair over the last 12 months, the variable is left-censored at zero. Therefore, we will employ the Tobit procedure to estimate the coefficients.

As we have seen, the impacts of Damrey on income and consumption are very significant and robust (Table 13). We therefore expected Damrey to have a strong impact on houses as well. As it turns out, the coefficient of Damrey in all the specifications is strongly significant and the sizes are very robust. The coefficient's sign is positive, suggesting that households affected by Damrey had to raise their spending on house repairs. Specifically, due to Damrey, they had to spend from 12% to 14% of total expenditure on repairing their houses. These expenses contribute to the reasons why households had to reduce food and other consumption.

**Table 13: Dependent Variable: House Repairs (% in total expenditure)**

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Damrey | 0.13*** | 0.13*** | 0.13*** | 0.13*** |
| | (0.042) | (0.042) | (0.042) | (0.045) |
| Pscore | | 0.08 | 0.06 | -0.09 |
| | | (0.206) | (0.206) | (0.233) |
| Log head's age | | 0.05 | -0.09 | -0.10 |
| | | (0.072) | (0.099) | (0.098) |
| Head's gender | | 0.06 | 0.06 | 0.06 |
| | | (0.053) | (0.055) | (0.054) |
| Head's education is college or above | | -0.07 | -0.06 | -0.04 |
| | | (0.059) | (0.059) | (0.072) |
| Head works for firms | | 0.06 | 0.02 | 0.02 |
| | | (0.050) | (0.062) | (0.062) |
| Household size | | 0.01 | -0.05 | -0.05 |
| | | (0.061) | (0.063) | (0.063) |
| Head's ethnicity is minority | | 0.01 | 0.02* | 0.02* |
| | | (0.012) | (0.014) | (0.015) |
| % of children | | | -0.24** | -0.24** |

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | | | (0.112) | (0.112) |
| % of elderly | | | 0.09 | 0.10 |
| | | | (0.102) | (0.102) |
| % with college or higher degree | | | 0.13 | 0.12 |
| | | | (0.119) | (0.120) |
| % wage workers | | | 0.21** | 0.21** |
| | | | (0.084) | (0.085) |
| Region fixed-effects | N | N | N | Y |
| Constant | -0.75*** | -1.06*** | -0.58 | -0.49 |
| | (0.087) | (0.328) | (0.397) | (0.394) |
| Observations | 3,123 | 3,123 | 3,123 | 3,123 |
| Pseudo R-squared | 0.00438 | 0.00734 | 0.0137 | 0.0147 |

*Note:* Robust standard errors in parentheses, clustered at commune level;
Meaning of asterisks: *** p<0.01, ** p<0.05, * p<0.1

## 3. Disaster Risk Management in Vietnam

### 3.1.Policy Responses

The Government of Vietnam has considered the dangers of climate change and natural disasters to be a national threat, and established a specialized agency to control and coordinate the whole system. In Vietnam, several ministries take part in the national system, including the Ministry of Natural Resources and Environment (MONRE), the Ministry of Agricultural and Rural Development (MARD), the Ministry of Transport (MOT), the Ministry of Health (MOH), the Ministry of Construction (MOC), the Ministry of Industry and Trade (MOIT), the Ministry of Investment and Planning, the Ministry of Finance (MOF) and the Ministry of Education and Training (MOET).

**National Targeted Program to Respond to Climate Change (NTPRCC)**

The NTPRCC was initiated in 2008, after a decade of preparation and gradually increasing international cooperation. The Program has specified 8 national objectives, including:

1. Assessing the extent and impacts of climate change in Vietnam in the context of global climate change;

2. Identifying measures to respond to climate change;
3. Enhancing research activities to develop scientific and practical foundations for measures to respond to climate change;
4. Enhancing and strengthening institutional, organizational policies and capacities on climate change issues;
5. Raising awareness and a sense of responsibility of the population and strengthening human resources;
6. Enhancing international cooperation and promoting low-emission development
7. Integrating climate change issues into socio-economic, sectoral and local development strategies, plans and planning; and
8. Developing and implementing the action plans of ministries, sectors and localities in responding to climate change.

The NTRPC has so far been operational for nearly four years, with encouraging achievements. Five years ago, policies on climate change were vague and overlapped across ministries and sectors. As of today, according to Mr. Naoki Mori of the Japan International Cooperation Agency (JICA), efforts in responding to climate change have resulted in achievements in "designing and developing policies and legal frameworks; promoting policy discussions; strengthening coordination; identifying financing sources for climate change projects and mobilizing various resources" (MONRE, 2012).

**Table 14: Policy Matrix: Support Program to Respond to Climate Change**

| ID | Objective | | Agency |
|---|---|---|---|
| 1 | COPING | Development together with Coping with Climate Change: Enhancing Coping Capacity of Water Resources | MONRE; MARD |
| 2 | | Development together with Coping with Climate Change: Enhancing General Management of Coastal Areas | MONRE |
| 3 | | Development together with Coping with Climate Change: Enhancing Management of Natural Resources | MONRE; MARD |
| 4 | | Development together with Coping with Climate Change: Enhancing Management of Infrastructure | MOT; MOC |
| 5 | | Development together with Coping with Climate Change: Enhancing Management of Health System | MOH |
| 6 | | Development together with Coping with Climate Change: Enhancing Management of Agriculture and Food Security | MARD |
| 7 | MITIGATION | Development with less Carbon Emissions: Exploiting potential Mechanisms of Economical and Efficient use of Energy | MOIT; MOT; MOC |
| 8 | | Promoting Development of Renewable Energy | MOIT; MARD |
| 9 | | Carbon Reservoir: Enhancing Management of Development of Forests | MARD |
| 10 | | Enhancing Management of Wastes | MOC; MONRE; |
| 11 | | Reducing Green House Gas Emissions in Agriculture and Food Security | MARD |
| 12 | LEGAL FRAMEWORK | Enhancing Autonomy in Designing, Prioritizing and Implementing CC Policies | MPI; MONRE; MARD |
| 13 | | Enhancing Legal Framework for Financing Climate Change-Related Activities | MPI; MOF |
| 14 | | Promoting Information on Climate Change for the Public | MONRE |

*Source:* National Targeted Program to Respond to Climate Change

The Program has identified a 3-Year Policy Matrix that specifies clear objectives of responding policies and implementing agencies, focusing on three pillars, namely, coping, mitigating, and the legal framework and cross-sectoral coordination. The

Matrix has been approved by the Prime Minister and in the process of implementation. Its structure is summarized in Table 14.

To achieve an effective system for natural disaster risk management, one cannot separate disaster management and environment management. Tran and Shaw (2007) have pointed out that there is a big gap between policies and actions on disaster and environment management in Thua Thien – Hue province of Vietnam. They argue that most recent projects focus on addressing the hazard risk by building durable infrastructure to mitigate the impact of disasters, rather than looking at a broader picture having both hazard risk and environment dynamic elements.

## 3.2.Towards an Effective Disaster Risk Management System in Vietnam

### *3.2.1. Review of Disaster Risk Management Approaches*

The literature has accumulated long chapters on disaster risk management approaches. Guzman (2003) has briefly summarized the most important approaches that have been discussed in the field of risk management so far. To draw focus we discuss further several approaches that are potentially relevant for Vietnam.

*The "all-hazards" approach* proposes to tackle many disasters in one risk management framework. The all-hazards approach has certain strengths, such as the capacity to provide similar emergency responses in response to a wide range of disasters (Cornall, 2005) and the ability to avoid the artificial divide between a physical and a social emphasis (Berkes, 2007). Nevertheless, disasters are far from homogeneous in any aspect, from consequences to responses needed, and thus require specific actions to deal with them. The approach "cannot be stretched to every potential crisis situation" as argued in McConnell and Drennan (2006).

*The integrated approach* involves the participation of all the stakeholders, namely government, private sectors, public and community organizations and households, into the disaster risk management system. Thus, many responses such as mitigation, preparedness, and warning can be efficiently coordinated and carried out before disasters take place (Moe and Pathranarakul, 2006).

*The "vulnerability reduction" approach* functions by interfering with and managing the risk exposure and coping capability components of the disaster risk. This approach seemingly assumes that the third component of the risk, namely the hazard potential or the possibility of being hit by disasters is out of human control. For instance, one can possibly argue that nobody has the ability to control when or where a typhoon will appear.

*3.2.2. Total Disaster Risk Management (TDRM) Approach*

This approach to disaster risk management is thoroughly documented in Guzman, 2003. The TDRM Approach originated in the Asian Disaster Reduction Center and UN Office for the Coordination of Humanitarian Affairs (OCHA) Asian Disaster Reduction Unit. Guzman (2003) outlines the core of the TDRM approach as the following:

- The foundation of this approach is based on the integration of existing knowledge and techniques on disaster reduction and response, and risk management.
- It necessarily focuses on the underlying causes of disasters, the conditions of disaster risks and the vulnerability of the community. It also emphasizes multilevel, multidimensional and multidisciplinary cooperation and collaboration, in achieving effective disaster reduction and response. This approach intends to integrate, complement, and enhance existing disaster reduction and response strategies.
- The approach promotes effective integration of stakeholders' action through multilevel, multidimensional and multi-disciplinary coordination and collaboration, a critical strategy toward improving disaster reduction and response. Also, it facilitates broad-based participation in policy and program development in disaster reduction and response as they relate with other development concerns, such as poverty reduction, land use planning, environmental protection, and food security.
- However, in adopting the TDRM Approach, accurate and reliable hazard, vulnerability and disaster risk information is vital. The approach attaches great importance to hazard mapping and vulnerability assessment as a fundamental tool for good decision-making and efficient sharing of disaster risk information.

With the outlined foundation, the TDRM approach aims at achieving 3 objects:

1. To address holistically and comprehensively the various concerns and gaps in the different phases of the disaster management cycle by considering the underlying causes of disasters (i.e. the conditions of disaster risks) and the broader set of issues and contexts associated with disaster risk and its management;
2. To prevent, mitigate, prepare for, and respond effectively to the occurrence of disasters through the enhancement of local capacity and capability, especially in disaster risk management (i.e. recognizing, managing and reducing disaster risks, and ensuring good decision-making in disaster reduction and response based on reliable disaster risk information); and
3. To promote multilevel, multidimensional and multidisciplinary coordination and collaboration among stakeholders in disaster reduction and response as they ensure the participation of the community, the integration of stakeholders' action, and the best use of limited resources.

Guzman (2003) proposes five implementation steps to achieve the three objectives as follows:

1. Achieving effective disaster reduction and response through multilevel, multi-dimensional and multidisciplinary cooperation and collaboration.
2. Making decisions based on reliable disaster risk information from hazard mapping and vulnerability assessment.
3. Enhancing coordination and integration of stakeholders' action through good communication and efficient exchange of relevant and reliable information
4. Ensuring that appropriate enabling mechanisms are in place, including policy, structure, capacity building, and resources.
5. Implementing the disaster risk management process from the national level to the community level.

A number of countries have adopted the TDRM approach and contributed good practices for other countries to draw lessons learnt. Among those countries are Armenia, India, Indonesia, Japan, Myanmar, Nepal, Singapore, Sri Lanka, and Thailand. We strongly believe that adopting the TDRM approach could be a way towards effective disaster risk management for Vietnam.

## 4. Policy Recommendation

### 4.1. National Level

***Recommendation 1: Concentrate on implementing the NTPRCC***

The Government of Vietnam has been very active in the fight against climate change and natural disasters. It has put these two areas among the top priorities such as poverty reduction and healthcare. The National Target Program to Respond to Climate Change (NTP-RCC) was approved by the Prime Minister in December 2008. In March 2012, the Government launched the National Strategy on Climate Change (NSCC). Issues, objectives, methods and tools have been identified; the Government now has to focus of the implementation of the NTP-RCC and the NSCC.

***Recommendation 2: Stay open-minded and make necessary changes along the way***

Over a relatively short period of time, from 2007 to 2011, the Government has achieved much in terms of identifying climate change and natural disasters issues; setting objectives and goals; and setting legal frameworks for measures to be implemented. Policies have been designed and stated clearly in the NTP-RCC's documents and the NSCC. However, it is likely that the context will change in the years to come, and new issues as well as challenges will emerge. The Government thus needs to stay alert, open-minded to make necessary changes on time.

***Recommendation 3: Achieve objectives by taking all possible opportunities***

Issues of climate change and natural disasters can be addressed by direct measures such as raising awareness, conducting research and applying research outcomes and preventing deforestation. However, the Government should not restrict itself to direct measures. The ultimate and intermediate goals of the work in relation to climate change and natural disasters can also be achieved via indirect measures. For instance, deforestation is mainly due to human activities which are driven by economic pressures. In most cases, poor people are 'forced' to go to forests and cut down trees because they have no livelihood alternatives. Thus, to prevent deforestation, the Government can instead focus on job creation programs (together with others) rather than just stressing forest-policing work. Measures like this are called indirect measures and, in many cases, indirect measures help address the issues from their root-causes.

### 4.2. Regional Cooperation

As a matter of fact, Vietnam is part of a global chain when dealing with natural disasters and climate change. While Vietnam has to be proactive in dealing with natural disasters and climate change issues, it can shorten the road with cooperation and assistance from other countries. This section presents recommendations that can be relevant for Vietnam in the context of regional cooperation.

***Recommendation 1: Utilize the advantages of being a developing country***

Although Vietnam has achieved remarkable successes in economic growth and poverty reduction over the last few decades, it is still one of the poorest countries in the world. It is fair to say that a large part of recent success is due to external support. Vietnam can become a middle-income country in the near future, but until then, Vietnam should be active in approaching the donor community to seek both technical and financial support. However, the most important thing is that Vietnam has to utilize any support in the most responsible and effective way.

***Recommendation 2: Promote capacity building***

Capacity building is a useful measure to achieve stated goals, because how successful the implementation of a policy will be depends on people's awareness and cooperation. The Government should intensify its capacity building activities to date (for example, community-based risk management projects) and set up channels for new activities. Another reason to promote capacity building is that it is a good selling point in seeking financial support from the donor community.

***Recommendation 3: Highlight clean energy and low-emission development***

A development strategy that developing countries like Vietnam are tempted to adopt is "cheap development", focusing on current and short-term economic growth and accepting a negative impact on environmental protection goals. Vietnam has already experienced the way in which such a strategy brings about increasing environmental problems (Agusa, *et al*., 2006; Jacobs, 1995; O'Rourke, 2004). It is about time for Vietnam to reconsider and make necessary changes in its development strategy. A wise choice would be to highlight and stress the use of clean energy and to target a low-emission development strategy. Doing so, Vietnam can not only ensure engines to sustain economic growth, but also could appear more “friendly” to the donor community and is more likely to receive support.

***Recommendation 4: Be active in regional coordination***

Vietnam should play a considerable role in the South East Asia region in the fight against climate change and natural disasters. In a recent publication, Aggarwal and Sivakumar (2011) discuss an adaptation and mitigation framework for South Asia to cooperate in climate change and food security policies and highlight the following key areas:

- Assisting Farmers in Coping with Current Climatic Risks
- Intensifying Food Production Systems
- Improving Land, Water, and Forest Management
- Enabling Policies and Regional Cooperation
- Strengthening Research for Enhancing Adaptive Capacity

The key areas are not only what Vietnam should focus on, but some of them are areas in which Vietnam can play a leading role, such as food production systems and land, water, and forest management.

***Recommendation 5: Seek for more bilateral cooperation***

Besides regional cooperation, Vietnam should also intensify existing bilateral partnerships and expand to new relationships. Bilateral collaborations such as the Norwegian-Vietnamese Scientific Cooperation on Climate Change should be expanded to take opportunities from developed countries.

## 5. Conclusion

After two decades achieving high and steady economic growth, in the midst of global financial and economic crises, the economy of Vietnam has started to slow down significantly. Vietnam’s economic structure is still heavily dependent on agriculture with nearly three quarters of the population currently living in rural areas. The country is therefore very vulnerable to natural disasters and climate change.

Unfortunately, natural disasters are real threats to the country. Storm and flood are deadly disasters that occur very frequently, killing many people and devastating huge amounts of assets every year. Vietnam is also considerably vulnerable to climate change. Under the scenario that the sea level rises by 100 cm, nearly one quarter of Ho Chi Minh city, Vietnam's largest city and its major economic driving force, will be submerged and 13% of the Mekong River Delta, the major rice producing region, will be under the water.

The Government of Vietnam has been actively engaged in the fight against natural disasters and climate change. It has set climate change at the top of its priorities. At the same time, the Government is also very active in regional and international cooperation related to climate change. Nevertheless, the country has much to do to prepare for challenges in the years to come and help its people adequately mitigate and cope with natural disasters and climate change.

This chapter is an attempt to provide an evidence-based assessment of natural disasters and recommendations to policies makers to help the country move toward effective disaster risk management. It finds that storms greatly affect household welfare and livelihoods. The finding suggests that while short-term aftermaths are tremendously high, the impact of natural disasters can persist, bringing down living standards for some time.

Based on a review of existing studies, the chapter suggests an array of recommendations with the hope that they can make positive contributions to the policy making process in Vietnam, so as to achieve its declared goals. The recommendations focus on measures and approaches relevant for national implementation as well as regional collaboration.

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# CHAPTER 8

# Impact of the 2011 Floods, and Flood Management in Thailand

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*This chapter first describes the causes of the major flooding in Thailand in 2011, which include natural events, unregulated land-use patterns and flood mismanagement. It discusses the government's quick response in drafting a flood management master plan and allocating USD 11,290 million for assistance and compensation for flood victims, restoration of damaged property, and implementation of the master plan. The weakness of the master plan is also pointed out.*

*The study goes on to develop the "difference-in-difference" method to estimate the impact of the flooding on household income and expenditure in 26 flooded provinces. It matches the addresses of flooded households taken from the 2011 Socio-economic Survey, which did not have questions regarding the impact of floods, with the flooded areas from satellite radar images. Quantile regressions are employed to quantify the differential impact of the flood on households with different income levels. The results show that the flooding reduced total household expenditures by 5.7% to 14%. These findings are consistent with the reported negative national GDP growth of 8.9 % in the fourth quarter of 2011 when Thailand was flooded. One interesting finding is that the 2011 floods had a significantly negative impact on the income and expenditure of middle and high income households, but that its impact on poor households was not statistically significant. The study also finds that the 2011 floods had a negative impact on the money and wage incomes of some middle income households living in the flooded areas. All estimated coefficients in the business income regression are not statistically significant. Comparing farmers' income in the 2011 Socio-economic Survey with that in 2009, the study also finds that the 2011 flooding had a large negative impact on the farm profits of some middle income households in the flooded provinces.*

*Finally, the study discusses some policy implications, particularly weaknesses in the current information system for flood management.*

***Keywords**:* Flood, Flood management master plan, Impact on household income, Expenditures and farm profit, Quantile regression, Radar satellite images.

The 2011 flood was the worst flood in modern Thai history,[1] inundating 9.1 % of the total land area of the country, affecting more than 13 million people, with 680 deaths, causing total damage and loss of USD 46.5 billion, and paralyzing Bangkok and its vicinity for two months, which seriously affected investors' confidence. Damaged areas were dispersed in 69 provinces in every region of the country, with most damage and loss concentrated in the industrial estates and residential areas located in Bangkok, the adjacent provinces to the north and west of Bangkok, and the farm areas in some provinces in the Lower Northern region and Central Plains.

## 1. Rationale and Objectives

The government had been under political pressure to allocate 119.5 billion baht (or USD 3.85 billion) as assistance, restoration and compensation to the flood victims. However, the compensation depends heavily upon self-report by the victims, which tend to be exaggerated. The responsible bureaucrats have neither adequate resources (capability) nor incentive to assess the claims. In addition, since the estimate of output loss caused by the floods in the national income account is partly based on the loss and damage reported by the government agencies, it is useful to carry out an independent assessment of the impact of the flood on household income and loss in agricultural output, based on scientific evidence. Thus, interesting research questions are "what is the actual output loss?" and "are the compensation claims exaggerated?"

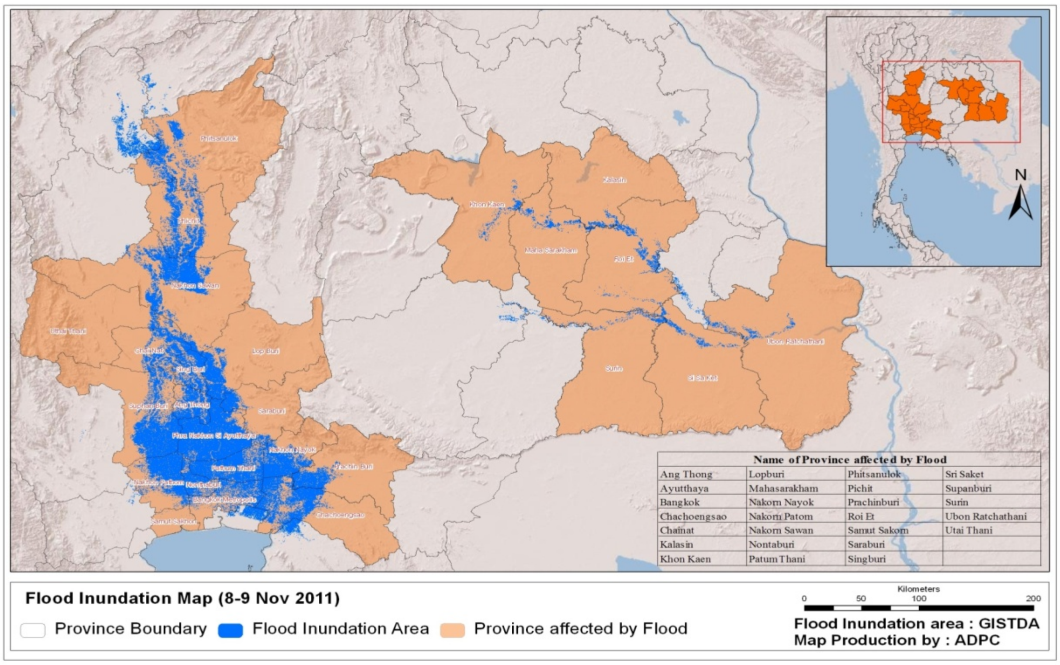
This chapter is a partial attempt to revise the World Bank's estimates of agricultural output loss in November 2011, for several reasons. First, the WB estimates were done when the flood was yet to recede. Secondly, the flooded area was the only parameter determining the agricultural loss and damage at the provincial level, regardless of the duration of the flooding, let alone its severity. Thirdly, despite the availability of primary data on the impact of the flooding collected by some government agencies, particularly the satellite images secured by the Geo-informatics

[1] The previous biggest flood in Bangkok occurred in 1942. Based on the current river discharge, the World Bank (2012) estimates that the 2011 flood is a 1 in 50-100 year event. The total rain for July to September was about 1,156 mm- the highest amount of rain recorded since record keeping began in 1901.

and Space Development Agency (GISTDA) and the Socio-economic Survey, there has been no attempt to utilize such data.

The objectives of this study are threefold. It will first describe briefly the causes of the 2011 flood and the policy response of the government. The second objective is to revise the World Bank's estimates of agricultural loss.[2] Thirdly the study will estimate the impact of the flood on the expenditures and incomes of households in 26 flooded provinces (see Figure 1) in comparison with those of households in the non-flooded areas. Finally, some policy implications will be drawn.

**Figure 1: Map of Flood Inundated Areas, 8-9 November 2011**




*Source*: The World Bank (2012). Original source of satellite image is GISTDA.

## 2. The 2011 Thailand Flood: Causes and Policy Response

The 2011 flood affected 69 provinces with the total flood inundation area of 41,381.8 square km (GISTDA). Of these, 19 provinces were most severely inundated, located in the Chao Phraya and Tha-Jeen River basin, including Bangkok

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[2] At first the authors planned to revise the estimate of agricultural damage using the survey of famers who borrow from the Bank for Agriculture and Agricultural Cooperatives (BAAC). Unfortunately BAAC did not digitize the detailed data on damaged assets and farm machinery into its computer system.

and surrounding provinces. Flooding began around late July 2011, and receded in mid-December 2011.

**Facts Relating to the 2011 Thailand Floods**

Given the higher altitudes of the Northern provinces, the surface water from the Northern provinces flows south to the sea through a few major rivers in the three major river basins in the Lower North and the Central Plains, i.e., the Chao Phraya River, the Tha-Jeen River and the Pasak River basins. Once the floods over-flowed the river banks in the Central Plains, they moved only very slowly, i.e., 2-3 km per day, thanks to the "flat" land. Farmers who live along the rivers or in the flooding areas near the rivers have been used to and well adapted to the annual flood. Thus, unlike in a flash flood, losses were greater than damage to property and life, because people had plenty of time to prepare and evacuate. In addition, since Bangkok's sewage and canal systems are designed for the drainage of rain water and not for flood discharge, most flood water had to be diverted either to the east or the west of Bangkok. Without this diversion loss and damages would have been astronomical, and would have led to loss of confidence in Thailand's management capability.

**Impact of 2011 Flood: Loss and Damages**

The 2011 flood affected 12.8 million people, caused 728 deaths, and damaged 10.417 million rais (16,668.55 square km) of agricultural area (Ministry of Agriculture 2012) and 9,859 factories. It also affected 660,000 jobs as of 25 November 2011.

Overall, the total damage and loss amounted to THB1.43 trillion (USD 46.5 billion), with losses accounting for 56 % of the total (Table 1). The World Bank estimates that recovery and reconstruction would cost THB1.49 trillion (USD 50 billion) over the next 6 months and beyond.

**Table 1: Damages and Losses by Sector (mil USD)**

| Sub Sector | Disaster Effects | | | Ownership | |
|---|---|---|---|---|---|
| | Damage | Losses | Total | Public | Private |
| Infrastructure | | | | | |
| Water resources management | 284 | - | 284 | 284 | - |
| Transport | 768 | 226 | 995 | 990 | 5 |
| Telecommunication | 42 | 83 | 126 | 52 | 73 |
| Electricity | 104 | 187 | 291 | 176 | 115 |

| | | | | | |
|---|---|---|---|---|---|
| Water supply and sanitation | 114 | 65 | 179 | 179 | - |
| Cultural heritage | 145 | 100 | 245 | 99 | 146 |
| Productive | | | | | |
| Agriculture, livestock and fishery | 185 | 1,133 | 1,318 | - | 1,318 |
| Manufacturing | 16,773 | 16,100 | 32,874 | - | 32,874 |
| Tourism | 168 | 2,927 | 3,095 | 13 | 3,081 |
| Finance & banking | - | 3,763 | 3,763 | 2,418 | 1,345 |
| Social | | | | | |
| Health | 55 | 70 | 125 | 53 | 71 |
| Social | - | - | - | - | - |
| Education | 426 | 59 | 485 | 346 | 138 |
| Housing | 1,498 | 1,237 | 2,735 | - | 2,735 |
| Cross Cutting | | | | | |
| Environment | 12 | 6 | 18 | 7 | 11 |
| TOTAL | 20,575 | 25,956 | 46,531 | 4,618 | 41,913 |

*Source*: World Bank, 2012 . Note Exchange rate is 30.6366 Baht/USD.

### Factors Causing the 2011 Floods: from Mother Nature to Man-made Mistakes

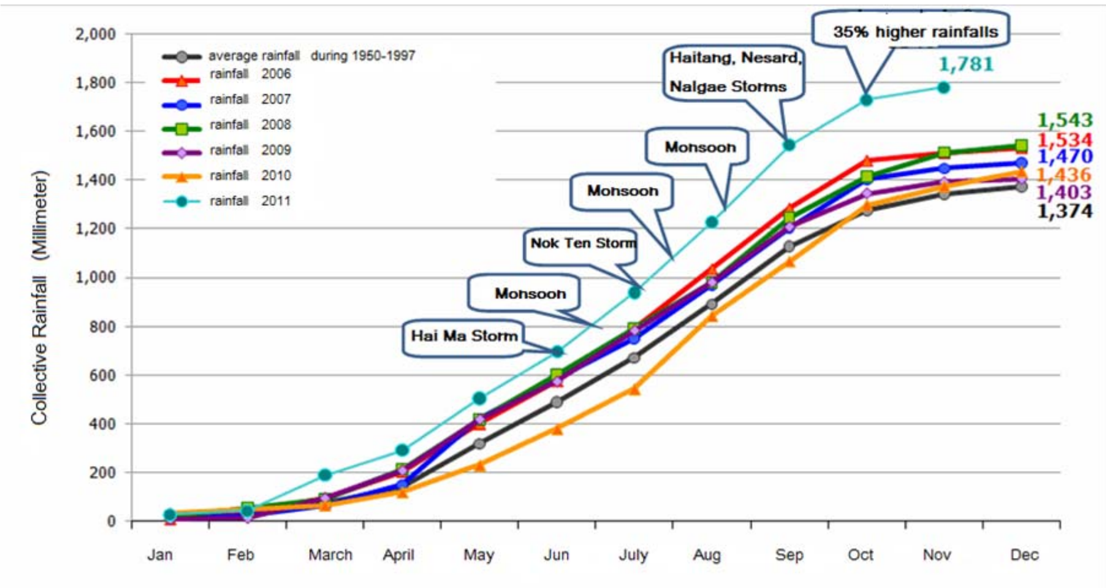
There were four major factors causing the 2011 floods (Suppaisarn 2011). These were 1) the highest recorded rainfall together with five consecutive tropical storms in the mid rainy seasons, which in turn, caused 2) water runoff from the major rivers, 3) unsuitable land use in the flood plains, and 4) flood mismanagement.

**Factor 1:** The average rainfall of 1,781 millimeters between January and October 2011 was the highest on record, and was 35 % higher than the 50-year average (Figure 2). Moreover, 5 tropical storms, which happened consecutively between the end of June and the beginning of October (Figure 2), contributed to heavy rain in the mountains to the North and in the Central regions. “The total rain for July to September was 1,156 mm – the highest amount of rain recorded since record keeping began in 1901. The probability of such a rain event has been estimated at 1 in 250 years” (World Bank 2012:77). The storms also caused flash floods in several Northern and Northeastern provinces in the early rainy season and raised the water levels in the major dams to their maximum capacity (Suppaisarn 2011):

- Haima Depression (from 23-27 June, 2011): rainfall 5 days > 150 mm.
- Nok Ten Depression (from 30 July-1 Aug, 2011): rainfall 3 days > 150 mm.
- Hai Tang Storm (from 26-28 Sep, 2011): rainfall 3 days > 180 mm.
- Nesard Storm (from 2-3 Oct, 2011): rainfall 2 days >120 mm.
- Nalkae Storm (from 6-7 Oct, 2011): rainfall 2 days >100 mm.

The high density of rain between July and September generated an unprecedented flood peak in the Chao Phraya river at the tide station in Nakorn Sawan province (C2) of 4,686 cubic meters per second (cms) against the maximum channel capacity of 3,500 cms (see Figure 2).

**Figure 2: Average Cumulative Annual Rainfall – 1960-2011**




*Source*: Thailand Integrated Water Resources Management. (www.thaiwater.net)

**Factor 2:** Water runoff from major rivers exceeded the capacity of the rivers. Both heavy rainfalls in the North and the Northeast and water discharged from major dams exceeded the capacity of the rivers, overflowed the riverbanks, and inundated vast flood plains. The World Bank (2012: 78) argues that "A major difference between this flood and other severe flood events was that water levels rose at a slow, steady rate, and flood water persisted in some areas for almost 70 days before receding. The main cause of the flooding was the low flow capacity of the river, which resulted in river dykes overtopping and breaching in many river arms. Also the river's capacity decreased downstream, which implies that spillage from the river channel gradually occurs in the upstream areas when a large-scale flood occurs". Though some questions were raised regarding the operation of the major reservoirs (more below), the Bank argues that "there was simply much more water upstream than the downstream channel was able (to) manage".

It should be noted that water runoff in the Lower North and the Central Plains did not exceed the channel capacity (3,500 cubic meters per second (cms) at Nakorn Sawan tide station (C2), and 2,500 cms in Chainart) until September. One reason is that water outflows from the two Northern dams, i.e., the Bhumibol and the Sirikit dams, were much less than the water inflows into the dams between June and September. This controversial issue of flood mismanagement will be discussed below.

Floods in Bangkok and surrounding provinces, therefore, were caused by a combination of four factors, i.e., high discharges from the upstream Chao Phraya River, releases from the mainstream reservoirs, high sea levels in the Gulf of Thailand and high intensity rainy in the city, exceeding the drainage network (World Bank 2012).

**Factor 3:** Rapid (and unplanned) urbanization and unsuitable land use in the flood plain areas is probably one of the most important factors worsening the floods. For example, industrial and housing estates were located in the areas which were supposed to be the flood plains, thanks to the mistake of industrial promotion policy in the 1980s and other reasons discussed below; and many infrastructural facilities also block the canals and rivers, etc.

Except in Bangkok, there has been no implementation of land use zoning in most provinces. In Ayuthaya province, several industrial estates and housing developments were allowed to locate in the flood prone areas, just because the land prices were the lowest[3]. Since the estates blocked the flood ways, it is not surprising that they were severely inundated for months. In Bangkok where there has been land use zoning, the zoning law has been changed by politicians to serve the interests of business and property developers. The most obvious example is the lobby to convert the eastern areas of Bangkok, which were designated as flood ways, to residential areas. To make things worse, the government is also the main culprit as it decided to build the new Suvarnabhumi airport in the flood plains of eastern Bangkok. Flood plains and canals were also blocked by both public and private infrastructure and urban sprawl. Many public canals simply disappeared because of illegal encroachment. Such

[3] Since the flood-prone areas can grow only low yield floating rice, the land price is low. Other reasons why the estates are located in Ayuthaya, which is less than 50 km from Bangkok, are policy distortions, i.e., the factories there were entitled to higher tax "holidays" and lower minimum wages than those in Bangkok.

changes in land use took away the ability to drain water from the northern part of Bangkok into the canals and drainage systems, and then to the drainage stations by the sea coast of the city.

**Factor 4:** The floods were worsened by man-made mistakes, particularly political intervention and mismanagement. Flood mismanagement includes (a) the weakness of existing operations of major reservoirs, (b) political intervention in dam operation and irrigation management, (c) ageing structures and deferred essential maintenance of the irrigation and flood protection infrastructure, which was the primary reason for structural failure and breaches of the flood protection embankment along the Chao Phraya River[4], and (d) lack of an effective flood forecasting and early warning system, and (e) the emergency mismanagement, e.g., the mis-handling of refugee centers for flood victims and flood relief management. We will discuss only four of these problems.

a) *The weakness of the existing operations of major reservoirs.* This involves the validity of current estimates for extreme floods together with the ambiguous instructions for the operation of the spillway crest gates at major dams. For example, the inflexible and probably out of date "Rule Curve"[5] results from lack of information on seasonal weather forecasts, out-dated flood hydrology evaluations and routing (or a process of selecting paths) of the probable maximum flood (PMF), and a one-in-10,000 year flood (World Bank 2012: A-36), and inadequate information on changes in cropping patterns which affect the detailed gate operation schedule. In addition, the small height difference between normal water level and maximum water level (narrow Rule curves) at several major dams means that there is little time for the dam operators to deliberate and seek approval from higher authority when they need to quickly change the schedule of gate opening in response to an emergency.

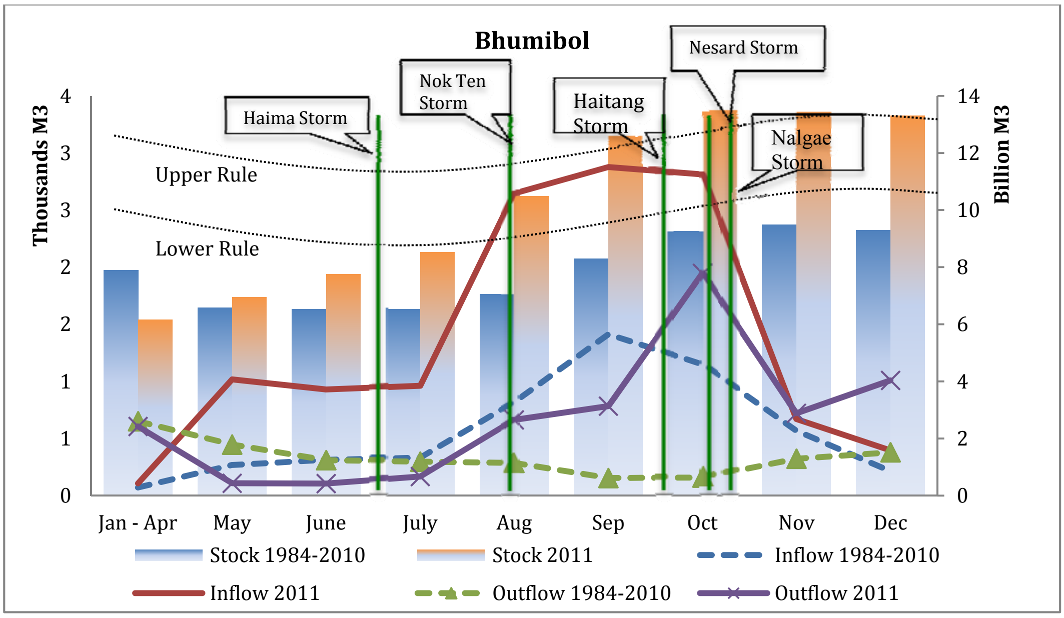
   It is claimed that there were political pressures on the dam operators to delay opening the gates, in order to avoid flooding downstream and to conserve maximum water for the dry season crops, as well as financial incentives for the

[4] At least there were ten major dyke breaches and damage to the flood control infrastructure in the Chao Phraya River basin between 14 September and 3 October 2011 (Royal Irrigation Department).

[5] Rule curve is the optimum operation rules for reservoir systems with multiple purposes. The rules involve non-linear and complex mathematical relations among hydropower plant's efficiency, flow rate, reservoir water level, and storage.

Electricity Generating Authority of Thailand (EGAT) to deliberately keep stock water in Bhumibol and Sirikit Dams at high levels since the second quarter of 2011 in order to gain higher revenue from the lower cost of electricity generation. In response, EGAT stated that their measures of water management, including discharging water from the dams, were taken in accordance with the Rule Curves of the dams. It also declared that EGAT could not profit from ROIC by retaining more water in dams, given the method of fuel tariff (FT) charges.

**Figure 3: Monthly Water Inflow, Outflow, and Stock at Bhumibol Dam, 1984-2011**



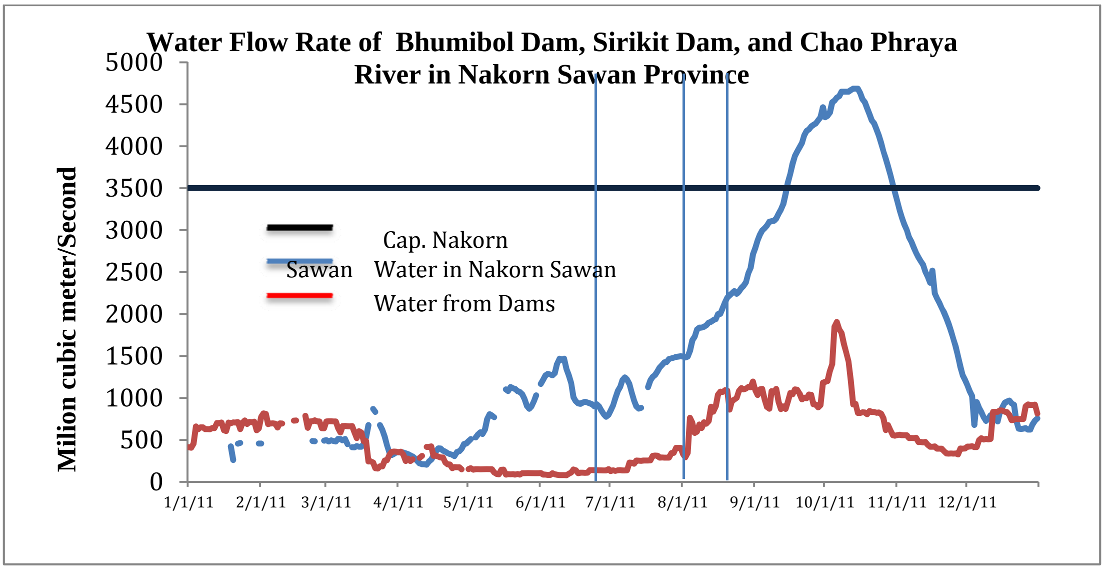

*Source*: EGAT

According to Figure 3, in spite of the exceptionally high water inflow into the Bhumibol Dam between July and September 2011, which was higher than the average water inflow between 1984-2010, the rate of water outflow was lower than the inflow. From mid-September until November, the water inflow to the dam surged rapidly due to the effects of the Haitang, Nesard, and Nalgae storms. The water level quickly reached the dam’s capacity. The exceptionally high rate of water outflow therefore had to be drained through the Ping River. Sirikit Dam's water inflow and outflow showed a similar trend. Water discharged from these two dams significantly increased the water level in the Ping and Nan rivers , which then flowed downstream to the Central Region, aggravating the flood there.

There are 3 main causes that may have contributed to the flood mismanagement.

- The dependence on rigid and out-of-dated Rule Curves may have caused the water discharge measure to be unfit for the extreme weather conditions, particularly in the case of the 2011 flood, according to some engineers. In addition to the bureaucrats' inadequate attention to the weather conditions and the exceptionally high water inflows in the major dams, the government does not yet have adequate capability in seasonal weather forecasting (i.e., the weather forecast for 3-4 months), and does not yet have catchment-based flow forecasting systems. Given the modern technology of seasonal weather forecasting and the increasing incidence of extreme weather, it has been recommended that the government commission a study on the modernization of dam management (World Bank, 2012).
- EGAT argued that the water outflows from the two major dams were not the major factor contributing to the flood in the Central Plains since they accounted for only 16-17 % of total surface water flowing from the dams, and other Northern rivers, (which do not have large reservoirs, i.e., the Wang and Yom rivers) that flowed through Nakorn Sawan province (Figure 4). But this may lead to the conclusion that when EGAT made decisions to discharge water from the dams, they ought seriously to have taken into account the volumes of rain water that would have overflowed from all four Northern rivers between August and September. By doing so they would have made better decisions relating to the discharge of more water from the two Northern dams between July and September.
- Finally, although EGAT cannot charge a higher tariff for its electricity, the lower cost of electricity generation when the water stock in the dams is at peak level will result in higher net revenue for EGAT and, hence, higher bonuses for its employees.

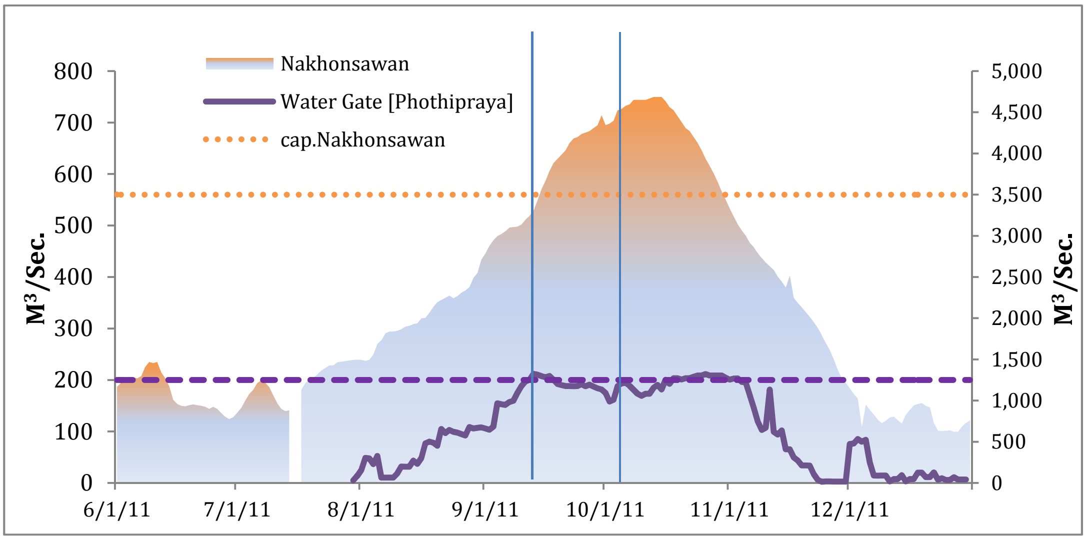
**Figure 4: Water Flowing through Nakorn Sawan Province**




*Source*: RID.

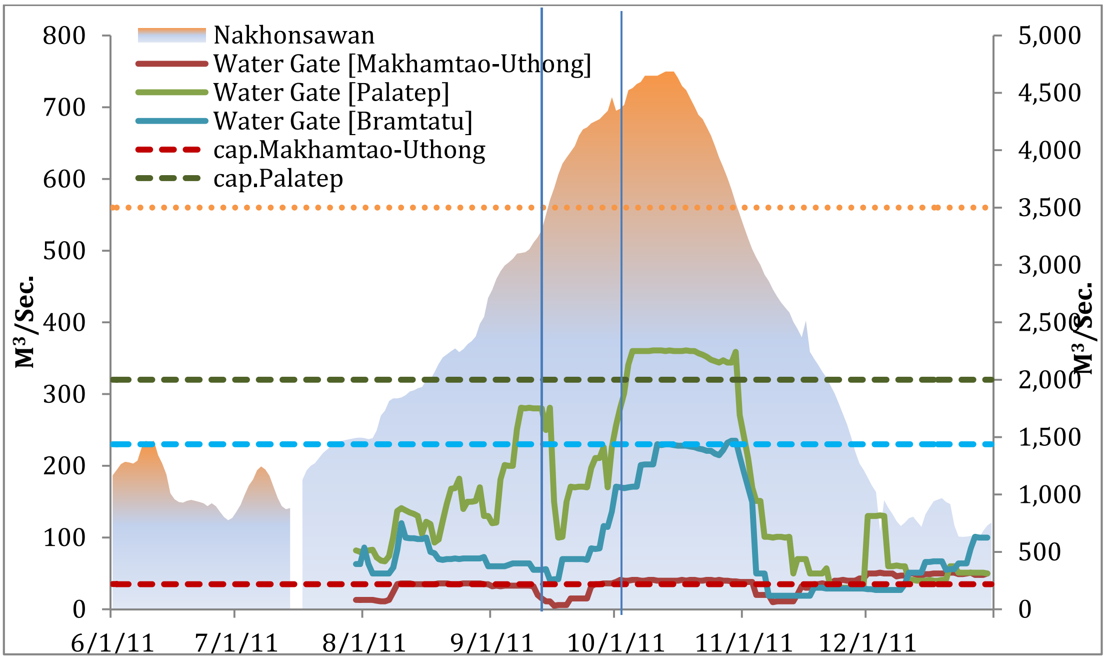
*b) Political influences.* When the water from the four Northern rivers, reaches Nakorn Sawan, a Lower Northern province where the four rivers merge and form the Chao Phraya river, it can be diverted by the Chainart barrage into five major natural or artificial channels, three on the west bank (i.e., Makhamtao-Uthong canal, the Supan and Noi rivers), and two on the east bank (Chainart-Ayuthaya and Chainart-Pasak Canals). There is a criterion that all the sluice gates will open on August 15. But there was one newspaper report that some politicians might have influenced the decision to control the sluice gates, and to delay the water discharge into the western province for 15 days, to allow the farmers in their constituency to harvest their rice crop. Figure 5 shows the diversion of water through the sluice gates in the eastern side of the Chao Phraya River, compared to the amount of water flowing through Nakorn Sawan. Figure 6 compares the flows of water through the western gates with the amount of water flowing through Nakorn Sawan.

**Figure 5: Water Flowing through Chao Phraya River in Nakorn Sawan and Phothipraya Gate on the East Side of the River**




*Source*: RID

**Figure 6: Water Flowing through Gates on the Western Side of Chao Phraya River and Chao Phraya River in Nakorn Sawan**




*Source*: RID

According to Figure 4, water in Nakorn Sawan started to rise above its capacity in mid-September. It also shows that the Phothipraya sluice gate started to open to its maximum capacity at the same time, and remained open at a very high level until November.

Yet, according to Figure 6, the three sluice gates in the western side of the Chao Phraya river were not open to their maximum capacity until the beginning of October. Compared to the Phothipraya sluice gate in the east, the Pollathep, and Baromathad sluice gates in the west were only opened at their maximum capacity when it was too late, during October and November. Water was not allowed to flow through the Makhamtao gate at maximum capacity for a week in September so that farmers in Supanburi had time to harvest their paddy.[6] Most water, therefore, had to flow down the Chao Phraya river or was diverted to the east. If the sluice gates had been opened wider and earlier, water could have flowed to Derm-Bang Nangboach, Sri Prajan, Donjadee and Muang districts in Suphanburi Province, which have at least 500,000

[6] This explains why only 35,018-64,458 rais of farm land in Supanburi were reported to be damaged, despite the fact that 975,756 rais were flooded according to the satellite images from GISTDA.

rais of flood plain area to retain water. The result of these sluice gates' water mis-management, together with the deferred essential maintenance of the sluice gate at Bang Chomsri was that water inundated 402,164 rais of agricultural land in Lopburi, particularly in Ban Mi and Tha Wung districts, and other districts in Chainart and Sing Buri (Bangkokbiznews, 2011).

One reason the floods in Ayuthaya and Bangkok were more serious than they should be is that water was blocked from flowing into the Raphibhat canal for three weeks, according to water experts. The canal is the key channel to divert excess water to the east of Bangkok where there are flood way, canal network and large pumping capacity to bring water to the sea.

c) *Ageing structures and deferred maintenance of flood protection and irrigation facilities.* There were at least 13 sluice gates that were damaged in the 2011 flood. Three of them collapsed causing major flooding in some areas. The damage was not only caused by the major flood but also by the lack of proper maintenance of the flood protection infrastructure.

d) *Emergency mismanagement.* Here are some reported cases of emergency mismanagement of the 2011 flood.

-The slow response to the Bang Chom Sri sluice gate's collapse caused too much water to flow into Lopburi province, which then flowed back to Ayuthaya district via the Lopburi river. Not only was there a slow response, but the repair of the Bang Chom Sri sluice gate was left to the resource-poor local government instead of being undertaken professional central authorities.

-The Prempracha and Ladprao canals, which are drainage channels, have been illegally occupied by hundreds of slum dwellers. Both channels are now half of their previous sizes.

-There was a claim that the authorities in charge made a grave mistake by diverting a large flow of water to the west of Bangkok and then to the Tha-Jeen river, which does not have the facilities to manage the water runoffs. This measure had never been taken in the past and proved to be ineffective since the Tha-Jeen river is winding and not suitable to divert water to (Tobunmee, 2012). There were several instances where local politics overrode the central government (FROC) authority in flood management and flood relief activities. For example, some local politicians led the people who were affected by flooding to destroy the flood protection dykes or to pry open the sluice gates so that water could be diverted to other areas. Such action was for local interest at the expense of the wider public benefit. On the other hand, there were also conflicts between people in communities that were outside the flood barriers which were used to protect people in another province. For instance, the locals of Chainart protested against the Minister of Agriculture and Cooperatives, and accused him of favoring Supanburi by blocking the flood water from entering into Supanburi, thus inundating Chainart. Ultimately, they, by force, removed 3 levels of sandbags that were placed across the Pollathep waterway to let water flow to Supanburi (Thairath online, 2011).

-There were serious coordination problems between the central government and the local government administration, especially Bangkok Metropolitan Authority (Komchadluek online, 2011), thanks to the fact that they belong to different political parties.

**How did Thailand Handle the Flood?**

**a) Flood Management during the Crisis**

The Thai Government established a Flood Relief Operation Center (FROC) in October, 2011. FROC's central office was located in Don Muang district of Bangkok. It served as the migrant center and shelter for flood victims. It also functioned with assistance from the military to repair irrigation facilities, evacuated flood victims from flooded areas, delivered survivor kits, etc. About USD 17.89 million were spent for flood relief activities. Unfortunately, the FROC office in Don Muang district was later heavily flooded, and was forced to relocate.

**b) Flood Management Master Plan**

Right after the flood, the government set up two committees to draft a flood management master plan, which was finished in a few months. The plan has 3 objectives:

1. to prevent, mitigate and reduce the damage caused by flooding
2. to improve the efficiency of the flood prevention and the emergency flood management systems
3. to build public confidence and security, to increase national income and to manage natural resources on a sustainable basis.

The master plan is based upon two approaches, i.e., the structural (or physical infrastructural) measures and non-structural measures based upon the Royal Initiative (which was first publicly disseminated in 1983).

The structural approach to flood management includes measures to "store and divert" water. One clear option is to increase the number and capacities of water reservoirs. At present Thailand has about 1,000 cubic meters of water storage capacity per inhabitant compared to the US, which has over 5,000 cubic meters (World Bank 2012:81). Another flood protection structure is the construction of floodways to divert water. The government will rely upon a Japan International Cooperation Agency (JICA) study which will make recommendations on infrastructural investment and flood management for both short-term and long-term solutions.

The non-structural Royal Initiative is to create "room for the river", which would allow for increased areas for floods to spread. Reforestation is also part of the Initiative to prevent rapid flooding in the upstream river basins. The concept of "room for the river" consists of the large flood retention areas and Monkey Cheek[7] reservoirs (the so-called *"Gamling"*). A study of the potential flood retention areas in Bang Ban sub-district in province finds that the Bang Ban area has a potential to be developed into a reservoir for the following reasons (Suppaisarn, *et al.* 2008):

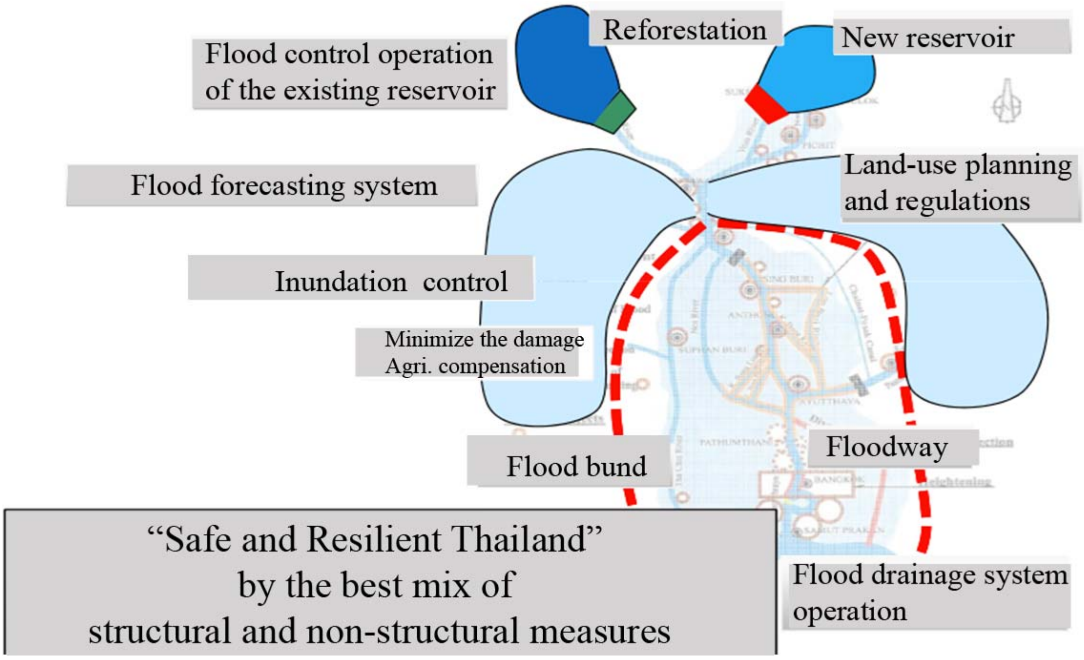
- It is easy to divert water excess to designated reservoir areas with flood barriers surrounded the area
- There is a protection plan for residential houses, industrial sections, and agriculture areas, i.e., designating areas for collective residential housing and building barriers for houses and farmlands along the waterways.
- Bang Ban has drainage channels, natural water trails, and spaces that can be converted into flood division channels, if needed. It also has a water-controlling station, which consists of a sluice gate, drainage channels, and a water-pumping station.
- Water can be drained from Bang Ban when water levels in areas outside the reservoir decrease by closing the sluice gate and pumping water out.

The "Monkey Cheek" concept is also useful, as His Majesty the King Bhumibol Adulyadej stated in 2003 that, "...Monkey Cheek reservoirs are needed in order to retain water when the sea water rises and water excess cannot be drained. During the flooding season between September and November, the seawater will push water in rivers until it reaches Ayuthaya province, which will make it impossible to drain excessive rain water into the sea. As a result, the areas along the Chao Phraya river in the lower Central Plains will remain flooded.Therefore, we need Monkey Cheek reservoirs" to receive water excess during the flooding season (Suppaisarn, 2011).

[7] The term 'Monkey Cheek' was coined by King Bhumibol of Thailand as a metaphor to promote local water retention systems. It refers to monkeys filling up their cheeks with excess food. The food is stored and chewed and eaten later. The monkey cheek program was initially started to solve the flood problems in Bangkok, bur has subsequently been replicated all over the country. (http://www.thewaterchannel.tv).

Figure 7 presents the overall framework of the flood water management as envisaged by the JIAC study.

**Figure 7: The Best Mix of Structural and Non-structural Measures**




*Source*: Takeya Kimio, " JICA's Support 'Toward Safe & Resilient Thailand' through revising the Comprehensive Flood Management Plan for the Chao Phraya River Basin". 20 February 2012.

The water management master plan consists of 8 work plans, and implements guidelines as follows (from *"Master Plan on Water Resource Management"* by the Office of the Strategic Committee for Water Resource Management (SCWRM), and the Office of the National Economic and Social Development Board in January 2012):

(1) *Work Plan for Restoration and Conservation of Forest and Ecosystem*: aiming to restore watershed forest where water is retained, to develop additional water reservoirs according to the capacity of the areas and to develop land usage plans that fit with their local and socio-geographical conditions by restoring and conserving the degraded watershed areas, developing projects for soil and water conservation by promoting economic and community afforestation while rehabilitating mangrove forest, improving water and land usage, increasing storage capacity, and revising and drafting relevant laws.

(2) *Work Plan for Management of Major Water Reservoirs and Formulation of the National Annual Water Management Plan*: aiming

to prevent and alleviate the impacts of possible floods in the future by developing water management plans for major dams and river basins, formulating water management plans under different scenarios, improving the Rule Curves in water management to balance water use in several sectors, and presenting water related information to the public.

(3) *Work Plan for Restoration and Efficiency Improvement of Current and Planned Physical Structures:* aiming to prevent and mitigate the impact of flooding by implementing 4 sub-work plans including (1) renovating dikes, water control buildings, and water drainage systems to ensure effectiveness in every area, (2) improving drainage waterways, dredging canals, removing barriers in canals and draining waterways, (3) increasing efficiency in management of water drainage and overflows in specific areas, and (4) reinforcing dikes and following the King's initiatives. In the long term, several measures will be implemented, including the construction of flood-ways or water diversion channels, and preventive dikes for key economic areas, as well as land use planning.

(4) *Work Plan for Information Warehouse as well as Forecasting and Disaster Warning System:* aiming at developing data systems, creating hypothetical scenarios based on technical principles, setting up water management institutions, and increasing efficiency in the warning system by (1) setting up a national water information center, (2) constructing hypothetical water scenarios, forecasting and disaster warning systems, (3) enhancing the national disaster warning system to become capable of monitoring and analyzing the water situation in a timely manner by improving and increasing the number of water monitoring stations in major rivers, installing CCTVs at the water gates and pumping stations, upgrading satellite and remote sensing systems, and reorganizing and developing disaster warning systems.

(5) *Work Plan for Preparedness for Emergency Situations in Specific Areas*: aiming to build capacity in prevention and mitigation of impacts from floods by developing the systems of flood prevention and mitigation in the important areas such as agriculture, industry, and dense communities, creating a system for negotiating between the affected parties, constructing warehouses for tools, and assessing the impacts of private prevention systems.

(6)*Work Plan for Assigning Water Retention Areas and Recovery Measures*: by assigning water retention areas in the upper and lower Chao Phraya River basins, developing the water retention areas to slow down water flow during flash floods, formulating a plan for diverting water into water retention areas whilst creating measures for special compensation to those areas assigned to be water retention areas.

(7) *Work Plan for Improving Water Management Institutions*: aiming at setting up integrated water management organizations, as a single command authority that can make prompt decisions during a crisis and is responsible for planning, monitoring and evaluation, revising rules and regulations. For the urgency period, this single command authority is the Ad Hoc Committee chaired by the Prime Minister or the assigned Deputy Prime Minister and comprises ministers and permanent secretaries of related ministries as members. In the long term, a national integrated water management agency should be set up permanently.

(8) *Work Plan for Creating Understanding, Acceptance, and Participation in Large Scale Flood Management from all Stakeholders*: Government and development partners would call for collaboration with community and people in managing the impacts of floods and other major disasters.

**c) Flood Action Plan and Budget**

The action plan budget consists of an immediate flood compensation budget and a budget for the flood action plans.

(1) *Assistance, restoration, and compensation budget:* The government allocatedUSD 3,902 million of the central budget (~USD 1,534 in FY 2011, and ~USD 2,383 in FY 2012) to provide assistance, restoration, and compensation to flood victims.

From October 2011 to May 2012, state agencies have already spent 79,750 million baht from these budgets through related projects/work plans.

*(2) Flood action plan,* including 2 related action Plans: an action plan for water management for the emergency period and an action plan for integrated and sustainable flood mitigation in the Chao Phraya river basin:

(2.1) Action plan for water management for the emergency period. Its key principle is to reduce losses and damage due to flooding, and to minimize its economic and social impacts. There are 6 main work plans with a total budget of 18,110 million baht (see details in the Flood Management Master Plan 2012)

(2.2) Integrated and sustainable flood management action plan. This comprises 8 work plans with a budget of 300,000 million baht. The government has already passed a law enabling it to borrow 300,000 million baht.

- Work plan for restoration and conservation of forest and ecosystem
- Work plan for management of major water reservoirs and formulation of water management
- Work plan for restoration and efficiency improvement of current and planned physical structures
- Work plan for information warehouse and forecasting and disaster warning system
- Work plan for response to specific area aims at building the capacity in prevention and mitigation of impacts from flood by developing the systems of flood prevention and mitigation in the important areas.
- Work plan for assigning water retention areas and recovery measures
- Work plan for improving water management institutions
- Work plan for creating understanding, acceptance, and participation in large scale flood management from all stakeholders.

**What is the Weakness of the Master Plan?**

Though the master plan nominally consists of both the master plan for infrastructural investment, rehabilitation and maintenance, and the non-infrastructural management plan, the government does not give much attention to the latter. No concrete policy nor any measures have been proposed, e.g., (a) no concrete proposal on how to compensate farmers in the flood retention areas, (b) too little attention to the issue of drought, given the increasing incidence of extreme weather, and (c) inadequate attention to the complex long-term issues of fragmented water management and required institutional changes in integrated water management to cope with extreme weather conditions, plus the appropriate combination of a single command authority and decentralization. The most challenging issues are how to create effective coordination of more than 40 government agencies with overlapping responsibilities, and what is the appropriate combination of single command authority and decentralization of power.

There are also some crucial policies that are still missing, i.e., a policy to facilitate farmers' adaptation in the flood retention areas, and a water management institution. The plan is also silent on adaptation to climate change, which includes drought management. There are, therefore, research needs in the areas of adaptation strategies, water management institutions, and compensation measures. It is also important to bring attention to the enforcement of work plans and consistency in carrying them out, because practical strategies can only be effective when they are enforced in a consistent manner.

## 3. Impact of the 2011 Flood on Agricultural Output

This part of the discussion will first compare the farm areas damaged by floods as reported by the Ministry of Agriculture and Cooperatives (MOAC) and DDPM with information obtained from satellite images. Then it will update the World Bank's estimate of loss of agricultural output caused by the 2011 flood. The update will employ a new set of secondary data from GISTDA radar satellite images which were taken weekly between May and December 2011, with 50×50 meters resolution. Finally, it will compare the estimated agricultural loss and damage with the reported compensation paid by the MOAC and the DDPM.

In estimating the land areas that were damaged by floods, the researchers will use the Thai government's definition of 2-week flood duration as the criterion for payment of compensation to farmers whose farms were damaged by floods. Therefore the weekly satellite images that were taken between May and December 2011 are overlaid and the districts/ sub-districts that were inundated for at least two consecutive weeks are identified. At the same time the land-use pattern is also overlaid so that the inundated farm lands by broad types of agricultural product can be identified. Then, the farm lands that were inundated for at least 2 weeks will, in turn, be used as the new proxy for damaged farm land in the estimate of agricultural output loss.

The first question is how serious was the effect of flood on agricultural land? GISTDA only has information on the duration of flooding, classified by land use. It still does not have a digitized elevation map (DEP). The land use pattern is obtained from the Department of Land Development which carried out a survey during the period 2006-09.

Table 2 compares the flooded agricultural areas estimated from the satellite images with the agricultural areas "damaged by flood" as reported by the farmers to the Department of Agricultural Extension (DOAE) and the Department of Disaster

Prevention and Protection (DDPM). One striking observation is that the flooded areas in all Central provinces are larger than the damaged farm areas.

**Table 2: Flooded Agricultural Areas Reported by MOAC GISTDA and DDPM in Selected Provinces (hectares)**

| Region/Province | | Flooded Agricultural Areas | | | Agricultural Areas | | Province Areas[6] |
|---|---|---|---|---|---|---|---|
| | | MOAC[1] | GISTDA[2] | DDPM[3] | DLD[4] | DOAE[5] | |
| **Lower North** | | **2,577,137** | **1,932,026** | **2,677,864** | **11,756,120** | **10,298,133** | **19,430,794** |
| | Phitsanulok | 654,923 | 639,469 | 785,519 | 3,113,389 | 3,006,736 | 6,622,288 |
| | Phichit | 516,432 | 447,234 | 501,666 | 2,347,494 | 2,198,034 | 2,699,381 |
| | Nakhon Sawan | 1,353,032 | 789,740 | 1,353,032 | 4,636,802 | 4,361,396 | 5,953,538 |
| | Uthai Thani | 52,750 | 55,583 | 37,647 | 1,658,436 | 731,967 | 4,155,588 |
| **North East** | | **2,120,011** | **2,037,427** | **2,172,839** | **28,934,864** | **21,398,868** | **40,307,785** |
| | Kalasin | 180,614 | 191,272 | 227,360 | 3,175,170 | 2,308,026 | 4,335,194 |
| | Khon Kaen | 352,624 | 252,681 | 352,624 | 4,731,818 | 4,183,528 | 6,662,175 |
| | Maha Sarakham | 223,760 | 76,062 | 211,803 | 2,919,249 | 2,234,707 | 3,504,863 |
| | Roi Et | 536,674 | 778,489 | 617,625 | 3,937,468 | 3,551,380 | 4,920,269 |
| | Si Sa Ket | 233,656 | 284,247 | 89,280 | 4,174,315 | 2,505,799 | 5,584,435 |
| | Surin | 244,429 | 219,818 | 325,990 | 4,266,633 | 2,792,141 | 5,533,919 |
| | Ubon Ratchathani | 348,254 | 234,858 | 348,157 | 5,730,211 | 3,823,287 | 9,766,931 |
| **Central** | | **1,686,235** | **6,310,333** | **1,691,645** | **16,959,195** | **13,530,730** | **25,806,307** |
| | Chai Nat | 118,256 | 345,266* | 154,264 | 1,285,915 | 1,210,201 | 1,567,000 |
| | Sing Buri | 88,519 | 284,290 | 178,290 | 395,921 | 407,382 | 510,764 |
| | Ang Thong | 96,038 | 352,659 | 97,277 | 462,151 | 464,568 | 594,065 |
| | Ayutthaya | 356,482 | 568,393* | 97,665 | 1,249,922 | 689,929 | 1,592,079 |
| | Lop Buri | 386,522 | 402,164 | 573,507 | 2,879,391 | 2,419,975 | 4,064,213 |
| | Saraburi | 110,130 | 185,483 | 120,381 | 1,252,214 | 924,089 | 2,180,102 |
| | Suphan Buri | 35,018 | 294,115* | 64,458 | 2,521,942 | 2,227,827 | 3,379,156 |
| | Nakhon Pathom | 101,317 | 327,997* | 39,429 | 950,553 | 814,300 | 1,338,940 |
| | Pathum Thani | 80,740 | 239,034* | n/a | 568,046 | 393,895 | 950,744 |
| | Nonthaburi | 68,226 | 120,299* | 105,095 | 234,505 | 180,637 | 397,751 |
| | Samut Sakhon | 5,313 | 3,728 | n/a | 324,351 | 119,861 | 541,525 |
| | Chachoengsao | 94,909 | 94,565* | 94,437 | 2,292,061 | 1,740,712 | 3,231,100 |
| | Nakhon Nayok | 88,985 | 186,411* | 112,811 | 700,327 | 502,223 | 1,338,094 |
| | Bangkok | 907 | 52,536* | n/a | 258,488 | 174,917 | 980,000 |
| | Prachin Buri | 54,873 | 15,556* | 54,031 | 1,583,409 | 1,260,214 | 3,140,775 |

*Note*: * Adjusted as follows: adjusted flooded farm land= GISTDA flooded farm land – (DLD farm land in 2006 – DOAE farm land in 2011).
** Flooded area (between Sep. 28 – Oct. 29, 2011)

*Source*: (1) Ministry of Agriculture and Cooperatives; (2) Geo-Informatics and Space Technology Development Agency, Radar Satellite Images; (3)Department of Disaster Prevention and Mitigation, Flooded Agricultural lands that were damaged and claimed for compensation; (4) Department of Land Development, Land Use Pattern; (5) Department of Agriculture Extension; (6) Ministry of Interior.

There are two explanations. First, the estimates of agricultural land from the satellite images are based on the land-use survey by the Department of Land Development (DLD) in 2006-2009. The latest estimates of agricultural land (from farmer registration) by the DOAE are smaller than that of DLD, particularly in some rapidly developing provinces such as Ayuthaya, Lopburi, Saraburi, Supanburi, Nakorn Pathom, Pathum Thani, and Chachoengsao where large areas of farm land have been converted into areas of non-agricultural use (see columns 5-6 in Table 2). Secondly, since the flood travelled slowly, there was adequate time for the farmers in the lower part of the Central Plains to harvest their paddy, provided that their crop was ready for harvest. This is what happened in Supanburi where sluice gates were kept closed for more than a week so that farmers had time to harvest most of their paddy. It explains why the reported damaged farm areas in the Cental Plains were very small, i.e., 1.69 million ha, compared with 6.31 million ha of flooded farm land estimated from the satellite images and DLD survey.

Therefore, the flooded farm areas from GISTDA need to be revised by subtracting the difference between farm land estimated by DLD and that by DOAE from the flooded agricultural lands estimated from satellite images. A second method of performing this estimation is to re-estimate the land area that were flooded for two consecutive weeks, and calculate the ratio of farm lands that were flooded for at least two weeks to total farm land in each district. This ratio is then used to estimate the loss of agricultural output.

**Table 3: Number of Districts and Provinces by Share of Their Agricultural Areas that were Flooded for at least Two Weeks**

| Farm area flooded at least 2 weeks/ district farm area | No. of districts where farm areas were flooded for 2 weeks + | | | |
|---|---|---|---|---|
| | Number of districts[1] | | Number of provinces | |
| | GISTDA[2] | DDPM[3] | GISTDA | DOAE[4] |
| 0% | 13 | 14 | - | - |
| 1 - 20% | 32 | 88 | 10 | 18 |
| 21 - 40% | 19 | 31 | 5 | 6 |
| 41 - 60% | 20 | 13 | 5 | 1 |
| 61 - 80% | 28 | 6 | 1 | 1 |
| 80 - 100% | 47 | - | 5 | - |
| > 100% | - | 7 | - | - |
| Total | 159 | 159 | 26 | 26 |

*Note*: (1) Excludes Bangkok and Northeast region. (2) Flooded farm areas from satellite images divided by farm areas surveyed by Department of Land Development in 2006-09. (3) Farm areas damaged by flood as reported by DDPM divided by farm areas surveyed by DOAE in 2011. (4) Provincial flooded farm areas reported by Ministry of Agriculture divided by farm areas surveyed by DOAE in 2011.

*Source*: Calculated from (1) GISTDA, satellite images; (2) Department of Land Development, Land Use Pattern; (3) DDPM, Reported Loss and Damages Caused by Flood between July and December 2011.; (4) Department of Agricultural Extension, Reported Damaged Agricultural Land Caused by Flood between July and December 2011.

Table 3 compares the ratio of two-week flooded farm lands (from satellite images) with the ratio of damaged farm lands (calculated from the data collected by the DOAE and DDPM). One observation is there are more districts and provinces that have higher ratios of flooded farm land in the GISTDA data set than those in the DOAE and DDPM data sets. But the DDPM reports 7 districts where damaged areas were larger than their total agricultural land.

**Revising the World Bank Estimates of Loss in Agriculture**

The World Bank's estimates of agricultural loss and damage were based on only one important parameter, i.e. the flooded areas reported by MOAC. [8] This study will use the satellite images of farm lands that were flooded for at least 2 consecutive weeks to estimate the loss of agricultural output. This should provide a better estimate because the information is science-based and is free from any moral hazard problems in the MOAC report. In fact, one can estimate agricultural loss more accurately if there is information both on the length of the flooding and the depth of the flood waters. Most, if not all, plants and permanent trees die after two weeks of immersion. Table 4 shows that the number of sub-districts (tambons) that were flooded for at least 2 weeks is smaller than the number of sub-districts that were flooded for at least one day. Moreover, floods were more serious in a few provinces in the Central Plains as most or all sub-districts (tambons) in the province were flooded for more than 2 weeks, e.g., Ayuddhaya, Ang Thong, Singburi and Patum Thani. So using the one-day flood duration, as in the World Bank study, will bias upward the agricultural loss and damage estimate. Moreover if plants are submerged under water for a few days, they will not die. Unfortunately, GISTDA does not yet have any DEM (digital elevation map) data. In addition to such information, the satellite images should be regularly confirmed by a systematic process of calibrating the satellite images with reality on the ground (known as a "ground-truthing" survey). Again the Thai government does not adequately invest in these activities.

[8] It should be noted that during the 2011-flood, GISTDA provided every government agency with flood maps. Whether or not they were used in their reports is not clear.

**Table 4: Number of Tambons that were Flooded for at least One Day and at least Two Weeks by Regions and Provinces**

| Regions | Provinces | Numbers of tambons | | |
|---|---|---|---|---|
| | | Flooded>1 day | Flooded>14 days | Total number |
| Central Plains | | 1230 | 1121 | 1349 |
| | Ang Thong | 73 | 73 | 73 |
| | Ayutthaya | 207 | 207 | 209 |
| | Bangkok (no. sub-districts) | 137 | 90 | 169 |
| | Chachoengsao | 91 | 87 | 93 |
| | Chainat | 51 | 50 | 53 |
| | Lopburi | 85 | 72 | 124 |
| | Nakorn Nayok | 39 | 39 | 41 |
| | Nakorn Patom | 126 | 118 | 106 |
| | Nontaburi | 52 | 52 | 52 |
| | Patum Thani | 60 | 60 | 60 |
| | Prachinburi | 58 | 55 | 65 |
| | Samut Sakorn | 31 | 15 | 40 |
| | Saraburi | 90 | 76 | 111 |
| | Singburi | 43 | 43 | 43 |
| | Supanburi | 87 | 84 | 110 |
| North | | 284 | 269 | 382 |
| | Nakorn Sawan | 100 | 91 | 130 |
| | Phitsanulok | 47 | 44 | 93 |
| | Pichit | 81 | 81 | 89 |
| | Utai Thani | 56 | 53 | 70 |
| North East | | 791 | 503 | 1244 |
| | Kalasin | 42 | 20 | 135 |
| | Khon Kaen | 109 | 75 | 199 |
| | Mahasarakham | 91 | 54 | 133 |
| | Roi Et | 178 | 134 | 193 |
| | Sri Saket | 157 | 81 | 206 |
| | Surin | 96 | 62 | 159 |
| | Ubon Ratchathani | 118 | 77 | 219 |
| Total 26 Provinces | | 2305 | 1893 | 2975 |

*Source*: Calculated from (1) GISTDA, radar satellite images; (2) Bangkok Metropolitan Authority, districts and sub-districts that were classified as most severely flooded (red) and heavily flooded (orange).

Table 5 compares the World Bank estimates of agricultural loss and damage with estimates from two different sources of data. The first estimates (in column 8-10) are based on the flooded farm lands that were reported by the DOAE, while the second estimates (column 11-13) use GISTDA's data on the "ratio" of farm lands that were flooded for at least two weeks. The World Bank estimates of crop loss and damage are higher than those based on the information from both the DOAE and GISTDA. This is because the World Bank estimates were done when the flood had not yet receded and several bold assumptions had to be made. On the other hand, the World Bank estimates of damage for livestock and fishery were lower than the new estimates. This is because the new estimates of fishery loss are based on more complete (and thus higher) estimates of the cost of losses in fresh water fish production. The new estimates of livestock losses are also based on the latest survey information by the Ministry of Agriculture (Department of Livestock Development). One important observation from Table 5 is that the estimates which are based on the ratio of farm lands that were flooded for at least two weeks are lower than both those of the World Bank and the estimates based on the damaged farm lands reported by the DOAE.

**Table 5: Comparing Estimates of Damages and Loss in Agriculture Sector**

**(Million USD)**

| Sector | World Bank (Million USD) | | | MOAC (Million USD) | | | GISTDA (Million USD) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Damage | Losses | Total | Damage | Losses | Total | Damage | Losses | Total |
| Agriculture | 482.4 | 426.6 | 909.0 | 291.5 | 288.9 | 580.3 | 210.9 | 212.2 | 423.0 |
| - Paddy | 471.3 | 323.5 | 794.8 | 283.3 | 228.5 | 511.8 | 204.7 | 162.5 | 367.5 |
| - Field Crops | 2.6 | 19.9 | 22.5 | 3.3 | 18.3 | 21.5 | 1.3 | 14.0 | 15.3 |
| - Permanent crops | 8.5 | 83.2 | 91.7 | 4.9 | 41.8 | 47.0 | 4.9 | 35.3 | 40.1 |
| Livestock* | 95.3 | 0.0 | 95.3 | 115.5 | 0.0 | 115.5 | 115.5 | 0.0 | 115.5 |
| Fishery* | 4.6 | 0.0 | 4.6 | 12.1 | 0.0 | 12.1 | 12.1 | 0.0 | 12.1 |
| Grand Total | 582.3 | 426.6 | 1008.9 | 419.1 | 288.9 | 708.0 | 338.5 | 212.2 | 550.3 |

*Note*: MOAC Ministry of Agriculture and Cooperatives DDPM Department of Disaster Prevention and Mitigation, Ministry of Interior
* mostly property damage

*Sources*: (1) The World Bank 2011 and 2012; (2) MOAC and DDPM; (3) Authors' estimates based on data on farm land s that were flooded for at least two weeks from GISTDA, Land Development Department, Bangkok Metropolitan Authority.

Since the government paid large amounts of compensation to the farmers for part of their loss and damage (Table 6), it is interesting to compare the compensation with our estimates of loss and damage. Table 7 lists the compensation criteria, while Table 6 shows the actual compensation paid to the farmers as at February 3rd 2012. Total farm compensation was USD 557.5 million, plus USD 348 million for farm (and house) property damage to be paid by the DDPM. The total compensation is 65 % higher than our estimates of total farm loss and damage. It is possible that there may be moral hazard in the farmers' claim for compensation. One reason is that the compensation payment structure may have distorted the farmers' reports of actual loss and damage. Although the compensation for each type of crop is fixed at an amount based on some percentage of production costs, there is no limit to the amount of crop lands for which claims for flood damage could be made (see compensation criteria in Table 7). But there are limits on the number of livestock and the amounts of fish production for which claims could be made. This is why the compensation for livestock and fishery losses is relatively low.

It should also be noted that both the World Bank's and our estimates do not include the loss of livestock and fishery production. Yet our estimates of livestock damage (3.54 billion baht in Table 3) is several times higher than the compensation payments in Table 4; while our fishery damage estimate (USD 4.47 million ) is much lower than the actual compensation (USD 35.58 million ). This implies that if the World Bank methodology is to be used in the future, it has to be properly modified.

**Table 6: Compensation for Farmers Affected by 2011 Flood**

| Flood compensation (USD Million ) | 26 Provinces | 19 Provinces |
|---|---|---|
| Department of Agriculture Extension | 514.7 | 351.9 |
| Department of Livestock Development | 7.4 | 6.9 |
| Department of Fisheries | 35.4 | 33.0 |
| Total | 557.5 | 391.8 |

*Source*: Department of Agriculture Extension, Department of Livestock Development and Department of Fisheries.3 February 2012

**Table 7: Compensation Criteria**

| Issues | Compensation |
|---|---|
| Crop | |
| Loss of crops and opportunities to grow in the regular seasons | Government compensation in case of 100% damaged production (unlimited amounts of lands)<br>Rice: 2,222 bht/ rai<br>Crop Fields: 3,150 Baht/ rai<br>Permanent Trees: 5,098 Baht/ rai<br>For partial damage, the compensation is 2,549 baht/rai |
| Damaged lands | - In the case of landslide, the compensation is 7,000/rai, max 5 rais<br>- 400 bht/ rai for cleaning up the lands, max 5 rais |
| Higher price of inputs | -Government promises to provide seeds to farmers, i.e., 10 kgs of rice seeds for 1 rai with max 10 rais. |
| Livestock | |
| Loss of stocks | The amount of compensation varied depending on the types of the stocks and their ages i.e. |
| Higher prices of inputs (no compensation) | Pigs: less than 1 mth: 1,200 bht/ head, more than 1 mth: 2,500 bht/ head, max 10 heads each farmer |
| Livestock's sickness | -Providing veterinarian services and supplements to the livestock |
| Fishery | |
| Loss of fish stock | All fish: 4,225 baht per rai, max 5 rais |
| Higher price of inputs (no compensation) | Shrimps, Crabs and Clams: 10,920 baht per rai, max 5 rais<br>Caged Fish: 315 baht per sq.m, max 80 sq.m |

*Note*: (1) One rai equals 0.16 ha; (2) Baht 30.6366 equal one USD.
*Source*: Ministry of Agriculture and Cooperatives

## 4. Impact on Household Income and Expenditure

This part will estimate the impact of the 2011 flood on household income and expenditure. It will first compare the incomes and expenditures of households in the flooded sub-districts in quarters 1-3 (the non-flooding period) with their incomes and expenditures in the fourth quarter (the flooding period) of 2011. The incomes and expenditures of the flooded households will also be compared with those of non-flooded households for both periods. Secondly it will compare household income and expenditure in the fourth quarter of 2011 (the flooding year) with those in 2009. Thirdly, it will develop a "difference in difference" approach to measure the impact of flooding, using the quantile regression technique.

### 4.1. Method of Estimation of the Flood Impact

The "difference - in - difference" approach to measure the impact of the flood can be described by the following equations.

(1) $Y_{ist} = \alpha + \mathrm{T}\, D_{s*}D_t + \beta D_s + \delta D_t + \varepsilon_{st} + \mu_{ist}$

(2) $\bar{y}_{11} = \bar{y} + \mathrm{T} + \beta + \delta + \varepsilon_{11}$ where $\alpha = \bar{y}$

(3) $\bar{y}_{10} = \bar{y} + \beta + \varepsilon_{10}$

(4) $\bar{y}_{01} = \bar{y} + \delta + \varepsilon_{01}$

(5) $\bar{y}_{00} = \bar{y} + \varepsilon_{00}$

(6) $\bar{y}_{11} - \bar{y}_{10} = \mathrm{T} + \delta + \varepsilon_{11} - \varepsilon_{10}$

(7) $\bar{y}_{01} - \bar{y}_{00} = \delta + \varepsilon_{01} - \varepsilon_{00}$

(8) $(\bar{y}_{11} - \bar{y}_{10}) - (\bar{y}_{01} - \bar{y}_{00}) = \mathrm{T} + (\varepsilon_{11} - \varepsilon_{10}) - (\varepsilon_{01} - \varepsilon_{00})$

(9) $E[(\bar{y}_{11} - \bar{y}_{10}) - (\bar{y}_{01} - \bar{y}_{00})] = \mathrm{T} + E[(\varepsilon_{11} - \varepsilon_{10}) - (\varepsilon_{01} - \varepsilon_{00})]$

$= \mathrm{T}$

Where

$Y_{ist}$ = income of household i, living in area "s" in the "t" period

s = 0 if non flood areas

= 1 if flooded areas (19 or 26 provinces)

t = 0 if non-flooded months (January-September)

= 1 if flooded months (October- December)

$D_s$ = Area dummy

$D_t$ = Monthly dummy

$(\bar{y}_{01} - \bar{y}_{00})$ = change in income between 2 periods in non-flooded areas (control)

$(\bar{y}_{11} - \bar{y}_{10})$ = change in income between 2 periods in flooded areas (treatment)

$(\bar{y}_{11} - \bar{y}_{10}) - (\bar{y}_{01} - \bar{y}_{00})$ = direct effect of flood

**What is a Quantile Regression?**

To estimate the effect of flood on income and expenditure, equation (1) is estimated using the quantile regression technique (Firpo, *et al.,* 2009).

A quantile regression is a new method to evaluate the impact of changes in the distribution of the explanatory variables on quantiles of the unconditional (marginal) distribution of an outcome variable. The method consists of running a regression of the (re-centered) influence function (RIF) of the unconditional quantiles on the explanatory variables.

The following statement is a brief summary of the quantile regression: " Whereas the method of least squares results in estimates that approximate the conditional *mean* of the response variable given certain values of the predictor variables, quantile regression aims at estimating either the conditional median or other quantiles of the response variable…….One advantage of quantile regression, relative to the ordinary least squares regression, is that the quantile regression estimates are more robust against outliers in the response measurements.” (Wikipedia, “Quantile Regression”).

## 4.2. Data Sources

1) NSO, 2009 and 2011 Socio-Economic Survey. Note that SES did not ask any question on 2011 flood.
2) GISTDA, Satellite Images on a list of flooded tambons (sub-districts).

Since the Socio-economic Survey contains data on the address of the households, especially the names of village and tambons, this allows the researchers to identify the tambons that were flooded when the information from SES is matched with the satellite images. As a result, we can identify the households that were affected by floods in 19 provinces in the Lower North and Central Plains and 7 Northeastern provinces. The period of flood was between May and December 2011.[9] Note that all households in Bangkok were treated as flooded households, despite the fact that some districts in Bangkok were not flooded, because the satellite images do not allow us to identify flood in cities with a high density of buildings.

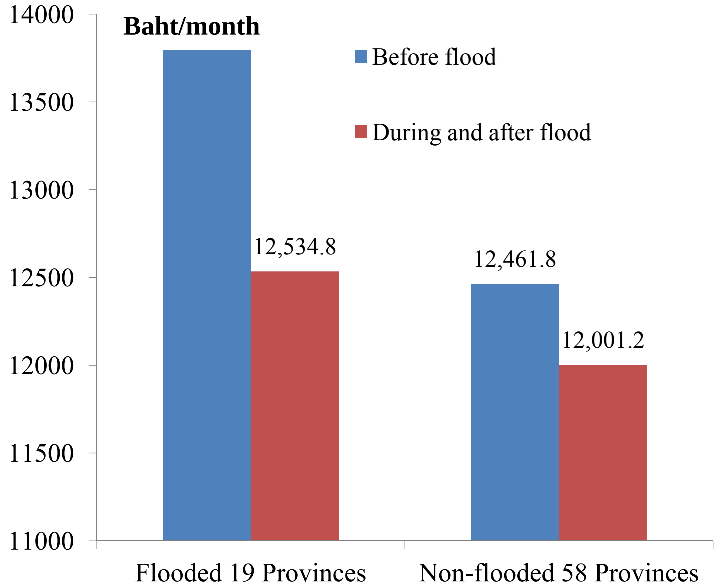
[9] Although the Socio-economic Survey allows us to identify the villages in which the households live, the researchers cannot identify the village boundary from the satellite images due to the lack of official digitalized data on village boundaries.

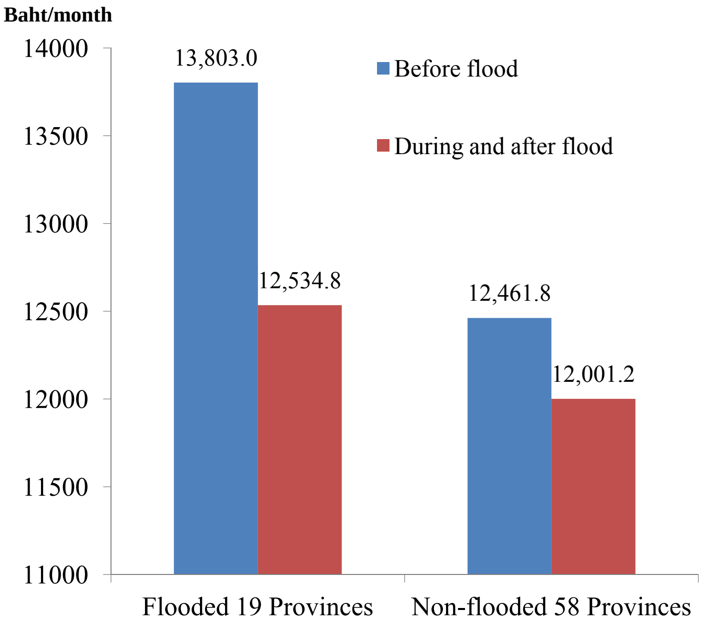
### 4.3. Tabulation of Impact on Expenditures

In general, the 2011 floods had negative effects on expenditure and income of flooded households in the flooding period (Figure 8 and Figure 9). The expenditures of households in the non-flooded areas were also affected but to a smaller extent (Table 8). One possible explanation of the indirect effect on those who live outside the flooded areas is that the flood in the most important business and industrial areas might have had a spill-over effect throughout the whole economy. The impact works through three channels of the supply chain effect, i.e., (a) a shortage of raw materials, parts and components for industrial plants outside the flooded area; (b) the loss of jobs or reduction of income as a result of the closure of industrial plants and firms; and (c) disruption of logistics.

The flood impact on household expenditures in 19 provinces was larger than that in 26 provinces because the flood was more severe in 19 provinces in the Lower North and Central Plains than the other 7 provinces in the Northeast. Households did not reduce expenditures across the board. Instead, they incurred higher expenditures on hiring household services (see Table 8). The expenses that were reduced by the largest percentage we cloth, transportation, housing, medical expenses, personal care, toys & sport activities, and eating out, respectively.

**Figure 8: Impact of Flood on Household Monthly Expenditure**




*Note*: Baht 30.637 equal one US$

*Source*: NSO, Socio-economic Survey, 2011

**Table 8: Effect of Flood by Type of Expenditure (baht per month)**

| Expenditure | Flooded 19 Provinces | | | % | Flooded 26 Provinces | | | % |
|---|---|---|---|---|---|---|---|---|
| | Before flood | During and after flood | Total | | Before flood | During and after flood | Total | |
| A1.Housing and household operation | 3,968.9 | 3,444.5 | 3,834.9 | -13.2 | 3,698.6 | 3,389.7 | 3,621.3 | -8.4 |
| A2.Service workers in household | 59.3 | 96.0 | 68.7 | 61.9 | 50.8 | 75.2 | 57.0 | 48.0 |
| A3.Cloth-clothing material | 574.4 | 408.2 | 531.9 | -28.9 | 512.0 | 373.2 | 477.3 | -27.1 |
| A4.Personal care | 662.7 | 599.9 | 646.6 | -9.5 | 633.5 | 591.7 | 623.1 | -6.6 |
| A5.Medical and health care | 297.8 | 259.1 | 287.9 | -13.0 | 274.5 | 260.5 | 271.0 | -5.1 |
| A6.Transportation and communication | 1,952.6 | 1,595.7 | 1,861.4 | -18.3 | 1,779.0 | 1,535.6 | 1,718.1 | -13.7 |
| A7.Toys, pets, trees,sport and admissions | 302.1 | 272.7 | 294.6 | -9.7 | 272.4 | 270.7 | 272.0 | -0.6 |
| A8.Food | 5,985.2 | 5,858.7 | 5,952.9 | -2.1 | 5,868.6 | 5,939.3 | 5,886.3 | 1.2 |
| A9.Alcoholic and non-alcoholic beverages | 383.8 | 356.5 | 376.9 | -7.1 | 366.0 | 351.4 | 362.3 | -4.0 |
| A10.Prepared food consumed at home, and | 1,188.6 | 1,122.8 | 1,171.8 | -5.5 | 1,162.4 | 1,124.6 | 1,152.9 | -3.2 |
| A11….consumed away from home | 815.0 | 741.8 | 796.3 | -9.0 | 781.1 | 752.2 | 773.8 | -3.7 |

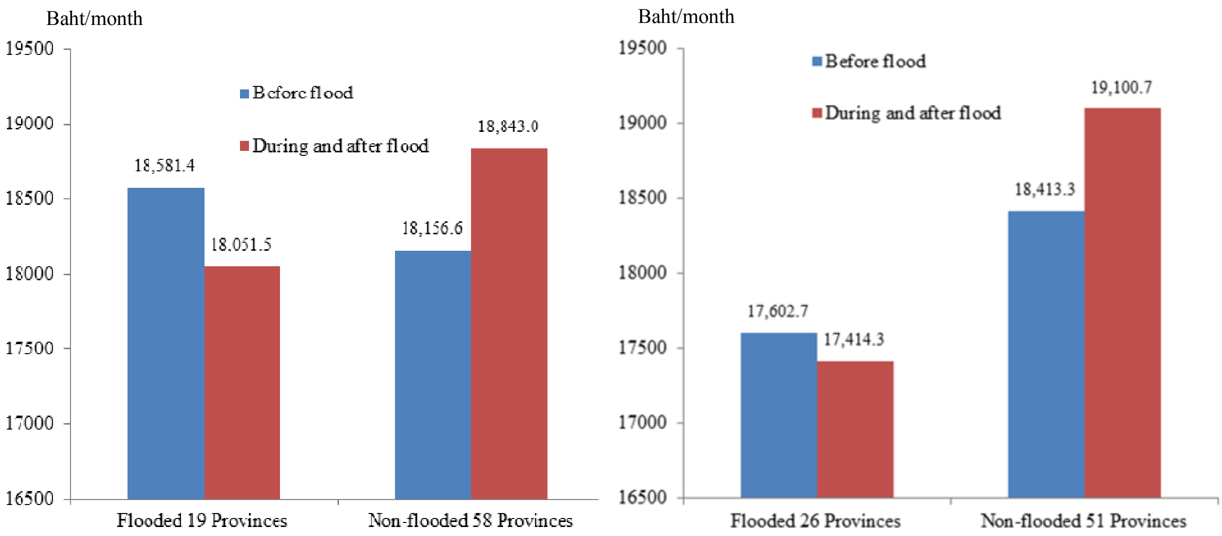
*Note*: Baht 30.637 equal one USD.
*Source*: NSO, Socio-economic Survey, 2011

## 4.4. Tabulation of Impact on Income

The 2011 floods had a negative impact on the money income of households in the flooded areas, while those in the non-flooded areas still enjoyed an increase in total money income (Figure 9 and Table 9). Yet, the flood had a negative impact on the wages & salary income of households in both the flooded and non-flooded areas (Table 9), implying that there was a negative spillover effect on wage employment throughout the country.

Despite the fact that most farm income occurs in October and December, it is surprising to find that there was no negative impact of flooding on farm income and profit from business. Thus, the appropriate way to measure the impact of flooding on farm income is to compare farm income in Q4/ 2011 with that in Q4/2009 (because there was no income survey in 2010). For business income, the result can be reconciled by the fact that household business might be able to make more net profit due to increased prices of consumer goods & services caused by the disruption of supplies. However, the price effect dominated the income effect of the flood, which resulted in lower household expenditures.

## Figure 9: Impact of Flood on all Money Income




*Note*: Baht 30.637 equal one USD
*Source*: NSO, Socio-economic Survey, 2011

## Table 9: Impact of Flood by Types of Income and Flooded Areas

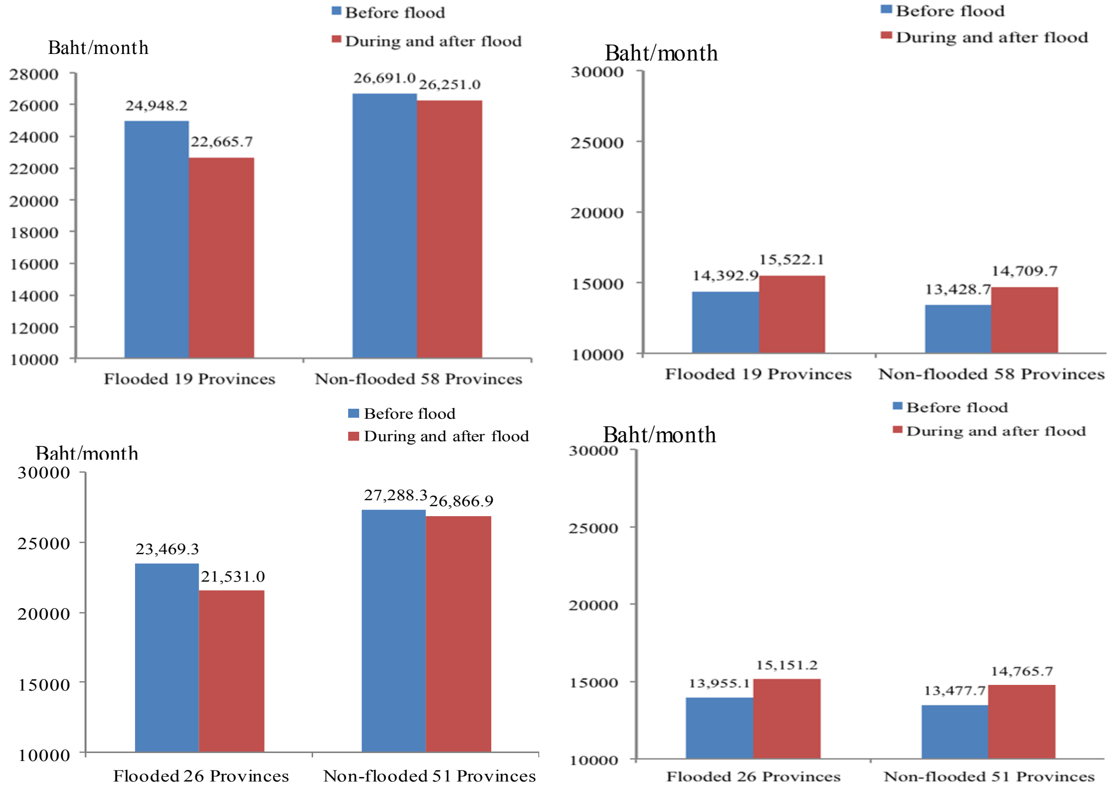
| Province | Income | Flood months | | | % |
|---|---|---|---|---|---|
| | | **Before flood** | **During and after flood** | **Total** | |
| Flooded 19 Provinces | All money income | 18,581.4 | 18,051.5 | 18,446.0 | -2.9 |
| | Wage and salaries | 11,538.7 | 9,911.5 | 11,123.0 | -14.1 |
| | Net profit from business | 3,831.9 | 4,731.7 | 4,061.8 | 23.5 |
| | Net profit from farming | 694.9 | 812.2 | 724.9 | 16.9 |
| Non-flooded 58 Provinces | All money income | 18,156.6 | 18,843.0 | 18,321.2 | 3.8 |
| | Wage and salaries | 8,690.1 | 8,074.5 | 8,542.5 | -7.1 |
| | Net profit from business | 4,385.6 | 4,466.1 | 4,404.9 | 1.8 |
| | Net profit from farming | 2,521.8 | 3,408.5 | 2,734.4 | 35.2 |
| Flooded 26 Provinces | All money income | 17,602.7 | 17,414.3 | 17,555.6 | -1.1 |
| | Wage and salaries | 10,640.1 | 9,551.8 | 10,367.7 | -10.2 |
| | Net profit from business | 3,661.7 | 4,379.2 | 3,841.2 | 19.6 |
| | Net profit from farming | 996.5 | 1,007.3 | 999.2 | 1.1 |
| Non-flooded 51 Provinces | All money income | 18,413.3 | 19,100.7 | 18,578.4 | 3.7 |
| | Wage and salaries | 8,738.1 | 8,050.4 | 8,572.9 | -7.9 |
| | Net profit from business | 4,478.1 | 4,556.5 | 4,497.0 | 1.7 |
| | Net profit from farming | 2,572.2 | 3,540.3 | 2,804.7 | 37.6 |

*Source*: NSO, Socio-economic Survey, 2011

### 4.5. Tabulation of Impact by Areas

The income of urban households was more seriously affected than that of rural households, except for wages and salaries (Figure 10). While urban households suffered a decline in all types of income, their rural counterparts suffered only the reduction in wages and salaries.

**Figure 10: Impact of Flood on Total Money Income by Areas**




*Note*: Baht 30.637 equal one USD
*Source*: NSO, Socio-economic Survey, 2011

## 4.6. Tabulation of Impact by Months

Monthly expenditures declined during the flooding months (Figure 11-a). But there is no clear trend in the impact of the floods on monthly income (Figure 11-b).

**Figure 11-a: Impact of Flood on Monthly Money Income**

All money Income (Baht per month)

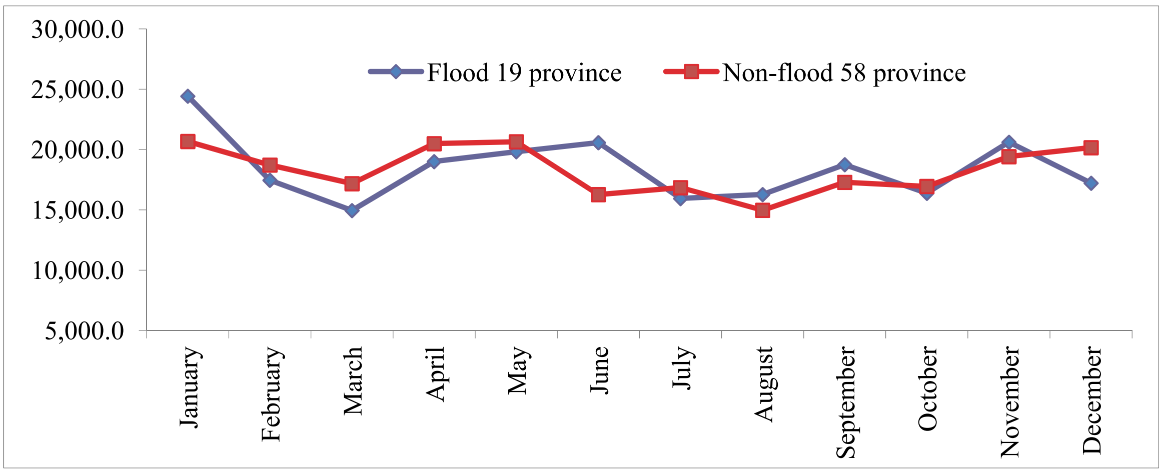
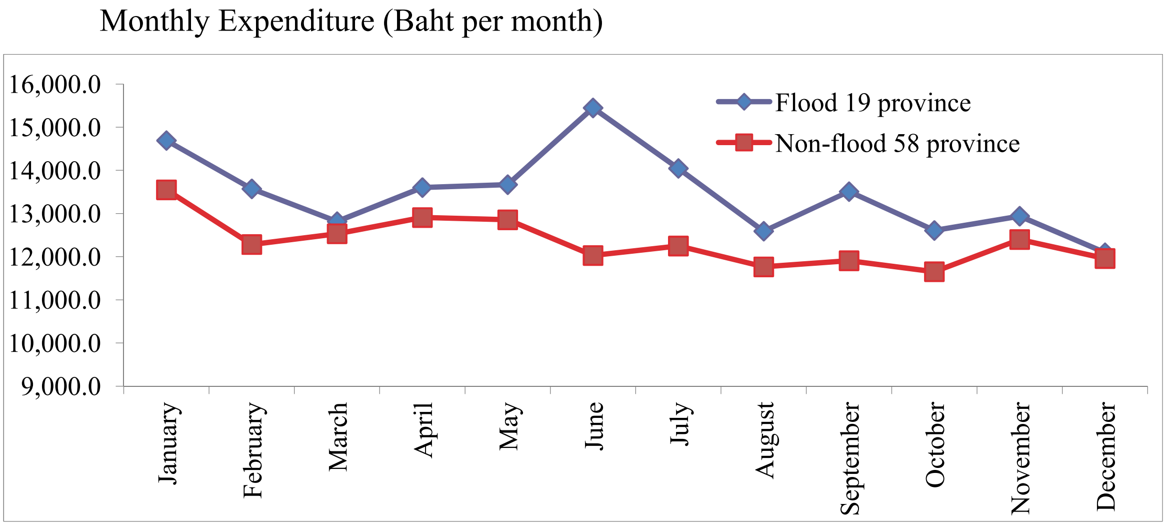


**Figure 11-b: Impact of Flood on Monthly Expenditures**




*Note*: Baht 30.637 equal one USD.
*Source*: NSO, Socio-economic Survey, 2011

### 4.7. Results from Quantile Regressions on Household Expenditures

Based on equation (1) in part 4.1, we ran two sets of regressions, i.e., one OLS regression and 20 quantile regressions to measure the impact of flooding on household expenditures and income. The households that were in the sub-districts that were flooded for at least one day during May and December 2011 are identified by matching the list of flooded sub-districts in the satellite images with that in the Socio-economic Survey in 2011.[10] The dependent variables are the household expenditures (in log form) and income (in level), while the independent variables include a dummy variable representing area that was flooded for at least two weeks (flodarea1), the flooding month dummy (t), an interaction between flooded area dummy and flooding month dummy (c.t#c.flodarea), and control variables, e.g., socio-economic and demographic characteristics. They are as follows: (1) years of education of household head, 'headsch'; (2) male household head dummy, 'malehead'; (3) married household head, 'headmarried'; (4) number of adult male family members, 'adultmale'; (5) number of adult female family members, 'adultfem'; (6) number of children aged 0-3 years, 'children03'; (7) number of

[10] The researchers dropped the plan to use the 2-week flood period for two reasons. First, there are problems of estimating the areas that were flooded for more than 14 days from the satellite data. Secondly, in reality the flood not only had an impact on expenditures of households that were flooded for a long time, but also on those that were flooded for a short period.

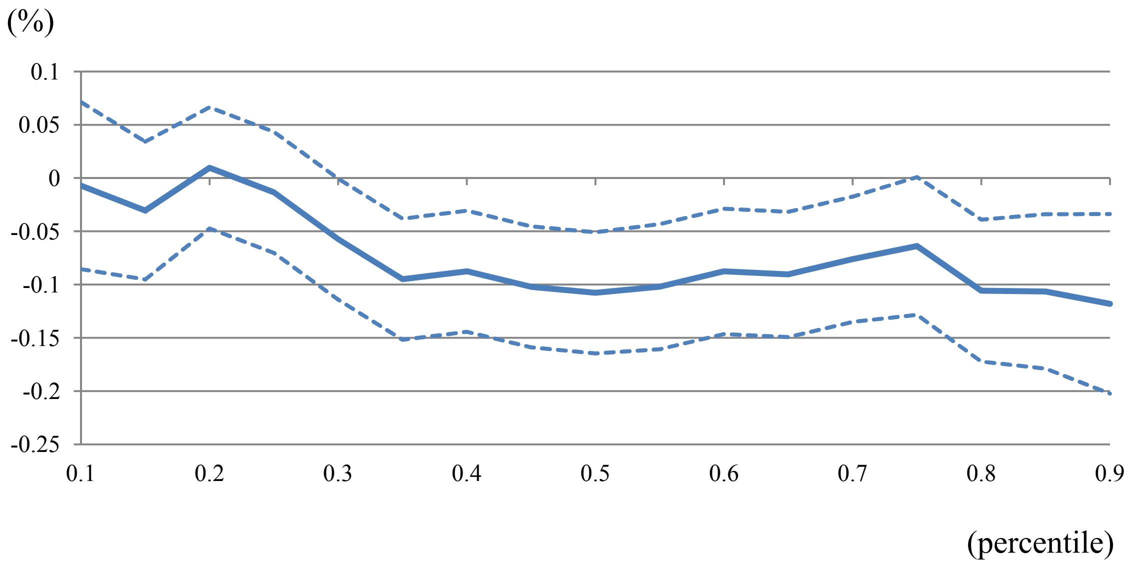
children aged 4-15, ‘children415’; and (8) number of older household members (aged 60 years and older), ‘adult60’.

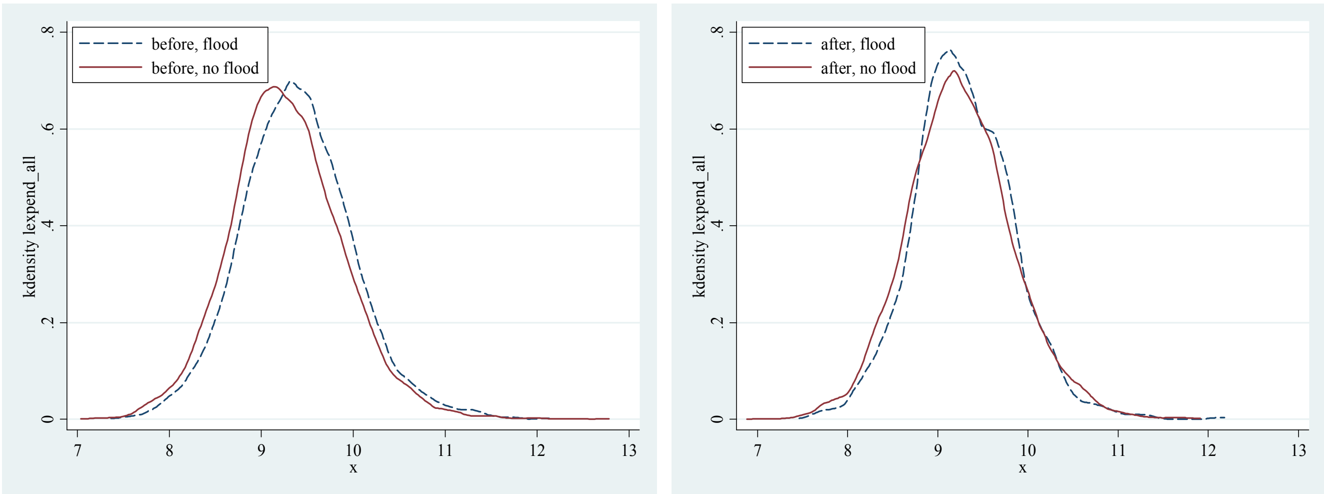
All control variables are statistically significant (Table 10). The flooded area dummy is significant in both the OLS and quantile regressions. But the flooding month dummy is statistically significant only in some quantile regressions. The interaction of the flooding month dummy and the flooding area dummy is statistically significant in the OLS and most of the quantile regressions, except for a few lowest percentiles.

In the lower part of Figure 12, the expenditure distribution of households living in the flooded areas and non-flooded areas are compared in two periods, i.e., before and after the flood. Before the flood, the households in the flooded areas spent slightly more than those in the 56 non-flooded provinces, (with a higher value of mode). But after the flood, the former apparently reduced their spending.

The upper part of Figure 12 plots the flood impact on the percentage change of household expenditures, by percentiles. The 95% levels of change are also depicted. Floods caused the household expenditures to decline by 5.7 % to 14.1%, with an average of 6.7%. Flooding had a statistically significant impact on the expenditure of the households in the 30$^{th}$ and higher percentile income classes. It is surprising that the poor households in the flooded areas did not spend statistically significantly less during the flooding months (Figure 12 and Table 10).

**Figure 12: Flood Effect on Total Household Expenditure**




*Source*: Calculated from NSO, *Socio-economic Survey*, 2011

## Table 10: Flood Effect on Household's Expenditure

| VARIABLES | lexpend_all | rif5 | rif10 | rif15 | rif20 | rif25 | rif30 | rif35 | rif40 | rif45 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 0.063*** | 0.043*** | 0.048*** | 0.046*** | 0.045*** | 0.045*** | 0.046*** | 0.048*** | 0.051*** | 0.053*** |
| | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| malehead | -0.049*** | -0.065** | -0.041** | -0.034** | -0.028** | -0.038*** | -0.044*** | -0.048*** | -0.051*** | -0.056*** |
| | (0.009) | (0.026) | (0.020) | (0.017) | (0.014) | (0.013) | (0.012) | (0.012) | (0.012) | (0.012) |
| headmarried | 0.074*** | 0.307*** | 0.242*** | 0.198*** | 0.163*** | 0.140*** | 0.123*** | 0.106*** | 0.094*** | 0.082*** |
| | (0.009) | (0.028) | (0.022) | (0.018) | (0.015) | (0.014) | (0.013) | (0.012) | (0.012) | (0.012) |
| adultmale | 0.222*** | 0.186*** | 0.218*** | 0.210*** | 0.195*** | 0.202*** | 0.209*** | 0.212*** | 0.216*** | 0.218*** |
| | (0.006) | (0.011) | (0.010) | (0.008) | (0.008) | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) |
| adultfem | 0.289*** | 0.239*** | 0.269*** | 0.267*** | 0.264*** | 0.265*** | 0.270*** | 0.275*** | 0.278*** | 0.286*** |
| | (0.006) | (0.012) | (0.010) | (0.008) | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) |
| children03 | 0.043*** | 0.040*** | 0.058*** | 0.075*** | 0.066*** | 0.074*** | 0.070*** | 0.072*** | 0.067*** | 0.069*** |
| | (0.010) | (0.013) | (0.014) | (0.013) | (0.012) | (0.012) | (0.012) | (0.012) | (0.013) | (0.014) |
| children415 | 0.090*** | 0.128*** | 0.145*** | 0.135*** | 0.124*** | 0.119*** | 0.115*** | 0.111*** | 0.110*** | 0.104*** |
| | (0.005) | (0.009) | (0.008) | (0.007) | (0.006) | (0.006) | (0.006) | (0.006) | (0.006) | (0.006) |
| adult60 | 0.223*** | 0.084*** | 0.096*** | 0.106*** | 0.123*** | 0.133*** | 0.149*** | 0.162*** | 0.179*** | 0.193*** |
| | (0.006) | (0.013) | (0.011) | (0.010) | (0.008) | (0.008) | (0.008) | (0.007) | (0.007) | (0.007) |
| t | -0.001 | -0.001 | 0.018 | 0.031* | 0.004 | 0.009 | 0.024* | 0.023* | 0.011 | 0.017 |
| | (0.010) | (0.029) | (0.022) | (0.018) | (0.015) | (0.014) | (0.014) | (0.013) | (0.014) | (0.014) |
| flodarea1 | 0.105*** | 0.104*** | 0.129*** | 0.124*** | 0.122*** | 0.114*** | 0.119*** | 0.116*** | 0.129*** | 0.127*** |
| | (0.009) | (0.021) | (0.018) | (0.015) | (0.013) | (0.012) | (0.012) | (0.012) | (0.012) | (0.013) |
| c.t#c.flodarea1 | -0.067*** | 0.04 | -0.007 | -0.031 | 0.01 | -0.013 | -0.057** | -0.095*** | -0.088*** | -0.102*** |
| | (0.020) | (0.048) | (0.040) | (0.033) | (0.029) | (0.029) | (0.029) | (0.029) | (0.029) | (0.029) |
| Constant | 8.153*** | 7.315*** | 7.441*** | 7.631*** | 7.785*** | 7.887*** | 7.952*** | 8.021*** | 8.069*** | 8.122*** |
| | (0.013) | (0.046) | (0.035) | (0.026) | (0.021) | (0.018) | (0.016) | (0.015) | (0.014) | (0.014) |
| Observations | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 |
| R-squared | 0.463 | 0.112 | 0.173 | 0.22 | 0.248 | 0.268 | 0.281 | 0.291 | 0.298 | 0.301 |

**Table 10: Flood Effect on Household's Expenditure (cont.)**

| VARIABLES | rif50 | rif55 | rif60 | rif65 | rif70 | rif75 | rif80 | rif85 | rif90 | rif95 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 0.056*** | 0.060*** | 0.064*** | 0.066*** | 0.069*** | 0.074*** | 0.078*** | 0.083*** | 0.089*** | 0.104*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) | (0.002) | (0.002) | (0.004) |
| malehead | -0.055*** | -0.051*** | -0.052*** | -0.053*** | -0.055*** | -0.066*** | -0.066*** | -0.058*** | -0.045** | -0.018 |
| | (0.012) | (0.012) | (0.012) | (0.012) | (0.013) | (0.014) | (0.015) | (0.017) | (0.020) | (0.029) |
| headmarried | 0.066*** | 0.051*** | 0.031** | 0.014 | -0.003 | -0.01 | -0.034** | -0.064*** | -0.095*** | -0.113*** |
| | (0.012) | (0.012) | (0.012) | (0.012) | (0.013) | (0.014) | (0.015) | (0.017) | (0.020) | (0.030) |
| adultmale | 0.221*** | 0.220*** | 0.220*** | 0.219*** | 0.222*** | 0.237*** | 0.237*** | 0.240*** | 0.247*** | 0.254*** |
| | (0.007) | (0.008) | (0.008) | (0.008) | (0.008) | (0.009) | (0.010) | (0.012) | (0.015) | (0.023) |
| adultfem | 0.292*** | 0.302*** | 0.307*** | 0.301*** | 0.299*** | 0.309*** | 0.307*** | 0.306*** | 0.308*** | 0.323*** |
| | (0.007) | (0.008) | (0.008) | (0.008) | (0.008) | (0.009) | (0.010) | (0.012) | (0.015) | (0.024) |
| children03 | 0.063*** | 0.058*** | 0.060*** | 0.046*** | 0.056*** | 0.043** | 0.034* | 0.03 | 0.002 | -0.074** |
| | (0.014) | (0.015) | (0.015) | (0.015) | (0.016) | (0.017) | (0.018) | (0.020) | (0.024) | (0.030) |
| children415 | 0.099*** | 0.094*** | 0.087*** | 0.079*** | 0.069*** | 0.065*** | 0.066*** | 0.043*** | 0.036*** | 0.015 |
| | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) | (0.008) | (0.009) | (0.010) | (0.011) | (0.016) |
| adult60 | 0.206*** | 0.220*** | 0.234*** | 0.247*** | 0.266*** | 0.284*** | 0.301*** | 0.326*** | 0.364*** | 0.442*** |
| | (0.007) | (0.007) | (0.008) | (0.008) | (0.008) | (0.009) | (0.009) | (0.011) | (0.014) | (0.023) |
| t | 0.016 | 0.002 | 0.001 | -0.001 | -0.017 | -0.029* | -0.030* | -0.026 | -0.015 | -0.011 |
| | (0.014) | (0.014) | (0.014) | (0.014) | (0.014) | (0.015) | (0.017) | (0.018) | (0.022) | (0.030) |
| flodarea1 | 0.121*** | 0.120*** | 0.113*** | 0.102*** | 0.105*** | 0.098*** | 0.090*** | 0.068*** | 0.057** | 0.04 |
| | (0.013) | (0.013) | (0.014) | (0.014) | (0.015) | (0.016) | (0.017) | (0.020) | (0.023) | (0.032) |
| c.t#c.flodarea1 | -0.108*** | -0.102*** | -0.088*** | -0.090*** | -0.076** | -0.064* | -0.106*** | -0.106*** | -0.118*** | -0.141** |
| | (0.029) | (0.030) | (0.030) | (0.030) | (0.030) | (0.033) | (0.034) | (0.037) | (0.043) | (0.057) |
| Constant | 8.172*** | 8.216*** | 8.278*** | 8.362*** | 8.431*** | 8.470*** | 8.565*** | 8.670*** | 8.786*** | 8.893*** |
| | (0.013) | (0.014) | (0.014) | (0.013) | (0.013) | (0.015) | (0.017) | (0.020) | (0.027) | (0.044) |
| Observations | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 |
| R-squared | 0.304 | 0.301 | 0.299 | 0.294 | 0.289 | 0.274 | 0.253 | 0.224 | 0.182 | 0.126 |

*Note*: Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

*Source*: Calculated from NSO, Socio-economic Survey, 2011.

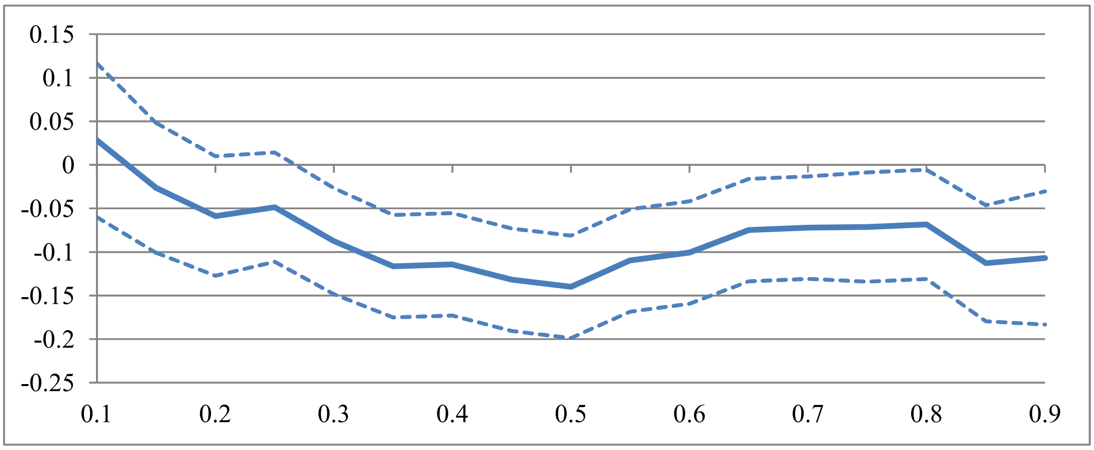
Figure 13-a shows the impact of flooding on household expenditures, excluding housing expenses such as rent and maintenance. The result shows that the 2011 flood had more impact on the spending of middle income families than on households at both tails of the income distribution. The changes in food expenditures (Figure 13-b) show a similar pattern.

Political economy: The estimates confirm that the 2011 flood seriously affected the middle class, who constitute the largest voting constituency. This explains why the government hurriedly allocated 350 billion baht for the flood management plan, 300 billion baht of which came from an emergency law which empowers the government to borrow the money.

Figure 13-b and Table 11 show that the food expenditures of most income quintiles declined by 6%-12%. Most coefficients are statistically significant. Again the percentage decline in food expenditure for the middle income class is the highest.

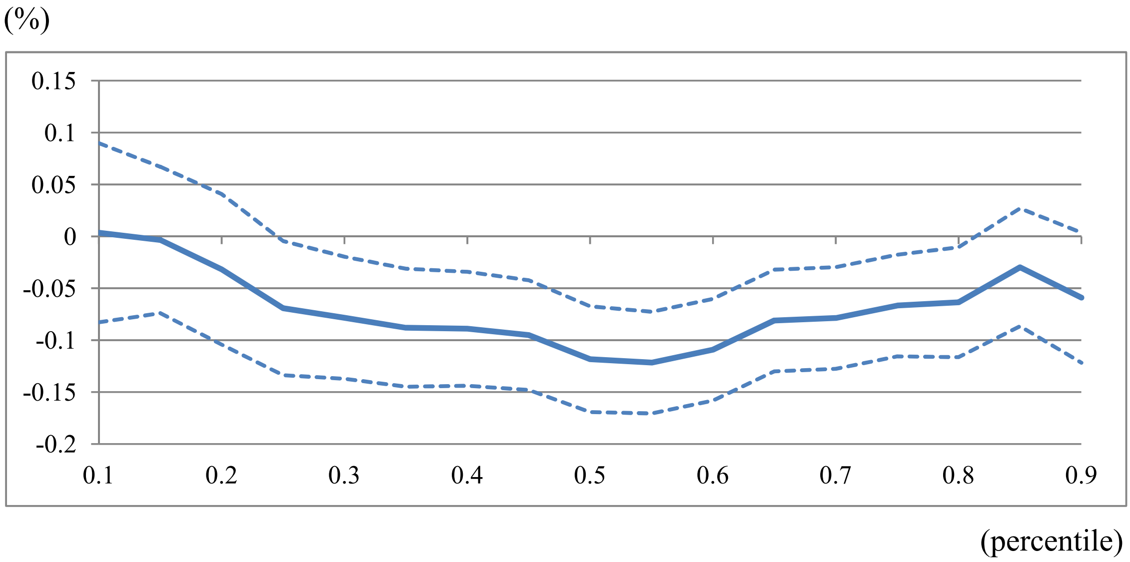
**Figure 13-a: Flood Effect on Total Household Expenditures** (not including housing expenses)

(%)




(percentile)

**Figure 13-b: Flood Effect on Household Food Expenditures**




*Source*: Calculated from NSO, *Socio-economic Survey*, 2011

## Table 11: Flood Effect on Household's Food Expenditure (Dependent variable is log of food expenditure)

| VARIABLES | OLS | rif5 | rif10 | rif15 | rif20 | rif25 | rif30 | rif35 | rif40 | rif45 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 0.028*** | 0.021*** | 0.025*** | 0.025*** | 0.027*** | 0.026*** | 0.025*** | 0.027*** | 0.028*** | 0.029*** |
| | (0.001) | (0.003) | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| malehead | -0.025*** | 0.023 | 0.01 | -0.014 | -0.025 | -0.025* | -0.024* | -0.029** | -0.038*** | -0.040*** |
| | (0.009) | (0.033) | (0.022) | (0.018) | (0.016) | (0.014) | (0.013) | (0.012) | (0.012) | (0.011) |
| headmarried | 0.114*** | 0.298*** | 0.292*** | 0.261*** | 0.247*** | 0.208*** | 0.185*** | 0.156*** | 0.138*** | 0.123*** |
| | (0.010) | (0.034) | (0.024) | (0.019) | (0.018) | (0.015) | (0.014) | (0.013) | (0.012) | (0.011) |
| adultmale | 0.212*** | 0.209*** | 0.206*** | 0.214*** | 0.230*** | 0.228*** | 0.223*** | 0.221*** | 0.222*** | 0.214*** |
| | (0.006) | (0.014) | (0.011) | (0.009) | (0.009) | (0.008) | (0.008) | (0.007) | (0.007) | (0.007) |
| adultfem | 0.235*** | 0.223*** | 0.237*** | 0.232*** | 0.266*** | 0.257*** | 0.249*** | 0.248*** | 0.243*** | 0.242*** |
| | (0.006) | (0.015) | (0.011) | (0.011) | (0.010) | (0.009) | (0.008) | (0.008) | (0.008) | (0.008) |
| children03 | 0.141*** | 0.084*** | 0.095*** | 0.099*** | 0.116*** | 0.129*** | 0.128*** | 0.148*** | 0.146*** | 0.143*** |
| | (0.009) | (0.016) | (0.013) | (0.013) | (0.013) | (0.012) | (0.012) | (0.012) | (0.012) | (0.013) |
| children415 | 0.144*** | 0.165*** | 0.160*** | 0.158*** | 0.182*** | 0.173*** | 0.169*** | 0.160*** | 0.160*** | 0.152*** |
| | (0.005) | (0.010) | (0.008) | (0.007) | (0.007) | (0.007) | (0.006) | (0.006) | (0.006) | (0.006) |
| adult60 | 0.167*** | 0.120*** | 0.116*** | 0.119*** | 0.131*** | 0.131*** | 0.139*** | 0.147*** | 0.154*** | 0.151*** |
| | (0.006) | (0.015) | (0.012) | (0.010) | (0.010) | (0.009) | (0.008) | (0.007) | (0.007) | (0.007) |
| t | 0.01 | -0.002 | 0.007 | 0.016 | 0.015 | 0.018 | 0.02 | 0.019 | 0.032** | 0.018 |
| | (0.010) | (0.034) | (0.024) | (0.019) | (0.018) | (0.015) | (0.014) | (0.013) | (0.013) | (0.013) |
| flodarea1 | 0.063*** | 0.131*** | 0.093*** | 0.083*** | 0.082*** | 0.089*** | 0.073*** | 0.069*** | 0.062*** | 0.063*** |
| | (0.009) | (0.026) | (0.020) | (0.017) | (0.016) | (0.014) | (0.013) | (0.013) | (0.013) | (0.012) |
| c.t#c.flodarea1 | -0.058*** | 0.037 | 0.004 | -0.003 | -0.032 | -0.069** | -0.078*** | -0.088*** | -0.089*** | -0.095*** |
| | (0.019) | (0.057) | (0.044) | (0.036) | (0.037) | (0.033) | (0.030) | (0.029) | (0.028) | (0.027) |
| Constant | 7.642*** | 6.622*** | 6.841*** | 7.027*** | 7.080*** | 7.228*** | 7.348*** | 7.433*** | 7.516*** | 7.608*** |
| | (0.013) | (0.056) | (0.036) | (0.028) | (0.025) | (0.021) | (0.018) | (0.016) | (0.015) | (0.015) |
| Observations | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 |
| R-squared | 0.375 | 0.07 | 0.132 | 0.176 | 0.215 | 0.244 | 0.263 | 0.275 | 0.278 | 0.28 |

**Table 11: Flood Effect on Household's Food Expenditure (Dependent variable is log of food expenditure) (cont.)**

| VARIABLES | rif50 | rif55 | rif60 | rif65 | rif70 | rif75 | rif80 | rif85 | rif90 | rif95 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 0.028*** | 0.030*** | 0.031*** | 0.031*** | 0.031*** | 0.031*** | 0.033*** | 0.033*** | 0.034*** | 0.038*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) | (0.002) |
| malehead | -0.035*** | -0.023** | -0.029*** | -0.024** | -0.021* | -0.019* | -0.026** | -0.022* | -0.024 | -0.02 |
| | (0.011) | (0.011) | (0.011) | (0.011) | (0.011) | (0.011) | (0.012) | (0.013) | (0.015) | (0.019) |
| headmarried | 0.103*** | 0.084*** | 0.065*** | 0.046*** | 0.025** | 0.004 | -0.01 | -0.026** | -0.047*** | -0.081*** |
| | (0.011) | (0.011) | (0.011) | (0.011) | (0.010) | (0.011) | (0.012) | (0.012) | (0.014) | (0.018) |
| adultmale | 0.212*** | 0.207*** | 0.211*** | 0.204*** | 0.199*** | 0.205*** | 0.222*** | 0.217*** | 0.223*** | 0.211*** |
| | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) | (0.008) | (0.009) | (0.009) | (0.011) | (0.016) |
| adultfem | 0.235*** | 0.241*** | 0.236*** | 0.231*** | 0.222*** | 0.227*** | 0.223*** | 0.219*** | 0.225*** | 0.225*** |
| | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.009) | (0.010) | (0.011) | (0.015) |
| children03 | 0.140*** | 0.159*** | 0.165*** | 0.160*** | 0.144*** | 0.153*** | 0.166*** | 0.170*** | 0.163*** | 0.169*** |
| | (0.013) | (0.013) | (0.014) | (0.014) | (0.014) | (0.015) | (0.016) | (0.018) | (0.020) | (0.028) |
| children415 | 0.147*** | 0.141*** | 0.140*** | 0.135*** | 0.127*** | 0.121*** | 0.122*** | 0.116*** | 0.111*** | 0.113*** |
| | (0.006) | (0.006) | (0.006) | (0.006) | (0.006) | (0.007) | (0.008) | (0.008) | (0.010) | (0.013) |
| adult60 | 0.154*** | 0.168*** | 0.171*** | 0.170*** | 0.172*** | 0.184*** | 0.199*** | 0.200*** | 0.211*** | 0.238*** |
| | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) | (0.008) | (0.009) | (0.010) | (0.015) |
| t | 0.017 | 0.018 | 0.021* | 0.019 | 0.026** | 0.025* | 0.014 | 0.011 | 0.014 | -0.002 |
| | (0.012) | (0.012) | (0.013) | (0.012) | (0.013) | (0.013) | (0.014) | (0.015) | (0.017) | (0.021) |
| flodarea1 | 0.065*** | 0.071*** | 0.060*** | 0.042*** | 0.037*** | 0.027** | 0.011 | 0.013 | 0.02 | 0.022 |
| | (0.012) | (0.012) | (0.012) | (0.012) | (0.012) | (0.012) | (0.013) | (0.014) | (0.016) | (0.021) |
| c.t#c.flodarea1 | -0.118*** | -0.122*** | -0.109*** | -0.081*** | -0.079*** | -0.067*** | -0.063** | -0.03 | -0.059* | -0.036 |
| | (0.026) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.027) | (0.029) | (0.032) | (0.041) |
| Constant | 7.696*** | 7.742*** | 7.823*** | 7.918*** | 8.014*** | 8.083*** | 8.155*** | 8.263*** | 8.376*** | 8.544*** |
| | (0.014) | (0.013) | (0.013) | (0.012) | (0.012) | (0.013) | (0.014) | (0.016) | (0.019) | (0.028) |
| Observations | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 | 31,360 |
| R-squared | 0.277 | 0.278 | 0.268 | 0.26 | 0.245 | 0.229 | 0.206 | 0.181 | 0.15 | 0.1 |

*Note*: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*Source*: Calculated from NSO, Socio-economic Survey, 2011.

### 4.8. Quantile Regression Results on Household Income

Since some households do not have every type of income, the dependent variable is total income level. But we also ran a subset of households who have at least one member who is a wage employee, using the log of monthly wage as a dependent variable.

We ran one OLS and 20 quantile regressions, i.e., every five percentiles. In general, the results of income regressions are mixed and not satisfactory, i.e., some key variables are not statistically significant with unexpected signs, e.g., the flooded area dummy and the interaction dummy which measure the impact of flooding.

#### Regression results on income effect of floods

In the OLS specification, the flooded area dummy is significant in 4 out of 5 equations of different types of income, but with positive sign in two wage regressions (Table 12). The interaction dummy is not statistically significant in all OLS regressions, with negative sign in three regressions.

With regards to the quantile regressions on total money income in Figure 14-a and Table 12, the interaction dummy (t*s) is significant for the $30^{th}$, $35^{th}$, $40^{th}$, …, to $60^{th}$ , and $75^{th}$ to $95^{th}$ quintuple regressions. This means that the 2011 flood had relatively more negative impact on the middle class and very severe impact on the upper middle-income class.

Most of the impact comes from the reduction in wages and salaries of the upper middle-income households, i.e., the $50^{th}$, $80^{th}$, $85^{th}$ and $90^{th}$ quintuple regressions (Figure 14-b).

The interaction term is not statistically significant in any business profit regressions (Appendix Table A-1). It is significant with negative coefficients in four regressions on farm income, i.e., $15^{th}$, $35^{th}$, $55^{th}$ and $70^{th}$ (Appendix Table A-1). Figure 14-c plots the effect of floods on business profit.

All coefficients in the farm profit regressions are not statistically significant (not shown here). One drawback to the use of the 2011 Socio-economic Survey to measure the impact of floods on agricultural income is that the 2011 flood destroyed most, if not all, of the paddy output in the main crop which would be harvested in November and December. The use of regression to control for the socio-economic variables may not be able to capture the pure flood effect because the treatment groups, i.e., the affected farmers in the flat land of the Chao Phraya River basin, have rather different physical farm characteristics from the farmers in the controlled (non-flood areas) group. This issue will be resolved in the following section by using the data on farm households in two different years.

**Figure 14: Flood Effect on Household Income**

**a) Total money income**

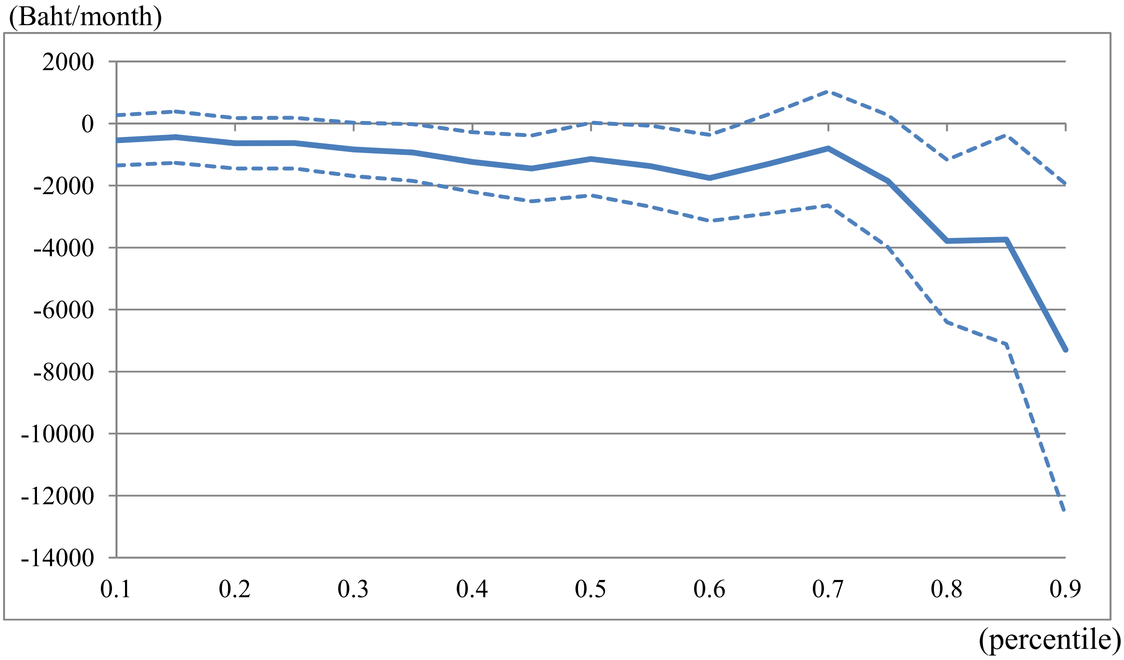
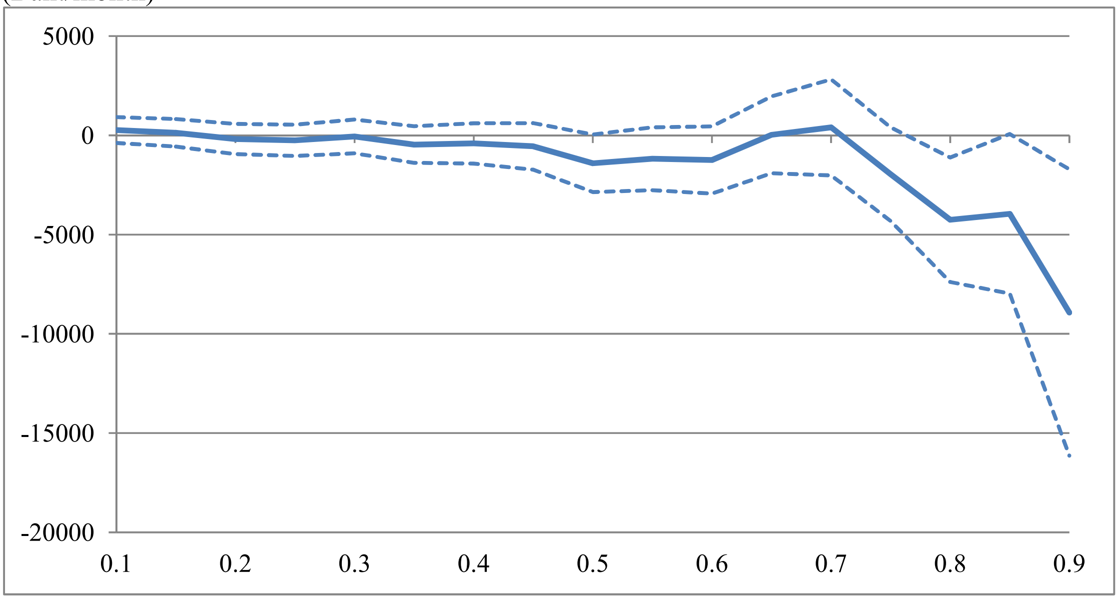


**Figure 14: Flood Effect on Household Income (cont.)**

**b) Wages and salaries**

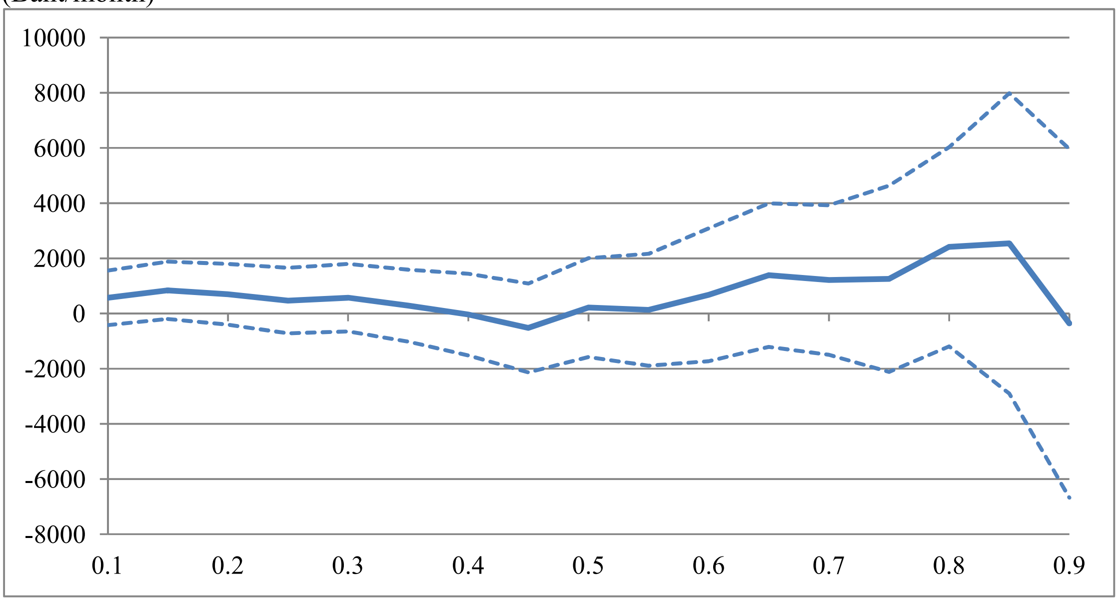
(Baht/month)




(percentile)

**c) Profit from business**

(Baht/month)




(percentile)

*Source*: Estimated from the quintile regressions of household income, wage and salary income (Tables 12 and 13) business profit (Appendix A-1) , using the 2011 Socio-economic Survey.

## Table 12: Flood Effect on Total Household's Money Income (Dependent variable in money income per month)

| VARIABLES | OLS | rif5 | rif10 | rif15 | rif20 | rif25 | rif30 | rif35 | rif40 | rif45 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 2,601.033*** | 166.356*** | 301.776*** | 438.830*** | 514.759*** | 610.272*** | 717.788*** | 832.265*** | 918.687*** | 1,075.344*** |
| | (178.214) | (11.559) | (12.029) | (12.904) | (12.918) | (13.150) | (14.004) | (15.048) | (15.963) | (18.018) |
| malehead | -1,612.022** | -782.757*** | -1,123.457*** | -1,083.902*** | -855.585*** | -693.414*** | -778.925*** | -687.462*** | -904.655*** | -865.735*** |
| | (691.253) | (134.219) | (161.962) | (177.764) | (178.525) | (179.074) | (185.630) | (197.865) | (209.070) | (233.177) |
| headmarried | 516.068 | -955.773*** | 247.901 | 411.742** | 395.638** | 423.185** | 662.083*** | 830.994*** | 1,087.738*** | 1,159.963*** |
| | (659.303) | (133.914) | (163.174) | (180.907) | (181.480) | (183.447) | (191.314) | (204.384) | (214.914) | (237.500) |
| adultmale | 7,771.800*** | 104.387 | 579.785*** | 1,344.052*** | 1,664.146*** | 2,033.532*** | 2,426.419*** | 2,810.832*** | 3,182.181*** | 3,731.362*** |
| | (782.590) | (77.649) | (87.586) | (94.290) | (96.801) | (100.388) | (105.611) | (114.632) | (122.389) | (137.997) |
| adultfem | 8,059.988*** | 73.458 | 793.094*** | 1,494.909*** | 1,987.480*** | 2,415.860*** | 2,825.218*** | 3,297.497*** | 3,603.764*** | 4,148.529*** |
| | (1,204.819) | (81.885) | (89.940) | (95.141) | (95.889) | (97.507) | (104.157) | (112.645) | (120.405) | (142.422) |
| children03 | -3,033.535*** | 245.43 | 472.173*** | 399.381** | 304.084* | 129.776 | 229.139 | -107.69 | -295.551 | -530.932** |
| | (833.362) | (154.907) | (147.183) | (170.317) | (175.191) | (189.951) | (200.661) | (218.026) | (232.727) | (259.271) |
| children415 | 28.415 | 19.229 | 443.243*** | 611.162*** | 706.615*** | 655.038*** | 513.782*** | 399.944*** | 300.968*** | 331.725*** |
| | (578.616) | (80.798) | (80.829) | (87.927) | (89.360) | (94.109) | (100.157) | (107.568) | (114.239) | (126.993) |
| adult60 | 8,453.124*** | 1,145.138*** | 246.431** | 289.293*** | 171.38 | 511.696*** | 746.378*** | 934.594*** | 1,258.387*** | 1,928.995*** |
| | (1,060.894) | (82.507) | (98.227) | (106.581) | (108.302) | (109.575) | (114.241) | (122.221) | (128.387) | (141.028) |
| t | 1,437.459* | 583.203*** | 165.23 | 86.083 | 271.086 | 231.477 | 234.663 | 161.908 | 337.492 | 419.924 |
| | (823.782) | (143.087) | (189.101) | (202.503) | (199.684) | (203.473) | (211.106) | (224.620) | (236.053) | (260.750) |
| flodarea1 | -1,386.252* | -420.332** | -235.079 | 238.55 | 565.897*** | 834.800*** | 1,063.760*** | 1,092.097*** | 1,098.681*** | 1,329.123*** |
| | (743.595) | (178.859) | (185.506) | (188.058) | (186.189) | (186.349) | (193.852) | (207.254) | (219.054) | (244.042) |
| c.t#c.flodarea1 | -1,486.32 | -1,192.548*** | -541.024 | -439.785 | -636.432 | -632.242 | -835.623* | -934.094** | -1,239.794** | -1,448.258*** |
| | (1,493.568) | (398.423) | (413.571) | (422.056) | (414.864) | (417.850) | (438.694) | (466.742) | (490.255) | (541.734) |
| Constant | -17,079.454*** | -472.240*** | -1,757.952*** | -3,087.183*** | -3,425.234*** | -3,954.030*** | -4,611.570*** | -5,204.522*** | -5,481.906*** | -6,897.172*** |
| | (2,634.886) | (179.527) | (241.024) | (256.094) | (251.720) | (246.883) | (247.229) | (253.484) | (258.708) | (276.704) |
| Observations | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 |
| R-squared | 0.068 | 0.027 | 0.042 | 0.092 | 0.133 | 0.168 | 0.2 | 0.223 | 0.235 | 0.248 |

## Table 12: Flood Effect on Total Household's Money Income (cont.)

| VARIABLES | rif50 | rif55 | rif60 | rif65 | rif70 | rif75 | rif80 | rif85 | rif90 | rif95 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 1,239.309*** | 1,447.310*** | 1,578.924*** | 1,842.871*** | 2,162.554*** | 2,644.234*** | 3,267.548*** | 3,901.613*** | 5,649.895*** | 6,492.830*** |
| | (20.010) | (22.454) | (24.408) | (28.716) | (34.736) | (44.879) | (63.662) | (87.796) | (159.521) | (283.708) |
| malehead | -866.840*** | -979.689*** | -1,103.551*** | -1,142.558*** | -1,315.425*** | -1,392.318*** | -1,389.151** | -2,528.684*** | -2,482.790* | -2,124.51 |
| | (257.990) | (282.290) | (299.672) | (338.716) | (391.073) | (479.019) | (625.349) | (802.755) | (1,311.969) | (2,039.063) |
| headmarried | 1,328.472*** | 1,312.204*** | 1,478.042*** | 1,286.974*** | 1,046.471*** | 565.458 | 226.79 | 351.409 | -284.98 | -909.92 |
| | (261.580) | (286.149) | (303.385) | (343.333) | (397.384) | (482.294) | (623.103) | (790.008) | (1,314.006) | (2,064.575) |
| adultmale | 4,185.651*** | 4,781.948*** | 4,825.763*** | 5,559.824*** | 5,894.378*** | 7,118.293*** | 8,551.235*** | 10,122.190*** | 14,146.749*** | 16,858.681*** |
| | (153.634) | (171.622) | (184.338) | (211.631) | (246.094) | (306.507) | (407.982) | (553.226) | (962.238) | (1,732.754) |
| adultfem | 4,710.407*** | 5,465.782*** | 5,592.435*** | 6,441.616*** | 7,254.604*** | 8,431.478*** | 10,123.128*** | 12,038.263*** | 16,502.679*** | 18,846.971*** |
| | (157.240) | (175.709) | (197.367) | (225.291) | (263.311) | (326.906) | (430.141) | (562.309) | (961.173) | (1,641.400) |
| children03 | -891.642*** | -981.100*** | -788.448** | -1,033.251*** | -1,184.752*** | -1,068.487* | -1,557.306** | -1,997.503** | -5,360.250*** | -10,132.886*** |
| | (286.983) | (320.202) | (344.749) | (393.064) | (450.368) | (561.252) | (721.587) | (931.232) | (1,494.938) | (2,156.605) |
| children415 | 288.290** | 219.941 | 111.274 | 1.884 | 158.635 | 367.649 | 571.445 | -533.522 | -1,013.91 | -2,794.150** |
| | (139.968) | (154.254) | (163.826) | (184.486) | (214.599) | (266.108) | (349.585) | (444.304) | (730.745) | (1,107.649) |
| adult60 | 2,295.111*** | 3,106.959*** | 3,613.271*** | 4,545.651*** | 5,792.090*** | 7,392.913*** | 9,561.745*** | 12,478.319*** | 19,059.324*** | 22,763.541*** |
| | (154.829) | (170.767) | (181.777) | (206.759) | (239.523) | (294.656) | (394.758) | (524.571) | (916.932) | (1,579.068) |
| t | 375.093 | 232.836 | 232.752 | 317.111 | 99.087 | 174.34 | 899.027 | 1,368.03 | 3,453.967** | 7,347.375*** |
| | (286.791) | (314.978) | (337.128) | (385.522) | (440.992) | (545.510) | (707.782) | (928.997) | (1,570.266) | (2,596.823) |
| flodarea1 | 1,422.754*** | 1,425.263*** | 1,319.974*** | 1,082.470*** | 463.698 | -537.652 | -1,066.46 | -1,553.171* | -3,302.300** | -5,636.062*** |
| | (271.273) | (304.137) | (322.971) | (370.529) | (429.922) | (526.729) | (675.388) | (860.884) | (1,365.175) | (2,055.344) |
| c.t#c.flodarea1 | -1,144.186* | -1,374.835** | -1,753.561** | -1,300.02 | -803.27 | -1,849.092* | -3,786.939*** | -3,740.769** | -7,293.960*** | -8,113.003* |
| | (598.106) | (667.063) | (708.107) | (816.989) | (940.066) | (1,085.930) | (1,336.315) | (1,720.657) | (2,728.850) | (4,402.806) |
| Constant | -7,701.619*** | -9,182.793*** | -8,538.819*** | -10,334.700*** | -11,534.327*** | -14,717.278*** | -18,934.794*** | -21,453.673*** | -34,279.352*** | -25,731.404*** |
| | (294.794) | (313.514) | (339.690) | (376.459) | (437.207) | (539.865) | (716.871) | (971.079) | (1,756.762) | (3,114.636) |
| Observations | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 | 31,390 |
| R-squared | 0.258 | 0.269 | 0.264 | 0.267 | 0.259 | 0.25 | 0.229 | 0.203 | 0.164 | 0.098 |

*Note*: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*Source*: Calculated from NSO, Socio-economic Survey, 2011.

### Table 13: Flood Effect on Total Household's Wage Income (Dependent variable is wage income)

| VARIABLES | OLS | rif5 | rif10 | rif15 | rif20 | rif25 | rif30 | rif35 | rif40 | rif45 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 2,359.878*** | 271.919*** | 306.250*** | 386.188*** | 454.389*** | 491.493*** | 564.285*** | 635.820*** | 746.628*** | 871.967*** |
| | (103.126) | (14.755) | (12.135) | (12.483) | (12.952) | (13.184) | (14.219) | (15.396) | (16.698) | (19.037) |
| malehead | -736.926 | 372.386* | 385.295** | 175.744 | 39.203 | 21.77 | -26.979 | -242.573 | -146.328 | -193.29 |
| | (617.098) | (214.523) | (176.010) | (179.034) | (180.952) | (183.600) | (197.876) | (211.041) | (229.304) | (257.458) |
| headmarried | 523.893 | -445.714** | -260.392 | -193.909 | -40.688 | 152.736 | 157.136 | 282.236 | 528.858** | 655.154** |
| | (670.571) | (214.693) | (177.640) | (181.905) | (183.701) | (187.210) | (200.894) | (213.638) | (233.032) | (261.171) |
| adultmale | 5,192.941*** | 1,139.720*** | 1,113.496*** | 1,224.516*** | 1,335.206*** | 1,384.808*** | 1,620.073*** | 1,623.412*** | 1,830.271*** | 2,264.693*** |
| | (573.647) | (109.109) | (91.726) | (97.610) | (100.547) | (102.287) | (112.062) | (124.942) | (136.085) | (152.365) |
| adultfem | 5,359.297*** | 1,080.051*** | 967.501*** | 1,109.270*** | 1,284.577*** | 1,416.495*** | 1,577.282*** | 1,718.307*** | 2,100.395*** | 2,405.973*** |
| | (612.470) | (104.905) | (86.196) | (90.572) | (95.819) | (97.635) | (107.529) | (132.415) | (143.691) | (161.426) |
| children03 | -2,740.179*** | 11.556 | -50.717 | -245.765 | -267.543 | -403.046* | -391.907* | -405.362* | -579.974** | -801.234*** |
| | (549.658) | (191.253) | (181.404) | (201.993) | (203.763) | (207.659) | (217.777) | (233.918) | (250.029) | (279.270) |
| children415 | -918.554*** | -141.193 | -4.787 | -131.878 | -317.484*** | -313.468*** | -310.649*** | -334.188*** | -338.738*** | -424.106*** |
| | (310.027) | (115.394) | (88.637) | (93.919) | (99.381) | (100.855) | (107.950) | (114.512) | (123.782) | (137.809) |
| adult60 | 5,995.122*** | -209.388 | -77.612 | 180.432 | 257.744** | 294.928** | 443.794*** | 603.136*** | 920.436*** | 1,275.540*** |
| | (624.530) | (142.765) | (113.190) | (115.868) | (117.540) | (119.460) | (127.407) | (133.597) | (143.112) | (159.541) |
| t | -658.603 | -855.835*** | -498.117** | -411.380* | -413.643* | -373.551* | -360.484 | -284.876 | -245.819 | -353.796 |
| | (660.760) | (277.736) | (205.782) | (212.715) | (214.556) | (217.068) | (228.234) | (242.026) | (261.572) | (293.959) |
| flodarea1 | 1,112.828* | 1,086.745*** | 1,144.643*** | 1,414.623*** | 1,528.846*** | 1,559.578*** | 1,597.551*** | 1,733.952*** | 1,897.410*** | 2,122.511*** |
| | (606.527) | (155.397) | (139.209) | (149.297) | (161.698) | (167.769) | (190.239) | (208.327) | (231.017) | (265.860) |
| c.t#c.flodarea1 | 158.263 | 543.711 | 264.851 | 126.522 | -186.933 | -248.912 | -55.073 | -465.367 | -407.175 | -556.326 |
| | (1,771.881) | (411.643) | (331.321) | (353.929) | (388.768) | (401.532) | (432.870) | (470.271) | (518.305) | (598.469) |
| Constant | -13,660.258*** | -1,855.801*** | -599.139** | -962.998*** | -1,093.324*** | -717.815*** | -802.801*** | -858.840*** | -1,956.990*** | -2,996.180*** |
| | (1,239.733) | (355.787) | (286.411) | (280.158) | (273.427) | (275.754) | (290.503) | (318.396) | (334.542) | (366.448) |
| Observations | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 |
| R-squared | 0.255 | 0.062 | 0.096 | 0.116 | 0.139 | 0.151 | 0.164 | 0.17 | 0.191 | 0.202 |

**Table 13: Flood Effect on Total Household's Wage Income (cont.)**

| VARIABLES | rif50 | rif55 | rif60 | rif65 | rif70 | rif75 | rif80 | rif85 | rif90 | rif95 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 1,128.895*** | 1,274.785*** | 1,420.258*** | 1,631.073*** | 2,045.992*** | 2,310.346*** | 3,288.445*** | 4,035.355*** | 6,627.008*** | 9,565.937*** |
| | (23.143) | (25.370) | (26.988) | (32.203) | (40.815) | (47.127) | (71.748) | (101.470) | (215.089) | (478.539) |
| malehead | -169.906 | -226.309 | -278.729 | -175.983 | -494.407 | -419.067 | -331.48 | -2,094.373** | -3,115.072* | -2,286.78 |
| | (312.314) | (332.634) | (347.973) | (388.613) | (473.554) | (519.248) | (732.017) | (948.145) | (1,815.705) | (3,461.169) |
| headmarried | 845.441*** | 868.361*** | 1,261.105*** | 643.473* | 800.040* | 113.6 | -129.63 | 363.309 | -1,023.69 | -388.769 |
| | (316.600) | (334.035) | (346.042) | (386.346) | (471.982) | (518.688) | (733.767) | (947.479) | (1,848.406) | (3,597.894) |
| adultmale | 2,951.771*** | 3,339.068*** | 3,312.543*** | 3,766.629*** | 4,399.786*** | 4,647.507*** | 5,985.892*** | 7,805.080*** | 11,827.516*** | 19,641.886*** |
| | (184.700) | (201.172) | (210.845) | (235.675) | (291.484) | (326.862) | (473.986) | (654.576) | (1,349.485) | (3,102.017) |
| adultfem | 3,192.167*** | 3,742.242*** | 3,966.880*** | 4,469.096*** | 5,286.477*** | 5,589.193*** | 7,434.637*** | 8,963.053*** | 14,404.545*** | 21,348.008*** |
| | (195.545) | (211.778) | (223.139) | (250.331) | (310.040) | (346.242) | (500.254) | (652.196) | (1,283.388) | (2,739.193) |
| children03 | -914.163*** | -1,219.807*** | -1,438.870*** | -1,915.028*** | -2,054.261*** | -2,422.000*** | -3,832.990*** | -4,194.018*** | -7,780.194*** | -13,588.242*** |
| | (339.904) | (370.043) | (385.522) | (424.635) | (515.134) | (544.808) | (740.140) | (934.066) | (1,666.703) | (3,212.438) |
| children415 | -521.967*** | -573.963*** | -626.320*** | -507.794** | -359.549 | -174.989 | -191.116 | -1,206.279** | -3,125.020*** | -5,364.226*** |
| | (164.646) | (175.558) | (183.688) | (205.908) | (255.182) | (281.381) | (403.983) | (514.464) | (955.535) | (1,981.023) |
| adult60 | 1,976.689*** | 2,443.734*** | 2,896.184*** | 3,271.430*** | 4,342.638*** | 5,242.528*** | 7,799.290*** | 10,207.195*** | 17,270.207*** | 27,123.456*** |
| | (192.470) | (207.146) | (218.984) | (253.695) | (311.561) | (343.755) | (493.709) | (656.480) | (1,311.378) | (2,822.208) |
| t | -488.228 | -354.725 | -233.379 | -486.639 | -717.047 | -1,008.846* | -632.185 | -560.219 | 593.63 | -1,705.01 |
| | (352.172) | (378.535) | (397.064) | (435.411) | (525.090) | (565.685) | (806.269) | (1,043.500) | (2,062.412) | (4,030.064) |
| flodarea1 | 2,732.406*** | 2,761.241*** | 2,530.639*** | 2,684.808*** | 2,643.344*** | 2,051.683*** | 1,656.580** | 1,488.66 | 1,360.13 | -4,460.33 |
| | (329.445) | (360.364) | (376.303) | (426.896) | (531.630) | (587.189) | (839.176) | (1,080.707) | (2,060.267) | (3,723.203) |
| c.t#c.flodarea1 | -1,406.372* | -1,182.31 | -1,244.86 | 27.85 | 401.75 | -1,955.34 | -4,255.118*** | -3,955.750* | -8,927.554** | -1,820.17 |
| | (738.822) | (808.869) | (863.164) | (986.699) | (1,233.768) | (1,205.229) | (1,599.277) | (2,050.184) | (3,681.917) | (7,133.437) |
| Constant | -5,431.782*** | -6,718.577*** | -6,722.888*** | -7,878.818*** | -11,019.166*** | -10,913.265*** | -19,128.517*** | -23,450.180*** | -46,130.065*** | -68,798.809*** |
| | (427.623) | (449.173) | (465.329) | (516.398) | (632.636) | (697.078) | (1,003.632) | (1,363.986) | (2,781.331) | (6,122.757) |
| Observations | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 | 16,293 |
| R-squared | 0.223 | 0.237 | 0.25 | 0.258 | 0.261 | 0.264 | 0.26 | 0.244 | 0.196 | 0.125 |

*Note*: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*Source*: Calculated from NSO, Socio-economic Survey, 2011.

## 4.9. Effect of Flood on Household Income and Expenditure: Comparing 2009 and 2011

The simple tabulation in Figure 15-(a) shows that the real net farm income (or farm profit) in the 2011- flood year was substantially lower than that in 2009, by more than 60%. Although the result does not yet control for the changes in prices of agricultural products and cultivated land, it implies that the 2011 flood had a severe impact on the farmers in the Lower Northern and Central provinces along the Chao Phraya river basin. The households' business income also declined by less than 7 % between 2009 and 2011 (Figure 15-b).

Figure 16 compares the real income of households in 2009 and 2011 in two periods, i.e., a twelve month period, and the three months of October to December. In general the fourth quarter income of households in the flooded areas declined more than their annual income. The fourth quarter real income of households in 19 flooded provinces declined by 11.4 % between 2009 and 2011. Surprisingly, household income in 26 provinces also declined, and by a larger percentage, i.e., 12.8%, despite the fact that flood in the Northeast was not as severe as that in the Central Plains. On the other hand, the income of households in the non-flooded provinces increased between 2009 and 2011.

Except for the annual expenditure of households in the non-flooded areas, household expenditures of those in both the flooded and non-flooded areas declined between 2009 and 2011, implying that the 2011 flood had a widespread impact on household expenditure throughout the country. The monthly household expenditures of households in the 19 flooded provinces in the fourth quarter declined by a larger percentage than their average monthly expenditures over twelve months (Figure 17). The average 12-month expenditures of households in the non-flooded provinces in 2011 were slightly higher than that in 2009. But their fourth quarter monthly expenditures declined by almost 3 % between 2009 and 2011 (Figure 17).

The above tabulation does not control for other factors affecting real farm income. The researchers therefore use quantile regressions based on the "difference-in-difference" approach to estimate the effect of the 2011 flood on farm profits in 2011, using the households' farm profit in 2009 and 2011. The rationale is that most agricultural outputs are harvested during October and December of every year. Therefore, the full impact of a flood can be measured only when one has complete information on annual farm income of the farm households in 2009 and can compare this with farm income in 2011. The results in Table 14 shows that the coefficients of the interaction between the time (flood period) and area (flooded areas) dummies are statistically significant with expected negative sign in only 6 regressions, i.e., 55th to 80th percentiles. The negative impact on farm profit of the middle income farmers is consistent with the estimated effect of floods on household expenditures of the middle income households. Another interesting variable is the flooded area dummy. The coefficients in all the regressions have the expected negative sign, but only nine out of 20 regressions are statistically significant. They are in the 5th to 45th percentiles (Table 14). The coefficients of time dummy (2011 equals 1) also have the expected negative sign in all regressions, but are statistically significant in 8 equations, i.e., from the 15th to the 75th percentile. The impact of floods on farm profit in 2011 relative to that in 2009 is calculated and shown in Figure 18.

Appendix Table A-2 also presents the estimates of flood impact on business profit in 2011 comparing to that in 2009. Although the results for all the flood variables have the expected negative sign, they are not significant, except the coefficient of interaction dummy (flooded area*flooded period) in two regressions.

**Figure 15-a: Flood Impact on Net Farm Income in 2011 Relative to that in 2009**

(Baht/month)

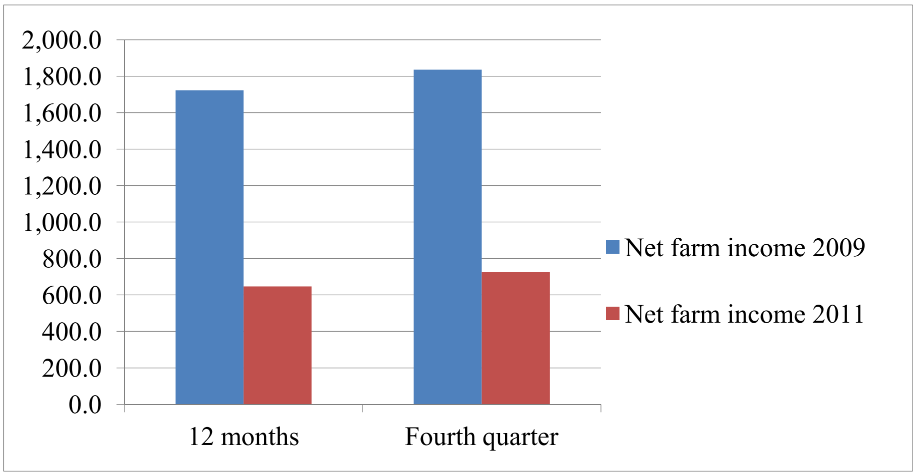
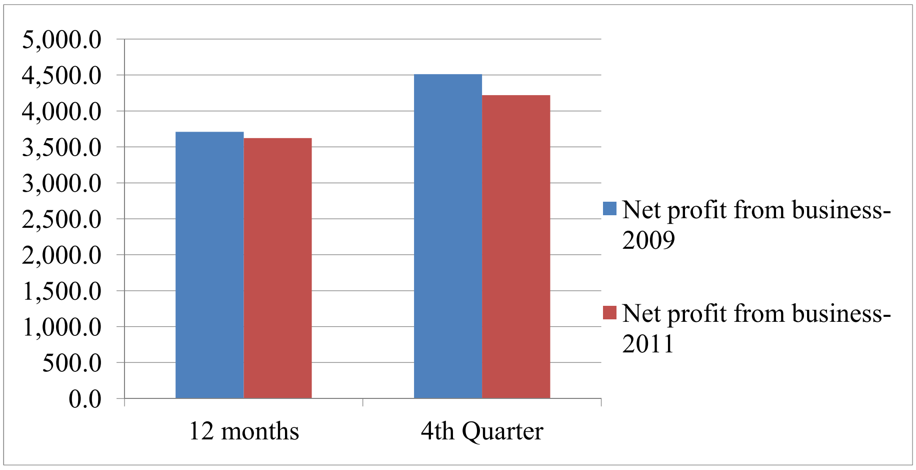


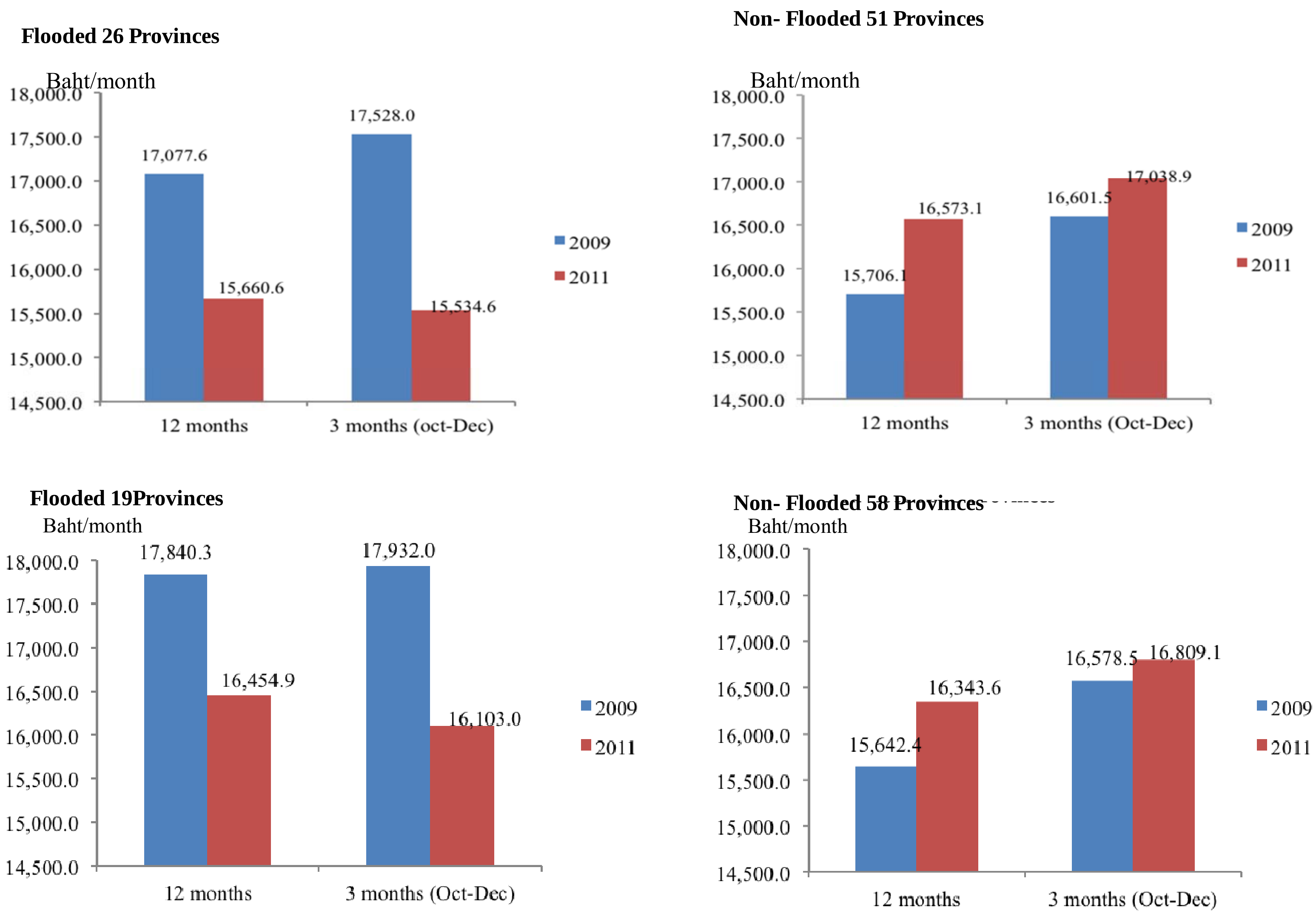
**Figure 15-b: Flood Impact on Business Profit in 2011 Relative to that in 2009**

(Baht/month)




*Note*: Baht 30.637 equal one USD.
*Source*: Calculated from NSO, SES 2009 and 2011.

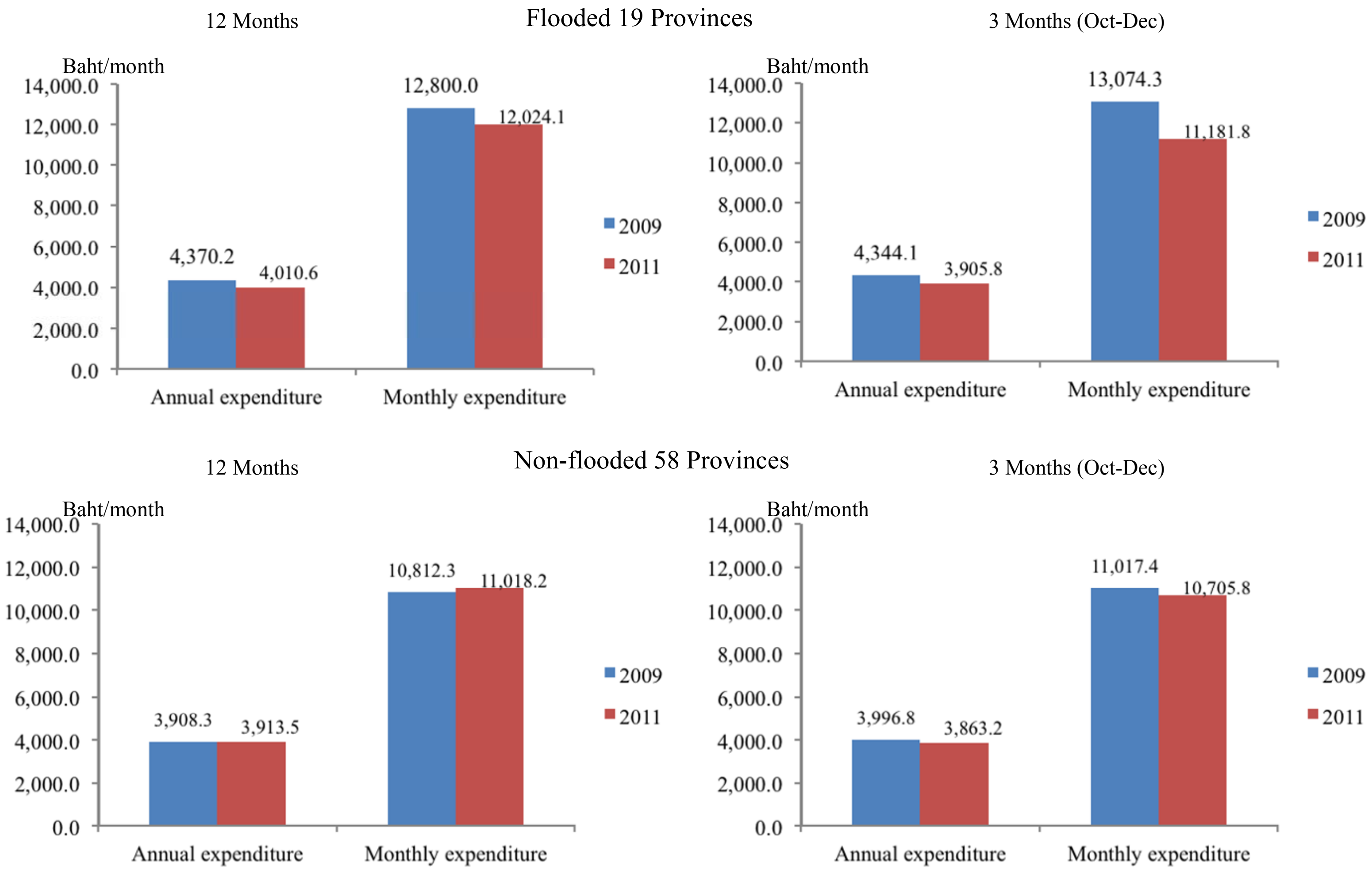
**Figure 16: Real Income of Households in 2009 and 2011 (2007 = 100)**




*Note:* Baht 30.637 equal one USD.

*Source*: Calculated from NSO, Socio-economic Survey, 2009 and 2011

**Figure 17: Real Expenditure of Households in 2009 and 2011 (2007 = 100)**




*Note*: Baht 30.637 equal one USD.
*Source*: Calculated from NSO, Socio-economic Survey,2009 and 2011.

## Table 14: Flood Effect on Total Household's Farm Profit in 2009, 2011(Dependent variable is farm profit)

| VARIABLES | OLS | rif5 | rif10 | rif15 | rif20 | rif25 | rif30 | rif35 | rif40 | rif45 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 1,264.915** | 436.105* | 46.057 | 81.373 | 159.105*** | 224.005*** | 329.927*** | 385.571*** | 397.658*** | 478.793*** |
| | (605.208) | (228.080) | (67.507) | (58.531) | (60.157) | (67.293) | (72.100) | (74.414) | (80.530) | (92.894) |
| malehead | 2,977.99 | -4,065.650* | 446.756 | -124.111 | 488.987 | 1,676.344** | 1,702.043** | 1,672.424** | 1,409.258* | 1,748.992** |
| | (2,519.451) | (2,129.393) | (712.102) | (671.987) | (712.846) | (735.020) | (734.010) | (748.987) | (778.264) | (856.623) |
| headmarried | -1,817.06 | 2,499.34 | -772.638 | 675.263 | 871.332 | 175.483 | 78.926 | -61.724 | -226.206 | -315.247 |
| | (3,268.974) | (2,914.557) | (789.427) | (801.197) | (821.075) | (807.822) | (793.174) | (811.967) | (845.517) | (950.367) |
| adultmale | -197.027 | -1,389.87 | -26.927 | 351.26 | 714.606** | 617.130* | 922.023*** | 1,050.130*** | 1,120.693*** | 1,243.165*** |
| | (1,484.726) | (1,215.500) | (352.153) | (295.289) | (319.798) | (341.646) | (347.051) | (356.339) | (384.126) | (431.135) |
| adultfem | 4,251.347** | -1,573.08 | -0.001 | 516.193 | 352.195 | 965.132** | 1,125.830*** | 1,255.584*** | 1,497.616*** | 1,595.872*** |
| | (1,934.675) | (1,404.780) | (399.353) | (397.033) | (406.644) | (410.551) | (425.322) | (440.867) | (465.007) | (529.563) |
| children03 | -2,095.78 | -113.57 | -191.284 | 307.204 | 501.498 | -208.29 | -815.976 | -556.438 | -642.781 | -169.02 |
| | (2,536.750) | (3,028.362) | (784.058) | (607.360) | (602.800) | (654.399) | (693.015) | (704.708) | (727.505) | (817.533) |
| children415 | 1,674.22 | 718.285 | 294.143 | 801.474*** | 1,197.882*** | 987.630*** | 638.958* | 558.840* | 744.562** | 596.382 |
| | (1,189.332) | (1,033.762) | (328.399) | (281.057) | (286.351) | (301.367) | (330.840) | (337.368) | (354.944) | (406.029) |
| adult60 | 1,900.95 | -999.91 | -570.393 | -348.916 | -316.727 | -49.83 | -28.735 | 90.717 | 327.011 | 310.843 |
| | (1,731.965) | (1,412.726) | (413.125) | (377.925) | (377.736) | (384.663) | (395.750) | (405.071) | (428.130) | (481.814) |
| t | -1,678.93 | 701.405 | 237.884 | 1,252.864** | 1,422.572** | 2,232.755*** | 1,820.585*** | 2,408.661*** | 2,608.219*** | 2,647.215*** |
| | (3,550.387) | (2,070.463) | (571.483) | (581.998) | (626.535) | (654.455) | (653.739) | (677.693) | (719.266) | (798.618) |
| flodarea1 | -8,857.085* | -21,097.093** | -7,021.029*** | -3,983.871** | -3,971.470** | -3,882.423** | -3,799.162*** | -2,992.452** | -3,616.446*** | -3,226.870** |
| | (5,065.984) | (10,017.855) | (2,243.694) | (1,736.352) | (1,688.745) | (1,509.448) | (1,417.530) | (1,424.224) | (1,394.089) | (1,501.769) |
| c.t#c.flodarea1 | 208.36 | 4,567.58 | 490.04 | -1,255.79 | -578.66 | -465.85 | -990.83 | -2,478.94 | -1,883.95 | -2,187.93 |
| | (6,094.346) | (11,303.364) | (2,653.337) | (2,059.501) | (1,982.608) | (1,817.660) | (1,720.391) | (1,719.575) | (1,701.610) | (1,836.080) |
| Constant | 5,180.98 | -3,141.55 | 358.23 | -1,730.03 | -2,933.309*** | -4,213.689*** | -3,845.599*** | -3,852.676*** | -3,723.597*** | -3,622.720*** |
| | (4,312.918) | (3,273.565) | (998.162) | (1,083.441) | (1,112.097) | (1,121.737) | (1,116.758) | (1,130.564) | (1,174.137) | (1,301.867) |
| Observations | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 |
| R-squared | 0.029 | 0.04 | 0.06 | 0.065 | 0.079 | 0.09 | 0.098 | 0.11 | 0.105 | 0.098 |

## Table 14: Flood Effect on Total Household's Farm Profit in 2009, 2011 (cont.)

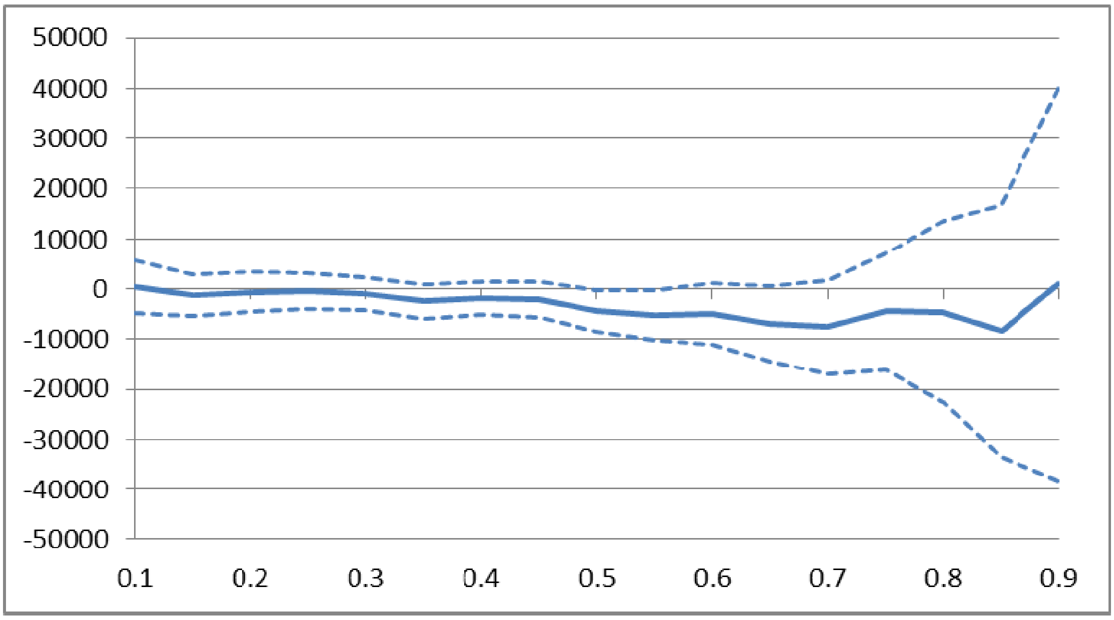
| VARIABLES | rif50 | rif55 | rif60 | rif65 | rif70 | rif75 | rif80 | rif85 | rif90 | rif95 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 614.699*** | 792.238*** | 1,082.802*** | 1,130.576*** | 1,354.177*** | 1,106.008** | 1,189.69 | 1,225.34 | 2,829.78 | 3,328.97 |
| | (111.293) | (144.579) | (193.485) | (256.622) | (336.097) | (452.288) | (747.172) | (1,057.739) | (1,770.621) | (2,523.388) |
| malehead | 2,593.010*** | 3,996.051*** | 4,293.527*** | 3,973.182** | 3,328.31 | 3,698.24 | 2,819.90 | 1,990.87 | 8,204.15 | 5,220.89 |
| | (979.884) | (1,222.090) | (1,562.891) | (1,941.123) | (2,348.170) | (2,975.701) | (4,620.966) | (6,332.883) | (10,069.103) | (12,145.892) |
| headmarried | -403.318 | -724.41 | -655.037 | 204.53 | 1,088.79 | 1,882.43 | 3,797.40 | 794.16 | -17,000.15 | -15,842.16 |
| | (1,090.617) | (1,356.204) | (1,741.028) | (2,172.328) | (2,665.948) | (3,399.883) | (5,176.986) | (7,325.842) | (12,656.446) | (15,998.476) |
| adultmale | 1,310.876** | 1,161.947* | 1,155.87 | 1,428.00 | 2,306.254* | 2,661.98 | 1,979.52 | -1,702.35 | -2,018.33 | -5,637.32 |
| | (515.658) | (657.687) | (862.738) | (1,065.002) | (1,355.734) | (1,788.574) | (2,621.847) | (3,006.478) | (4,512.428) | (5,836.926) |
| adultfem | 1,958.517*** | 1,811.008** | 2,391.643** | 2,604.698** | 2,335.27 | 4,351.610** | 7,086.892** | 7,859.243* | 15,178.389** | 18,221.667* |
| | (622.759) | (815.655) | (1,051.362) | (1,309.090) | (1,636.967) | (2,097.578) | (3,400.413) | (4,307.452) | (6,935.185) | (9,296.260) |
| children03 | -597.991 | -959.366 | -2,404.07 | -3,731.088** | -4,477.796* | -3,708.12 | -7,718.504* | -6,817.37 | -10,106.66 | -2,618.92 |
| | (950.677) | (1,199.917) | (1,523.531) | (1,846.616) | (2,286.080) | (2,942.638) | (4,520.705) | (5,981.098) | (9,378.844) | (12,045.688) |
| children415 | 675.595 | 1,455.673** | 1,818.458** | 1,702.945* | 2,156.126* | 3,363.202* | 6,573.760** | 7,456.937* | 8,557.37 | 3,810.70 |
| | (477.666) | (603.357) | (793.169) | (1,009.872) | (1,294.780) | (1,719.358) | (2,826.470) | (3,919.036) | (5,243.005) | (4,742.016) |
| adult60 | 584.711 | 811.462 | 952.254 | 650.588 | 847.06 | 844.98 | 558.95 | -614.28 | 2,352.94 | 8,845.28 |
| | (564.734) | (710.859) | (934.665) | (1,155.533) | (1,462.248) | (1,835.250) | (2,833.580) | (3,894.604) | (6,094.767) | (8,234.038) |
| t | 3,454.003*** | 4,137.008*** | 4,882.607*** | 5,655.532*** | 5,915.280** | 3,919.82 | 3,232.54 | 2,301.43 | -4,020.70 | -18,561.87 |
| | (935.478) | (1,185.755) | (1,548.059) | (1,922.823) | (2,446.310) | (3,209.193) | (5,103.727) | (6,970.535) | (11,228.551) | (15,344.416) |
| flodarea1 | -2,771.01 | -2,715.23 | -3,218.12 | -2,139.93 | -2,500.20 | -6,189.31 | -7,942.07 | -3,258.62 | -11,633.74 | -6,777.68 |
| | (1,718.691) | (2,102.178) | (2,590.264) | (3,213.371) | (4,050.799) | (4,821.884) | (7,598.690) | (10,681.557) | (16,494.296) | (22,860.246) |
| c.t#c.flodarea1 | -4,373.674** | -5,134.246** | -5,062.05 | -6,922.886* | -7,643.52 | -4,514.00 | -4,611.16 | -8,340.34 | 960.17 | 14,719.43 |
| | (2,056.134) | (2,515.438) | (3,118.586) | (3,856.616) | (4,831.085) | (5,865.569) | (9,276.700) | (12,796.969) | (19,982.814) | (28,282.853) |
| Constant | -4,693.931*** | -5,548.246*** | -6,731.189*** | -5,845.011** | -4,994.02 | -2,797.41 | -1,316.78 | 13,754.21 | 24,278.02 | 50,739.712** |
| | (1,486.848) | (1,844.161) | (2,388.509) | (2,951.684) | (3,735.755) | (4,767.591) | (7,467.826) | (10,074.274) | (15,796.039) | (21,546.685) |
| Observations | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 | 1,689 |
| R-squared | 0.111 | 0.105 | 0.096 | 0.076 | 0.065 | 0.047 | 0.037 | 0.021 | 0.022 | 0.019 |

*Note*: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*Source*: Calculated from NSO, Socio-economic Survey, 2011.

**Figure 18: Flood Effect on Farm Profit in 2011 Relative to that in 2009**

(Baht/month)




*Source*: Calculated from Table 14.

## 5. Conclusion and Policy Implications

The objectives of this study are threefold: to describe the causes of Thailand's 2011 flood, and the government's response; to revise the World Bank's estimated agricultural loss; and to estimate the impact of the 2011 flood on household expenditure and income, using the "difference-in-difference" method.

The 2011 flood -the biggest and worst flood in Thailand's modern history- resulted in total damage and loss of USD46.5 billion. It was caused by the highest recorded rainfall, including 5 tropical storms which were concentrated in a short period of 106 days in the mid rainy season. But man-made mistakes worsened the situation, particularly the unregulated changes in land-use pattern and flood mismanagement. Political pressure has forced the government to allocate USD 11.29 billion for assistance of, and compensation to flood victims, restoration of damaged property, and flood management action plans, under a comprehensive flood management master plan, all of which were drafted in relatively few months following the flood.

This chapter revises the World Bank's estimates of agricultural loss, using satellite radar images which allow researchers to identify districts (and sub-districts or "tambons") that were flooded for at least two consecutive weeks. The revised estimates of loss are lower than those of the World Bank. This is because the World Bank estimates were based solely on the size of farm lands that were flooded, without taking into account the flood's duration. Using the two-week duration of flood from the satellite images, the study also argues that the MOAC reported loss of agricultural output might be too high, thanks to the moral hazard of farmers' self-reports that were filed for compensation from the government. Compensation for farmers accounted for most (49%) of the government compensation for households. But our estimates also suffer from the problem of outdated information on agricultural land use, which recently has rapidly been taken up by non-agricultural uses, particularly in some rapidly developed provinces.

Finally, the study develops the "difference-in difference" method to estimate the impact of the flood on expenditure and income of households in 26 flooded provinces. Since the 2011 Socio-economic Survey did not contain questions regarding the impact of floods, the researchers have had to identify households that were affected by the flood in the fourth quarter of 2011. Thanks to the satellite radar images, the households in the flooded sub-districts (tambons) can be matched with the flooded areas in the satellite images. The estimated results confirm that the 2011 flood had a significant negative impact on expenditures of not only households in the flooded provinces but also those in non-flooded areas, indicating the inter-dependence between families in the flooded areas and those in non-flooded areas. One explanation is that the 2011 flood seriously affected Bangkok and its vicinity, which are the main economic activity zones of the country, where workers from every province come to work. When their income declined significantly, their families in the non-flooded areas received smaller repatriation income and thus had to reduce their expenditures. The study also finds that the 2011 flood had a negative impact on money income and wage income of households in the flooded areas. The results for business income are not statistically significant. Using the Socio-economic Survey in 2009 and 2011, the study also finds that the 2011 flood had a large negative impact on the farm profits of households in the flooded provinces.

One interesting finding is that the 2011 flood had relatively more impact on the expenditures and incomes of middle income households than other income classes, thus explaining why the government paid billions of baht for compensation, has been very active in formulating the flood management master plan, and plans to spend more almost $17 billion in the coming years.

Finally, the study finds several weaknesses in the current information for flood management. (a) Despite the huge volume of information on the impact of flooding on output and damage to property, as reported by millions of flooded citizens, no government agency has paid attention to computerizing the flood data-base and information system and strengthening the capability of their information centers. As a result, valuable individual data have been discarded and were not brought into use for the policy making process.

(b) GISTDA still lacks some crucial information on flooding that will allow users to measure the true impact of a flood. Two important areas need to be urgently implemented. These are the construction of a digital elevation map, and investment in ground truthing activities to validate the information from satellite images. Some of the most important information urgently needed includes updated land-use patterns and the digitization of village boundaries. There is additionally a need to explore the possibility of using new techniques to identify and measure flooding in the cities.

The following are some policy recommendations. First, the capability of statistical agencies and agencies that are responsible for flood management should be urgently strengthened in the following areas: data collection, data base development, data processing and reporting using IT, and human resource development. Secondly, these agencies should be encouraged to communicate and exchange information and ideas with data users.

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# Appendix

## Table A-1: Flood Effect on Total Household's Business Profit in 2009, 2011 (Dependent variable is household's business profit)

| VARIABLES | OLS | rif5 | rif10 | rif15 | rif20 | rif25 | rif30 | rif35 | rif40 | rif45 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 1,393.003*** | 96.554*** | 112.587*** | 158.260*** | 159.967*** | 214.073*** | 233.358*** | 279.959*** | 328.499*** | 410.923*** |
| | (220.479) | (28.524) | (32.729) | (34.294) | (36.083) | (38.592) | (41.143) | (42.439) | (45.255) | (48.991) |
| malehead | -466.43 | 401.141 | 341.557 | 263.332 | 332.082 | 273.182 | 583.257 | 36.789 | 210.423 | 60.258 |
| | (2,695.472) | (495.827) | (472.146) | (462.244) | (451.652) | (457.633) | (470.047) | (487.735) | (511.974) | (550.582) |
| headmarried | 4,982.308* | -229.057 | 342.489 | 33.97 | 579.38 | 664.176 | 801.139 | 1,365.318** | 1,675.672*** | 1,507.781** |
| | (2,767.904) | (483.583) | (491.658) | (486.759) | (487.945) | (494.153) | (505.011) | (530.574) | (554.677) | (589.900) |
| adultmale | 3,150.567*** | 232.495 | 400.255** | 523.980*** | 673.105*** | 704.179*** | 646.160*** | 834.367*** | 922.150*** | 1,042.665*** |
| | (1,171.139) | (200.398) | (202.095) | (198.456) | (198.386) | (214.050) | (235.348) | (249.878) | (270.507) | (298.232) |
| adultfem | 1,212.35 | 856.572*** | 804.651*** | 1,034.425*** | 1,051.828*** | 1,101.294*** | 959.472*** | 1,000.019*** | 1,256.463*** | 1,091.528*** |
| | (1,813.278) | (234.485) | (224.741) | (219.894) | (218.872) | (226.999) | (244.354) | (258.913) | (274.264) | (301.860) |
| children03 | -2,293.42 | -588.226 | -590.008 | -567.937 | -743.856* | -562.378 | -456.313 | -323.145 | -716.804 | -527.468 |
| | (1,653.711) | (443.706) | (438.099) | (423.248) | (429.574) | (444.349) | (463.494) | (481.583) | (533.205) | (579.760) |
| children415 | -327.389 | -133.631 | -195.797 | -166.516 | -321.298 | -294.42 | -173.761 | -201.758 | -177.281 | -120.049 |
| | (1,169.230) | (201.966) | (188.607) | (215.514) | (214.971) | (230.055) | (232.719) | (242.525) | (257.769) | (275.761) |
| adult60 | 2,538.87 | -836.941*** | -946.892*** | -968.932*** | -1,015.096*** | -887.239*** | -1,026.494*** | -791.996** | -585.856* | -676.940* |
| | (1,724.363) | (241.441) | (256.941) | (267.638) | (270.557) | (279.246) | (298.664) | (309.979) | (328.202) | (357.019) |
| t | -334.652 | -587.811* | -349.834 | -752.719** | -216.584 | -126.964 | -822.686** | -889.940** | -963.675** | -685.551 |
| | (1,782.536) | (351.483) | (360.695) | (361.484) | (377.729) | (399.277) | (417.182) | (433.497) | (463.485) | (505.479) |
| flodarea1 | 1,902.13 | 257.223 | 247.335 | 158.399 | 722.684 | 929.343* | 807.57 | 388.093 | 831.207 | 1,573.028** |
| | (2,651.200) | (327.738) | (410.098) | (430.666) | (445.194) | (477.532) | (505.588) | (557.337) | (605.256) | (672.918) |
| c.t#c.flodarea1 | 3,573.67 | 576.132 | 472.09 | 923.276 | -20.301 | -734.463 | -235.694 | -270.709 | -506.447 | -1,768.304* |
| | (7,241.631) | (591.768) | (641.411) | (677.735) | (693.276) | (742.796) | (775.165) | (849.524) | (901.281) | (987.828) |
| Constant | -666.78 | 110.173 | 542.186 | 1,261.936** | 1,447.223** | 1,542.596** | 2,476.164*** | 2,754.488*** | 2,744.561*** | 3,165.717*** |
| | (2,807.874) | (637.768) | (662.863) | (625.446) | (651.071) | (686.650) | (722.151) | (738.444) | (779.206) | (834.950) |
| Observations | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 |
| R-squared | 0.015 | 0.036 | 0.041 | 0.053 | 0.058 | 0.06 | 0.065 | 0.068 | 0.075 | 0.076 |

**Table A-1: Flood Effect on Total Household's Business Profit in 2009, 2011 (cont.)**

| VARIABLES | rif50 | rif55 | rif60 | rif65 | rif70 | rif75 | rif80 | rif85 | rif90 | rif95 |
|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 492.898*** | 647.323*** | 767.467*** | 836.493*** | 847.724*** | 1,120.722*** | 1,219.233*** | 1,552.926*** | 2,228.049*** | 6,137.706*** |
| | (52.113) | (62.890) | (75.852) | (82.034) | (89.780) | (127.664) | (145.741) | (181.335) | (317.096) | (1,023.550) |
| malehead | 280.385 | 513.896 | 853.053 | 101.345 | -299.708 | -311.83 | -106.56 | -478.75 | -1,174.42 | -6,617.25 |
| | (576.822) | (683.839) | (801.506) | (838.931) | (907.119) | (1,255.317) | (1,403.849) | (1,701.840) | (2,800.549) | (8,643.603) |
| headmarried | 1,385.944** | 2,142.999*** | 2,525.807*** | 3,320.821*** | 3,322.135*** | 3,425.072*** | 3,128.824** | 3,275.326** | 3,226.38 | 15,564.040** |
| | (616.188) | (718.612) | (837.148) | (855.039) | (920.547) | (1,267.065) | (1,418.540) | (1,635.598) | (2,684.213) | (7,883.914) |
| adultmale | 1,541.421*** | 1,906.198*** | 2,389.268*** | 2,317.403*** | 2,401.784*** | 3,306.422*** | 3,326.970*** | 4,621.746*** | 6,275.712*** | 17,073.464*** |
| | (315.739) | (377.525) | (447.980) | (481.845) | (535.343) | (768.075) | (898.710) | (1,182.378) | (2,023.268) | (5,355.287) |
| adultfem | 1,174.705*** | 1,491.900*** | 1,946.428*** | 2,178.605*** | 2,478.758*** | 3,884.892*** | 4,257.461*** | 4,637.939*** | 7,577.311*** | 7,710.07 |
| | (315.230) | (378.621) | (450.781) | (482.308) | (533.848) | (764.605) | (906.857) | (1,235.911) | (2,279.645) | (5,391.501) |
| children03 | -487.663 | -977.834 | -1,180.72 | -1,491.16 | -1,232.39 | -1,193.50 | -703.728 | 810.358 | -153.46 | -1,655.09 |
| | (625.856) | (748.555) | (895.388) | (963.704) | (1,051.955) | (1,498.834) | (1,683.314) | (2,110.520) | (3,704.825) | (9,763.440) |
| children415 | -221.298 | -218.374 | -182.074 | -121.597 | 135.706 | 5.204 | -69.624 | -282.775 | 552.024 | 1,471.89 |
| | (287.659) | (343.521) | (403.497) | (427.478) | (468.562) | (652.362) | (718.177) | (902.182) | (1,547.062) | (4,754.876) |
| adult60 | -644.434* | -865.132** | -688.765 | -411.248 | -199.297 | 31.959 | 983.313 | 2,792.282** | 5,364.513*** | 13,000.359** |
| | (371.720) | (440.862) | (505.931) | (516.745) | (557.242) | (767.535) | (869.825) | (1,099.775) | (1,897.524) | (6,217.280) |
| t | -1,235.387** | -1,150.172* | -1,156.29 | -1,292.56 | -1,502.642* | -2,727.027** | -2,935.288** | -1,247.21 | 557.191 | 3,673.65 |
| | (536.459) | (639.768) | (758.896) | (796.541) | (862.446) | (1,218.597) | (1,374.824) | (1,675.460) | (2,780.541) | (7,989.081) |
| flodarea1 | 1,447.637* | 2,458.470*** | 2,953.804*** | 3,119.355*** | 2,693.991** | 2,614.51 | 2,742.97 | 5,438.703* | 3,917.11 | 7,010.19 |
| | (741.757) | (899.301) | (1,110.324) | (1,209.761) | (1,361.146) | (1,934.879) | (2,229.982) | (2,815.213) | (4,550.012) | (13,655.054) |
| c.t#c.flodarea1 | -856.594 | -1,923.25 | -2,040.01 | -2,319.60 | -2,184.03 | -1,950.72 | -1,425.80 | -5,690.02 | -5,022.89 | -7,692.92 |
| | (1,068.079) | (1,284.049) | (1,547.880) | (1,650.949) | (1,802.827) | (2,521.776) | (2,883.149) | (3,584.924) | (6,016.096) | (18,349.805) |
| Constant | 2,783.425*** | 1,653.731* | 728.432 | 1,720.74 | 2,496.085** | 1,664.65 | 3,106.90 | 573.49 | -4,509.51 | -36,767.987*** |
| | (847.511) | (984.938) | (1,142.022) | (1,176.071) | (1,251.404) | (1,768.860) | (1,989.470) | (2,402.659) | (4,188.466) | (11,648.178) |
| Observations | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 | 4,113 |
| R-squared | 0.094 | 0.109 | 0.11 | 0.108 | 0.098 | 0.091 | 0.08 | 0.075 | 0.052 | 0.037 |

*Note:* Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

*Source*: Calculated from NSO, Socio-economic Survey, 2011.

## Appendix A-2: Regressions of Business Profits in 2009, 2011 (Dependent variable is household's business profit)

| VARIABLES | OLS | rif5 | rif10 | rif15 | rif20 | rif25 | rif30 | rif35 | rif40 | rif45 | rif50 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| headsch | 1,444.767*** | 95.149*** | 138.896*** | 126.397*** | 218.618*** | 279.800*** | 323.968*** | 386.109*** | 476.515*** | 547.685*** | 677.759*** |
| | -242.488 | -31.081 | -33.073 | -34.115 | -38.965 | -40.576 | -42.829 | -45.528 | -49.617 | -55.032 | -63.796 |
| malehead | 109.744 | -210.653 | -8.281 | 127.592 | -337.168 | -216.275 | -160.995 | -255.845 | 39.072 | 84.616 | 397.791 |
| | -3,081.84 | -377.776 | -426.414 | -409.155 | -417.168 | -443.641 | -481.435 | -519.639 | -563.663 | -624.521 | -715.588 |
| headmarried | 5,320.392* | 148.406 | 481.416 | 808.574* | 833.764* | 811.702* | 1,384.226*** | 1,798.655*** | 1,929.581*** | 1,655.899** | 2,290.510*** |
| | -3,075.48 | -362.768 | -452.375 | -452.591 | -454.594 | -481.387 | -520.436 | -556.965 | -591.852 | -649.969 | -740.788 |
| adultmale | 2,897.262** | 435.592** | 506.640** | 501.505** | 806.544*** | 701.582*** | 585.716** | 567.699** | 737.160** | 1,240.359*** | 1,225.860*** |
| | -1,449.61 | -216.105 | -203.109 | -199.896 | -208.506 | -224.075 | -261.333 | -284.392 | -311.358 | -344.393 | -393.567 |
| *adultfem* | *3,192.643*** | *447.257** | *720.745**** | *828.325**** | *837.407**** | *1,053.406**** | *1,143.801**** | *1,482.319**** | *1,690.815**** | *1,613.355**** | *1,937.648**** |
| | -1,393.87 | -231.532 | -218.922 | -219.622 | -226.869 | -240.666 | -260.341 | -279.467 | -310.395 | -347.186 | -400.283 |
| children03 | -1,847.76 | -742.336 | -248.959 | -247.052 | -83.967 | -178.096 | -62.563 | -173.061 | -44.98 | -90.187 | -693.078 |
| | -2,011.13 | -565.659 | -457.08 | -437.886 | -443.342 | -481.394 | -507.917 | -552.802 | -616.543 | -700.352 | -800.91 |
| children415 | 400.427 | 11.415 | -56.008 | -331.042* | -485.137** | -350.476 | -347.341 | -221.434 | -582.233** | -369.139 | -363.681 |
| | -1,446.66 | -187.093 | -192.492 | -199.856 | -209.879 | -237.455 | -248.554 | -269.675 | -288.27 | -321.046 | -366.829 |
| adult60 | 4,999.068*** | -1,018.313*** | -1,129.085*** | -1,253.238*** | -764.232** | -796.905*** | -942.865*** | -755.381** | -803.471** | -534.183 | -915.871* |
| | -1,867.83 | -294.32 | -300.463 | -292.558 | -297.732 | -308.406 | -331.936 | -352.281 | -387.704 | -422.293 | -479.862 |
| t | 2,411.08 | 142.176 | 78.118 | 606.771 | 126.382 | -182.443 | -281.876 | -648.987 | -597.425 | -173.562 | -161.376 |
| | -2,226.60 | -397.699 | -393.383 | -385.559 | -409.429 | -431.03 | -456.501 | -485.401 | -524.466 | -576.015 | -660.968 |
| flod2wk | -701.64 | -47.139 | -396.923 | -50.272 | -387.455 | -190.939 | -642.404 | -1,050.75 | -492.931 | -554.655 | 56.489 |
| | -2,969.35 | -516.066 | -566.554 | -547.469 | -573.619 | -587.031 | -642.85 | -699.084 | -755.463 | -847.007 | -975.127 |
| c.t#c.flod2wk* | -306.34 | 639.422 | 1,003.75 | 579.54 | 875.799 | 992.50 | 1,516.387* | 1,778.884* | 865.86 | 933.92 | 151.67 |
| | -4,372.32 | -697.728 | -768.429 | -744.966 | -810.968 | -845.806 | -901.454 | -1,040.24 | -1,114.39 | -1,245.36 | -1,436.85 |
| Constant | -5,057.672* | 486.062 | 608.619 | 1,329.382** | 1,480.790** | 1,672.629** | 1,961.682*** | 1,877.322** | 1,656.720* | 1,299.92 | 877 |
| | -3,039.78 | -587.809 | -635.282 | -627.645 | -650.368 | -715.297 | -758.308 | -805.26 | -862.324 | -930.50 | -1,055.91 |
| | | | | | | | | | | | |
| Observations | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 |
| R-squared | 0.017 | 0.028 | 0.044 | 0.052 | 0.053 | 0.062 | 0.072 | 0.081 | 0.097 | 0.094 | 0.107 |

*Note*: * c.t#c.flod2wk is an interaction dummy variable between t and flod2wk.

*Source*: Calculated from NSO, SES 2011

## Appendix A-2: Regressions of Business Profits in 2009, 2011 (cont.)

| VARIABLES | rif55 | rif60 | rif65 | rif70 | rif75 | rif80 | rif85 | rif90 | rif95 |
|---|---|---|---|---|---|---|---|---|---|
| headsch | 822.857*** | 874.206*** | 943.872*** | 1,077.997*** | 1,040.973*** | 1,110.912*** | 1,682.416*** | 2,747.259*** | 11,978.189*** |
| | -74.411 | -82.93 | -91.989 | -119.877 | -128.558 | -141.147 | -218.485 | -388.809 | -2,173.09 |
| malehead | 610.24 | 331.835 | -385.878 | 587.58 | 905.20 | 1,595.38 | 2,233.63 | 883.00 | -8,957.93 |
| | -826.433 | -894.181 | -985.479 | -1,244.91 | -1,304.20 | -1,434.47 | -2,161.45 | -3,625.39 | -19,182.49 |
| headmarried | 2,671.781*** | 3,384.688*** | 3,370.647*** | 3,181.828** | 3,823.113*** | 3,143.404** | 4,211.667** | 5,877.261* | 38,470.915** |
| | -851.496 | -902.848 | -988.012 | -1,246.66 | -1,287.66 | -1,412.61 | -2,012.62 | -3,282.59 | -16,693.57 |
| adultmale | 1,667.278*** | 1,822.067*** | 1,909.273*** | 2,755.858*** | 1,889.679** | 2,663.755*** | 3,460.546** | 3,315.40 | 27,504.179** |
| | -449.799 | -505.493 | -565.312 | -737.515 | -787.793 | -895.289 | -1,454.11 | -2,140.73 | -10,735.29 |
| adultfem | 2,431.849*** | 2,932.047*** | 3,219.124*** | 4,013.541*** | 4,935.102*** | 4,992.175*** | 6,977.535*** | 11,455.305*** | 14,475.08 |
| | -463.208 | -510.207 | -574.574 | -747.253 | -801.053 | -937.13 | -1,569.65 | -2,923.15 | -11,259.58 |
| children03 | -968.551 | -1,237.04 | -1,177.48 | -1,749.27 | -905.36 | 59.00 | 349.71 | -1,183.86 | 11,883.67 |
| | -935.088 | -1,042.98 | -1,146.41 | -1,478.83 | -1,582.20 | -1,777.81 | -2,601.31 | -4,553.21 | -22,526.63 |
| children415 | -266.5 | -148.898 | 116.949 | -63.512 | 1.873 | -304.34 | -338.561 | -150.84 | 9,215.69 |
| | -417.844 | -461.25 | -513.513 | -662.698 | -686.637 | -753.72 | -1,192.47 | -2,000.35 | -11,012.19 |
| adult60 | -762.08 | -401.477 | 70.187 | 133.382 | 1,059.30 | 1,956.034** | 3,490.323** | 6,284.936** | 40,211.567*** |
| | -528.932 | -555.671 | -610.675 | -789.448 | -844.195 | -948.801 | -1,472.58 | -2,544.96 | -15,231.41 |
| t | -559.30 | 298.66 | 216.54 | -209.847 | -1,205.32 | -530.46 | 1,542.83 | 4,042.96 | 20,281.28 |
| | -755.673 | -818.01 | -892.523 | -1,147.20 | -1,211.77 | -1,348.16 | -2,071.39 | -3,532.93 | -19,060.74 |
| flod2wk | 208.037 | 566.063 | 454.194 | -610.21 | -1,922.24 | -945.46 | 38.475 | -2,292.76 | -20,429.22 |
| | -1,142.50 | -1,246.86 | -1,368.56 | -1,722.99 | -1,721.56 | -1,897.64 | -2,930.45 | -4,668.99 | -21,201.43 |
| c.t#c.flod2wk | 633.94 | 563.51 | -899.39 | 365.33 | 2,549.83 | 1,143.83 | -1,527.62 | -3,814.17 | -11,811.09 |
| | -1,677.88 | -1,842.91 | -1,987.84 | -2,518.45 | -2,589.05 | -2,749.02 | -4,199.03 | -6,225.76 | -29,220.95 |
| Constant | -63.00 | -579.18 | -148.87 | -336.33 | 1,638.91 | 2,454.86 | -3,629.61 | -11,854.070** | -133,574.365*** |
| | -1,168.19 | -1,222.94 | -1,315.35 | -1,688.54 | -1,765.70 | -1,982.03 | -2,974.03 | -5,360.82 | -26,470.71 |
| | | | | | | | | | |
| Observations | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 | 3,806 |
| R-squared | 0.117 | 0.115 | 0.105 | 0.094 | 0.087 | 0.082 | 0.073 | 0.063 | 0.044 |

*Note*: * c.t#c.flod2wk is an interaction dummy variable between t and flod2wk.

*Source*: Calculated from NSO, Socio-economic Survey 2011.

# CHAPTER 9

# Impact of Recent Crises and Disasters on Regional Production/Distribution Networks and Trade in Japan

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*This chapter sheds light on domestic/international production networks in machinery industries and examines how the economic crisis and natural/technological disaster that Japan encountered in recent years affected the networks and trade, mainly from the viewpoint of Japan's exports. More specifically, the chapter first decomposes changes in machinery exports into extensive and intensive margins and then examines the probability of trade declines and recoveries, using a logit estimation, in order to capture the natures of international production/distribution networks under the crises, i.e., the 2008-2009 Global Financial Crisis (GFC) and the 2011 Great East Japan Earthquake (EJE). Discussion is also presented focusing on domestic activities as well as the impacts of the 2011 Thailand floods. Moreover, considering that the 2011 EJE is not only a natural disaster but also a technological disaster that seriously affected Japan's agriculture and food exports, the impacts on their exports are investigated as well. Our analyses suggest that, regardless of whether demand shock or supply shock, the economic/natural disasters revealed the stability and robustness of production networks in machinery sectors, though their negative impacts are severe and transmitted through production networks at the beginning. At the same time, our analyses draw various policy implications from the experiences of these crises.*

**Keywords**: International production/distribution networks, Economic crisis and natural/technological disaster, Japan

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## 1. Introduction

Japan has recently encountered several crises and disasters. First, Japan faced a worldwide economic crisis, namely the 2008-2009 Global Financial Crisis (GFC) that primarily started as a demand shock due to drastic falls in demand in the US and EU markets. The 2008-2009 GFC seriously affected the world economy including Japan and other East Asian countries, as well as international production/distribution networks, mainly in machinery industries in the region. Second, Japan experienced a natural and technological disaster in March 2011, i.e., the 2011 Great East Japan Earthquake (EJE). The 2011 EJE brought about a supply shock due to the devastation of production plants located in the disaster areas caused by the tsunami, and had negative impacts on domestic/international production networks. Moreover, the 2011 EJE was not a simple natural disaster; the Fukushima nuclear accident resulting from the Tsunami caused a serious technological disaster and significantly affected Japan's agriculture and food exports. Third, the Japanese economy suffered from another natural disaster that occurred in Thailand in October 2011 (the 2011 Thailand floods) because many Japanese firms have operations in the disaster areas of Thailand, playing important roles in supply chains.

Given the fact that serious negative impacts of these crises/disasters were transmitted through domestic/international production/distribution networks, some people, including researchers and government officials, claimed that production networks had revealed their vulnerability toward shocks. As Ando and Kimura (2012) demonstrate, by analyzing the impacts of the 2008-2009 GFC and the 2011 EJE on Japan's exports, however, international production/distribution networks rather demonstrated their resiliency in the face of these two massive shocks, despite their initial negative impacts.

This chapter sheds light on domestic/international production networks in machinery industries and examines how these economic crises and natural disasters affected the networks, mainly from the viewpoint of Japan's exports. More specifically, the chapter first decomposes changes in exports into "extensive and intensive margins", i.e.,the quantity effect, the price effect, the effect due to exiting products, and the effect due to new products entering the market, in order to capture the features of trade declines and recoveries resulting from the crises for machinery parts and components and machinery final products. The chapter also examines the probability of trade declines and recoveries, using a logit estimation, to formalize the natures of international production/distribution networks under the crises. Discussion is also presented focusing on domestic activities as well as the impacts of the 2011 Thailand floods. Furthermore, as mentioned above, the 2011 EJE was not only a natural disaster but also a technological disaster that seriously affected Japan's agriculture and food exports. The chapter therefore also investigates the impacts on their exports as well.

The rest of the chapter is organized as follows: section 2 describes the patterns of Japan's exports. Sections 3 and 4 provide analyses of reduction and recovery of machinery exports resulting from the 2008-2009 GFC and the 2011 EJE, using the decomposition approach as well as a logit estimation. Section 5 in turn focuses on agriculture and food exports and examines the impacts of the two crises, using the same methodologies used in the previous sections. Section 6 briefly investigates the impacts of the GFC and the EJE on domestic activities, and the impacts of the 2011 Thailand floods, using indices of industrial production, regional input-output tables, and the Japan External Trade Organization (JETRO) survey. Section 7 concludes the chapter.

## 2. Patterns of Japan's Exports[1]

Figure 1 presents trends of Japan's real exports in US dollars for all products, machinery parts and components, and machinery final goods (in total and automobiles only) from January 2007 to October 2011.[2] While the figure clearly shows the existence of significant negative impacts from the 2008-2009 GFC on Japan's exports, it displays a V-shaped recovery for all products, particularly for machinery parts and components. East Asia is the most important destination for

[1]Sections 2 to 4 are based on some of the results in Ando and Kimura (2012).

[2] Machinery goods are composed of general machinery, electrical machinery, transport equipment, and precision machinery (Harmonized System (HS) 84-92). See Ando and Kimura (2012) for the definition of machinery parts and components. Machinery final products are defined as machinery goods other than machinery parts and components. Automobiles are final products only in HS87.

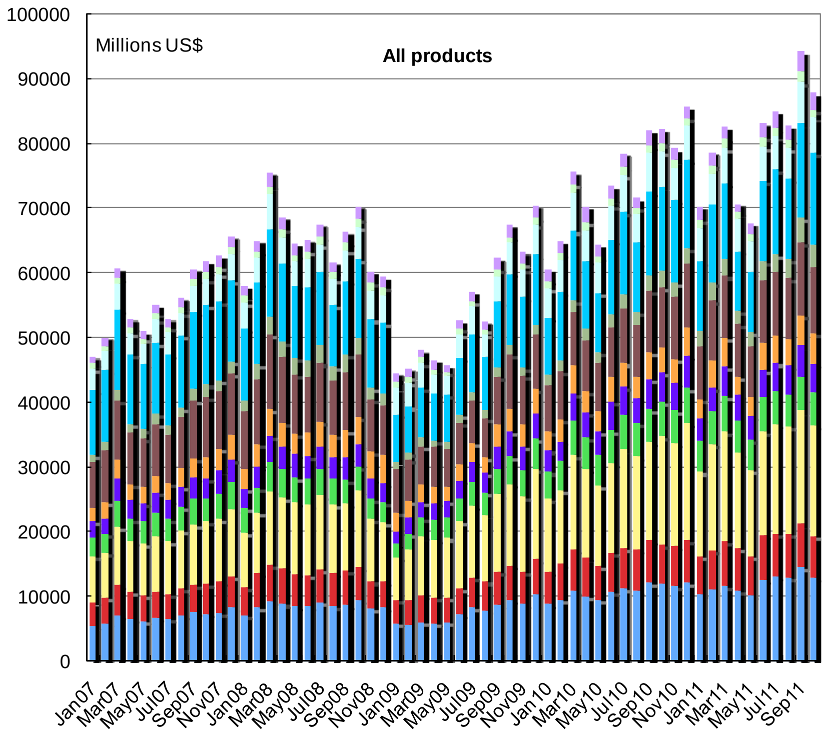
Japan's exports in machinery parts and components, and a very quick recovery of exports to East Asia contributes to the rapid recovery of Japan's exports in machinery parts and components (Table 1 and Figure 1).[3] In addition, East Asia is growing in terms of the value of exports as well as the share in total exports of machinery final products; the value in 2010 was 1.6 times as high as that in 2007, and the share increases from 22 % in 2007 to 30 % in 2010.[4] The corresponding value and share in 2010 for automobiles only (final products) doubled from those in 2007. With the GFC as a trigger, East Asia is gaining importance as a market for machinery final products, though the United States (US) and European Union (EU) remain as important markets.[5]

[3] East Asia in this chapter includes the following 14 countries/economies: Association of South-East Asian Nations (ASEAN) 10, China, Korea, Hong Kong, and Taiwan.

[4] East Asia itself also became a major contributor to the recovery of East Asian trade, not only for machinery parts and components but also for machinery finished products (Ando, 2010). Also see Haddad and Shepherd (2011) for an interesting series of analyses of trade and economies under the GFC.

[5] EU refers to the EU27 in this chapter.

**Figure 1: Japanese Real Exports by Region**



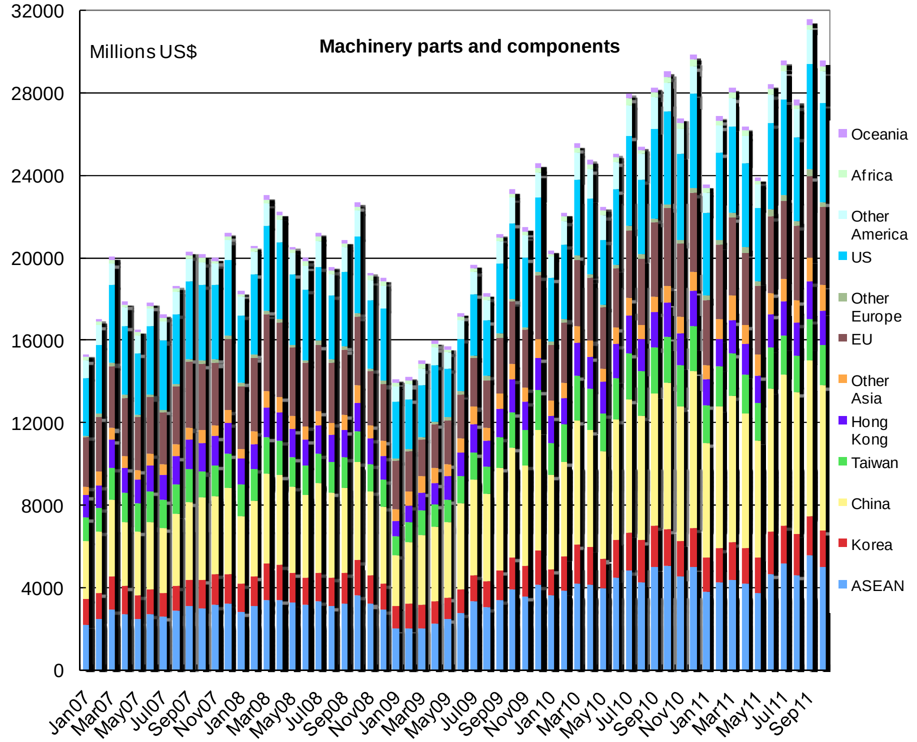
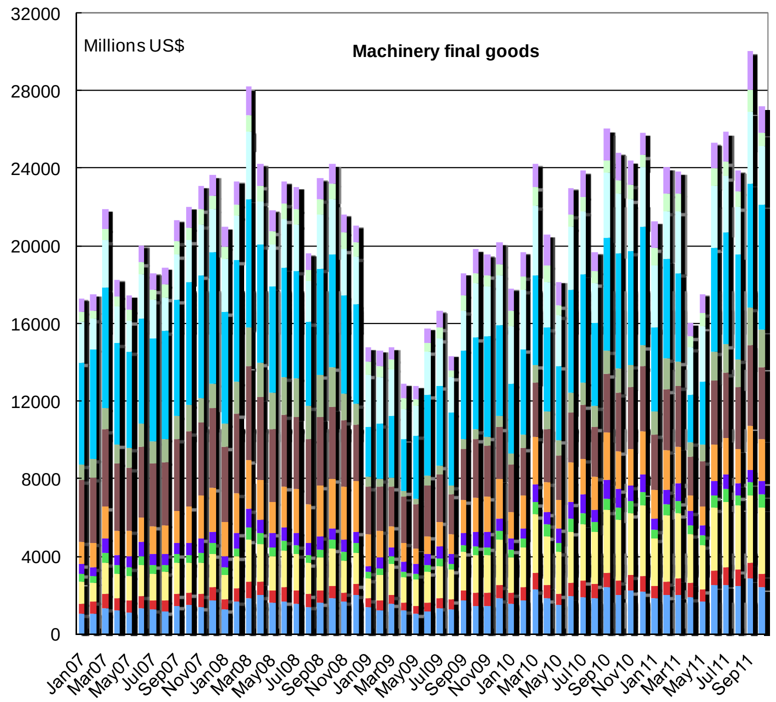
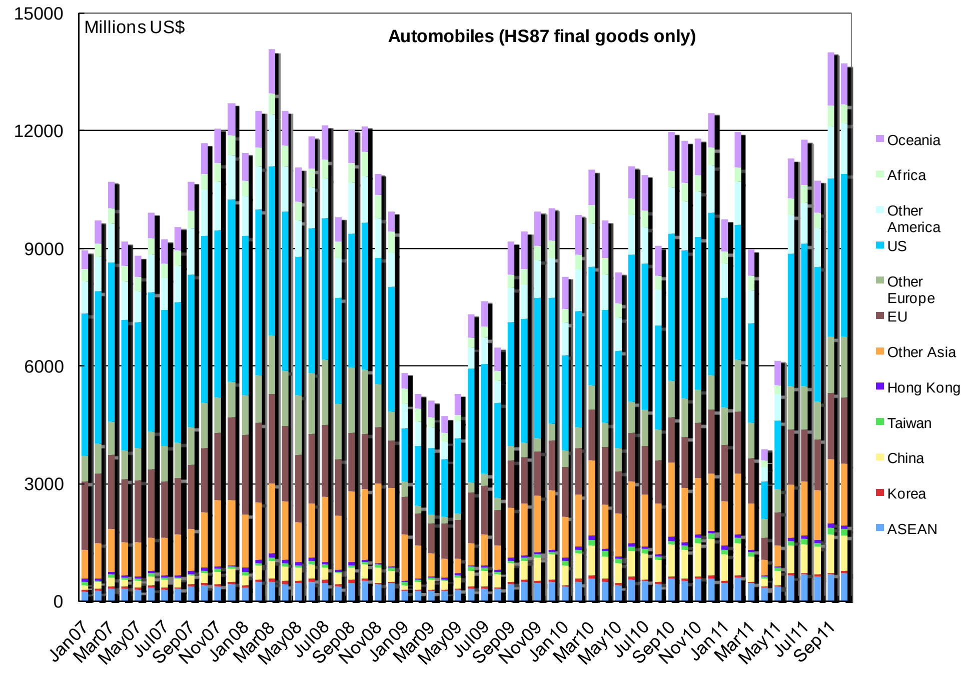



**Figure 1: Japanese Real Exports by Region (Continued)**




*Data*: Ando and Kimura (2012).

**Table 1: By-region Values and Shares of Japan's Real Exports**

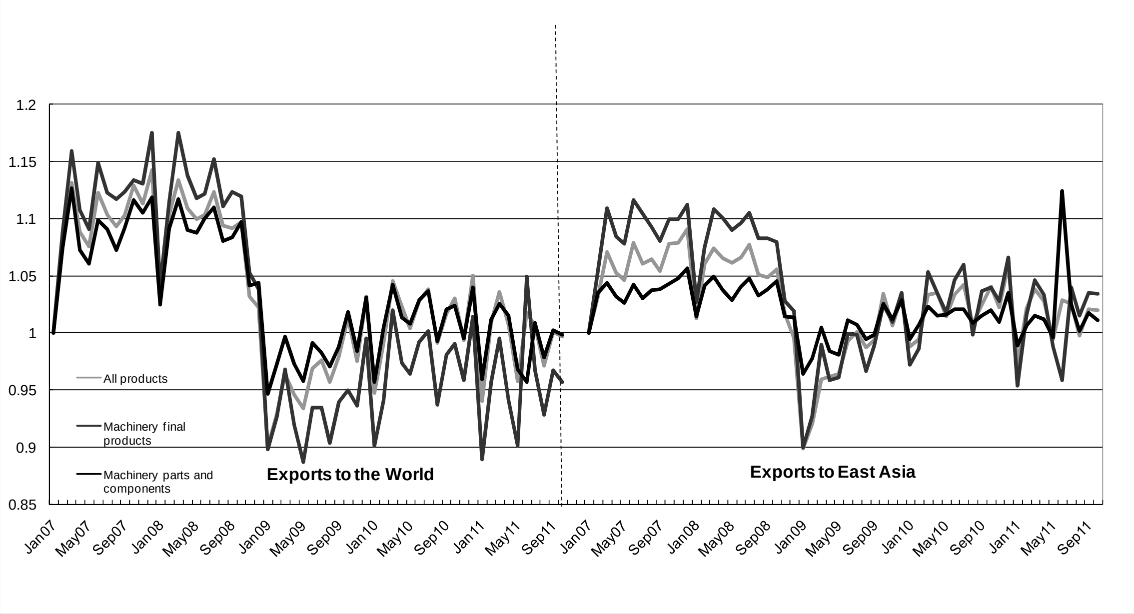
| Destinations | The value of exports, indexed to 2007=1 | | | | Share in total exports (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2009 | 2010 | 2007 | 2008 | 2009 | 2010 |
| All products | | | | | | | | |
| East Asia | 1.00 | 1.18 | 1.09 | 1.53 | 47 | 48 | 53 | 54 |
| US | 1.00 | 1.01 | 0.78 | 1.01 | 20 | 18 | 16 | 15 |
| EU | 1.00 | 1.10 | 0.82 | 1.00 | 15 | 14 | 12 | 11 |
| World | 1.00 | 1.16 | 0.97 | 1.31 | 100 | 100 | 100 | 100 |
| Machinery parts and components | | | | | | | | |
| East Asia | 1.00 | 1.13 | 1.06 | 1.54 | 56 | 56 | 59 | 62 |
| US | 1.00 | 1.04 | 0.85 | 1.13 | 18 | 17 | 16 | 15 |
| EU | 1.00 | 1.11 | 0.83 | 1.13 | 15 | 15 | 13 | 13 |
| World | 1.00 | 1.11 | 0.99 | 1.38 | 100 | 100 | 100 | 100 |
| Machinery final products | | | | | | | | |
| East Asia | 1.00 | 1.19 | 1.02 | 1.55 | 22 | 23 | 28 | 30 |
| US | 1.00 | 0.97 | 0.66 | 0.86 | 29 | 24 | 23 | 22 |
| EU | 1.00 | 1.06 | 0.69 | 0.78 | 18 | 16 | 15 | 12 |
| World | 1.00 | 1.15 | 0.81 | 1.12 | 100 | 100 | 100 | 100 |
| HS87 final goods only | | | | | | | | |
| East Asia | 1.00 | 1.38 | 1.20 | 2.00 | 7 | 8 | 12 | 14 |
| US | 1.00 | 0.96 | 0.64 | 0.86 | 37 | 31 | 34 | 31 |
| EU | 1.00 | 1.01 | 0.62 | 0.76 | 17 | 15 | 15 | 12 |
| World | 1.00 | 1.14 | 0.70 | 1.02 | 100 | 100 | 100 | 100 |

*Note*: export values are in USD.
*Data*: Ando and Kimura (2012).

While machinery export values *per se* recovered theirpre- GFC levels, there exists a permanent change in the “extensive margins” of machinery exports. The number of exported product-country pairs for all products exported to the world significantly dropped in the 2008-2009 GFC, with a minimum in January 2009 (Figure 2).[6] Although the number of exported product-country pairs has had a tendency to increase since January 2009, it has not returned to the level of 2007 or 2008. The number of product-country pairs for exports to East Asian countries only dropped significantly as well, though the decline was not as pronounced as in the case of exports to all countries in the world. These reflect the fact that the geographical distribution of activities by Japanese firms, including those in East Asia, was reshuffled and the basis of Japan’s exports has been narrowed down with the GFC as a trigger.

[6]The number of exported product-country pairs is expressed as an index based on the number in January 2007; the corresponding number for all products exported to the world is 66,119.

**Figure 2: The Number of Exported Product-country Pairs, Indexed to January 2007=1**




*Data*: Ando and Kimura (2012).

The negative effects of the EJE are reflected in exports particularly in April and May 2011. Exports rapidly increased in June, however. achieving a positive growth in terms of both changes from the previous month and from the previous year. Compared with the 2008-2009 GFC, the magnitude of the fall in overall exports, including exports in machinery parts and components, was much smaller, recovery was more rapid, and no distinctive change in the extensive margins of exports is observed.

Machinery final product statistics depict a somewhat different picture; their exports suffered from both the GFC and the 2011 EJE, and exports of automobiles, in particular, were even lower in April 2011 than they were at theirlowest point resulting from the 2008-2009 GFC. As critical small and medium-sized enterprises (SMEs) were located in the disaster areas of the 2011 EJE, negative supply shocks affected exports through production chains. Exports of machinery final products, including automobiles, however, rapidly recoveredafter May and even exceeded the level of the previous year in June. There also seems to be very little evidence of any long term affect on their exports

## 3. Machinery Exports: Decomposition of Trade Reduction and Recovery

This section investigates patterns of trade reduction and recovery, using the decomposition approach. For the analysis of the 2008-2009 GFC, the chapter sets the period of trade reduction from October 2008 to January 2009 and the period of trade recovery from January to October 2009. For the analysis of the 2011 EJE, this chapter focuses on monthly changes, or changes from previous months, to capture features of trade movements within a short period.

### 3.1. Methodology and Data

The decomposition approach used in this section is the one proposed by Haddad, *et al.* (2010). As a first step, the category of a product exported to a given partner country is identified as "continuing", "entry", or "exit". If a product is exported to a given country in both period $t-1$ and period $t$, the category of the product for the corresponding country (the product-country pair) is defined as "continuing". Similarly, the category is defined as "entry" if the product is exported only in $t$, and the category is defined as "exit" if the product is exported to the corresponding country only in $t-1$. Changes in export values from period $t-1$ to period $t$ are then decomposed into extensive and intensive margins, based on the categories defined above. Intensive margins are composed of effects due to changes in quantity and price; that is, changes in export values for country-product pairs in the category "continuing" due to changes in quantity (the quantity effect) and changes in price (the price effect). On the other hand, extensive margins consist of an effect due to exiting products (exit effect hereafter) and an effect due to new products (entry effect hereafter); that isreduction in export values due to no exports in $t$ for product-country pairs in the category "exit", and an increase in export values due to new exports in $t$ for product-country pairs in the category "entry". According to the decomposition approach, the percentage change in the total value of exports can be expressed as the sum of the quantity effect, the price effect, the entry effect, and the exit effect:

$$\frac{dv_t}{v_{t-1}} = \frac{\sum_{c=1}^{C} \frac{p_t^c + p_{t-1}^c}{2} \Delta q_t^c}{v_{t-1}} + \frac{\sum_{c=1}^{C} \Delta p_t^c \frac{q_t^c + q_{t-1}^c}{2}}{v_{t-1}} + \frac{\sum_{n=1}^{N} p_t^n q_t^n}{v_{t-1}} - \frac{\sum_{x=1}^{X} p_{t-1}^x q_{t-1}^x}{v_{t-1}}$$

$$(I = C + N + X)$$

where $v_t$ stands for the total value in $t$, which is the sum of value of each product $i$, $c$ for products that are traded in both $t-1$ and $t$ (in the category "continuing"), $n$ for products that are traded only in $t$ (in the category "entry"), $x$ for products that are traded only in $t-1$ (in the category "exit"), $I$ for the total number of products, $C$ for the total number of products in the category "continuing", $N$ for the total number of products in the category "entry", and $X$ for the total number of products in the category "exit".

To decompose changes in values of Japan's exports by applying this method, monthly data of Japanese bilateral exports at the most disaggregated level or the Harmonized System (HS) 9-digit level, which are available from the Trade Statistics of Japan, the Ministry of Finance, Japan, are employed.[7] The nominal export values in Japanese Yen are converted into real export values in US dollars, using an export price index, available from the Bank of Japan, and exchange rates that are the monthly average of public rates announced by Japan Customs, available from the Ministry of Finance, Japan.

### 3.2. Results[8]

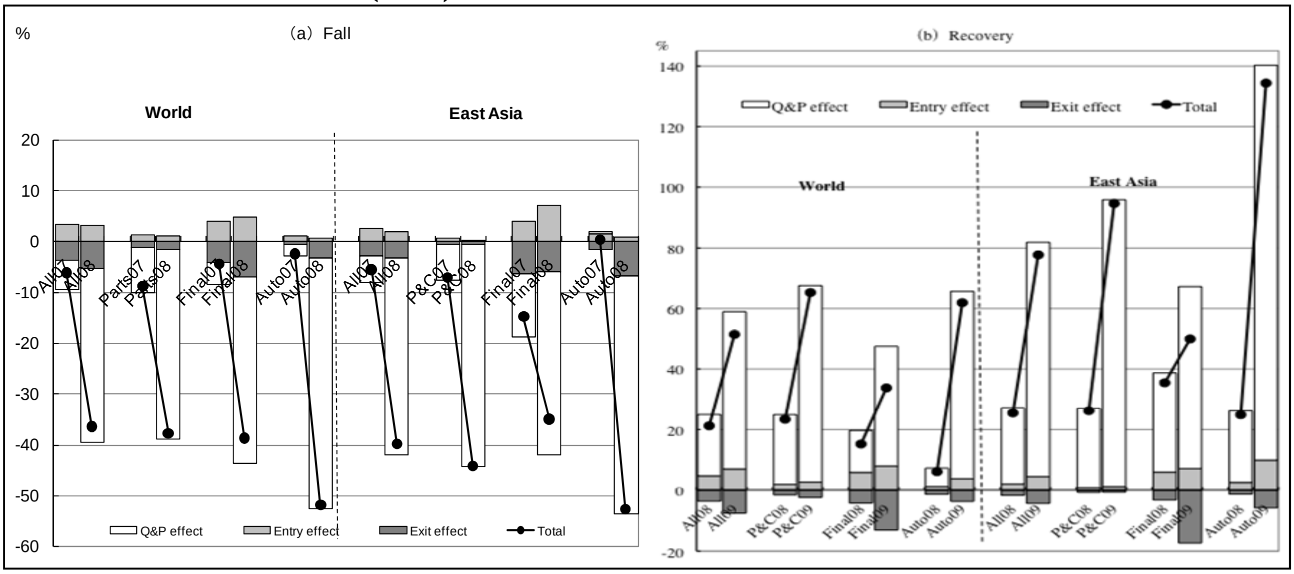
Figure 3 represents export changes during the periods of trade reduction and recovery, together with export changes in the same period of the previous year, to partially consider seasonal fluctuations. The figure clearly demonstrates that exports declined from October 2008 to January 2009 by almost 40 %. Even in normal years, Japanese exports tend to fall from October to January; for instance, exports declined

[7] The decomposition of changes in trade into extensive and intensive margins may change when data at a different level of disaggregation are used. For instance, the results based on data at the most disaggregated level (HS 9-digit level in the case of Japan) may be more likely to make the extensive margins appear larger than the results based on data at more aggregated levels such as the HS 6-digit level. Also, if we use some cutoff point to identify the extensive margins, the results may change. However, the major findings discussed here do not change even if we use different levels of aggregation.

[8] See Ando and Kimura (2012) for the features of exports to the US and EU.

in the same period of the previous year by 5 to 10 %. A 40 % drop, however, is certainly far beyond a drop due to seasonality. In particular, exports of automobiles dropped by more than 50 %, which is much larger than the decline in the same period of the previous year (3 %). The 2008-2009 GFC therefore did have significant negative impacts on Japanese exports.

**Figure 3: Decomposition of Changes in Japanese Real Exports under the 2008-2009 crisis (USD)**



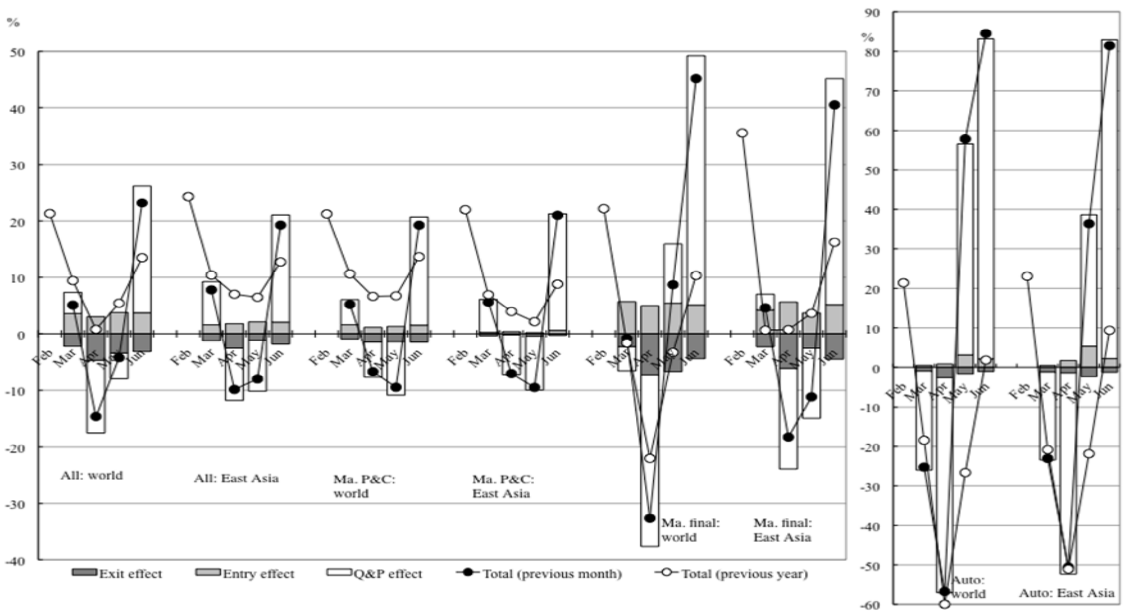

*Notes*: Q&P effect is the sum of quantity effect and price effect. All08 (All07) for (a) Fall and All09 (All08) for (b) recovery, for instanec, denote all products in the priod from October 2008 to January 2009 and in the period from January to October 2009 (2008). P&C, Final, and Auto denote machinery parts and components, machinery final goods, and automobiles (HS87 final only).

*Data*: author's preparation, based on the results in Ando and Kimura (2012).

The figure also demonstrates that the exit effect is much smaller in absolute terms for machinery parts and components than for other products; the exit effect is only -1.6 % for the world. Moreover, the exit effect is even smaller for East Asia with -0.7 %, and is almost at the level of the same period of the previous year. Although large intensive margins induced a significant decline in their exports, particularly for East Asia, such a small exit effect suggests the robustness of trade relationships for machinery parts and components within dense production/distribution networks in the region. Furthermore, the pattern of export recovery shows a symmetric picture to the export fall; the extensive margin was quite small, and a large positive quantity effect was observed for machinery parts and components exported to East Asia.

Figure 4 in turn represents monthly changes in real exports to the world after the EJE from March to June 2011, and the change in real exports to East Asia only. Unlike the GFC, monthly changes, i.e., changes from the previous month are decomposed into extensive and intensive margins, since drastic fluctuations in a short period are observed. Similarly to the analysis for the GFC, however, changes from the corresponding month of the previous year (changes from previous year) are also considered, as monthly changes tend to be significantly influenced by seasonality.

**Figure 4: Decomposition of Changes in Japanese Real Exports under the 2011 EJE (USD)**




*Data*: author's preparation, based on the results in Ando and Kimura (2012).

As is the case of the GFC, the exit effect is much smaller for machinery parts and components than for other products: the exit effect is only around -1.5 % in a month. Moreover, the exit effect for machinery parts and components is more or less equal to the low level in the same month of the previous year, 2010. Although their exports decreased in April and May 2011, they significantly expanded in June 2011, reflecting a large and positive quantity effect. As a result, exports in June 2011 exceeded those in June 2010 by 14 %. Furthermore, the exit effect was even smaller for East Asia, i.e., less than -0.5 % in a month, compared with other regions. These findings suggest that trade relationships for machinery parts and components are robust, and that firms prioritize international production networks even following the EJE, just as is the case of the GFC.

On the other hand, exports in machinery final goods substantially declined in April 2011 by a greater extent than machinery parts and components, mainly due to a significant negative quantity effect as well as an exit effect. A dramatic recovery was seen, however, in May and June. The outstanding recovery can be observed particularly for automobiles. Exports of automobiles drastically declined in April by around 60 % from the previous month,and from the same month of the previous year, mostly due to a negative quantity effect, which fell even below the minimum level of exports following the GFC. Although exports were negatively affected through production chains, because some of the critical SMEs are located in the disaster areas, they mostlyreturned to the level of the previous year in June. Behind such a dramatic recovery for automobiles, there were great "private" efforts to restore supply chains by private companies. One symbolic episode is the case of Japan Renesas. This company was producing several key electronic parts and components called micro-processing units (MPU), memory control units (MCU), and application specific standard products (ASSP) for automobiles and various ICT products. The EJE severely damaged its factories, including the Naka Factory in Ibaraki Prefecture. In order to resume their supply chains, the Japan Automobile Manufacturers Association (JAMA) and others gathered workers from a number of companies and sent them to the Naka Factory to help restore the operation; the number of such helpers exceeded 2,500 a day at maximum. Thus a strong incentive to maintain the supply chains worked even beyond the boundaries of individual firms, even if negative impacts were transmitted through the supply chains at the beginning of the crisis.

## 4. Machinery Exports: Probability of Trade Fall and Recovery

To formalize the features of machinery exports in responding to the crises, this section first investigates probability of reduction and recovery of machinery exports resulting from the two crises, using a logit estimation.

### 4.1. Methodology and Data

For the analysis of trade reduction as a result of the 2008-2009 GFC [the 2011 EJE], those product-country pairs at the HS 9-digit level with exports in October 2008 (and/or one-month before and after) [March 2011 (and/or one-month before and after)] are employed to examine whether or not their exports existed in January 2009 [May 2011]. For the analysis of trade recovery under the GFC [the EJE], on the other hand, those product-country pairs at the HS 9-digit level with exports in October 2008 (and/or one-month before and after) [March 2011 (and/or one-month before and after)] and no exports in January 2009 [May 2011] are used to investigate whether their exports recover by October 2009 [July 2011].

The equation for our logit estimation analyses is as follows:

$$EXchange_{i,j} = \beta_0 + \beta_1 \ln Dist_i + \beta_2 Parts_j + \sum_n^N \alpha_n Country_n + \varepsilon,$$

where $EXchange_{i,j}$ is a binary variable representing fall/recovery of exports; $EXchange_{i,j}$ is 1 if no export of product $j$ to country $i$ is observed in January 2009 [May 2011] and 0 otherwise for the analysis of trade fall at the 2008-2009 GFC [the 2011 EJE]. In contrast, $EXchange_{i,j}$ is 1 if exports of product $j$ to country $i$ are observed in October 2009 (July 2011) and 0 otherwise for the analysis of trade recovery under the 2008-2009 GFC (the 2011 EJE). $\ln Dist_i$ denotes the distance between Japan and country $i$ in the form of a natural logarithm. $Parts_j$ is 1 if product $j$ is machinery parts and components, and 0 otherwise. In addition, country/region dummies expressed as $Country_n$ are included for 14 East Asian countries, the US, and EU to capture the features of trade relationships with these countries/region at the crises.

### 4.2. Results

Given the control for distance, the results in Table 2 imply that machinery parts and components trade is less likely to be discontinued and is likely to recover even if it stops once, regardless of whether due to demand shock or supply shock. The coefficient for parts is negative for the analysis of trade fall and positive for the analysis of trade recovery with statistical significance, suggesting robust trade relationships for machinery parts and components, compared with machinery final products. This is consistent with the results of the decomposition analysis.

**Table 2: Probability of Trade Relantionships of Japan's Machinery**

| | 2008-2009 GFC | | | | | | 2011 EJE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fall | | | Recovery | | | Fall | | | Recovery | | |
| Distance (log) | -0.05 | (-1.55) | | 0.10 | (1.84) | * | -0.14 | (-3.87) | *** | 0.11 | (1.98) | ** |
| Parts | -0.51 | (-25.78) | *** | 0.28 | (8.84) | *** | -0.47 | (-22.3) | *** | 0.06 | (1.79) | * |
| Korea | -1.37 | (-13.54) | *** | 1.38 | (8.54) | *** | -1.88 | (-16.69) | *** | 0.96 | (5.01) | *** |
| China | -1.74 | (-18.85) | *** | 1.20 | (7.70) | *** | -2.11 | (-20.4) | *** | 0.89 | (4.81) | *** |
| Taiwan | -1.31 | (-14.91) | *** | 1.05 | (7.31) | *** | -1.69 | (-17.32) | *** | 0.95 | (5.63) | *** |
| Hong Kong | -1.35 | (-16.16) | *** | 0.91 | (6.54) | *** | -1.58 | (-17.12) | *** | 0.74 | (4.56) | *** |
| Viet Nam | -0.96 | (-12.11) | *** | 1.38 | (10.92) | *** | -1.30 | (-15.00) | *** | 0.87 | (5.85) | *** |
| Thailand | -1.53 | (-19.32) | *** | 1.11 | (8.11) | *** | -1.76 | (-19.8) | *** | 0.79 | (4.91) | *** |
| Singapore | -1.39 | (-17.88) | *** | 0.68 | (4.92) | *** | -1.39 | (-16.82) | *** | 0.77 | (5.29) | *** |
| Malaysia | -0.91 | (-12.33) | *** | 0.92 | (7.69) | *** | -1.18 | (-14.38) | *** | 0.77 | (5.46) | *** |
| Brunei | 0.88 | (4.17) | *** | -0.75 | (-2.38) | ** | 1.02 | (4.05) | *** | -0.38 | (-1.16) | |
| Philippines | -0.99 | (-12.17) | *** | 1.03 | (7.90) | *** | -1.18 | (-13.38) | *** | 0.33 | (2.10) | ** |
| Indonesia | -0.91 | (-12.41) | *** | 0.86 | (7.19) | *** | -1.15 | (-14.31) | *** | 0.83 | (5.96) | *** |
| Cambodia | 0.76 | (4.08) | *** | 0.30 | (1.45) | | 0.43 | (2.75) | *** | 0.12 | (0.55) | |
| Laos | 0.53 | (1.86) | * | -1.05 | (-1.99) | ** | 0.67 | (2.24) | * | -1.79 | (-2.46) | ** |
| Myanmar | 0.35 | (2.21) | ** | 0.12 | (0.58) | | 0.06 | (0.39) | | -0.03 | (-0.12) | |
| US | -1.99 | (-23.37) | *** | 0.37 | (2.18) | ** | -1.78 | (-20.61) | *** | 0.52 | (3.22) | *** |
| EU | -0.53 | (-22.05) | *** | 0.07 | (1.78) | * | -0.50 | (-19.43) | *** | 0.14 | (3.23) | *** |
| Constant | 0.93 | (2.89) | *** | -2.09 | (-4.38) | *** | 1.53 | (4.48) | *** | -2.06 | (-3.89) | *** |
| Log likelihood | -29744 | | | -11949 | | | -26132 | | | -9749 | | |
| Number of observatior | 45979 | | | 20507 | | | 41827 | | | 16221 | | |

*Notes*: dependent variable for the analysis of trade fall is 1 if trade stops and 0 otherwise. Similarly, dependent variable for the analysis of trade recovery is 1 if trade recovers and 0 otherwise. Figures in parenthesis are z-statistics. *** indicates that the results are statistically significant at the 1 % level, ** at the 5 % level, and * at the 10 % level.

*Data*: Ando and Kimura (2012).

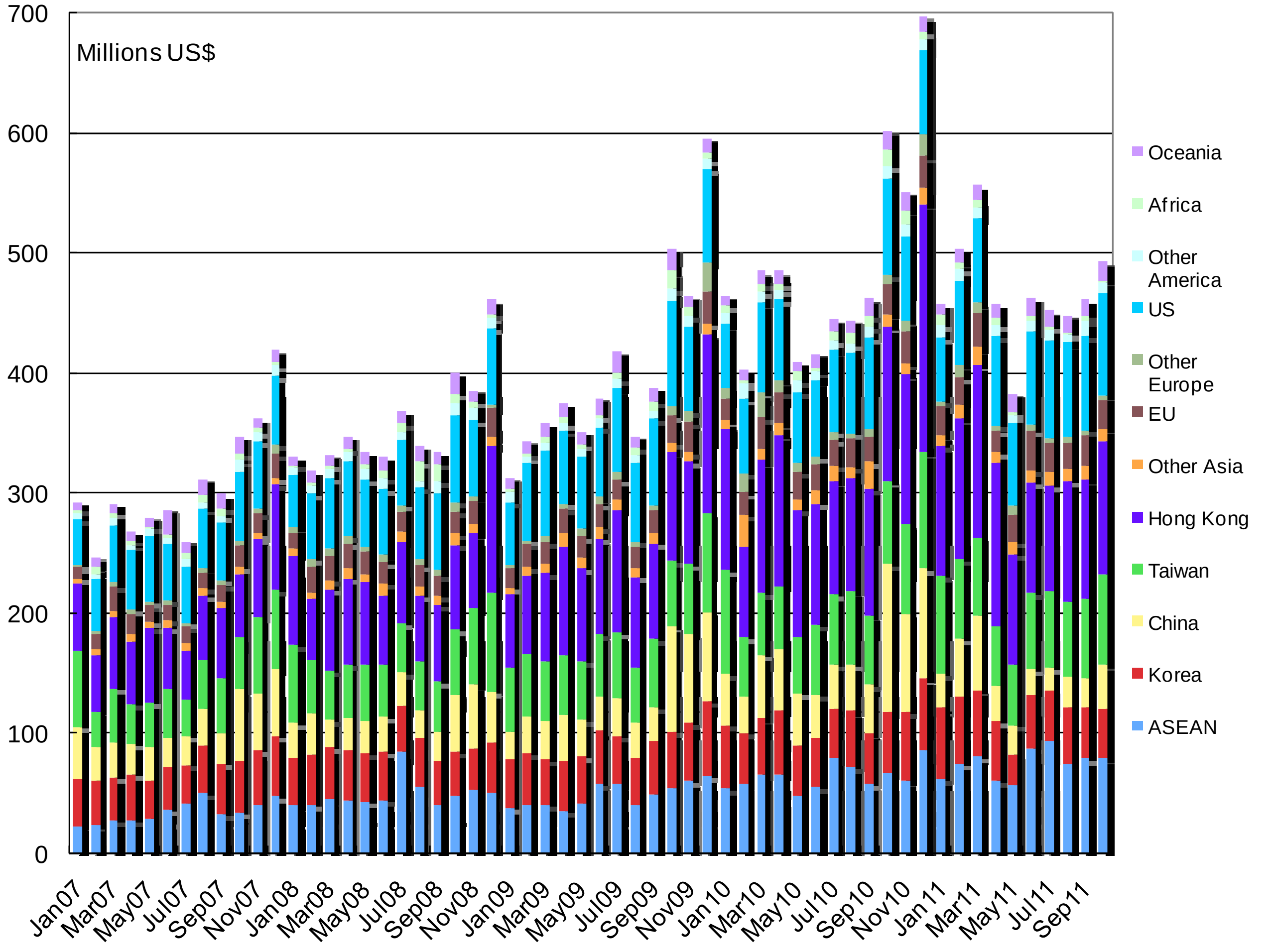
The results also indicate that, among East Asian countries, those who are heavily involved in the regional production networks tend to maintain their trade relationships and tend to recover trade even if they stopbriefly. The coefficients for East Asian countries are mostly negative for the analysis of trade fall and positive for the analysis of trade recovery with statistical significance. In particular, the absolute values of coefficients for countries such as China, Thailand, Korea, Taiwan, and Vietnam are large for the analysis of the GFC, indicating the strong trade relationships in the production networks. Similarly, the absolute values of coefficients for countries such as China, Korea, Thailand, Taiwan, and Vietnam are large for the analysis of the EJE. On the other hand, the coefficients for countries such as Brunei, Cambodia, Laos, and Myanmar are either statistically insignificant, small in absolute terms, or even opposite. This implies that these countries are not deeply involved in regional production networks in machinery industries.

In addition to the logit analysis mentioned above, Ando and Kimura (2012) conduct a survival analysis to investigate the long term probability of trade recovery, considering the timing of recovery. Their results also demonstrate that trade in machinery parts and components has a lower probability of being discontinued and has a higher probability of recovery even if briefly stopped. All findings in this section confirm that regional production networks are resilient against shocks to save transaction costs of firms' setting-up production networks even if negative impacts are transmitted through the production networks at the outset of a crisis.

## 5. Agriculture and Food Exports

Unlike other commodities, destinations of exports in agriculture and food products are limited to specific countries/regions; major destination countries/regions are Hong Kong (24 % of total exports in 2010), the US (14 %), ASEAN (13 %), Taiwan (13 %), China (11 %), Korea (10 %), and the EU (5 %), accountingfor 90 % of the total (Figure 5). In addition, the seasonality is typical for exports in agriculture and food products, with a peak in December every year mainly due exports to Hong Kong.

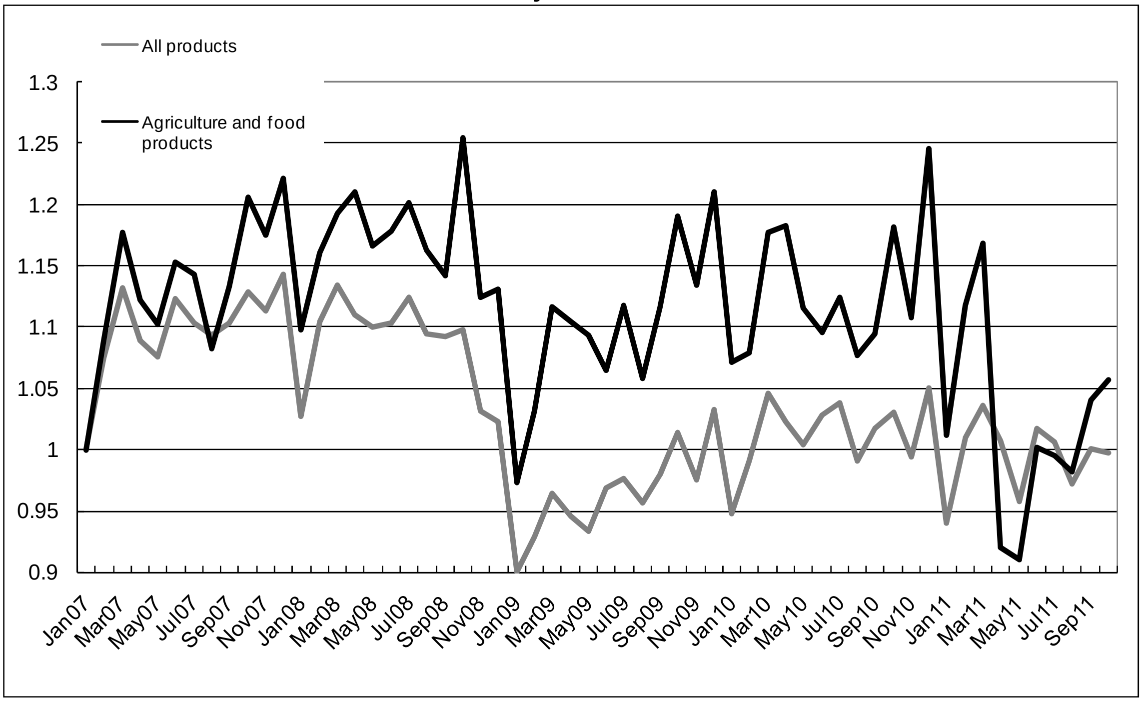
**Figure 5: Japanese Real Exports in Agriculture and Food Products by Region**




*Data*: author's calculation, using data available from the Ministry of Finance and the Bank of Japan.

While agriculture and food exports seem to have been less affected by the 2008-2009 GFC, they were significantly affected by the Fukushima nuclear accident caused by the Tsunami component of the 2011 EJE. The negative impacts of this technological disaster are clearly shown in a significant decline of exports in April and May; exports in April and May declined from the respective previous month by almost 20 %. The negative impacts are also reflected in the number of exported product-country pairs; the number for agriculture and food products drastically decreased in April and May, though the seasonality is stronger than other products (Figure 6).

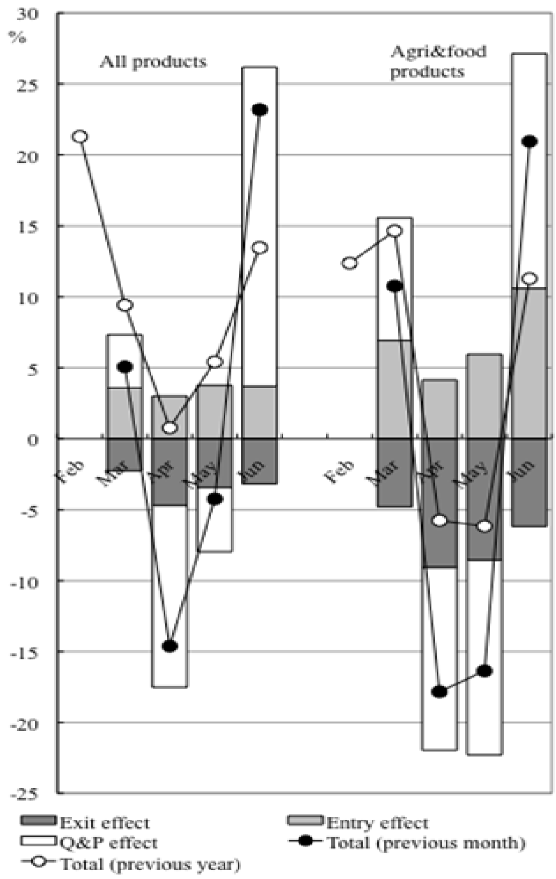
**Figure 6: The Number of Exported Product-country Pairs for Agriculture & Food Products, Indexed to January 2007=1**




*Data*: author's calculation, using data available from the Ministry of Finance.

The decomposition of trade reductions resulting from the EJE demonstrates that the serious decline in agriculture and food exports in April and May 2011 was largely induced by the exit effect or the effect by products for which exports discontinued, in addition to the negative quantity effect (Figure 7); the exit effect explains half of the export decline. Many countries introduced safety inspections and trade restrictions in various ways, including the obligation of submitting certificates of inspection for radioactive materials and/or certificates of origin at the prefecture level, sampling inspection on the import side, and import prohibition, for imports in agriculture and food products produced in Japan. Besides safety inspections and trade restrictions, there seem to have been exit blows from unfounded (but partially understandable) rumors induced by the nuclear disaster. Most of the major partner countries/regions also introduced import prohibition for specific agricultural and food products produced in specific prefectures (all products produced in specific areas in the case of China and Taiwan), in addition to the obligation of submitting certificates of origin and safety inspection. The effects of these trade restrictions are directly reflected in the significant reduction of exports.

**Figure 7: Decomposition of Changes in Exports to the World in Agriculture and Food Products under the 2011 EJE(USD)**




*Data*: author's calculation, using data available from the Ministry of Finance and the Bank of Japan.

Table 3 confirms how the number of exported products declined in each country/region. Even if the trend in the previous year is considered, the number of exported products is indeed low particularly for May and June in China (0.60 and 0.54, respectively), May in Korea (0.65), April in the EU (0.63), and April and May in the Middle East (0.59 and 0.65).[9] On the other hand, an upward trend is observed by June for some countries such as Korea and the EU, and also the reduction is rather marginal in terms of the number of products exported to the US and the ASEAN 10. As a result, agriculture and food exports were rapidly recovering in June.

**Table 3: The Number of Exported Agriculture and Food Products for Selected Countries/region in 2011**

| Destination | Share in total | The number of exported products | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | March | | April | | May | | June | |
| Hong Kong | 24% | 1.03 | (1.00) | 0.95 | (1.05) | 0.92 | (1.08) | 0.97 | (1.03) |
| US | 14% | 1.05 | (1.14) | 1.02 | (1.12) | 1.01 | (1.08) | 1.03 | (1.04) |
| ASEAN10 | 13% | 1.34 | (1.31) | 1.12 | (1.30) | 1.10 | (1.19) | 1.25 | (1.24) |
| Taiwan | 13% | 0.95 | (0.90) | 0.87 | (0.96) | 0.83 | (0.95) | 0.84 | (0.90) |
| China | 11% | 1.06 | (1.04) | 0.80 | (1.04) | 0.60 | (1.03) | 0.54 | (1.06) |
| Korea | 10% | 0.95 | (0.95) | 0.98 | (1.00) | 0.65 | (0.86) | 0.81 | (0.91) |
| EU27 | 5% | 1.18 | (1.24) | 0.63 | (1.33) | 0.95 | (1.15) | 1.02 | (1.00) |
| Middle East | 2% | 1.76 | (1.57) | 0.59 | (1.35) | 0.65 | (1.61) | 0.78 | (1.37) |

*Notes*: The number of exported products is indexed to January 2007. The figures in parenthesis are those for 2010. The shares are based on export values in 2010.
*Data*: author's calculation, using data available from the Ministry of Finance.

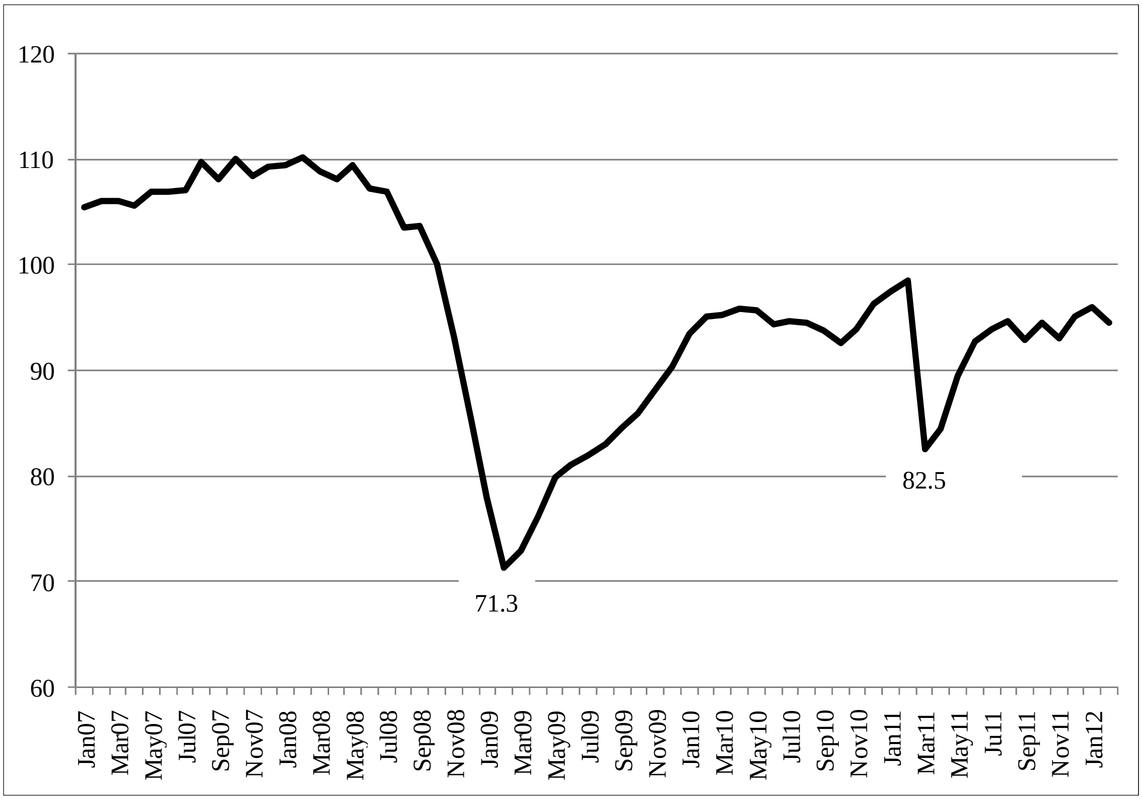
## 6. Domestic Activities and the 2011 Thailand Floods

While previous sections in this chapter focus on the patterns of exports, this section briefly investigates domestic activities from the perspective of industrial production and regional input-output tables.[10] As with the patterns of exports, the index of industrial production for the whole Japan suggests that the direct impacts of the 2008-2009 GFC

[9] Some countries in the Middle East imposed import prohibition on any agriculture and food products produced in Japan, regardless of where they were produced in Japan. Such strict trade restrictions should directly influence the number of exported products.
[10] Indices of industrial production and regional input-output tables are available from the following websites, respectively;
http://www.meti.go.jp/english/statistics/tyo/iip/index.html, and
http://www.meti.go.jp/statistics/tyo/tiikiio/result/result_02.html.

were more serious than those of the 2011 EJE (Figure 8). As Figure 9 clearly displays, the impacts of the EJE are indeed more serious if analysis is focused only on the disaster areas.[11] The magnitude of the direct impacts of the GFC, however, was more serious, at least from the perspective of production as well as exports for the whole country.

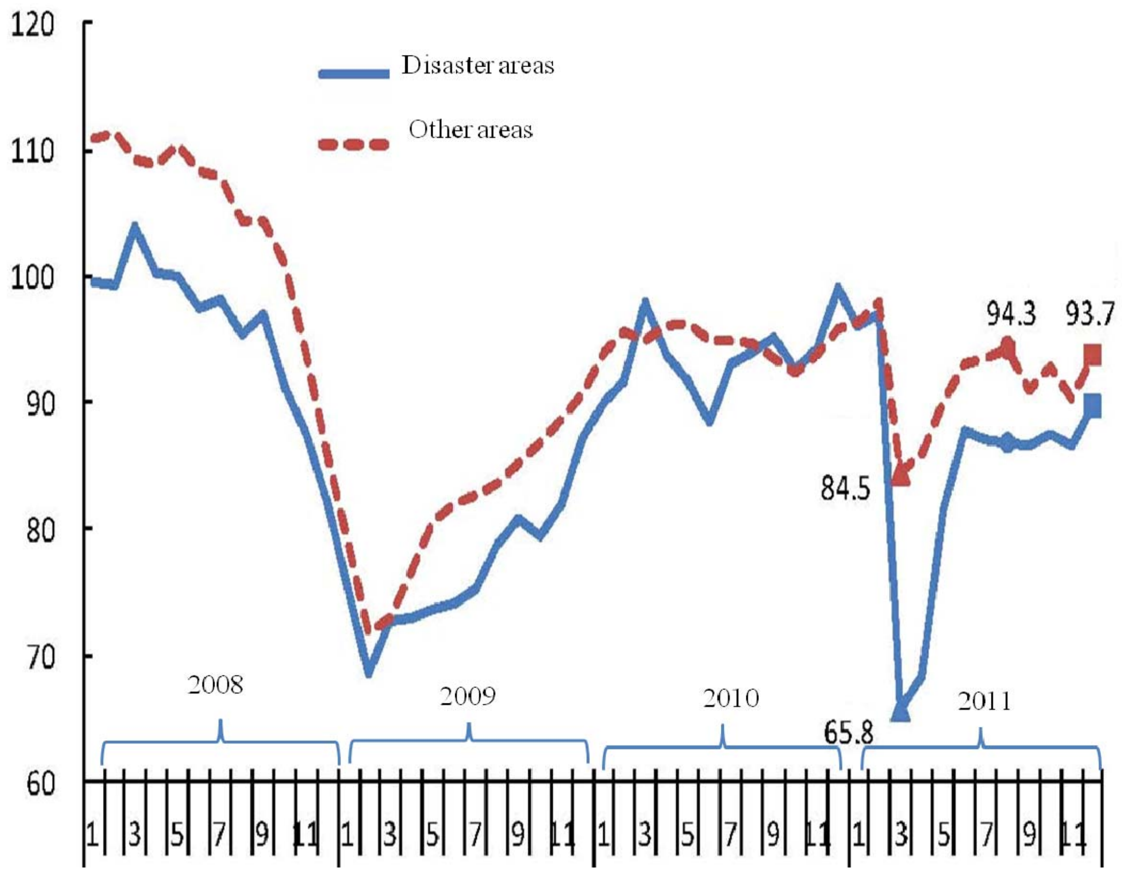
**Figure 8: Indices of Industrial Production: Manufacturing (2005=100)**




*Data*: author's preparation, based on data available from the METI (http://www.meti.go.jp/english/statistics/tyo/iip/index.html)

[11] The disaster areas in this figure are the designated regions to which the Disaster Relief Act (Saigai Kyujo Hou) may apply.

**Figure 9: Indices of Industrial Production by Disaster and Non-disaster areas: Mining and Manufacturing (2005=100)**




*Data*: METI (2012).

Production activities in the disaster areas are of course connected with those in other areas. Table 4 shows regional connections of production activities in terms of output in 2005: regional shares of demand for the production in the Tohoku (Northeast) region that had significant direct damage from the Tsunami. In many of the machinery sectors, a large portion of the products produced in the Tohoku region go to the Kanto region (where Tokyo is located): 51 % for office electric appliance, 49 % for industrial electric machinery, 40 % for household electrical machinery, 42 % for communication electronics equipment, and 55 % for auto parts. In the case of other transport equipment, 20 % of the products go to the Chubu region (where Toyota is located).

**Table 4: By-region Demand for Products produced in the Tohoku Region**

| Sector | Mfg production in Tohoku | Regional shares of demand for the production in Toyoku by sector (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sectoral shares | All regions | Hokkaido | Tohoku | Kanto | Chubu | Kinki | Chugoku-Shikoku | Kyushu&Okinawa |
| 1 Food and beverage | 18.6 | 100.0 | 5.2 | 45.4 | 34.3 | 4.6 | 5.9 | 2.2 | 2.5 |
| 2 Texitile | 0.2 | 100.0 | 0.5 | 56.1 | 26.8 | 1.6 | 6.4 | 3.0 | 5.6 |
| 3 Apparel | 1.8 | 100.0 | 3.3 | 14.3 | 64.4 | 7.6 | 5.6 | 2.5 | 2.3 |
| 4 Timber and wooden products | 2.7 | 100.0 | 2.4 | 42.8 | 42.6 | 6.1 | 4.8 | 0.6 | 0.7 |
| 5 Pulp and paper | 4.1 | 100.0 | 2.1 | 47.8 | 33.1 | 4.1 | 10.6 | 1.2 | 1.0 |
| 6 Printing and publishing | 1.5 | 100.0 | 0.2 | 88.0 | 11.2 | 0.2 | 0.1 | 0.3 | 0.1 |
| 7 Basic industrial chemicals | 1.3 | 100.0 | 2.5 | 57.2 | 29.6 | 4.7 | 2.9 | 1.5 | 1.7 |
| 8 Synthetic resins and fiber | 0.2 | 100.0 | 0.2 | 74.6 | 20.1 | 1.0 | 2.7 | 0.9 | 0.5 |
| 9 Other chemical products | 1.1 | 100.0 | 2.7 | 34.1 | 40.4 | 4.7 | 9.7 | 4.8 | 3.5 |
| 10 Drugs and medicine | 2.7 | 100.0 | 2.1 | 40.7 | 23.8 | 4.7 | 18.5 | 5.0 | 5.1 |
| 11 Petroleum and petro products | 3.0 | 100.0 | 4.3 | 71.2 | 23.6 | 0.1 | 0.2 | 0.6 | 0.0 |
| 12 Plastic products | 2.9 | 100.0 | 1.3 | 50.7 | 31.2 | 6.0 | 6.7 | 2.3 | 1.7 |
| 13 Cement and cement products | 3.2 | 100.0 | 1.4 | 58.5 | 23.2 | 5.5 | 5.9 | 2.0 | 3.5 |
| 14 Iron and steel | 3.3 | 100.0 | 0.6 | 54.1 | 27.5 | 4.2 | 4.8 | 7.6 | 1.2 |
| 15 Non-ferrous metal | 3.6 | 100.0 | 1.0 | 45.2 | 39.0 | 4.8 | 5.3 | 3.7 | 1.0 |
| 16 Metal products | 4.0 | 100.0 | 2.7 | 43.9 | 38.2 | 6.2 | 4.6 | 2.4 | 2.0 |
| 17 General machinery | 6.1 | 100.0 | 1.3 | 44.0 | 34.5 | 6.6 | 5.8 | 3.0 | 4.7 |
| 18 Office electric appliance | 1.3 | 100.0 | 0.5 | 34.8 | 50.8 | 11.9 | 1.5 | 0.2 | 0.4 |
| 19 Industrial electric machinery | 1.7 | 100.0 | 0.6 | 34.7 | 49.3 | 3.3 | 3.3 | 7.0 | 1.8 |
| 20 Other electric machinery and appliance | 2.6 | 100.0 | 1.0 | 47.6 | 33.0 | 6.2 | 5.2 | 3.5 | 3.5 |
| 21 Household electrical machinery | 0.2 | 100.0 | 4.3 | 32.0 | 39.9 | 6.2 | 7.8 | 5.1 | 4.6 |
| 22 Communication electronics equipment | 5.6 | 100.0 | 2.3 | 26.7 | 42.1 | 6.0 | 10.4 | 5.4 | 7.2 |
| 23 Electronic computing equipment | 4.8 | 100.0 | 1.1 | 54.2 | 27.6 | 6.9 | 3.6 | 4.6 | 2.0 |
| 24 Electronic parts | 11.1 | 100.0 | 0.9 | 61.0 | 26.4 | 5.0 | 2.7 | 1.8 | 2.2 |
| 25 Passenger cars | 2.1 | 100.0 | 1.0 | 66.2 | 18.5 | 4.3 | 5.1 | 1.9 | 3.0 |
| 26 Other motor vehicles | 0.0 | 100.0 | 19.4 | 41.9 | 17.0 | 0.9 | 4.0 | 9.8 | 7.0 |
| 27 Auto parts | 4.3 | 100.0 | 0.0 | 28.8 | 55.1 | 6.6 | 2.6 | 0.9 | 5.9 |
| 28 Other transport equipment | 0.6 | 100.0 | 2.9 | 56.2 | 16.2 | 19.6 | 1.8 | 0.8 | 2.6 |
| 29 Precision machinery | 2.3 | 100.0 | 2.5 | 40.4 | 30.1 | 5.3 | 10.5 | 6.1 | 5.1 |
| 30 Other manufacturing products | 3.2 | 100.0 | 2.9 | 44.2 | 29.2 | 14.8 | 3.3 | 2.0 | 3.5 |

*Note*: figures for Tohoku are the sum of intra-regional demand and net exports.
*Data*: author's calculation, based on the regional input-output table in 2005 (the version with 53 sectors).

Table 5, on the other hand, presents the regional connections of production activities in terms of input in 2005: that is, the shares of manufacturing inputs from the Tohoku region in the production of machinery sectors for all regions as well as the Kanto region. In machinery sectors, the manufacturing input from the Tohoku region is large: in particular, in sectors of communication electronics equipment, electronic computing equipment, and electronic parts, the Tohoku region has a share of 10 % of the production in the whole Japan. Interestingly, electronic parts produced in the Tohoku region are used in various machinery sectors. Moreover, auto parts produced in the Tohoku region are used in various transport equipment sectors, though the portion of input is smaller than in the case of electric machinery sectors.

**Table 5: Shares of Manufacturing Direct Inputs from the Tohoku Region in the Production of Machinery Sectors: All Regions and the Kanto Region**

(%)

| | All regions | | | | | | | | | | | | | Kanto region | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| 1 Food and beverage | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2 Texitile | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 Apparel | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4 Timber and wooden products | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 Pulp and paper | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6 Printing and publishing | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 7 Basic industrial chemicals | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8 Synthetic resins and fiber | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9 Other chemical products | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 10 Drugs and medicine | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11 Petroleum and petro products | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 12 Plastic products | 0.0 | 0.2 | 0.1 | 0.3 | 0.1 | 0.4 | 0.3 | 0.2 | 0.1 | 0.0 | 0.1 | 0.0 | 0.3 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 |
| 13 Cement and cement products | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 14 Iron and steel | 0.3 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.5 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.3 | 0.0 |
| 15 Non-ferrous metal | 0.1 | 0.0 | 0.3 | 0.8 | 0.1 | 0.3 | 0.1 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | 0.1 | 0.0 | 0.2 | 0.3 | 0.2 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 |
| 16 Metal products | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 |
| 17 General machinery | 0.7 | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.9 | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 |
| 18 Office electric appliance | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 19 Industrial electric machinery | 0.1 | 0.1 | 0.5 | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.1 | 0.2 | 0.1 | 0.8 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.3 | 0.1 | 0.3 | 0.1 | 0.0 |
| 20 Other electric machinery and appliance | 0.0 | 0.1 | 0.1 | 0.4 | 0.1 | 0.3 | 0.1 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | 0.4 | 0.1 | 0.3 | 0.0 | 0.2 | 0.1 | 0.1 | 0.0 | 0.1 | 0.1 |
| 21 Household electrical machinery | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22 Communication electronics equipment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 |
| 23 Electronic computing equipment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24 Electronic parts | 0.1 | 1.5 | 0.4 | 1.3 | 0.6 | 4.0 | 6.6 | 3.8 | 0.0 | 0.0 | 0.1 | 0.0 | 2.1 | 0.1 | 1.2 | 0.5 | 1.4 | 0.9 | 2.5 | 2.9 | 2.7 | 0.0 | 0.0 | 0.1 | 0.0 | 1.3 |
| 25 Passenger cars | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 26 Other motor vehicles | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 27 Auto parts | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 1.9 | 1.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 2.4 | 1.8 | 0.2 | 0.0 |
| 28 Other transport equipment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 |
| 29 Precision machinery | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 30 Other manufacturing products | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.1 | 0.1 | 0.0 |
| Total intermediate inputs | 2.5 | 4.6 | 2.9 | 4.6 | 1.9 | 8.0 | 12.1 | 7.4 | 2.7 | 2.9 | 2.5 | 1.7 | 5.7 | 2.5 | 3.5 | 2.9 | 3.1 | 2.4 | 4.1 | 4.1 | 4.2 | 3.7 | 3.5 | 3.4 | 1.9 | 2.9 |
| Total production | 4.0 | 5.7 | 4.3 | 6.7 | 2.4 | 11.0 | 17.1 | 10.3 | 3.0 | 2.9 | 3.1 | 2.3 | 9.5 | 2.5 | 3.5 | 2.9 | 3.2 | 2.4 | 4.1 | 4.1 | 4.2 | 3.7 | 3.5 | 3.4 | 2.0 | 2.9 |

*Notes*: machinery sectors are from the sector 17 to the sector 29. Non-manufacturing sectors are excluded on the input side, and only machinery sectors on the output side are shown.

*Data*: author's calculation, based on the regional input-output table in 2005 (the version with 53 sectors).

When we focus only on the production in the Kanto region, the share of input from the Tohoku region exceeds 4 % in total in sectors of the communication electronics equipment, electronic computing equipment, and electronic parts. In particular, electronic parts and auto parts that are produced in the Tohoku region seem to form an important part of production; the share of input of auto parts from the Tohoku region is larger for the production in the Kanto region than the average (the whole Japan). All of these analyses suggest that non-disaster areas, particularly the Kanto region, are tightly connected with disaster areas in domestic production networks, and thus they had negative impacts on production activities particularly in the machinery sector through supply chains.

Insufficient supply of intermediate goods from the disaster areas had direct negative effects on production in non-disaster areas, particularly just after the EJE from March to June. What was more serious for production activities from July to September in Japan was the implementation of an electricity saving policy (compulsory regulation on the usage of electric power to save electricity). Although firms made great efforts to cope with this regulation and took various actions, this regulation apparently resulted in the reduction of production.[12]

The 2011 Thailand floods, which occurred in October 2011, also had negative impacts on production networks and Japanese firms, because many Japanese firms have operations in the disaster areas and play important roles in supply chains. The JETRO conducted an interesting survey on the firms suffering from the floods in Thailand. Table 6 presents the situation of the damage of Japanese firms in Thailand (multiple answers were allowed). Some firms were directly affected, while others were indirectly affected. 41 % of the manufacturing firms in the sample (81 firms) had indirect negative impacts; 16 % was due to the damage of the firm to which a firm in the survey sells its products, 22 % was due to the damage of the firm from which the corresponding firm purchases products, and 16 % are due to the damage of some firms in a line of supply chains. These figures confirm that many firms were indirectly affected even if they did not have direct damage from the floods. It implies that when production networks exist,

[12] See METI (2012) for the detailed analysis of industrial activities in F/Y2011.

negative impacts are likely to expand through supply chains.

**Table 6: Damage of Japanese Firms in Thailand from the 2011 Thailand Floods**

| | Manufacturing | | Non-manufacturing | |
|---|---|---|---|---|
| | Number of firms | Share | Number of firms | Share |
| **Directly damaged** | **40** | **49.4%** | **8** | **16.7%** |
| Inside of industrial estates | 36 | 44.4% | 6 | 12.5% |
| Outside of industrial estates | 4 | 4.9% | 4 | 8.3% |
| **Indirectly damaged** | **33** | **40.7%** | **11** | **22.9%** |
| Damage by firms to supply | 13 | 16.0% | 5 | 10.4% |
| Damage by firms to purchase | 18 | 22.2% | 2 | 4.2% |
| Damage by a part of supply chains | 13 | 16.0% | 4 | 8.3% |
| **Not damaged** | **8** | **9.9%** | **29** | **60.4%** |
| The number of effective answers (firms) | 81 | | 48 | |

*Notes*: multiple answers are allowed. The rate of effective answers in total is 69.3%.
*Data*: JETRO (2012).

On the other hand, the existence of the production networks seems to conferrobustness. Among firms that directly suffered from the floods, more than half of the firms in the sample (40 %) were planning to maintain the size of operations before the crisis, which is higher than the share for non-manufacturing firms (38 %) (Table 7). Moreover, more than three-quarters of the firms in the sample were planning to maintain operations at the same locations, and 15 % of the firms at different locations in Thailand, rather than going other countries (multiple answers wereallowed). Even those who were going to move some production blocks to other countries as a risk-diversificationmeasure were also intending to keep some production sites in Thailand.

**Table 7: The Expected Size of Operations and Locations for Firms Directly Damanged**

(a) The expected size of operations

| | Manufacturing | | Non-manufacturing | |
|---|---|---|---|---|
| Steady | 21 | 52.5% | 3 | 37.5% |
| Shrinkage | 16 | 40.0% | 3 | 37.5% |
| Expansion | 0 | 0.0% | 0 | 0.0% |
| Not decided yet | 3 | 7.5% | 2 | 25.0% |
| The number of effective answers (firms) | 40 | | 8 | |

(b) The expected location of operations

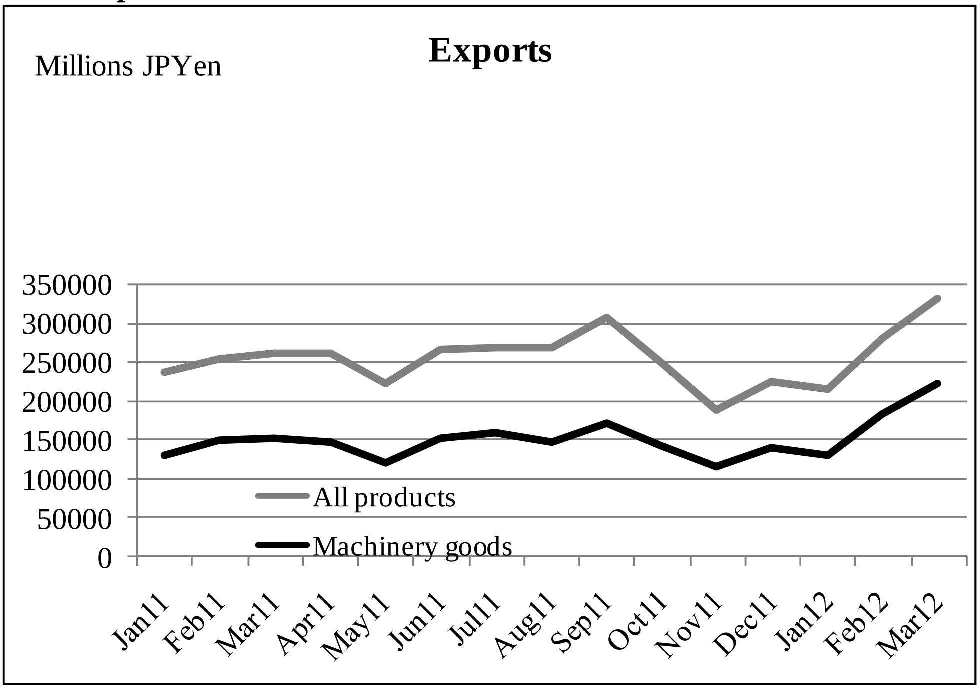
| | Manufacturing | | Non-manufacturing | |
|---|---|---|---|---|
| Same place | 31 | 77.5% | 7 | 87.5% |
| Other place in Thailand | 6 | 15.0% | 2 | 25.0% |
| Relocation to other countries | 3 | 7.5% | 0 | 0.0% |
| Exit | 0 | 0.0% | 0 | 0.0% |
| Not decided yet | 3 | 7.5% | 0 | 0.0% |
| The number of effective answers (firms) | 40 | | 8 | |

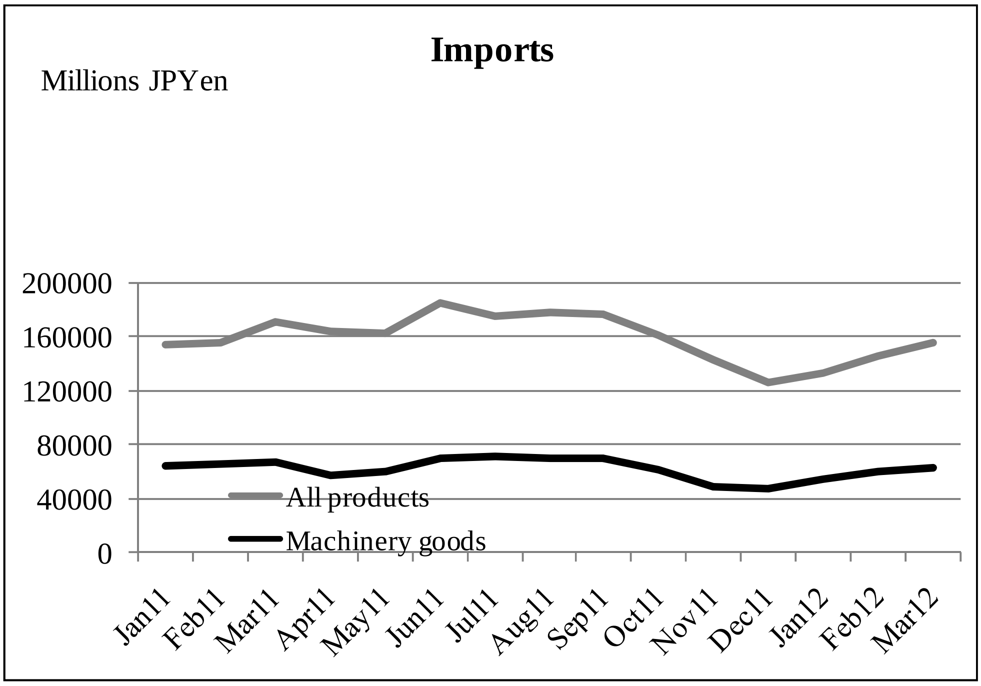
*Note*: multiple answers are allowed for (a).
*Data*: JETRO (2012).

The major reason why firms were intending to stay in the same places or at least to stay in Thailand was that most of them were already involved in supply chains in Thailand, and thus the movement of production blocks abroad would require a change in transactions, i.e., the origins of purchases and the destinations of sales, which would lead to large transaction costs. In practice, other countries also have risks, such as political risks and natural disasters, while Thailand has advantages in infrastructure and industrial clustering. Thus, with a consideration of these elements, firms tended to choose to stay in the same places, or to move only todifferent places in Thailand.

Actually, those firms that suffered seriously from the 2011 Thailand floods are making great efforts to restore operations as quickly as possible. As Figure 10 shows, Japan’s exports to and imports from Thailand declined in October and November 2011. In order to replace capital goods and other machinery damaged by the floods, however, Japan’s exports to Thailand are drastically increasing in 2012. In other words, involvement in production networks and the existence of industrial clustering generate strong incentives to maintain the networks in order to avoid transactions costs, even if the networks tend to spread negative shocks, at least temporarily, when they encounter supply or demand shocks.

**Figure 10: Japanese Trade with Thailand in 2011 and 2012**




*Data*: author's preparation, based on the data available from the Ministy of Finance.

*Source*: Ando and Kimura (2005) (adjusted to the HS2007 classification).

## 7. Conclusion

This chapter has focused on domestic/international production networks in machinery industries, and has examined how the economic crisis and natural/technological disaster that Japan encountered in recent years affected the networks and trade, mainly from the viewpoint of Japan's exports.Regardless of whether creating demand shock or supply shock, the economic/natural disasters revealed the stability and robustness of production networks in machinery sectors. It is true that the shocks seriously damaged production networks, and their negative impacts were transmitted through production networks, at theiroutset. Strong forces, however, worked to keep production networks in being, and quick adjustments for recovery were implemented. As the extended fragmentation theory states, the fragmentation of production takes advantage of the reduction in production cost within production blocks, while it should pay for the network set-up/adjustment cost and the service link cost.[13] The latter two costs are particularly high for transactions in parts and components compared with transactions in final products. In order to respond to massive shocks, firms try to save these costs by keeping existing transaction channels for parts and components. As a result, exports in machinery parts and components tend to be sustained, and are likely to recover rapidly even if they are temporarily discontinued. Even the behavior of firms involved in the production networks and suffering from the Thailand floods also confirms the existence of strong continuation forces and the deployment of efforts to keep production networks in being, in consideration of the various transaction cost implications of discontinuing a network.

Conversely, once production networks are moved away from Japan, it is not easy to get them back. Therefore, it is quite important to deal with various concerns in the business environment. Indeed, in the case of the EJE, there still remains the risk of "hollowing-out (kudo-ka)" due to continuing the shortage of electricity supply and substantial JP Yen appreciation. The same discussion can

[13] See Ando, *et al*. (2009) for the two-dimensional fragmentation and their costs in terms of fixed costs, services link costs, and production cost per se.

be applied to countries involved in the production networks, such as Thailand. To rebuild infrastructure and implement policies that help restart operations, such as tax-exemptions for imports of capital goods or what needs to make factories restart operations as quickly as possible, is important. So far, Thailand hasrelatively great advantages, particularly due to a better business environment in terms of infrastructure and industrial clustering, compared with that in surrounding countries, but it is important to recover the better business environment as soon as possible and further improve it. Otherwise, private firms may utilize the crisis as a trigger for removing production blocks to other countries.

The 2011 EJE and its aftermath as a technological disaster also remind us of the importance of reliable safety guarantees and of nurturing international credibility on export products such as agriculture and food products.

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## APPENDIX

**Table A.1 The Definition of Machinery Parts and Components**

| |
|---|
| 8406, 8407, 8408, 8409, 8410, 8411, 8412, 8413, 8414, 8416, 8417, 8431, 8448, 8466, 8473, 8480, 8481, 8482, 8483, 8484, 8486, 8487, 8503, 8505, 8507, 8511. 8512, 8522, 8529, 8531, 8532, 8533, 8534, 8535, 8536, 8537, 8538, 8539, 8540, 8541, 8542, 8544, 8545, 8546, 8547, 8548, 8607, 8706, 8707, 8708, 8714, 8803, 8805, 9001, 9002, 9003, 9013, 9014, 9033, 9104, 9110, 9111, 9112, 9113, 9114, 9209, 840140, 840290, 840390, 840490, 841520, 841590, 841891, 841899, 841990, 842091, 842099, 842123, 842129, 842131, 842191, 842199, 842290, 842390, 842490, 843290, 843390, 843490, 843590, 843691, 843699, 843790, 843890, 843991, 843999, 844090, 844190, 844240, 844250, 844391, 844399, 845090, 845190, 845240, 845290, 845390, 845490, 845590, 846791, 846792, 846799, 846890, 847490, 847590, 847690, 847790, 847890, 847990, 850490, 850690, 850870, 850990, 851090, 851390, 851490, 851590. 851690. 851770, 851840, 851850, 851890, 852352, 853090, 854390, 870990, 871690, 900590, 900691, 900699, 900791, 900792, 900890, 901090, 901190, 901290, 901590. 901790, 902490, 902590, 902690, 902790, 902890, 902990, 903090, 903190, 903290 |

*Source*: Ando and Kimura (2005) (adjusted to the HS2007 classification).

# CHAPTER 10

# Impact of Natural Disasters on Production Networks and Urbanization in New Zealand

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*New Zealand's history of natural disasters and its vulnerability to various types of disaster are outlined briefly. A summary description of the country's arrangements for preparing for natural disasters and managing the response to, and recovery from, them is provided.*

*The series of earthquakes that affected Christchurch, New Zealand's second largest city, between September 2010 and early 2012 is considered as a case study. The direct and indirect tangible costs of the events are estimated as $NZ 30.9 billion (approximately $US24.5billion), or 15.8% of the country's GDP, on a replacement cost basis. Approximately 78% of this cost will be covered by insurance. On a depreciated replacement cost basis the damage is estimated at $NZ18.7 billion.*

*The significant effects of the events on the population, labor market, reported crime, urbanization and location of businesses and production of the region are also described.*

*The case study suggests that New Zealand's arrangements for natural disasters worked well in most regards. The case study also highlights the advantage of international co-operation in the response to natural disasters. It also suggests that while high rates and levels of disaster insurance ameliorate the financial impact, they can complicate achieving effective recovery. This is because insurance funds increase the alternatives available to the affected population and investors in respect of reinvestment and rebuilding the damaged region. The lag before insurers will accept new risks can also create delays and impede the momentum to recovery.*

*The final section of the paper draws from New Zealand's recent disaster experience in Christchurch to present some policy recommendations relevant to New Zealand and the East Asia region.*

***Keywords:*** Natural disasters, Monitoring, Rescue, Recovery, Earthquakes, New Zealand, Christchurch earthquakes, Economic impact, Costs, Disaster insurance, East Asian regional co-operation

# 1. Introduction

## 1.1. Geography

New Zealand is a string of islands situated in the South West Pacific Ocean approximately 1,600 kilometers east of mainland Australia[1] and approximately 1,000 kilometers south of New Caledonia, Fiji and Tonga. The distance between the northernmost point of New Zealand (Nugent Island) and its southernmost point (Jacquemart Island) is 2,813 kilometers. The islands making up the country lie in a northwest-southeast direction between latitudes 29$^{o}$ and 53$^{o}$ South on the boundary of the Pacific and Indo-Australian continental plates.

The edges of the Pacific plate define most of the 'Ring of Fire'. This is the active volcanic and seismic area that encircles the Pacific Ocean and includes Japan, the Aleutian Island chain, the southern coast of Alaska, and the west coast of North America (California).

Virtually all of New Zealand's 4.4 million population lives on the two major islands – the North and South Islands. These are situated very close to one another near the center of the string of islands that make up the entire territory. The Pacific and Indo-Australian plates meet under the South Island and under and close to the southeast coast of the North Island.

## 1.2. Vulnerability to Natural Disasters

### *1.2.1. Geophysical Hazards*

In the region of New Zealand, the Pacific plate is currently moving slowly westward and sliding under the Indo-Australian plate. The result is that New Zealand experiences frequent earthquakes, often of significant magnitude, and contains several active volcanic and geothermal areas. The outlying islands are all volcanic in origin; some of them, like Raoul Island and White Island, are very active but others are dormant or extinct.

1 The shortest distance between Australian and New Zealand territory is the 617km between the Auckland Islands (New Zealand) and Macquarie Island (Australia) in the Southern Ocean, well away from the major land masses and population centres of both countries.

The major city, Auckland, with a population of 1.5 million, is spread across a field of 49 dormant volcanoes. All have erupted during the last 250,000 years; the most recent and largest eruption was approximately 600 years ago, after inhabitation of the area by humans. The very violent last eruption produced the same amount of lava as the eruptions that created the rest of the volcanic field.[2]

On 10 June 1886 the volcanic Mt Tarawera, south-east of Rotorua in the central North Island, erupted. It killed an estimated 120 people, caused a major rift in the landscape and submerged a natural wonder, the Pink and White Terraces, into LakeTarawera.[3]

The capital city, Wellington, with a population of 0.35 million, lies directly above the boundary of the Pacific and Indo-Australian plates. As a result, it has three major fault-lines in close proximity to it: the Ohariu, Wairarapa, and Wellington Faults.[4] There are frequent movements on these faults and since 1855 there have been three significant events generating earthquakes with magnitudes between 7.2 and 8.2 on the Richter scale (Table 1).[5]

Christchurch, which until recently was thought to be most vulnerable to a tsunami and not significantly at risk from earthquakes, experienced four major and approximately 11,000 other earthquakes in the 21 months after 4 September 2010. The largest quake, with a magnitude of 7.1, struck on 4 September 2010. Its epicenter was approximately 40 kilometers west of the city center near the small country town of Darfield. It caused significant property damage in the city but no loss of life. The most destructive, with a magnitude of 6.3, struck on 22 February 2011. Its epicenter was directly under the city. It caused very significant damage to most buildings in the Central Business District (CBD) and significant destruction to many housing areas in the suburbs, especially in the south and east of the city. The death toll was 185 with 134 of the deaths occurring in the collapses of just two relatively modern buildings in the CBD.[6]

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[2] Geonet (n.d.)a.

[3] New Zealand History online (n.d.)a.

[4] Wellington City Library (n.d.)

[5] Geonet (n.d.)d.

[6] Coronial Services of New Zealand (n.d.). The initial toll was 181 dead but subsequently the coroner (the official investigator into the causes of death) has classified 4 additional deaths as

**Table 1: New Zealand Earthquakes with Fatalities, 1855-2011**

| Date | Location | Richter scale / Modified Mercalli Scale | Impact | Number killed |
|---|---|---|---|---|
| 23 Jan 1855 | Wairarapa (Wellington) | 8.2 X (Intense) | Destroyed large proportion of buildings. Radically altered landscape in Wellington region | 5 - 9 |
| 17 June 1929 | Murchison (West Coast) | 7.8 IX (Violent) | Caused massive landslides. Destroyed many buildings | 17 |
| 3 Feb 1931 | Hawkes Bay (Napier) | 7.8 X (Intense) | Destroyed most buildings in Napier. Raised landscape. | 256 |
| 24 May 1968 | Inangahua (West Coast) | 7.1 X (Intense) | Destroyed most buildings. Caused massive landslides. | 6 |
| 22 Feb 2011 | Christchurch | 6.3 X (Intense) | Very extensive property damage. Liquefaction of low lying areas. Caused landslips on hills. | 185 |

*Note*: The Modified Mercalli Scale is a 12 point scale of the destructiveness of an earthquake. The scale is expressed in Roman numerals. An earthquake graded I is the least destructive. The most destructive is graded XII. The ratings given are for the destructiveness of the fatal earthquakes in this table relate to the destructiveness at the epicentre of each earthquake.

*Sources*: New Zealand History online (n.d.) a. and Mcsaveney (2012).

New Zealand has experienced approximately ten tsunami with waves higher than 5 meters since 1840. The four major cities are all located close to the sea and contain areas vulnerable to inundation by tsunami. Christchurch has the largest area and most vulnerable population. Most tsunami that have impacted on New Zealand recently have been generated by distant events on the Ring of Fire, for which there have been ample and effective warnings. There is potential, however, for tsunami to be generated by many numerous local sources. There could be very little or no effective warning of these events.[7]

directly attributable to the 22 February 2011 earthquake. See Lynch and Williams (n.d.) and Stylianou (n.d.)

[7] GNS Science (n.d.)b.

*1.2.2. Biological Hazards*

The major islands of New Zealand have been submerged below sea-level at various points in their geological history as a result of the movements relative to one another of the tectonic plates beneath the country. The consequence of this, and the relative isolation of the country, is that much of New Zealand's flora and fauna are unique and many plant and animal diseases found elsewhere in the world are not present in New Zealand.

The economy is heavily dependent on agricultural production, forestry and fishing and the processing of the products of these industries. As a result, the economy is almost uniquely vulnerable to introduced insect, animal and plant species and diseases.

There have been several introductions of economically significant biological hazards in recent years:

- painted apple moths – a serious apple and pear tree pest from Australia – were discovered in Glendene, Auckland in May 1999, but had been eradicated by March 2006;[8]
- gypsy moth – a serious tree pest - was discovered in Hamilton in March 2003, but an eradication programme was successful;[9]
- varroa bee mites – a parasite that targets honey bees – was discovered in the North Island in 2000. An attempt to eradicate the organism was unsuccessful and by 2006 it had spread throughout the North Island and much of the South Island;[10]
- a kiwifruit vine disease, PSA, was discovered in the Bay of Plenty, the major kiwifruit production region, in November 2010.[11] An attempt to confine and eradicate the disease has not been successful.[12]

New Zealand has a modern and effective health system and the last occasion on which an epidemic caused significant mortality was the "Spanish" influenza

[8] Ministry for Primary Industries (n.d.)c.
[9] Ministry for Primary Industries (n.d.)a.
[10] Wikipedia (n.d.)d.
[11] Ministry for Primary Industries (n.d.)b.
[12] Hembery (2011)

epidemic in 1918. An estimated 8.600 people died in that event.[13] The "SARS", avian-flu and swine-flu scares in the early years of this century impacted on travel and tourism but had little effect on the economy as a whole. SARS and avian-flu were not introduced into the New Zealand population[14] but a total of 22 deaths were recorded as due to the 2009 outbreak of swine-flu.[15]

*1.2.3. Hydrological and Meteorological Hazards*

The climate and maritime location of New Zealand can occasionally produce "weather bombs". These involve ultra-high rainfall in localized areas in a short period of time, high winds and, when near the coast, high surf and coastal erosion.[16] The combination of weather bombs and steep terrain can produce flash floods in small streams and rivers, and disasters involving multiple deaths can occur. The two major disasters of this kind were:[17]

- destruction on 19 February 1938 of a railway construction work camp at Kopuawhara on the East Coast killing 21 persons; and
- the deaths on 16 April 2008 of six students and a teacher caught by a flash flood in a stream in Tongariro National Park while undertaking outdoor education.

Weather bombs can also cause extensive erosion or silting of pastureland and have a significant economic effect on farm production at a local level. The impacts can last several years. The East Coast was badly affected this way by Cyclone Bola in March 1988.[18]

For a landslide to damage more than a handful of houses is rare, but not unknown. A suburb in Dunedin, the country's second largest city in the South Island, was the site of a large landslip on 1979. The result was that 70 houses had to be either destroyed or relocated. There were no serious injuries and no loss of life.[19] On

[13] New Zealand History online (n.d.)b.
[14] According to World Health Organization (n.d.) there was one death from SARS recorded in the country.
[15] Flucount (n.d.)
[16] The Weather Network (n.d.)
[17] New Zealand History online (n.d.)a.
[18] Wikipedia (n.d.)c.
[19] Christchurch City Libraries (n.d.)

7 May 1846 a massive landslide destroyed a settlement on the shores of Lake Taupo in the central North Island, killing around 60 people.[20]

New Zealand is not, however, vulnerable to any significant extent to tornadoes and hurricanes. Nor is it as vulnerable to widespread and multi-year droughts as are parts of Australia. Drought can materially impact agricultural production in some areas, but its bigger potential threat to the economy is through its impact on electricity supply.

## 2. Natural Disaster Risk Management

### 2.1. Monitoring

New Zealand has a comprehensive natural hazards monitoring regime.

#### *2.1.1. Geophysical Hazards*

All the active volcanoes in the country are monitored by GeoNet, a service of the Institute of Geological and Nuclear Sciences (GNS), a Crown Research Institute. A variety of techniques are used: high resolution GPS instruments to detect deformation of the volcano's shape; seismographs to detect movements in magma; and gas and water sampling to detect changes in chemical composition.[21] The Crater Lake on Mt Ruapehu is monitored, also by GeoNet, in order to provide warnings of lahar (volcanic mud) floods in the streams and rivers below the mountain.[22] The Auckland volcanic field is monitored by the regional government using in-ground and surface seismographs to detect signs of magma build up below the earth's surface.[23]

GeoNet provides a country-wide network of seismic stations that transmit their data to the GeoNet Data Management Centre where it is analyzed by automated processes. If the automated processes detect an earthquake of material strength, the

[20] New Zealand History online (n.d.)a.
[21] GNS Science (n.d.)a.
[22] Auckland Council (n.d.)
[23] GNS Science (n.d.)c.

Duty Response Team is notified and if the Duty Officer confirms that the earthquake is real and significant, the earthquake information is released.[24]

New Zealand is linked to the Pacific Ocean tsunami warning system which is based in Hawaii. It also has a network of 17 gauge stations around the coastline and on the outlying Kermedec and Chatham Islands. The network is operated by GNS as part of GeoNet[25] in conjunction with Land Information New Zealand and the National Institute of Water and Atmospheric Research (NIWA).[26]

*2.1.2. Biological Hazards*

The Biosecurity division of the Ministry for Primary Industries is responsible for preventing biological hazards from entering the country. It ensures passengers' baggage, postal and courier packages and aircraft and ship cargoes arriving in the country are inspected to detect biological hazards at the border. Virtually all baggage and parcels are scanned by electronic equipment able to detect biological material. Specially trained sniffer dogs are also used extensively.

Cargo with a moderate to high risk of containing biological material is identified from manifests on the basis of their source and the sending party. The identified risky items are inspected. Pheromone traps are located around airports and ports to attract unwanted insect species to check whether there has been an invasion. If an invasion is detected the Biosecurity division is responsible for deciding whether to attempt to eradicate the new organisms, and to organize the effort if it does.

The Ministry of Health has responsibility for border health protection measures. It is only active at points of entry when there is a perceived risk. It has two major operating documents: the National Health Emergency Plan and the New Zealand Pandemic Influenza Plan. The Epidemic Preparedness Act 2006 provides the legislative basis for the Ministry to respond in the event of an emergency.

[24] Geonet (n.d.)b.
[25] Geonet (n.d.)e.
[26] Morse (2008)

*2.1.3. Hydrological and Meteorological Hazards*

The Meteorological Service of New Zealand Ltd (MetService),[27] a State-owned Enterprise, undertakes short- and medium-term weather forecasting, including forecasting extreme weather events such as weather bombs, tornado strikes, lightning, and sea surges. There are also a number of private sector providers of short- and medium-term weather forecasts that compete with MetService.

NIWA, a state-owned research and consultancy company, undertakes long-term weather forecasts. It bases these largely on the state of the Southern Oscillation and whether the weather pattern is likely to follow a *La Nina* or *El Nino* pattern in the next few months, or whether it will be in a transition phase between these states.[28]

GeoNet monitors areas with significant potential for damaging and life-threatening landslips.[29]

Transpower New Zealand Ltd, the state-owned enterprise that operates the national electricity grid, produces hydrological risk curves which show the probability that the electricity system will exhaust the supply of water for hydro-generation, given current lake levels. It forecasts demand and production from non-hydro-generation plant, and takes account of the historical pattern of water inflows over the last 81-years. The lake level and inflow data are acquired by the Electricity Authority from providers such as NIWA and electricity generation companies.

## 2.2. Warnings

The principal vehicles for warning and informing the public about natural hazards are the public media: radio, television, the internet and print. GeoNet operates a website that is updated in real time with information about the risks it monitors.[30]

There are also some specialized communications channels. GeoNet, for example, provides eruption warnings directly to the aviation industry, and lahar warnings directly to those responsible for bridges and roads that are vulnerable. The hydrological information of relevance for electricity production is communicated to

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[27] http://www.metservice.com/national/index (last accessed 28 March 2012).
[28] http://www.niwa.co.nz/our-science/climate (last accessed 28 March 2012).
[29] Geonet (n.d.)c.
[30] http://www.geonet.org.nz/ (last accessed 28 March 2012).

market participants over the system used to trade electricity and by e-mail. It is also published on websites.

Warnings about tsunami generated distant from New Zealand are distributed over the radio and television media. There is currently no system to warn the public about tsunami originating close to New Zealand as it is considered the warning times would be too short to be useful.

### 2.3. Ex-post Rescue and Recovery

The Ministry of Civil Defence and Emergency Management (CDEM) is responsible for the management of major disasters due to earthquakes, volcanic eruptions, tsunami, floods and landslides. It does this by coordinating the capabilities of other emergency management organizations, such as the fire service, ambulance service, urban search and rescue (USAR), search and rescue (SAR), police, local authorities, gas, water, electricity and telecommunications utility operators, the military and local civil defense officials and volunteers.[31] CDEM has very wide powers to require co-operation in the provision of support and compliance with its instructions during a declared civil defense emergency.

In a very major natural disaster, CDEM will call on international support when the size of the task is beyond New Zealand's internal capacity to respond. For example, in the rescue phase following the 22 February 2011 Christchurch earthquake, USAR teams from Australia, Japan, China, Singapore, Taiwan, the United Kingdom and the United States, in addition to New Zealand's USAR team, searched for injured persons and bodies in the rubble. At the peak there were 600 USAR personnel, most of whom came from outside New Zealand.[32]

CDEM also used 330 police from four Australian States and the Australian Federal Police to assist New Zealand police.[33] The New Zealand military and 116 members of the Singapore Armed Forces provided transport support and manned cordons around the most damaged areas.[34] In the recovery phase, victim identification experts from Thailand, the United Kingdom, Israel, Australia and

[31] http://www.civildefence.govt.nz/ (last accessed 28 March 2012).
[32] Guy (2011)
[33] New Zealand Police (2011)
[34] NZarmy (2011)

Taiwan were used,[35] and engineers from several countries, including Australia, Singapore and Malaysia, have been used to assist in making geotechnical and building assessments.

New Zealand routinely assists other countries that experience major disasters by sending USAR personnel, rural fire fighters (almost routinely to the west coast of the United States and east coast of Australia), and victim identification experts. In recognition of the fact that New Zealand and Australia regularly provide disaster assistance to one another, since early 2012, New Zealand has been a full member of the Australian National Emergency Management Committee.[36] The Committee has effectively become an Australasian body.

In a more limited and local disaster of the kind dealt with by CDEM, the local civil defense organization, which is part of the local government authority of an area, is responsible for management of the emergency and coordinating the capabilities of the other emergency management organizations. It fulfills a role similar to the role of CDEM in more major events.

Biosecurity disaster management is the responsibility of the Biosecurity division of the Ministry for Primary Industries. It generally uses private sector contractors to spray for insects and plant diseases and to kill livestock or remove infected plants. It usually calls on the assistance of the police for enforcing quarantine restrictions around infected areas and properties but in a major disaster would also call upon the military to assist in this manner.

Public health management is the responsibility of the Ministry of Health and it has available to it the public and private health systems, and legal powers to exclude persons from entering the country and requiring people to remain in isolation.

Responsibility for declaring emergencies in the electricity system due to hydrological conditions rests with Transpower New Zealand Ltd. However, the Electricity Authority – the sector regulator – sets the rules under which Transpower must decide whether to do this and how it should operate if it does.

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[35] Wikipedia (n.d.)b.

[36] Ansely (2012)

## 2.4. Ex-post Recovery and Reconstruction

There have been two very major natural disasters in New Zealand in the last 100 years, along with numerous more minor ones. The first was a 7.8 scale earthquake on 3 February 1931. This killed 256 persons and destroyed Napier and much of Hastings in the Hawkes Bay, an area which at the time was home to 5% of the country's population.[37] The capital loss amounted to approximately 2.3% of New Zealand's annual GDP or 45% of the region's annual GDP at the time.[38]

The second was the series of sizeable earthquakes between September 2010 and December 2011 which killed 185 people and destroyed much of Christchurch's CBD and severely damaged some of the surrounding region, an area which at the time was home to approximately 12% of New Zealand's population. The loss at replacement cost in this case is currently estimated to be approximately 15.8% of New Zealand's GDP in 2010/11 and 114% of the region's annual GDP.

On both occasions, the central Government appointed a special body with wide powers to organize and oversee the recovery and reconstruction. In Napier in 1931, the power was placed in the hands of two commissioners – a judge and an engineer.[39] This action has been viewed as very successful. Recovery was relatively swift and successful, especially compared with Hastings, which had suffered less damage, and where the local authority was left to organize recovery. Following the Christchurch earthquakes, the power has been placed by legislation in the hands of a special government body – the Canterbury Earthquake Reconstruction Authority (CERA) – headed by a Cabinet Minister but subject to oversight of its exercise of its special powers by a review panel of highly respected citizens.[40] It is too early to judge whether CERA has been a success or not.

[37] Wikipedia (n.d.)a.
[38] Chapple (1997: 27)
[39] Sharpe (2011)
[40] http://cera.govt.nz/ (last accessed 28 March 2012).

## 3. Impact of Natural Disasters on Urbanization

### 3.1. Economic Impacts of Disasters: Case Study

*3.1.1. Impact on Christchurch*

The sequence of major earthquakes in Christchurch that started in September 2010 provide an instructive case study of the short-term and medium-term economic impacts of a major natural disaster in New Zealand and of the effectiveness of the country's regime for the management of natural disasters. The area directly affected by these earthquakes is home to around 12% of New Zealand's population and includes Christchurch, New Zealand's second largest city after Auckland.

**Table 2: Earthquakes in Christchurch Area 4 Sept 2010 – 24 June 2012**

| Richter scale | Number |
|---|---|
| Less than 4 | 10,685 |
| 4 to less than 5 | 380 |
| 5 to less than 6 | 49 |
| 6 to less than 7 | 3 |
| 7 and above | 1 |

*Source*: Crow (update live) (last accessed 25 June 2012).

Each of the four major earthquakes, and many of the smaller quakes, caused some property damage (Table 2). The event on 22 February 2010 caused by far the most damage. By 24 June 2012 orders requiring the total demolition of 798 commercial and industrial buildings and partial demolition of 208 more had been issued by the authorities.[41] A large proportion of the buildings in the CBD, which took the main force of the 22 February 2011 earthquake, have been demolished or are in the process of being demolished. This includes most of the high-rise buildings and a good proportion of the CBD's hotel accommodation capacity, along with several large public buildings, such as the Anglican and Catholic Cathedrals, the Town Hall and the Convention Centre.

[41] http://cera.govt.nz/demolitions/list (last accessed 25 June 2012).

Many roads were extensively damaged, and there was major damage to the underground sewage and water pipes. Christchurch does not have a piped gas supply except in small areas in isolated suburbs. The local electricity distribution system suffered some damage to underground and overhead cables, but greater damage to substations. The national electricity grid suffered only very minor damage.

Very little damage was sustained by plant, machinery and equipment in manufacturing plants and offices. Partly this was because virtually all office buildings and factories remained upright so their contents remained largely intact, despite the structures being damaged in many cases beyond repair. This is what the building codes had been designed to achieve – the preservation of structural form sufficient not to endanger human life and not necessarily the ability to repair the building. It is also partly because manufacturing in Christchurch is concentrated in the west of the city, which was less severely affected.

The public was not allowed into the CBD area for several months after 22 February 2011, not even to recover equipment and personal belongings. As a result, many businesses and local and central government agencies were required to replace their office equipment in order to remain functioning. They have since been able to recover their equipment, stocks and files.

The four most significant quakes caused some injuries but only the events on 4 September 2010 and 22 February 2011 caused serious injuries. Approximately 170 people were seriously injured by the two events.[42] 185 people died as a result of the 22 February 2011 earthquake but there were no fatalities resulting from the other earthquakes.

The four most significant earthquakes all resulted in liquefaction of the ground in many of the lower lying areas close to rivers in the greater Christchurch area. As a result, by the end of June 2012, 6,791 residential properties,[43] or 3.7% of the approximately 185,000 in the area, had been declared as unfit sites on which to rebuild because geo-technical problems with the soils upon which they are built mean it would be uneconomic to do so. These sites are mainly clustered adjacent to the lower reaches of two major rivers. The result will be that several areas of the

[42] Wikipedia (n.d.)b.
[43] Recovery Canterbury (2011) and Mann and Mathewson (2012).

greater metropolitan area will be abandoned and allowed to return to farmland or be converted to parks and reserves.

The Government has offered to purchase these residential sites at their 2008 market valuation, which it considers to be a good approximation of their market value at the time of the February 2011 earthquake. Approximately 3,000 other residential sites await final geotechnical assessment, so the total number of residential sites to be abandoned is likely to be between 7,000 and 9,000.

There are also several thousand houses in the city which require very substantial renovation or complete re-building on their existing sites, if they are to be occupied again. Approximately 165,000 residential properties suffered some degree of damage.

*3.1.2. Classification of Economic Costs*

The World Bank has recently published a suite of studies on the economic and social impact of natural disasters.[44] Most of the papers are empirical studies but one of the more recently published World Bank studies, the *Economics of Natural Disasters: Concepts and Methods* by Stephane Hallegatte and Valentine Przyluski provides a useful classification of the economic costs of a natural disaster.[45]

Hallegatte and Przyluski distinguish direct and indirect losses. The former they define as "the immediate consequences of the disaster physical phenomenon."[46] They further distinguish between direct market losses – losses to goods and services that are traded on markets, and for which a price can be observed - and direct non-market losses – all damage that cannot be repaired or replaced through purchases on a market.[47]

Hallegatte and Przyluski propose two criteria to help identify indirect losses. First, indirect losses are caused by secondary effects, not by the hazard itself. Secondly, costs are indirect if they span a longer period of time, a larger spatial area or a different economic sector than the disaster itself. They note that for capital destroying disasters, the term "indirect losses" is often used as a proxy for "output

[44] Lopez, R. (2009); Loayza, *et al.* (2009); Raddatz, (2009); Keefer, *et al.* (2010); Melecky and Raddatz (2010)
[45] Hallegatte and Przyluski (2010)
[46] *Ibid*., p.2.
[47] *Ibid*., pp.2-3.

losses" or the reduction in economic production provoked by the disaster, including the costs of business interruption and the longer term consequences of infrastructure and capital damages. Like direct losses, indirect losses may be market or non-market losses.

Indirect losses can have "negative-costs" components, i.e. gains from additional activity created by the reconstruction. These gains can occur in the affected region or in another region.[48]

Hallegatte and Przyluski note that to implement these definitions of costs it is necessary to define a baseline or counterfactual scenario; the scenario of what would have occurred in the absence of a disaster. They also note that identifying the relevant costs of a disaster cannot be done independently of the purpose of the assessment. The costs relevant to insurance companies, households, firms and the Government can all differ depending on their purpose.[49]

### *3.1.3. Cost Estimates*

Table 3 sets out estimates of the measurable direct and indirect costs of the earthquakes in the greater Christchurch area. Appendix I provides details of how the estimates have been derived using the data available at the end of June 2012. The estimates are in New Zealand dollars. New Zealand has a floating exchange rate and its value against other currencies, including the United States dollar, moves widely. The daily average exchange rate between the United States dollar and the New Zealand dollar in the calendar year 2011 was $NZ1 = $US0.7916.[50]

For most depreciable assets like buildings, network assets and commercial and industrial plant and equipment two cost estimates are provided: a replacement cost (RC) and a depreciated replacement cost (DRC) estimate. The RC estimates for these assets reflect the cost of replacing those destroyed in the earthquake with equivalent new assets at current market prices. The DRC estimates are the RC

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[48] Hallegatte and Przyluski (2010), p.4.
[49] *Ibid*., pp.4-5.
[50] Calculated from Reserve Bank data published in http://www.rbnz.govt.nz/statistics/exandint/b1/index.html (last accessed on 10 July 2012).

estimates adjusted for the estimated extent to which these replaced assets were already depreciated at the time they were destroyed or damaged.[51]

The DRC estimates for the assets for which they are given can be considered to be approximate current market value estimates. This is because the value of an asset to a firm is generally the present value of the expected future cash flows. If, however, as is usually the case, this is above the DRC of the asset, the firm will not pay more than DRC, assuming it can buy (or lease) second hand assets.

The estimates of the other cost components are at current market values. The result is that the estimates labeled Replacement Cost are reasonable indicators of the costs that would be incurred restoring the damage that resulted from the earthquakes.

The estimate labeled “Depreciated Replacement Cost”, however, is an indicator of the economic costs of the earthquakes, taking into account that some of the assets that were destroyed were part way through their useful economic lives but will be replaced by new assets, which will generally have a longer remaining economic life.

Only the costs (and benefits) that have been able to be expressed in monetary terms are included in the estimates. Other costs include loss of life and serious injury, the disruption to lifestyle, loss of heritage architecture and the stress from the experience and the on-going uncertainties around the future. All the figures in Table 3 should be treated as best estimates; they are inevitably subject to error.

One benefit not included in the estimates in Table 3 is the value of the reduction in crime in the region which followed the earthquake. In the year ended June 2011, the number of offenses reported to the police in the Canterbury region fell by 14.6% whereas the decline in the rest of the country was only 4.6% (Figure 1).

[51] It is likely that damaged motor vehicles will be replaced by second-hand vehicles of similar quality and age. This means the actual replacement cost will be the depreciated replacement cost for motor vehicles and two separate estimates are not required.

## Table 3: Estimated Costs of Christchurch Earthquakes, 2010-2012

| | Replacement Costs | | Depreciated Replacement Costs | |
|---|---|---|---|---|
| **Direct Costs** | $NZm | % | $NZm | % |
| ***Households:*** | | | | |
| - Dwellings | 12,947 | | 8,674 | |
| - Value of residential land losses | 911 | | 911 | |
| - House contents and personal property | 862 | | 431 | |
| - Motor vehicles | 4 | | 4 | |
| - Accident and emergency medical treatment | 9 | | 9 | |
| | *14,733* | 47.6% | *10,029* | 53.6% |
| ***Commercial and Industrial (C&I)*** | | | | |
| - Buildings | 9,306 | | 3,071 | |
| - Value of red-zoned former C&I land | 3 | | 3 | |
| - Plant, machinery and equipment | 362 | | 181 | |
| - Motor vehicles | 1 | | 1 | |
| - Stocks | 702 | | 702 | |
| | *10,374* | 33.5% | *3,958* | 21.2% |
| ***Infrastructure*** | | | | |
| - Roads - local and state highway | 801 | | 481 | |
| - Electricity distribution network | 70 | | 42 | |
| - Electricity transmission network | 7 | | 4 | |
| - Gas distribution network | - | | - | |
| - Sewage systems | 924 | | 554 | |
| - Stormwater systems | 119 | | 71 | |
| - Water supplies | 156 | | 94 | |
| - Solid waste disposal systems | 12 | | 9 | |
| - Telecommunications networks | 57 | | 43 | |
| - Port assets | 116 | | 29 | |
| - Airport assets | 3 | | 3 | |
| | *2,265* | 7.3% | *1,330* | 7.1% |
| ***Local government*** | | | | |
| - Buildings | 135 | | 45 | |
| - Sports facilities, parks and reserves | 59 | | 30 | |
| | *194* | 0.6% | *74* | 0.4% |
| ***Central government*** | | | | |
| - Buildings | 85 | | 43 | |
| - Value of red-zoned former government land | 1 | | 1 | |
| - Other | 1 | | 1 | |
| | *86* | 0.3% | *44* | 0.2% |
| **Total Direct Costs** | **27,652** | 89.4% | **15,435** | 82.5% |
| **Indirect Costs** | | | | |
| ***GDP*** | | | | |
| - GDP lost in Canterbury | 3,287 | 10.6% | 3,287 | 17.6% |
| - GDP gains in rest of New Zealand | -822 | -2.7% | -822 | -4.4% |
| ***Additional travel costs*** | | | | |
| - Schools | 7 | | 7 | |
| - Other intra-regional | 5 | | 5 | |
| - Other extra-regional | 5 | | 5 | |
| ***Temporary relocation costs*** | | | | |
| - Households | 300 | 1.0% | 300 | 1.6% |
| - Other | 482 | 1.6% | 482 | 2.6% |
| ***Value of land reclaimed at Lyttelton*** | -20 | | -20 | |
| ***Cost of temporary replacement for AMI stadium*** | 28 | | 28 | |
| **Total Indirect Costs** | ***3,272*** | 10.6% | ***3,272*** | 17.5% |
| **Total Direct and Indirect Costs** | ***30,924*** | 100.0% | ***18,707*** | 100.0% |

*Sources*: See Appendix I.

**Figure 1: Changes in Offences Reported to the Police, 2006-2011**
June year annual percentage changes


*Source*: Statistics New Zealand.

Table 4 sets out estimates of the contributions by different groups – insurers, households, Government, local authorities, donors, and commercial and industrial firms – to the estimated total replacement cost of the impact of the earthquakes. Appendix II provides details of how these estimates have been derived using the data available at the end of June 2012. The estimates are in New Zealand dollars.

By far the major contribution to the total replacement cost of $NZ30.9 billion will come from insurers; in total $NZ24.1 billion, or 78%. The central Government (i.e. the New Zealand taxpayer) is the second most significant contributor when the fact it tops up EQC's funds for all claims against it exceeding $NZ4.0 billion dollars for any one event. The third most significant contributor group is households, which bear an estimated 7.7% of the total replacement cost or about $NZ2.4 billion. A significant component of the cost to households is the reduction in incomes.

**Table 4: Contributions to Replacement Cost of Christchurch Earthquakes, 2010-2012**

| | $NZm | $NZm | % |
|---|---|---|---|
| ***Insurance and reinsurance (excluding EQC and AMI and ACC)*** | 13,317 | | |
| ***EQC (Including $4.2b sum reinsured and Government's contribution)*** | | | |
| - Houses | 10,194 | | |
| - Contents and personal property | 566 | | |
| - Residential land | 27 | | |
| ***ACC payments for treatment of injuries etc.*** | 9 | | |
| ***Total contribution from insurers*** | | *24,113* | 78.0% |
| ***Central government (excluding EQC)*** | | | |
| - Financial support to AMI | 100 | | |
| - Repair & replacement of state owned assets | 85 | | |
| - Contribution towards repair & replacement of local infrastructure assets | 653 | | |
| - Purchase of red-zoned residential land and related costs | 838 | | |
| - Demolition of CBD properties | 112 | | |
| - Payments to local government for response and recovery costs | 82 | | |
| - Other earthquake related central government expenses | 522 | | |
| ***Total contribution from central government*** | | *2,391* | 7.7% |
| ***Private charity*** | | | |
| - Organised | 214 | | |
| - Families and friends | 20 | | |
| | | *234* | 0.8% |
| ***Households*** | | | |
| - Assets losses | 806 | | |
| - Loss of income | 1,282 | | |
| - Temporary relocation costs | 270 | | |
| | | *2,358* | 7.6% |
| ***Commercial and industrial businesses*** | | | |
| - Assets losses | 182 | | |
| - Loss of business profits | 604 | | |
| - Temporary relocation costs | 241 | | |
| | | *1,027* | 3.3% |
| ***Local government*** | | 802 | 2.6% |
| ***Discrepancy*** | | - 1 | 0.0% |
| **Total contributions to losses at replacement cost** | | **30,924** | 100.0% |

*Sources*: See Appendix II.

Households will also indirectly bear the costs of the other groups through future taxes (central government), future rates (local government property taxes), higher charges or rates (monopoly infrastructural providers) and higher future insurance premiums (insurance). The table does not reflect the indirect incidence of the costs.

All the figures in Table 4 should be treated as best estimates; they are inevitably subject to error.

A significant point to emerge from Table 4 is that an estimated 78% of the $NZ30.9 billion of direct and indirect costs of the earthquakes at replacement cost will be covered by insurance of one form or another.

Our estimate of the cost as $NZ30.9 billion at replacement cost is not out of line with other aggregate estimates. To date there are no other estimates for which a detailed breakdown is available. In October 2011, the Reserve Bank of New

Zealand's estimated, before the final major quake, the costs to rebuild as between $NZ15 billion and $NZ25 billion.[52] Subsequently, however, in late January 2012, the Reserve Bank revised its figure upwards to $NZ30 billion. It is clear this estimate is on a replacement cost basis.[53] Swiss Re, a reinsurance provider, estimated in late 2011 that the economic losses from the Christchurch earthquakes, excluding the December 2011 earthquake, was approximately $US18 billion[54] ($NZ22.9 billion). In late October 2011, Treasury warned that the costs of the quakes could be as high as $NZ30 billion.[55] It is clear from the context that Treasury's estimate was on a replacement cost basis as it refers to changes in building standards increasing costs.[56]

*3.1.4. Loss of Population*

According to official estimates by Statistics New Zealand,[57]a government agency, the population of the Canterbury Region, which includes Christchurch City, fell by an estimated 5,000 in the year to June 2011. The components of this change were natural increase of 2,600, as births exceeded deaths by this number, and net emigration of 7,600 from the region. In the four years ended 30 June 2010, the population of the Canterbury Region is estimated to have increased on average by 6,400 with 3,200 of the increase being from net immigration and 3,200 from natural increase. These figures suggest that the earthquakes resulted in a reduction in the natural increase in the region by approximately 600, a turnaround in migration of 10,800 and a gross reduction in regional population of around 11,400 from what it otherwise would have been if normal growth as experienced in the previous four years had continued. On the 30 June 2010 the population of the Canterbury Region was 565,700, so a reduction of 11,400 amounts to a change of 2.0%.

According to the same source,[58] the population of Christchurch City was 376,700 on 30 June 2010, but fell by 8,900 in the subsequent year to 30 June 2011. The reduction was composed of a natural increase of 1,700 and net emigration of

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[52] Bollard and Ranchhod (2011)
[53] Hickey (2012)
[54] Wood (n.d.)
[55] One News (2011a)
[56] *Ibid.*
[57] Statistics New Zealand (2011b)
[58] *Ibid.*

10,600. In the four years ended 30 June 2010, the population of Christchurch City is estimated to have increased on average by 3,700 with natural increase accounting for 2,200 per year and net immigration for 1,600. These figures suggest that the earthquakes resulted in a reduction in the natural increase in Christchurch City by approximately 500, a turnaround in migration of 12,200 and a gross reduction in the city's population of around 12,700 from what it would have been if 'normal' growth had continued. A reduction of 12,700 amounts to 3.4% of the population as at 30 June 2010.

There are currently no official estimates of the populations of the Canterbury Region and Christchurch City after June 30 2011. However, there were significant earthquakes in June 2011 and again on 23 December 2011. The indications from media reports are that there has been further net emigration from the region and the city since 30 June 2011, and that the population losses in both have increased in absolute and percentage terms.

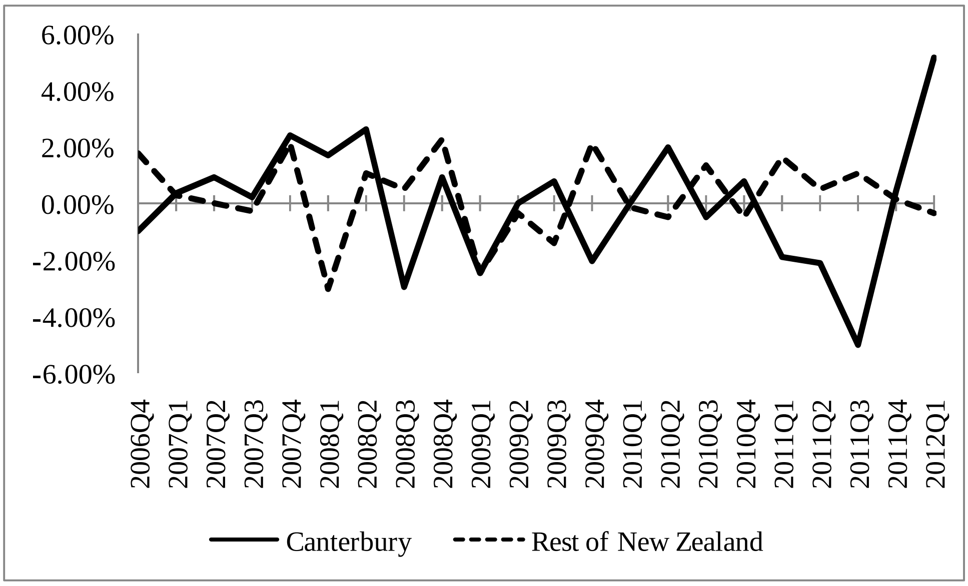
### *3.1.5. Changes in Labor Inputs*

Employment in the Canterbury Region fell by 26,800 persons, or 8.0%, in the year to September 2011 and reached its lowest level since June 2004 (Figure 2). A very slight increase in employment occurred in the December 2011 quarter followed by a substantial increase of 15,900 persons, or 5.1% in the March 2012 quarter. In the rest of the country, employment grew by 51,200 persons, or 2.8% over the year to September 2011 and was relatively static in the following six months to March 2012.

During 2010 employment had been relatively static in the Canterbury Region, having fallen prior to this by about 4% from its peak in mid-2008. This suggests that over the year to September 2011, employment in Canterbury fell below what it would have been without the earthquakes by between 30,000 and 35,000 persons, or around 10%. A 10% reduction in labor inputs is a significant change, as is the increase of 17,200 persons, or 5.6%, in the six months after September 2011.

**Figure 2: Changes in Persons Employed, 2006-12**

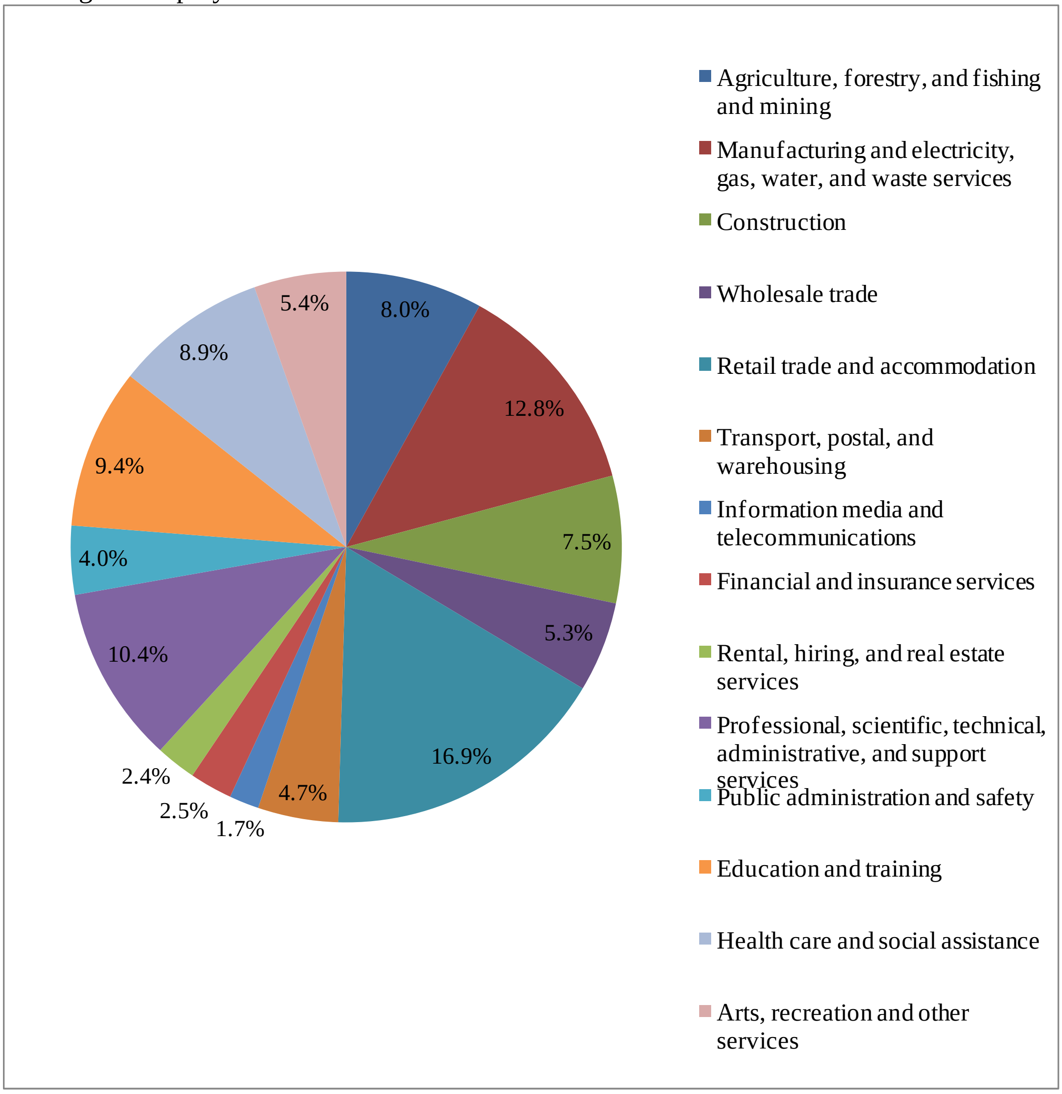
Quarterly percentage changes




*Source*: Statistics New Zealand.

Figure 3 shows the sector breakdown of the Canterbury labor force of 335,200 in September 2010. The sector with the largest share of employment was retail trade and accommodation (16.9%). This reflected the importance of tourism to the Canterbury economy. In the rest of New Zealand, 15.1% of employees were engaged in this activity. The next largest proportion of employees in Canterbury were engaged in the manufacturing and operating utilities (12.8%), followed by professional, etc. services (10.4%) and education and training (9.4%). Both manufacturing and education and training had larger shares of total employment in Canterbury than in the rest of the country.

**Figure 3: Employment by Sector in Canterbury, Sept 2010**
Percentage of employees



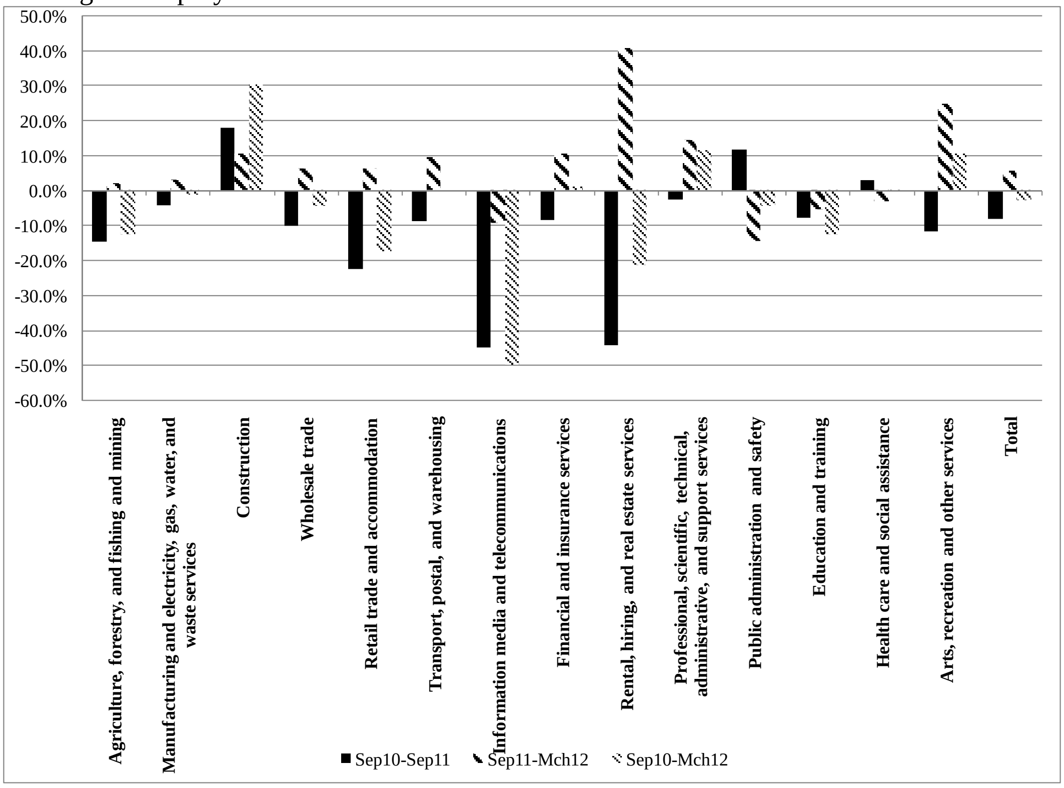

*Source*: Statistics New Zealand

The impact of the earthquakes on employment in the region had diverse effects. This can be seen from Figure 4.

The job losses in the Canterbury Region in the twelve months ended September 2011 were widespread among sectors, but particularly prevalent in the retail trade and accommodation sector that is more heavily concentrated in the extensively damaged CBD. In percentage terms, the losses in information media etc. approached 50.0%, but the sector was a relatively small percentage of total employment (1.7%). The only sectors to show job gains in the twelve months ended September 2011 were construction, public administration and professional services. Employment in manufacturing was relatively static.[59] In the rest of New Zealand over the same period there was employment growth in almost all sectors.

**Figure 4: Changes in Canterbury Employment by Sector, Sept 2010 – March 2012**

Percentage of employees




*Source*: Statistics New Zealand

In the period from September 2011 until March 2012, employment grew in the Canterbury region in most sectors. The exceptions in addition to the small information media sector were public administration and safety, education and training and health care and social assistance. Employment in the rental, hiring and real estate sector, which has fallen over 40% in the year to September 2011 rose by roughly the same amount in the six months to March 2012. This reflected the return of activity to the property market as people abandoned red-zoned and other residential properties and moved elsewhere, often within Christchurch.

[59] Statistics New Zealand (2011b)

*3.1.6. Loss of Output*

Regional GDP data are not officially compiled in New Zealand. However, the New Zealand Institute of Economic Research (NZIER) has long produced and published its own estimates. According to these estimates the GDP of the Canterbury region fell by around 5-7% in the year to September 2011. The decline in Canterbury was, however, partly offset by resilience elsewhere in New Zealand.[60]

NZIER's *Quarterly Survey of Business Opinion* for the September 2011 quarter showed that Canterbury businesses were expecting a bounce back from the initial disruption in the six months to March 2012 and that investment activity in the region would pick up sharply, especially for building investment and construction labor hiring intentions.[61]

*3.1.7. Other Economic Indicators*

Electronic transaction data appears to indicate that retail spending in Canterbury dropped below what it would have been if it had of followed the national trend by between $NZ25 million and $NZ40 million per month, or by approximately 7 – 11%.[62] However, no similar drop in expenditure is evident in the quarterly retail sales statistics shown in Figure 5. The drop off in electronic transactions reflected a reduction in payments by this means as access to electronic payment facilities was disrupted.

House sales nearly stopped in Canterbury immediately after the major quakes but in recent months have bounced back to be more in line with national trends. House prices appear to be rising in Canterbury, compared to flat prices elsewhere but the increase is still very modest at less than 5% per year. The inventory of houses for sale relative to numbers of house sales has declined in Canterbury much more than in the rest of the country.[63]

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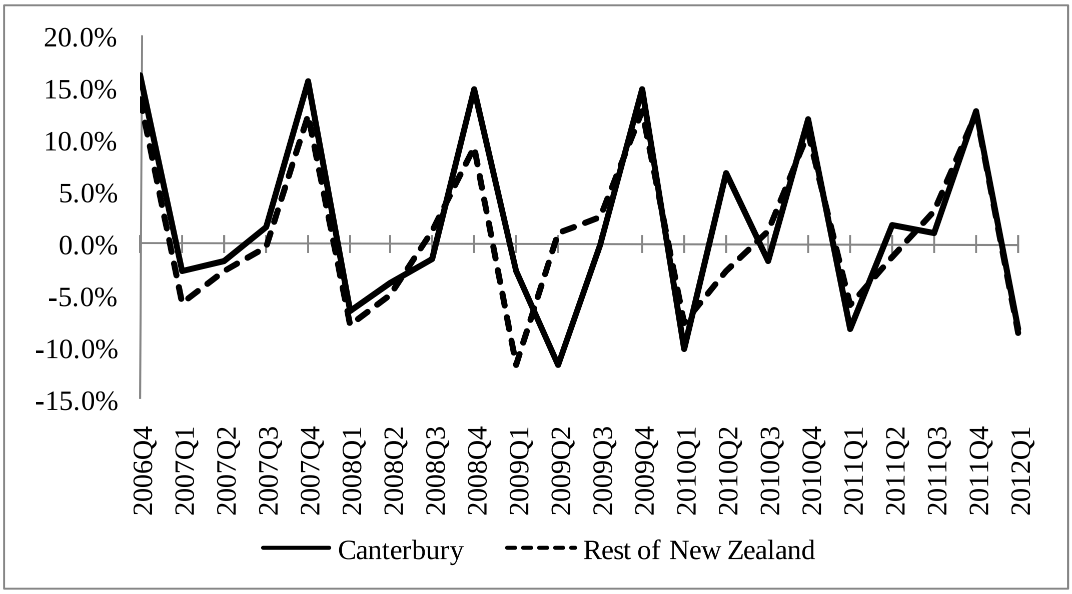
[60] NZIER (2011)
[61] *Ibid.*
[62] *Ibid.*
[63] *Ibid.*

**Figure 5: Changes in Retail Sales, 2007-2012**
Quarterly percentage changes

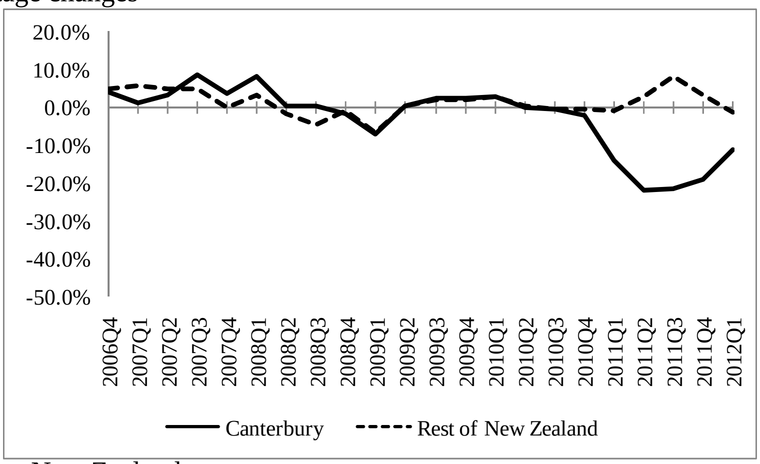



*Source*: Statistics New Zealand.

The number of bed nights in accommodation places in the Canterbury region fell sharply after the earthquakes and had not completely recovered by the December quarter 2011 (Figure 6). This is despite the people who have been brought in to Christchurch temporarily to undertake assessments and help with the recovery phase.

The number of bed nights in New Zealand reaching an all-time monthly high of approximately 2.5 million in October 2011, whereas those in Canterbury were 27% below their previous peak.[64]

**Figure 6: Changes in Total Guest Nights, 2006-2012**
Annual percentage changes



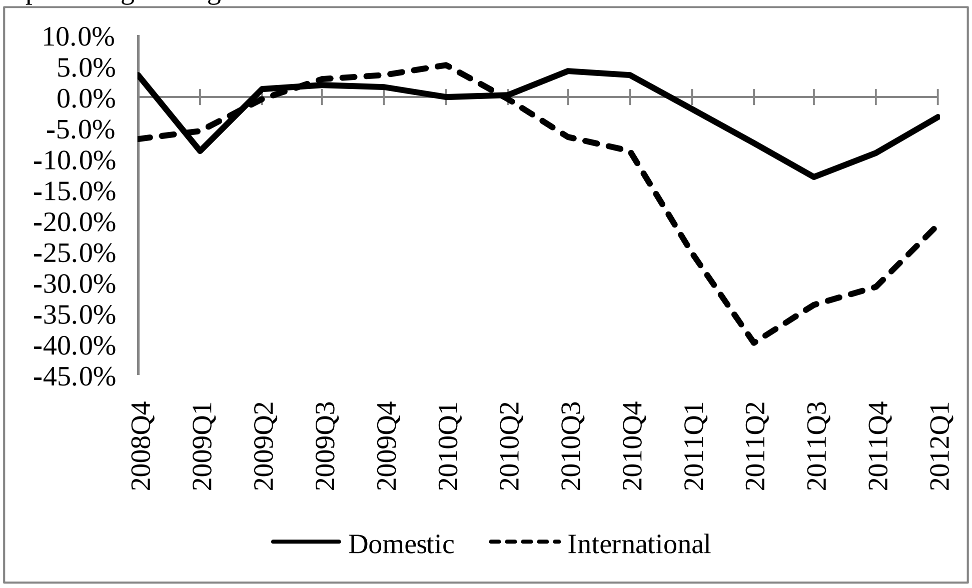

*Source*: Statistics New Zealand.

[64] *Ibid.*

From Figure 7 it is clear that the fall in the number of international guest nights in Canterbury was far more significant than the fall in the number of domestic guest nights. Of the major population centers in New Zealand, Christchurch is the one most dependent upon international tourism and the earthquakes severely disrupted this industry.

**Figure 7: Changes in Canterbury Guest Nights, 2008-2012**

Annual percentage changes



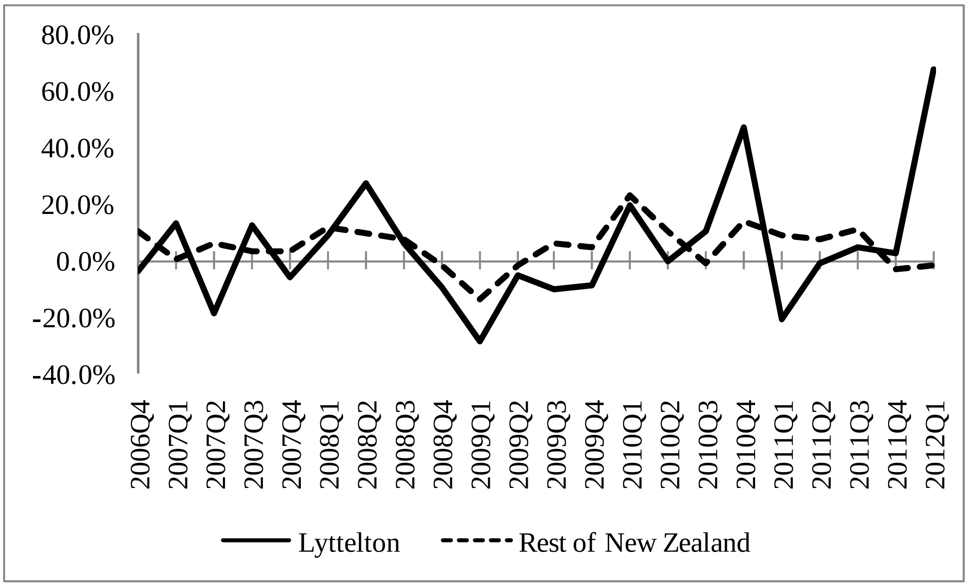

*Source*: Statistics New Zealand.

Despite very significant damage to the physical assets of the region's major port at Lyttelton, exports through the port were reasonably resilient after the earthquakes and reached an all-time high by value late in 2011.[65]

In terms of volumes of cargo, the throughput of Lyttelton has always been quite volatile. This is partly due to the importance of coal exports to the port; these vary significantly depending on the arrival times of ships. It is also partly due to the importance of primary produce in the exports through the port. Small variations in the timing of the seasonal meat kill and grain harvest can have a large impact on volumes exported in a quarter.

[65] *Ibid.*

**Figure 8: Changes in Trade Volumes through Seaports, 2006-2012**
Annual percentage changes, gross weight




*Source*: Statistics New Zealand.

Figure 8 illustrates the volatility of trade through Lyttelton and that there has been no obvious impact on this trade as a result of the earthquakes until the March quarter 2012. In that quarter total trade through the port was 67.2% greater than in the corresponding quarter the previous year. Import volumes rose 105% and export volumes by 55%. It is likely that imports for reconstruction activities contributed to the sharp increase in imports and total trade.

The impact of the earthquake on the Government's fiscal position has been significant. Both central and local government faced large costs. The central government has purchased residential properties in the zones that will be abandoned for geotechnical reasons. This is estimated to have cost approximately $NZ840 million. It has also offered financial support to AMI, a major insurer of households based in the region affected by the earthquakes. AMI held inadequate re-insurance to cover the string of earthquakes. The cost to the Government will be approximately $NZ100 million.

In addition to these costs, the Government faced significant expenses for welfare and emergency services and has to fund the on-going operation of the Canterbury Earthquake Recovery Authority (CERA), the special statutory body the Government established to manage the recovery of the region. In addition, the Government is the owner of EQC, a New Zealand Government agency providing natural disaster insurance to residential property owners, and underwrites the claims on it in excess of $NZ4.0 billion for any single event. The earthquakes in Christchurch have been considered to be several different events for the purposes of EQC liability.

The Reserve Bank estimated the Government's earthquake-related expenditure at $NZ13.6 billion in the June 2011 fiscal year.[66] This figure includes the expenses of EQC. Earthquake-related expenditure were a major contributor to the marked deterioration in the Government's operating deficit in the 2010/11 year and this contributed to a downgrading of New Zealand's long term sovereign rating by Standard and Poor's to AA.[67] The Government has tightened its expenditure in general in response to the deterioration in its fiscal position.

## 3.2. Impacts of Disasters on Urbanization in New Zealand

### *3.2.1. Short-term Relocations*

It is too early to identify the longer-term impact of the September 2010 – December 2011 earthquakes on the pattern of urbanization and production networks in Christchurch and New Zealand. However, the short-term impacts that have emerged are interesting, and suggest a number of points.

The earthquake on 22 February 2011 was by far the most destructive. It very nearly demolished the Christchurch CBD and led to it being subject to a 24 hour a day curfew that was still in place in March 2012 in the worst affected areas. Apart from members of the emergency services required to be in the area for their work, the public were excluded from most of the CBD for several months. This included all those that owned or worked in buildings in the city center.

Within hours of the very damaging February 2011 earthquake, service industry businesses located in the CBD – lawyers, accountants, financial advisers, banks, architects, dentists, doctors etc. – began relocating, mainly to the western side of the city, where damage to infrastructure such as roads, sewage, water and electricity was less severe and most buildings were either lightly or not damaged. They moved into former warehouses and distribution centers; in fact, into almost any space they could find. Other businesses relocated to garages and parts of dwellings in the suburbs,

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[66] Bollard and Ranchhod (2011)

[67] *Ibid.*

again mainly in the west of the city. Within days of the earthquake, a large proportion of former CBD located businesses, apart from retail shops, were operating from temporary premises elsewhere in the city.

A local commercial radio station set space aside on its webpage for firms to record where they had relocated from and to.[68] The service was provided free. The number of firms which used this service was small - approximately 90 - but the majority were originally located in the CBD. An analysis of the data reveals that of the 72 CBD firms, no less than 50.0% shifted to addresses in Sydenham, Addington or Riccarton. These three areas are adjacent to the CBD and form an arc to its south and west. No less than 77.8% of the CBD firms shifted to a suburb adjacent to the CBD.

The Christchurch telephone directory covers the greater Christchurch area and is usually produced annually. The yellow pages volume of the directory list businesses by the industry or service they provide. The 2010/11 volume was collated in August 2010, just before the first earthquake. The 2011/12 volume was collated in September 2011.

Table 5 contains a comparison of the listing in these directories of the accountants and auditors, lawyers and solicitors, barristers[69] and dentists recorded as located in the CBD in the 2010/11 volume. The popularity of relocating to the CBD fringe suburbs of Sydenham, Addington and Riccarton, especially by lawyers and solicitors can be seen from the data. Interestingly, while no accountants and auditors were recorded as having moved to the Merivale-Papanui area[70], and only 9.0% of firms of lawyers and solicitors, 25.8% of dentists are recorded as having done so.

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[68] The Breeze (n.d.)

[69] The terms "lawyer" and "solicitor" are used interchangeably in New Zealand. "Barristers" are lawyers who only represent clients in Court and do not undertake other legal functions. "Barristers and solicitors" are lawyers who undertake both Court and non-Court legal work.

[70] Also includes addresses described as in Strowan.

**Table 5: Relocation of Selected Professional Firms from Christchurch CBD, 2010 -2011**

Numbers and percentages of firms

| Professional occupation | Same location | New location: Elsewhere in CBD | New location: Sydenham, Addington & Riccarton | New location: Merivale & Papanui | New location: Other | No location | Total |
|---|---|---|---|---|---|---|---|
| Accountants and auditors | 28 | 6 | 13 | 0 | 30 | 3 | 80 |
| Lawyers and solicitors | 21 | 7 | 26 | 8 | 16 | 11 | 89 |
| Barristers | 20 | 2 | 7 | 6 | 4 | 10 | 49 |
| Dentitsts | 11 | 2 | 3 | 8 | 5 | 2 | 31 |
| Total | 80 | 17 | 49 | 22 | 55 | 26 | 249 |
| Accountants and auditors | 35.0% | 7.5% | 16.3% | 0.0% | 37.5% | 3.8% | 100.0% |
| Lawyers and solicitors | 23.6% | 7.9% | 29.2% | 9.0% | 18.0% | 12.4% | 100.0% |
| Barristers | 40.8% | 4.1% | 14.3% | 12.2% | 8.2% | 20.4% | 100.0% |
| Dentitsts | 35.5% | 6.5% | 9.7% | 25.8% | 16.1% | 6.5% | 100.0% |
| Total | 32.1% | 6.8% | 19.7% | 8.8% | 22.1% | 10.4% | 100.0% |

*Source*: Calculated from Christchurch yellow page phone books for 2010/11 and 2011/12.

Prior to the earthquakes, Riccarton already had clusters of legal and accounting firms, and this, along with the larger size of offices available in the area was undoubtedly an attraction to those firms that had to relocate. Dental practices tend to be small and not dissimilar in terms of the office space they require to medical specialists. Merivale-Papanui is a popular location for medical specialists because of its proximity to the two major private hospitals in Christchurch. That a significant proportion of dental practices needing to relocate should have been drawn here by the kinds of space available is not surprising.

Those recorded in the yellow pages as “barristers” rather than as “barristers and solicitors” or as “lawyers” are sole practitioners. It is common for several barristers to operate from the one building or chamber, and when they do they usually share secretarial and other support. However, they are sole practitioners. Many of those with no location recorded in the 2011/12 yellow pages have undoubtedly set up practice from their home address. There are also several instances of barristers recorded as shifting to the same building as others with whom they were formerly co-located.

Despite the disruption created by the series of major earthquakes and the speed with which decisions often had to be made, what is very clear is that the forces that lead to agglomeration of businesses were still at work when sites for relocation by professional firms and sole practitioners were being chosen.

In October 2011 the Department of Labour conducted a telephone survey of 1,689 employers trading before 4 September 2010 in the greater Christchurch area.[71] The survey did not cover owner operated businesses without any staff. One of the questions related to whether the workplace had partly or fully relocated as a result of the earthquake. Tables 6 and 7 summarize the results according to staff size and industry in which the workplace operates.

**Table 6: Proportion of Workplaces that Relocated Following the Earthquakes by Staff Size, October 2011**

Percentage of workplaces

| Staff size | Did not relocate | Relocated | | | Total |
|---|---|---|---|---|---|
| | | Permanent | Temporary | Unsure | |
| 1 to 5 | 72.0% | 9.8% | 15.1% | 3.0% | 100.0% |
| 6 to 9 | 77.9% | 10.0% | 8.8% | 3.3% | 100.0% |
| 10 to 24 | 70.3% | 12.0% | 15.5% | 2.2% | 100.0% |
| 25 to 49 | 74.9% | 5.5% | 13.7% | 5.9% | 100.0% |
| 50 to 99 | 68.2% | 12.6% | 14.3% | 4.8% | 100.0% |
| 100+ | 62.9% | 7.7% | 18.8% | 10.6% | 100.0% |
| Total | 72.4% | 10.0% | 14.2% | 3.3% | 100.0% |

*Source*: Department of Labour (2011: 13), Table A5

On average, 27.6% of the surveyed workplaces relocated, and 72.4% did not. In general, the larger workplaces – those with staff of 50 or more – were more likely to have relocated than smaller workplaces. Approximately 35% of the larger workplaces relocated compared with approximately 25% of the smaller ones. Of the workplaces that relocated, 36.4% thought in October 2011 that the change was permanent, 51.6% that it was temporary and 12.0% were unsure.

[71] Department of Labour (2011)

**Table 7: Proportion of Workplaces that Relocated Following the Earthquakes by Industry, October 2011**

Percentage of workplaces

| Industry | Did not relocate | Relocated | | | Total |
|---|---|---|---|---|---|
| | | Permanent | Temporary | Unsure | |
| Primary, Transport, Utilities | 87.6% | 7.1% | 4.8% | 0.4% | 100.0% |
| Public, Health, Education | 66.3% | 6.1% | 23.8% | 3.7% | 100.0% |
| Professional, Scientific and Technical Services | 40.2% | 13.3% | 39.3% | 7.2% | 100.0% |
| Manufacturing | 84.0% | 10.9% | 2.7% | 2.4% | 100.0% |
| Construction | 78.0% | 5.2% | 13.2% | 3.6% | 100.0% |
| Retail, wholesale | 79.4% | 12.2% | 5.9% | 2.5% | 100.0% |
| Hospitality | 88.4% | 7.5% | 3.6% | 0.5% | 100.0% |
| Other | 64.8% | 13.3% | 17.5% | 4.4% | 100.0% |
| Total | 72.4% | 10.0% | 14.2% | 3.3% | 100.0% |

*Source*: Department of Labour (2011: 13), Table A6

No less than 59.8% of the workplaces engaged in professional, scientific and technical services relocated as a result of the earthquake. Of the public, health and education workplaces, which are predominantly in the government sector, 33.7% relocated. At the other end of the scale, only 11.6% of the hospitality workplaces shifted and only 16% of those engaged in manufacturing.

The new locations did not initially have the car parking facilities, bus services, coffee shops, and restaurants, lunch bars etc. that were a feature of the CBD and supported its service industry. However, the coffee bars, lunch bars and restaurants very quickly followed their customers. In some instances they did this by subleasing space from new tenants, the employees of whom they had served in the CBD. In other cases, they relocated to trucks and vans on the street side.

The CBD retailers found it much harder to relocate. Some were able to move to vacant shops in the suburbs and in suburban malls, but there was a limited supply of these, and some of the malls had also sustained damage and were temporarily shut. After several months a temporary shopping area was opened in the former heart of the retail area of the CBD. Shops from all over the former CBD agglomerated into a new center made up of 40 very colorfully painted and decorated shipping containers.

They decided to relocate to one relatively small area rather than re-open close to their former locations because they considered this would attract customers. This has turned out to be the case. The opening of the temporary shopping center– Re:Build – was timed to coincide with a festival and public holiday in the city and with the re-opening of a major department store whose relatively modern building was able to be repaired.[72]

*3.2.2. Longer-term Issues: Theory*

One interesting issue raised by the literature on natural disasters is whether the Christchurch CBD will ever be completely reconstructed and how long it will take for the city more generally to recover.

Members of the Faculty and students of the Kennedy School of Government at Harvard University have worked on the recovery of New Orleans following its devastation in 2005 by Hurricane Katrina and the flooding it produced.[73] This followed on from work they had undertaken during the recovery from the earthquake in San Francisco in 1989. More recently they have also been working with Los Angeles following an earthquake there in 2007 and with the government of Chile after that country's 8.8 magnitude quake on 27 February 2010. From experience in these recoveries and from observations of recoveries from other disasters, the director of Harvard's New Orleans Recovery Initiative, Douglas Ahlers, and colleagues have developed several concepts relating to the dynamics of recovery, repopulation and reinvestment following natural disasters.[74]

Ahlers argues that much of disaster recovery where there has been a major loss in physical capital, as there has been in Christchurch, is an investment problem, and, more specifically, an investor confidence problem. Following a major natural disaster of this type, thousands of individuals have to make the decision of whether to re-build or not. Because of the existence of agglomeration benefits, the pay-off to

[72] One News (2011b)

[73] The work is known as the Broadmoor Project. See http://belfercenter.ksg.harvard.edu/project/54/broadmoor_project.html (last accessed 28 March 2012).

[74] See Douglas Ahlers' slide presentation to a public meeting in Christchurch entitled 'Disaster recovery: what the research shows', August 2011. Available at: http://futurechristchurch.wordpress.com/2011/10/11/douglas-ahlers/ (last accessed 28 March 2012).

an investor from a decision to re-build is influenced by the decisions of all the others in a similar locality as to whether they will rebuild or not.

Agglomeration benefits are the economic advantages in terms of higher productivity and lower costs firms (and individuals) obtain from locating near each other; i.e. from agglomerating. The advantages arise because of positive externalities through:

- the increased size of the pool of skilled labor available to the firms;
- the improved access to specialized goods and services and their lower cost due to increased competition among suppliers;
- the improved ability to specialize; and
- technological spill-overs in the form of quicker diffusion or adoption of new ideas.

The more people deciding to re-build in a locality, the higher the pay-off, and vice versa. So the probability an individual will decide to re-build is a function of his or her assessment of whether others will decide to rebuild or not. The situation is analogous to the prisoner's dilemma problem often analyzed using game theory.

The upshot is that there can be two equilibrium positions. One in which "everyone" tips in, and decides that they will re-build because they believe everyone else will re-build. The other one in which "everyone" tips out, and decides that, since it is unlikely that others will re-build, they will not re-build but instead invest elsewhere, where agglomeration benefits are known to be available, or in another activity.

In the short-term, investors can decide to "wait-and-see". In fact, from the point of view of an individual investor, this is the dominant strategy. However, the longer an investor "waits-and-sees" the more others faced with the same decision will take their inaction as evidence that they will not be re-building and this will lower the probability that re-building will actually occur.

The implication of this analysis is that uncertainty over time will slow and may even kill a recovery and reconstruction. For this reason, policy makers should avoid or rectify factors that will increase investor uncertainty, such as:

- lack of a clear leader of the recovery in whom or which people have confidence;

- where and what can be re-built not being settled quickly;
- who will provide affordable insurance for re-built structures and infrastructure, and on what terms; and
- how quickly infrastructure needed to support any rebuilding will be restored or provided in new locations.

A second implication is that recovery will tend to occur in pockets, interspersed among pockets not yet recovering. The resulting patch-work quilt of areas where re-building is occurring interspersed with other areas not currently being re-built was a noticeable feature of the recovery of the lower income areas of New Orleans.

A policy implication is that focusing recovery efforts on particular areas is likely to be more successful. Moreover, the most effective place to concentrate policy interventions is in the areas which are closest to the tipping point; closest to the point where the balance of investor decisions will be easiest to switch from “wait-and-see” to a decision to re-build.

Other implications are that recovery and reconstruction is less likely the easier it is for people to:

- abandon an area or decide not to re-build because, for example, the area was already in decline and/or still had surplus fixed assets relative to needs after the disaster;
- migrate elsewhere because they have the opportunity to do so as jobs are readily available; and
- shift because they have limited financial capital locked up in land or other assets in the area affected by the natural disaster that they will have to abandon or sell for a low return if they do not re-build.

In regard to the last factor, holding insurance cover for disaster damage to buildings, chattels, etc. means that, in the event the insured property is destroyed in a disaster, what was previously a fixed asset becomes a liquid and highly mobile one immediately the insurance pay-out is received.

For this reason, an implication of the Harvard Kennedy School model of recovery and reconstruction is that high levels of assets covered by insurance may not translate into rapid re-building following a disaster. The insurance pay-outs may facilitate re-building by giving parties the financial resources to do so, but they may also make it easier for people to relocate. This will be particularly the case if "insurance" compensation covers not only losses of buildings and chattels but also covers land and, for businesses, lost income and profits, as has been the case to some degree in Christchurch.

The Harvard Kennedy School are not the only ones to note the relevance of the new economic geography concept of agglomeration to the study of the impact of natural disasters, and specifically that one of its implications is that the shock associated with a natural disaster may in some circumstances lead to the relocation of an industry. Okazaki, Ito and Imazuimi have investigated the long-run impact of the Great Kanto Earthquake of 1923 on the geographic distribution of industries in the Tokyo Prefecture.[75] They found that while the effects of the temporary shock on most economic aspects had basically dissipated by 1936, the re-location of the machinery and metal industry following the earthquake was persistent and remained even in 1936.[76]

*3.2.3. Longer-term Issues: Application to Christchurch*

Will the Christchurch CBD ever be completely reconstructed and how long will it take for the city more generally to recover? Will the professional service organizations that shifted from the CBD to new locations in the days after the 22 February 2011 earthquake ever return to the CBD? Some have had to take long leases to secure new office accommodation and once the transport and other services are more fully developed in and around their new locations it is likely many will want to stay, especially since they have agglomerated at the new locations with other compatible organizations.

Will the mainly private owners of the city's numerous two and three storey masonry-fronted buildings invest to replace them or use the proceeds from their insurance policies to invest elsewhere, or in other assets? These buildings were generally old and had poor lighting, heating and space utilisation. Many were not heavily occupied and the economics of rebuilding them in a modestly growing city like Christchurch appears to be challenging.

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[75] Okazaki, *et al.* (2011).
[76] *Ibid*., p.10.

Will the retail activity in the CBD fully recover? Retailing in the Christchurch CBD has been an activity in decline since the 1960s as a result of the local government encouraging the development of suburban shopping malls. Christchurch currently has eight major suburban malls ringing the CBD. One of the lessons from previous natural disasters is that an activity in decline at the time may never recover, and at best will take a very long time to do so. A scenario the Harvard School literature suggests is more than possible is that the CBD, even when fully redeveloped, will have a smaller and more focused retail shopping area than it had prior to the earthquakes.

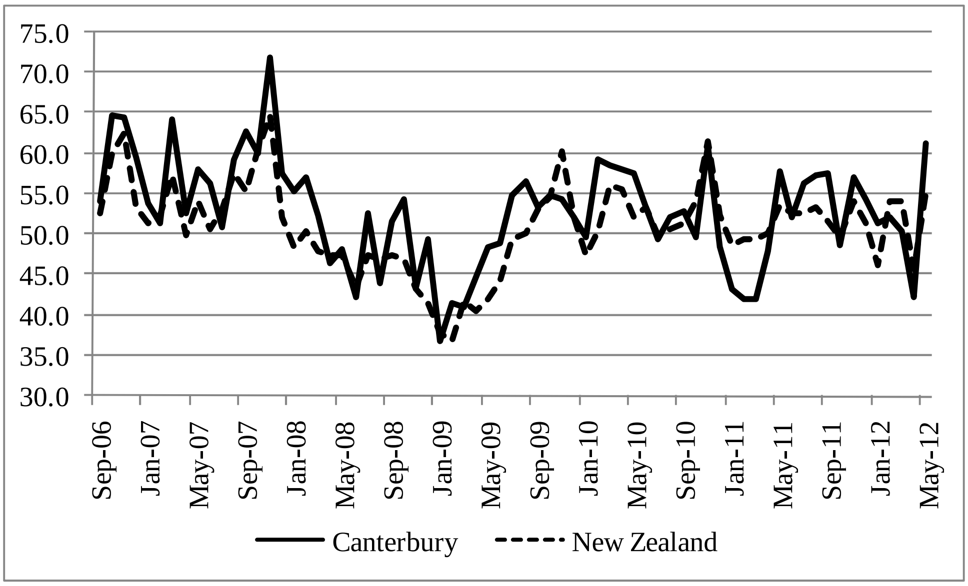
Will the people with houses in the residential red zone, where the Government has offered to buy the land at 2008 market value, relocate within Christchurch or shift elsewhere? Property owners in this situation, who have replacement insurance on their buildings, will be compensated for the land at 2008 market value by the Government and for the buildings at current replacement cost by their insurance company. In short, they will receive close to their entire equity in their residential property in cash. This applies to virtually all the estimated 8,200 residential red zone owners, as insurance coverage in New Zealand is extremely high, and is usually on a replacement basis for houses,

However, the replacement cost of the land in Christchurch is likely to be higher than most will receive from the Government. This is partly because land prices in Christchurch are likely to increase in response to demand relative to the reduced supply and partly because the areas condemned were among the areas with the lowest values in the city. This suggests there is a real possibility that some will decide to relocate elsewhere in New Zealand or Australia, rather than relocate within Christchurch. There are, however, only about 8,200 houses in the residential red zone, out of nearly 200,000 impacted directly. There could therefore be too few people in this situation to have more than a minor impact on the population growth and recovery of Christchurch overall.

The manufacturing sector, historically important in Christchurch, was not affected in a significant manner because it is largely located on the western side of the city outside the CBD. These areas suffered much less damage and, as a result, manufacturing is unlikely to be materially affected in future. Comparison of the

Business New Zealand Performance of Manufacturing Index (PMI) for Canterbury with the index for New Zealand as a whole is consistent with the impact on Canterbury manufacturing being limited (Figure 9). The PMI is an early indicator of levels of activity in New Zealand manufacturing.

**Figure 9: Business New Zealand Performance of Manufacturing Index, 2006-12**
Index Numbers




*Source*: Business New Zealand and Bank of New Zealand.

However, as was shown in Figures 6 and 7 above, tourism is in the opposite situation. Most major hotels have had to be demolished. In addition, virtually all the city's stone heritage buildings, a major attraction to tourists from within New Zealand and beyond, have been destroyed or, at best, will be very many years in the process of being restored. Unless the city re-invents its attractions to tourists this important industry for the local economy will take a long time to recover to its former level. It is not impossible. Napier, which was devastated by an earthquake in 1931, rebuilt in Art Deco style and this is now a major tourist attraction in itself.

*3.2.4. Disaster Insurance*

One unusual feature of New Zealand is the widespread level of insurance against damage from geophysical, hydrological and meteorological disasters. In 1945, the New Zealand Government established the Earthquake Commission (EQC) to provide insurance for residential dwellings (including apartments and holiday houses), most personal property, and the land immediately around a dwelling against damage caused by earthquake, volcanic eruption, hydrothermal activity, tsunami, natural landslips, storm or flood damage and fire caused by any of these natural disasters.

All parties with fire insurance over a dwelling and insurance over household goods and personal property are required to pay for insurance from EQC.[77] The levy used to be $NZ0.05 per $NZ100 insured but following the Christchurch earthquakes the rate has been tripled in order to restore the fund.

There are limits on the level of cover provided. For dwellings (i.e. house alone), the maximum is $NZ100,000. In November 2011, the median residential property (i.e. house and land) price was $NZ367,500.[78] For personal property, the maximum is $NZ20,000. Most insured parties top-up the EQC cover with private insurance so they are fully covered on a replacement basis. This extra insurance was in the past relatively cheap because insurance with EQC meant that only large claims above the maximums of EQC's coverage would fall on the private insurer. Since the Christchurch earthquake the rates for this kind of insurance have risen to reflect the greater perception of risk, but they are still affordable and obtainable by most parties outside Christchurch.

Insurance coverage levels are very high, however, partly because of the availability of EQC cover – in order to access EQC the party must hold house and/or contents insurance - and partly because New Zealand lending institutions will not advance funds against uninsured properties, and most dwelling owners borrow money to finance the purchase of a property, whether it is for their own occupation or to rent to tenants.

Although the EQC only covers residential and personal property, most businesses also carry property insurance and business interruption insurance for losses due to geophysical, hydrological and meteorological risks. This reflects the requirement of lenders that businesses hold adequate insurance cover before they will advance funds.

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[77] http://www.eqc.govt.nz/(last accessed 28 March 2012).

[78] http://www.nasdaq.com/aspx/stock-market-news story.aspx?storyid=201112081942dowjonesdjonline000649&title=new-zealand-november-median-house-price-nz367500-up-24on-october-reinz (last accessed 28 March 2012). This includes the value of the land upon which the house stands.

Over the years, EQC built up its own pool of funds as a result of its levies exceeding its pay-outs. In more recent years it bought additional cover on the international market through reinsurance organizations. Losses in excess of $NZ1.5 billion up to $NZ4.0 billion for any one event have been covered by international reinsurance. The Government covers losses in excess of $4.0 billion for any one event. Private insurance providers of the top ups to EQC cover and commercial disaster insurers also largely pass on the risks they cover to international reinsurers. Much of the financial burden of the earthquakes in Christchurch will fall in the first instance on international reinsurance businesses. In Table 4 above we estimate that insurers and reinsurers, including EQC and the Government-owned Accident Compensation Corporation (ACC) will contribute $NZ24.1 billion of the total $NZ30.9 billion, or 78.0% of the total cost at replacement cost.

We have already noted one of the potential consequences of the high level of insurance coverage. Parties receiving insurance payments may be tempted to use their liquidity in the asset they now hold to relocate elsewhere in New Zealand or overseas in places such as Australia.

Another related issue is that because of the size of the losses sustained, and the on-going seismic activity in the Canterbury regions, many insurers and reinsurers are reluctant to extend cover to new or replacement buildings in the region. This is now starting to hold back redevelopment and, as a result, creating uncertainty among investors; uncertainty which could lead to an unwillingness to invest and retard the time of the recovery, possibly, significantly. It remains to be seen how long it will take for the insurers and reinsurers to re-enter the Christchurch market.

## 4. Policy Recommendations

### 4.1. National Level

New Zealand has a comprehensive disaster monitoring and management regime, and while it is always possible to improve any regime of this kind, the only obvious policy points to emerge from the Christchurch experience are the need to more adequately assess the geotechnical characteristics of land when determining the use to which it should be put and the danger of unreinforced masonry fronts on “historic” buildings.

Of pressing concern at present is the need to create and maintain momentum in the reconstruction of Christchurch, to avoid the risk of the city never returning to its full economic strength and potential. There are several factors working against momentum in reconstruction that need to be overcome.

First, the extended period over which aftershocks have occurred, and the sizable magnitude of several of them, has delayed the return to the market of insurers and reinsurers. According to the telephone survey of workplaces in the greater Christchurch area conducted by the Department of Labour in October 2011, of the respondents that had had to renew insurance policies since 4 September 2010, 14.6% had experienced difficulty renewing existing policies.[79] Obtaining insurance on new and reconstructed buildings has been widely reported to be significantly more difficult than renewing an existing policy. Banks will not fund redevelopment of buildings in the absence of adequate insurance, including insurance against earthquakes.

Secondly, the high level of insurance and the fact that much of it is on a replacement basis, mean that many potential investors in the redevelopment of Christchurch have the funds to progress their aspect of the investment. The longer the delay the more likely they will decide to invest elsewhere.

Thirdly, New Zealanders are generally quite mobile and willing to shift residence and migrate overseas to places like Australia. Most New Zealanders are entitled to live and work in Australia without obtaining a visa. The slower the momentum of reconstruction in Christchurch the greater the number of residents who are likely to migrate to other parts of New Zealand or overseas.

Finally, the CBD of Christchurch has been in relative decline for a long period of time. This is an added barrier to stimulating investment in this part of Christchurch.

[79] Department of Labour (2011: 16), Table A11.

## 4.2. Regional

*4.2.1. Regional Co-operation in Disaster Management*

New Zealand's experience is that regional co-operation on search and rescue, maintaining security for people and property and victim identification in the period immediately after a major natural disaster is very worthwhile. Trained experts in these fields can provide much needed assistance. It is unlikely that even a medium sized country would have natural disasters frequent enough to warrant maintaining the number of people required for these tasks with the appropriate expertise.

Drawing on people with these skills on a regional basis, and sending local teams with these skills to assist in other countries in the region is a good means of maintaining high quality capacity and access to sufficient numbers on the relatively rare occasions they are required. Regional co-operation in setting standards and ensuring that personnel providing these specialist services have the required level of expertise and access to the necessary resourcing would also be desirable.

*4.2.2. Disaster Insurance*

New Zealand's experience with EQC and disaster insurance contains some lessons for others:

- high levels of disaster insurance properly backed by international reinsurance can go a long way to ameliorating the financial costs of a disaster;
- the provision of a national scheme, like New Zealand's EQC, encourages high levels of coverage by private parties;
- high penetration of insurance brings its own issues for the recovery task:
    - considerable resources are required to assess the numerous claims in a large event;
    - it increases the liquidity of the assets of persons affected by the disaster and this can stimulate migration to other regions rather than rebuilding the affected region; and
    - delays in re-establishing access to insurance can retard the recovery process.

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# Appendix I: Table 3 – Estimated Costs

## Direct Costs

### Households

*Dwellings*

The replacement cost figure has been estimated by adding to the estimated EQC claims for dwellings (http://canterbury.eqc.govt.nz/news/progress/statistics(last accessed 28 March 2012)and Appendix II) the estimated value of red-zoned residential buildings calculated as the estimated number of dwellings that will be red-zoned (8,206) times $NZ150,000 per dwelling plus allowance for dwelling costs over EQC limit of $NZ100,000 per dwelling (assumed to be 25,000 dwellings at $NZ35,000 on average). Adjusted by assuming that 95% of the dwellings subject to loss were covered by EQC. The depreciated replacement cost figure has been derived from the replacement cost figure by assuming that on average the houses requiring replacement were 33% depreciated. Many of the residential red-zoned buildings and others suffering severe damage, such as those on the Port Hills, are in relatively recently developed areas of the city; the assumed depreciation rate of 33% reflects this.

*Value of Residential Land Losses*

Estimated value of claims for land to EQC ($NZ27.0 million) plus estimated market value of residential land red-zoned under the Government's compulsory purchase scheme. The former figure is based on pro-rata scaling of EQC resolved claims data as at 22 March 2012 (http://canterbury.eqc.govt.nz/news/progress/statistics(last accessed 28 March 2012)and Appendix II). The latter figure is derived by adjusting the Government's 2012/13 budget estimates of the costs for the purchase, management and demolition of residential red-zone land and associated legal costs. The adjustment has been made to reflect the number of additional properties likely to be red-zoned (1,206) after 22 March 2011 and estimates of the likely market value of each of these properties. The figure has been adjusted by assuming that 95% of the dwellings subject to loss were insured and covered by EQC and the Government compulsory purchase scheme. Further assumptions are that the cost of demolition of each additional red-zoned house will be on average $NZ10,000 and the value of the land once vacant will be on average $NZ10,000 per hectare and there were on average 15 houses per hectare. The estimates are on a replacement cost basis as land does not depreciate.

*House Contents and Personal Property*

The replacement cost figure has been derived from an estimate of the claims for house contents and personal property to EQC based on pro rata scaling of data as at 22 March 2012 (see http://canterbury.eqc.govt.nz/news/progress/statistics (last accessed 28 March 2012) and Appendix II). Adjusted by assuming that 30% of the claims will be over the EQC limit of $NZ20,000 by on average $NZ10,000 each. Further adjusted by assuming that 90% of the house contents and personal property subject to loss was covered by EQC and assuming that 75% were insured on a replacement cost basis and 25% on an indemnity basis and that the latter was on average 50% of the replacement cost. The depreciated replacement cost figure has been derived from the replacement cost figure by assuming that on average the assets requiring replacement were 50% depreciated.

*Motor Vehicles*

The replacement cost figure has been estimated by assuming that 500 motor vehicles were damaged at an average replacement or repair cost of $NZ10,000 each and that 80% of them were private vehicles belonging to households and 20% were commercial and industrial vehicles. Since there is a good second hand market for vehicles the costs of replacement will not be the new cost of the vehicles but the cost of replacing like with like.

*Accident and Emergency Medical Treatment*

From Government Financial Statements to 30 June 2011 plus $NZ2 million additional cost to cover expenses incurred after 30 June 2011.

**Commercial and Industrial (C&I)**

*Buildings*

The rateable value(i.e. value of improvements for the purpose of levying local property taxes or estimated market value)in Christchurch City as at 1 July 2010 was $NZ41.747 billion. The rateable value of improvements inside the CBD area was $NZ3.370 billion and the rateable value of improvements in the area in the CBD cordoned off following earthquake on 22 Feb 2011 was $NZ1.071 billion (Source Christchurch City Council). We have assumed 95% of the cordoned area's value of improvements is commercial and 90% of the balance of CBD's rateable value of improvements is commercial and 20% of balance of city's rateable value of improvements is commercial. Moreover, we assume the loss of commercial rateable value of improvements in the cordon area was 80% and in the balance of CBD area it was 50% and 20% in the balance of the city. From these estimates we deduct the estimated commercial rateable value of improvements lost that are included elsewhere in the table - ports, airports, local and central government buildings, solid waste disposal and 5% of electricity transmission and distribution and telecommunications networks.

The replacement cost figure has been derived from this estimate, which is essentially a depreciated replacement cost estimate, by assuming that on average the assets requiring replacement were 67% depreciated. This high depreciation rate reflects the high average age of the buildings destroyed and damaged in the CBD and other commercial areas. Most modern buildings withstood the earthquakes better than the older buildings.

As at 24 June 2012, 798 commercial and industrial buildings had been issued with official notices requiring demolition, 99 had been issued with notices requiring them to be "made safe' and 208 with notices requiring their partial demolition (see http://cera.govt.nz/demolitions/list(last accessed on 24 June 2012)). This leads to a total of 1,105 buildings. The number of buildings subject to such orders was still increasing at that date. Assuming the final total increases to 1,200 buildings, the average loss per building is $NZ2.56 million. When demolition costs are taken into account this figure appears reasonable as an average.

*Value of Residential Red-zoned Former Commercial and Industrial Land*

Very little commercial or industrial land is in the area that is being abandoned for geo-technical reasons. The estimate of $NZ3.0 million is to cover small shopping areas that will be abandoned when the residents depart.

*Plant, Machinery and Equipment*

Assumed to average $NZ7,500 replacement cost for each of the 48,211 enterprises reported by Statistics New Zealand as operating in June 2010 in the three territorial local authority areas most affected by the quakes: Selwyn and Waimakariri Districts and Christchurch City. The depreciated replacement cost estimate has been derived from this figure by assuming that on average the assets requiring replacement were 50% depreciated.

*Motor Vehicles*

As noted in relation to household costs above, the replacement cost figure has been estimated by assuming that 500 motor vehicles were damaged at an average replacement or repair cost of $NZ10,000 each and that 80% of them were private vehicles belonging to households and 20% were commercial and industrial vehicles. Since there is a good second hand market for vehicles the costs of replacement will not be the new cost of the vehicles but the cost of replacing like with like.

*Stocks*

Calculated by multiplying the share of New Zealand enterprises in the 3 territorial local authorities most severely affected by the earthquake (9.55%) times total wholesale and retail stocks in New Zealand as at 31 December 2010 ($NZ14.6 billion) and assuming a 50% loss factor. The high loss factor includes an allowance for there being several earthquakes strong enough to damage stocks.

**Infrastructure**

*Roads – Local and State Highway*

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

*Electricity Distribution Network*

See http://www.scoop.co.nz/stories/AK1112/S00553/ independent-report-on-orions-earthquake-response.htm (last accessed on 28 March 2012). Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

*Electricity Transmission Network*

See http://www.transpower.co.nz/n4666.html (last accessed on 28 March 2012). Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

*Gas Distribution Network*

There are only very small local distribution networks in Christchurch and these are on the side of the city not severely affected by the earthquakes.

*Sewage System*

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

*Storm-Water Systems*

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

*Water Supplies*

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

*Solid Waste Disposal Systems*

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

*Telecommunications Networks*

Replacement cost estimate based on data provided in media statements and/or annual reports of four major telecommunications providers in New Zealand. Telecom $NZ35.0 million = $NZ42.0 million - $NZ7.0 million from annual report http://media.corporate-ir.net/media_files/IROL/91/91956/Annual_Report_NZ.pdf (last accessed on 28 March 2012) plus $NZ32.0 million*.5 = $NZ.016 million for Telstra Clear (see http://www.telstraclear.co.nz/company-info/media-release-template.cfm? newsid=420 (last accessed on 28 March 2012)) plus $NZ5.0 million for Vodafone (network remained operational) and $NZ1.0 million for 2degrees whose network was largely unaffected. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

*Port Assets*

According to the port company the adjustment to asset values to reflect the damage was $NZ29 million. http://www.lpc.co.nz/TempFiles/TempDocuments/2011%20Media%20Releases/NZX%20Release%20LPC%20Result%20for%20Year%20End%2030%20June%202011%20FINAL%2025%20August%202011.pdf (last accessed on 29 March 2012). The accounts of the company record assets at depreciated replacement cost. To derive the replacement cost value of assets it has been assumed that the assets requiring replacement were 75% depreciated. This high figure reflects the very old age of much of the fixed infra- structure – wharves, etc. – at the port.

*Airport Assets*

See http://www.stuff.co.nz/business/5732964/Quakes-hit-CIAL-revenue (last accessed on 28 March 2012). It is assumed that all the expenditure is on restoration and repair and that none will be capitalised so that the depreciated replacement cost and replacement cost are one and the same.

**Local Government**

*Buildings*

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 67% depreciated.

*Sports Facilities, Parks and Reserves*

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 50% depreciated.

**Central Government**

*Buildings*

*Budget Economic and Fiscal Update 2011*, p.98. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 50% depreciated.

*Value of Red-zoned former Government Land*

Very little red-zone land held by government. Notional figure to cover loss of value in land under schools.

*Other*

Notional figure to cover plant, equipment, etc. losses.

**Indirect Costs**

**Production**

*GDP Lost in Canterbury*

Based on mid-point of NZIER’s estimate of a 5-7% drop in Canterbury’s GDP in 2011. Assumed that loss in GDP is recaptured linearly over a 4 year period. $NZ3,287 million is the present value of the loss of GDP at a 10% discount rate.

*GDP Gains in Rest of New Zealand*

Assumed to be 25% of the loss of GDP in Canterbury.

**Additional travel costs**

*Schools*

Estimated that on average 10,000 pupils were shifted to a new school location five days a week for 26 weeks on average at an estimated average daily cost of $NZ5.

*Other Intra-regional*

Notional estimate of $NZ5.0 million to cover increased time and distance required to travel in the region due to the poor quality of some roads as a result of damage and the disruption to the road system.

*Other Extra-regional*

Notional estimate of $NZ5.0 million to cover increased inter-regional travel as relatives take extra trips to visit relatives and friends in the city and residents take extra trips to escape the damaged zone.

**Temporary relocation costs**

*Households*

An estimated 30,000 moves at an average $NZ10,000 per move.

*Other*

Temporary relocation of 10% of the 48,211 enterprises in the three most heavily affected territorial local authorities at an estimates cost of $NZ10,000

**Value of Land Reclaimed at Lyttelton**

Lyttelton Port Company Ltd obtained approval to use waste rubble from the demolition of buildings to reclaim 10 hectares of land from the harbour at Te Awaparahi Bay. In part, this permission is reflected in lower costs of disposal of waste; the annual report of the company estimates this to be in excess of $100 million. This aspect should be captured in the other cost estimates. It is also resulting in an additional 10 hectares of land adjacent to the port without the need to quarry rock. The economic value of this land is the present value of the future increment in free cash flows it will generate. A figure of $NZ2.0 million would appear a generous estimate of the annual average increase in free cash flow. Hence, our additional figure for this item is $NZ20.0 million. Since this is a benefit it is recorded as a negative cost in the table.

**Cost of Temporary Replacement for AMI Stadium**

The government paid $NZ28.0 million to provide Christchurch with a temporary replacement for its main sports arena, AMI Stadium. See Government's 2012/13 budget estimates showing the Financial Forecast Statements for the Canterbury Earthquake Recovery Authority p.32.

## APPENDIX II: Table 4 – Contributions to Replacement Costs

**Insurance and Reinsurance (excluding EQC and AMI and ACC)**

Late in 2011 Swiss Re, a re-insurance provider, estimated the insurance costs of the 4 September 2010 and 22 February 2011 earthquakes at $US17.0billion. To take account of additional damage in the June and December 2011 quakes, and business continuity costs being greater than probably expected at the time Swiss Re made its estimate, we have moved the figure up to $US19.0 billion. This has been converted to $NZ at an exchange rate of $NZ1.00 equal to 0.785 US cents, the approximate rate around the time of Swiss Re's press release. This figure has been adjusted down for payments by EQC and the Government's support for AMI, the New Zealand-based insurer that failed as a result of the quakes.

**EQC (Including $NZ4.2billion sum reinsured and Government's contribution)**

*Houses*

Calculated by scaling up on a pro rata basis the claims resolved by EQC as at 22 March 2012 http://canterbury.eqc.govt.nz/news/progress/statistics.

*Contents and Personal Property*

Calculated by scaling up on a pro rata basis the claims resolved by EQC as at 22 March 2012 http://canterbury.eqc.govt.nz/news/progress/statistics.

*Residential Land*

Calculated by scaling up on a pro rata basis the claims resolved by EQC as at 22 March 2012 http://canterbury.eqc.govt.nz/news/progress/statistics.

*ACC Insurance Payments for Treatment of Injuries etc.*

*Government Financial Statements for June 2011*, p.128 ($NZ7.0million) plus $NZ2.0million for post 30 June 2011 costs.

**Total Contribution from Insurers**

Sum of previous items.

**Government (excluding EQC)**

*Financial Support to AMI:*

Estimate taken from Treasury statements reported in *http://www.scoop.co.nz/stories/PA1204/S00072/govt-welcomes-completion-of-ami-sale.htm(5 April 2012)* (accessed on 24 June 2012)

*Repair and Replacement of State-owned Assets*

Government Financial Statements for June 2011, p.128.

*Contribution towards Repair and Replacement of Local Government-owned Assets*

75% of estimated costs of repair and replacement of local roads and state highways as per Appendix I and Table 3. The standard government contribution is 50% for local roads and 100% for state highways; plus $NZ28.0 million paid by the Government to construct a temporary replacement for AMI Stadium; plus $NZ24.34 million contribution to advanced payment for the estimatedcentral government share of the Stronger Infrastructure Rebuild Team's infrastructure costs. The latter two figures are contained in the Government's 2012/13 budget estimates showing the Financial Forecast Statements for the Canterbury Earthquake Recovery Authority p.32.

*Purchase of Residential Red-zone Land and Related Costs*

Derived from Government's 2012/13 budget estimates of the costs for the purchase and management of residential red-zone land and associated legal costs in the Financial Forecast Statements for the Canterbury Earthquake Recovery Authority p.32.

*Demolition of CBD Properties*

Derived from Government's 2012/13 budget estimates in the Financial Forecast Statements for the Canterbury Earthquake Recovery Authority p.32.

*Payments to Local Government for Response and Recovery Costs*

Derived from the Government's 2012/13 budget estimates in the Information Supporting the Supplementary Estimates: Vote Emergency Management, p. 293.

*Other Earthquake Related Expenses*

Residual item between sum of items above and *Total contribution from central government*.

**Total Contribution from Central Government**

Total from: Government Budget 2012/13 Performance Information for Appropriations: Vote Canterbury Earthquake Recovery, p. 31; plus estimates of *Financial support for AMI*; plus *Repair and replacement of state-owned assets*; plus *Contribution towards repair and replacement of local authority assets* (excluding to avoid double counting replacement of AMI stadium and advanced payment for Crown's share of infrastructure costs); plus *Payment to local government for response and recovery costs*; plus 20% of households' loss of income assumed to be covered by social welfare payments and special grants, etc.

**Private Charity**

*Organised*

See http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/6243606/200-million-donated-for-quake-relief (last accessed on 28 March 2012).

*Families and Friends*

Estimated as an average $100 per household for 200,000 households.

**Households**

*Asset Losses*

Losses of dwellings, land and household and personal property not covered by insurance. It is assumed that 5% of dwellings and land losses fall in this category and 10% of household and personal property losses.

*Loss of Income*

80% *of* 65% of the net loss of GDP. 65% represents approximately the share of labor in GDP. 80% is the share borne by households; the balance is estimated to be borne by the Government (as increased social welfare).

*Temporary Relocation Costs*

90% of the total relocation costs of households as estimated in Table 3 (see Appendix I). 10% of the costs are estimated to be borne by insurance companies.

**Commercial and Industrial Businesses**

*Asset Losses*

Losses of buildings, land, plant machinery and equipment, motor vehicles, stocks, electricity distribution and transmission, telecommunications networks, port and airport assets not covered by insurance. Assumed to be between 2% and 10% depending on the asset class. The figure is adjusted for the $20 million increase in the value of land at the port as a result of reclamation.

*Loss of Profits*

70% of 35% of the net loss of GDP. 35% represents approximately the share of capital and 70% the share borne by the owners of businesses. The balance is estimated to be borne by insurers.

*Temporary Relocation Costs*

Half the assumed total temporary relocation costs of businesses. The other half is estimated to be borne by insurance companies.

**Local Government**

Asset losses relating to local government assets not covered by insurance or central government contributions. Estimated to be 33.3% of the replacement value of the assets. The evidence is that local government was materially underinsured on a replacement cost basis.

**Discrepancy**

Balancing item so that total contributions to losses at replacement cost in Table 4 equal the estimated total losses at replacement cost in Table 3.

**Total Contributions to Losses at Replacement Cost**

Sum of the components in the table.

# CHAPTER 11

# Long-run Economic Impacts of Thai Flooding: Geographical Simulation Analysis

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*We discuss the long-run economic impact of natural disasters on the countries concerned by examining the case of Thai flooding in 2011. If the damage caused by disasters is really serious, industries will move out from the countries in question, and this outflow leads to a negative impact on the national economies in the long run. By using IDE/ERIA-GSM and utilizing short-run forecast for the basic setting, we estimate the seriousness of the flooding in terms of the long-term economic performance. Simulation results show that negative long-run impacts of the flood will be moderate, because many companies' first reaction to the flood was to seek possible relocation of their production sites within Thailand.*

***Keywords*:** Thailand, Flood, New economic geography, Computable general equilibrium models, Disaster management

## 1. Introduction

After the Great East Japan Earthquake and the flooding in Thailand in 2011, many media reported interruptions in production networks, or even in manufacturing industries in Japan and Thailand as a whole. Disruption of one factory in a value chain may lead to the halt of the total production and sales chains, and the media claimed that the vulnerability in production networks must be a serious risk to Japan and Thailand. However, as Ando (2012) pointed out, production networks have recovered very quickly and have showed resiliency of the value chain, because the value chain itself has a strong self-recovering function from disconnection.

This chapter discusses another aspect of the economic impacts of disasters, that is, the long-term economic impact of natural disasters on the countries concerned. If the damage caused by disasters is really serious, industries will move out from the countries in question, and the outflow of economic activities may cause a negative impact on the national economies in the long run. By using IDE/ERIA-GSM, we can estimate the seriousness of the disasters in terms of the long-term economic performance.

IDE/ERIA-GSM is a simulation model based on spatial economics, which is also known as new economic geography. The model is used as a tool for policy makers to judge what sorts of trade and transport measures (TTFMs) must be taken care of, how to prioritize them and how to combine them. It can also simulate possible negative impacts of disasters in the long run. The model consists of an original microeconomic model with a general equilibrium setting, original simulation programs, a huge dataset including 1,654 regions, 3,156 nodes and 5,029 routes, and several parameters obtained by econometric estimations. It covers 16 countries/economies in Asia and two non-Asian economies, namely; Bangladesh, Brunei Darussalam, Cambodia, China, Hong Kong, India, Indonesia, Japan, Lao PDR, Macao, Myanmar, Malaysia, the Philippines, Singapore, Thailand, Vietnam, the United States and the European Union (EU). The model provided theoretical foundation for the prioritization of infrastructure projects in the Comprehensive Asia Development Plan (CADP) and was also referred to in the Master Plan on ASEAN

Connectivity (MPAC) report (ERIA, 2010 and ASEAN, 2010).

We adopt the same methodology as Isono and Kimura (2011) to estimate the economic impacts of the 2011 flooding in Thailand. Isono and Kimura (2011) assessed the economic effects of the Great East Japan Earthquake and concluded that the earthquake might cause a shift of industrial structure from the east to the west of Japan, and to China and other East Asian counties. It claimed that further enhancement of the linkages between Japan and East Asia could mitigate this shift and for Fukushima, Miyagi and Iwate prefectures, tighter connections between Sendai Airport and Okinawa's logistics hub would positively stimulate electronics industries in the Tohoku area.

In addition to adopting the methodology in Isono and Kimura (2011), we reinforced our base settings with using the Current Quarter Model (CQM) by Kumasaka (forthcoming). By applying this short-run forecast as of December 2011 for the GSM, we can obtain a rough image of the magnitude of the damage to Thailand at a very early stage following the disaster. We here estimate long-run impacts and claim that these long-run impacts would be moderate, because many companies' first reaction to the flood is to seek possible relocation of their production sites within Thailand. In fact, simulation results reveal that, at the national level, some provinces in Thailand experiencing positive economic impacts following the flood, would mitigate the negative impacts on the affected provinces. At the time of writing, observations and surveys on the ground in Thailand report that some companies, including multinational enterprises, are relocating from the affected areas to safer provinces in Thailand, which clearly supports our estimations.

This chapter is structured as follows: Section 2 gives a brief explanation of the model. Section 3 provides the baseline scenario, the flooding scenario and alternative scenarios concerning recovery from the flood by enhancing connectivity. Section 4 concludes with some policy implications.

## 2. Simulation Model

### 2.1. Basic Structure of Our Simulation Model[1]

In our economic model, there are 1,654 locations, indexed by $r$ in 18 countries/economies. There are two productive factors: labor and arable land. Labor is mobile within a country but stays immobile across countries.

Consumer preferences, which are identical across the world, are described by a Cobb-Douglas consumption function for an agricultural product, a manufacturing aggregate and a services aggregate. The manufacturing aggregate and services aggregate are expressed by a constant elasticity of substitution (CES) consumption function for individual manufactured goods or services. There are three sectors: agriculture, manufacturing, and services, and the manufacturing sector is divided into 5 sub-sectors; automobile, electronics and electrical appliances, garment and textile, food processing and other manufacturing. The agricultural sector produces a single and homogeneous agricultural product from arable land and labor, using a constant-returns technology under perfect competition. Manufacturing firms produce differentiated products using an increasing-returns technology under monopolistic competition where they use their labor forces and intermediate goods as inputs. Manufacturing intermediaries are procured from all manufacturing firms. Services are produced with using an increasing-returns technology under conditions of monopolistic competition where they use labor only. Economies of scale arise at factory levels. Labor can move to the sectors that offer higher nominal wage rates within the region.

All products in the three sectors are tradable. Transport for an agricultural good is assumed to be costless. Note that the price of an agricultural good is chosen as the numeraire so that the price of the good is unitary across regions. Transport costs for manufactured goods and services are supposed to be of the iceberg type. An increase in purchaser's price compared to the manufacturer's price is regarded as the transport cost. Transport costs within a region are considered to be negligible.

[1] This section is excerpted and modified from Kumagai, *et al.* (forthcoming)

### 2.2. Parameters

We have a number of critical parameters in the model. The consumption share of consumers by industry is uniformly determined for the entire region in the model (Table 1).

**Table1: Consumption Share by Industry**

| | Consumption Share |
|---|---|
| Agriculture | 0.1623 |
| Automotive | 0.0092 |
| E&E | 0.0439 |
| Garment &Textile | 0.0428 |
| Food Processing | 0.0348 |
| Other Manufacturing | 0.1541 |
| Services | 0.5529 |

*Source*: Authors.

The labor input share for each industry is uniformly determined for the entire region in the model, according to that of Thailand in the year 2000, taken from the International Input Output Table by IDE-JETRO (Table 2). Because the simulation is run for more than 20 years, however, it may not be realistic to fix the labor input share for such a long period of time, especially for a developing country. However, we do not have a method to change the share with confidence. We therefore decided to use an "average" value, in this case that of Thailand as a country at the middle-stage of economic development.

**Table 2: Labor Input Share by Industry**

| | **Labor Input Share** |
|---|---|
| Agriculture | 0.633 |
| Automotive | 0.621 |
| E&E | 0.633 |
| Garments& Textile | 0.654 |
| Food Processing | 0.796 |
| Other Manufacturing | 0.733 |
| Services | 1.000 |

*Source*: Authors.

We adopt the elasticity of substitution for manufacturing sectors from Hummels (1999) and estimate that for services as follows: 5.1 for Food, 8.4 for Textile, 8.8 for

Electronics, 7.1 for Transport, 5.3 for Other Manufacturing, and 5.0 for Services. The estimates for the elasticity for services are obtained from the estimation of the usual gravity equation for services trade, including importer's GDP, exporter's GDP, importer's corporate tax, geographical distance between countries, a dummy for free trade agreement, a linguistic commonality dummy, and the colonial dummy as independent variables.

For the transport costs, we first estimate the multinomial logit model of firms' behavior in shipping their products by using firm-level data, based on the Establishment Survey on Innovation and Production Network (Intarakumnerd, 2010). Next, we estimate some parameters such as holding time across borders. By employing these estimates in addition to the multinomial logit results, we specify a transport cost as a function for calculating the transport costs between regions. After that, we estimate Policy and Cultural Barriers (PCBs). Finally, we derive the transport costs between regions to be used in the simulation. Specifically, the transport cost in industry *s* by mode *M* between regions *i* and *j* is assumed as

$$C_{ij}^{s,M} = \underbrace{\left[\left(\frac{dist_{ij}}{Speed_M}\right) + \left(1 - Abroad_{ij}\right) \times ttrans_M^{Dom} + Abroad_{ij} \times ttrans_M^{Intl}\right]}_{Total\ \ Transport\ \ Time} \times ctime_s$$

$$+ \underbrace{dist_{ij} \times cdist_M}_{Physical\ \ Transport\ \ Cost} + \underbrace{\left(1 - Abroad_{ij}\right) \times ctrans_M^{Dom} + Abroad_{ij} \times ctrans_M^{Intl}}_{Physical\ \ Transshipment\ \ Cost}$$

where $dist_{ij}$ is the travel distance between regions *i* and *j*, $Speed_M$ is travel speed per one hour by mode *M*, $cdist_M$ is physical travel cost per one kilometer by mode *M*, and $ctime_s$ is time cost per one hour perceived by firms in industry *s*. The parameters $ttrans_M^{Dom}$ and $ctrans_M^{Dom}$ are the holding time and cost, respectively, for domestic transshipment at ports or airports. Similarly, $ttrans_M^{Intl}$ and $ctrans_M^{Intl}$ are the holding time and cost, respectively, for international transshipment at borders, ports, or airports. The parameters in the transport function are determined by estimation and adaptation from the ASEAN Logistics Network Map 2008 by JETRO, as shown in Table 3 (JETRO, 2008 and 2009). $Abroad_{ij}$ is a dummy taking a value of one if the transaction is international while zero if domestic.

**Table 3: Parameters from Estimation and ASEAN Logistics Network Map 2008**

| | Truck | Sea | Air | Unit | Source |
|---|---|---|---|---|---|
| $cdist_M$ | 1 | 0.24 | 45.2 | US$/km | Map |
| $Speed_M$ | 38.5 | 14.7 | 800 | km/hour | Estimation |
| $ttrans_M^{Dom}$ | 0 | 11.671 | 9.01 | hours | Estimation |
| $ttrans_M^{Intl}$ | 13.224 | 14.972 | 12.813 | hours | Estimation& Map |
| $ctrans_M^{Dom}$ | 0 | 190 | 690 | US$ | Map |
| $ctrans_M^{Intl}$ | 500 | 504.2 | 1380.1 | US$ | Estimation& Map |

| | Food | Textile | Machineries | Automobile | Others |
|---|---|---|---|---|---|
| $ctime_s$ | 15.7 | 17.2 | 1803.3 | 16.9 | 16.5 |

*Notes*: Costs are for a 20-foot container. The parameter $ctrans_M^{Dom}$ is assumed to be half of the sum of border costs and transshipment costs in international transport from Bangkok to Hanoi. The parameters $ttrans_M^{Dom}$ and $ctrans_M^{Dom}$ for sea and air include one-time loading at the origin and one-time unloading at the destination.

*Source*: Authors' calculation.

In addition, $ttrans^{Dom}$ and speed of railway are estimated by the same dataset and the same estimating equation. Due to the minimal usage of railways in international transactions in the dataset, we adopted the same value for the time and cost of international transactions as in trucks from Table 3. Finally, we set the cost per km as half the value of road transport (Table 4).[2]

**Table 4: Parameters for Rail Transport**

| | Railway | Unit | Source |
|---|---|---|---|
| $cdist_M$ | 0.5 | US$/km | Half of Truck |
| $Speed_M$ | 19.1 | km/hour | Estimation |
| $ttrans_M^{Dom}$ | 2.733 | hours | Estimation |
| $ttrans_M^{Intl}$ | 13.224 | hours | Same as Truck |
| $ctrans_M^{Intl}$ | 500 | US$ | Same as Truck |

*Source*: Authors' calculation.

We use the estimated values as a general rule and additionally set the speed of land, sea, air and rail transport of each section differently from the data from UNESCAP and other various institutions, reflecting the gaps of the quality of

[2] The ASEAN Logistics Network Map 2008 offers an example where the cost per km for railway is 0.85 times that of trucks. However, this is only the case when we ship a quantity that can be loaded onto a truck. Railways have much greater economies of scale than trucks in terms of shipping volume, so some industries such as coal haulage incur much lower cost per ton-kilometer. Therefore, we need to deduct this from the value in the ASEAN Logistics Network Map 2008.

infrastructure and the frequency of transport modes. For example, we assume most land trunk routes in Thailand can be run at 60km/h, while some mountainous routes or poor roads can be run at only 19km/h.

So far, we have estimated several components of transport costs including cost for transportation time, cost for transshipment time (holding time), physical transport cost, and physical transshipment cost. These costs are collectively called "GSM transport cost" in this subsection. However, some important components of the broadly defined "transport costs" remain excluded in the model. Examples include tariffs, non-tariff trade barriers (e.g. quota restrictions), procedures before shipping, costs arising from political situations or from certain risks, cost arising from preference differences and cost arising from commercial customs differences. We call these collectively "Policy and Cultural Barriers" (PCBs). We employ the "log odds ratio approach", as initiated by Head and Mayer (2000), in order to avoid the problem of data availability in the estimation of the model, similar to our GSM model. We first estimate the values for Thailand, the Philippines, Malaysia, and Indonesia by using per capita GDP data from the World Development Indicator (World Bank) and input-output data from the Asian International Input-Output Table published by the Institute of Developing Economies, JETRO (IDE-JETRO). We regress days for customs clearance in importing (Days), for which data are drawn from the "Doing Business Indicator" from the World Bank, to get the other sample countries' PCBs. As a result, tariff equivalents of PCBs in the other GSM countries are provided as in Tables 5 and 6.

**Table 5: Tariff Equivalents of PCBs (%)**

| | Food | Textile | Machinery | Automobile | Others |
|---|---|---|---|---|---|
| Indonesia | 162.9 | 42.2 | 105.0 | 326.0 | 189.4 |
| Malaysia | 108.6 | 18.6 | 69.4 | 202.0 | 108.5 |
| Philippines | 127.9 | 27.1 | 82.2 | 244.5 | 136.3 |
| Thailand | 144.6 | 34.4 | 93.2 | 282.6 | 161.2 |

*Source*: Authors' estimation.

**Table 6: Tariff Equivalents of PCBs for the Remaining Countries (%)**

| | Food | Textile | Machinery | Automobile | Others |
|---|---|---|---|---|---|
| Bangladesh | 184.7 | 51.3 | 118.9 | 379.5 | 223.9 |
| Brunei | 132.3 | 29.1 | 85.1 | 254.4 | 142.8 |
| Cambodia | 188.6 | 52.9 | 121.4 | 389.5 | 230.4 |
| China | 152.2 | 37.6 | 98.1 | 300.5 | 172.8 |
| Hong Kong | 123.4 | 25.2 | 79.3 | 234.3 | 129.7 |
| India | 204.5 | 59.5 | 131.4 | 430.1 | 256.5 |
| Japan | 91.7 | 11.0 | 58.0 | 166.2 | 84.8 |
| Korea | 97.6 | 13.7 | 62.0 | 178.6 | 93.0 |
| Laos | 185.9 | 51.8 | 119.7 | 382.6 | 225.9 |
| Myanmar | 207.9 | 60.9 | 133.5 | 438.9 | 262.1 |
| Singapore | 34.2 | 0.0 | 17.8 | 56.7 | 11.5 |
| Vietnam | 148.5 | 36.0 | 95.7 | 291.7 | 167.1 |

*Source*: Authors' estimation.

We are then able to obtain the transport costs between regions, by industry, to be used in the simulation, using the transport cost function, several parameters, and PCBs. Firstly, we choose the economically shortest routes between regions by industry, adopting the transport cost function to all possible routes between regions. The shortest routes and utilized modes may differ among industries, even in the same regional pairs. Next, we calculate the transport costs between regions by industry. This cost is defined as the monetary cost when shipping products using a 20-foot container. Due to the fact that transport costs in this simulation are the ratio associated with the value of products being shipped, we need to transform the costs to fit into the simulation. Except for the electronics and electrical appliance industry, we adopt the average values in a 20-foot container from the preliminary survey results of the FY2010 ERIA-GSM Project, as in Table 7. In the case of the electronics and electric appliance industry, we assumed that firms ship 2 tons per 20-foot container. The value in 20-foot container for the electronics and electric appliance industries is calculated independently as USD 376,611 based on the trade value and volume data in Thailand. The reason why we adopt another value for those industries is the fact that some electronics firms answered in the survey that they selected mainly air transport, and that they did not utilize containers. This implies the existence of a sample selection bias in this survey for those industries. Finally, we transform the transport costs associated with the value of the products.

PCBs are multiplied by the factors as in Tables 5 and 6 when the products are imported to corresponding countries.

**Table 7: Average Value in 20-foot Container (USD)**

| | # of Sample | Average Value |
|---|---|---|
| Automobile | 6 | 89,691 |
| E & E | 11 | 92,746 |
| Garment and Textile | 10 | 34,560 |
| Agro and Food processing | 9 | 37,233 |
| Others | 8 | 59,450 |
| Total | 44 | |

*Source*: Preliminary survey results of FY2010 ERIA-GSM Project.

Wage equations in the model include the variable $A$, which represents technology, or the productivity of each region, and is set by industry. $A$ is calibrated at the beginning of the simulation to match the expected wage rate from the wage equation and the actual wage rate. It is a kind of "residual," including everything that affects the wage level, other than the variables explicitly included in the wage equation.

The parameters for labor mobility are set out at three levels, namely, international labor mobility ( $\gamma_N$ ), intranational (or intercity) labor mobility ( $\gamma_C$ ), and inter industry labor mobility ( $\gamma_I$ ) within a region. If $\gamma$=0.1, it means that a country/region/industry with twice as high real wages as the average attracts 10% labor inflow per year.

We set $\gamma_N$ =0. This means that the international migration of labor is prohibited. Although this looks like a rather extreme assumption, it is reasonable enough, taking into account the fact that most ASEAN countries strictly control incoming foreign labor.

We set $\gamma_C$ =0.02. This means that a region with twice as high real wages as the national average induces 2 percent labor inflow a year.

Finally, we set $\gamma_I$ =0.05, too. This means that an industrial sector with twice as high real wages as the average in the region induces 5 % labor inflow from other industrial sectors per year.

We assume exogenous population growth, given the predicted rate of population growth provided by the United Nation Population Division (Table 8).

**Table 8: Expected Population Growth Rate (2005-2030)**

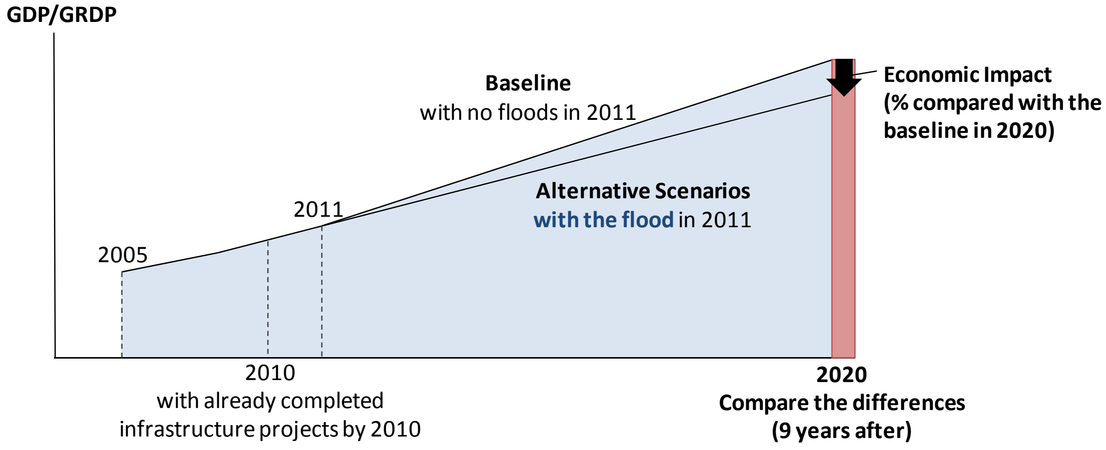
| | | | |
|---|---|---|---|
| Malaysia | 1.47% | China | 0.51% |
| Thailand | 0.49% | Hong Kong | 0.56% |
| Singapore | 0.92% | Macao | 0.84% |
| Cambodia | 1.69% | India | 1.29% |
| Lao PDR | 1.56% | Bangladesh | 1.80% |
| Myanmar | 0.74% | Indonesia | 1.00% |
| Vietnam | 1.18% | Philippines | 1.66% |
| Brunei | 1.74% | | |

*Source*: United Nation Population Division.

## 3. Baseline Scenario, Flood Scenario and Recovery Scenarios

In this section, we provide simulation results based on the settings and assumptions in the last section. The relationships between scenarios in terms of economic impacts are shown in Figure 1. Every simulation starts from 2005. We assume that there were some infrastructure projects completed by 2010. In the baseline scenario, we do not assume additional damage or infrastructure development and run a simulation toward 2020. In the alternative scenario of flooding in Thailand, we assume damage to production in 2011 and recovery in 2012, and run a simulation up to 2020. We compare the economic situations between the baseline scenario and the alternative scenario in 2020 and derive the economic impact of the flooding as a difference between the two scenarios. We also conduct various simulations to identify effective recovery measures, assuming various physical and institutional connectivity enhancements in addition to the damage caused by the flood.

**Figure 1: Baseline Scenario and Alternative Scenarios.**




*Source*: Authors.

### 3.1. Flood Scenario

First we set the flood scenario (Scenario 0). We assume that local infrastructure including the production infrastructure of the factories in affected provinces were damaged in 2011 and recovered in 2012. We describe the situation by lowering the technological parameter A in 2011 and restoring it in 2012. Parameter A includes elements as follows:

- Education level / skill level
- Logistics infrastructure within the region
- Communications infrastructure within the region
- Electricity and water supply
- Equipment in firms
- Utilization ratio / efficiency of this infrastructure and equipments

To set the magnitude of the damage, we use CQM of Thailand by Kumasaka (forthcoming). CQM, updating estimations by an ARIMA type analysis from various partially available information, can estimate very short run impacts of economic shocks to production or GDP. It can provide estimated values before actual official reports are released. As of December 22, 2011, CQM estimated the impacts on real and nominal GDP values in Q4 in 2011 as in Table 9, where we had no official reports on GDP yet.

**Table 9:CQM Short-run Forecasts on GDP of Thailand**

| Real | SR1000 | SR010 | SR020 | SR030 | SR040 | SR050 | SR060 | SR070 | SR080 | SR090 | SR100 | SR110 | SR540 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011Q1 | 7.52 | 47.89 | -0.08 | 5.68 | 1.63 | -16.67 | 1.31 | 14.57 | 4.23 | 16.18 | 13.05 | -11.21 | 3.37 |
| 2011Q2 | 0.19 | -1.04 | -14.39 | 0.24 | -9.31 | -13.22 | -0.64 | -0.12 | 5.87 | 16.89 | 2.56 | -7.60 | 2.42 |
| 2011Q3 | 2.14 | -30.54 | -13.13 | 7.22 | 20.92 | -1.05 | 6.71 | 3.85 | 1.40 | 17.17 | 1.18 | 1.53 | 1.08 |
| 2011Q4 | -21.38 | 1.48 | 8.82 | -40.80 | -10.38 | -11.24 | 1.73 | -27.85 | -28.62 | 6.05 | 4.12 | 11.27 | 6.00 |
| 2012Q1 | 2.32 | 21.26 | 3.59 | -2.76 | 4.40 | -2.82 | 2.58 | -7.28 | 10.28 | 4.21 | 1.76 | 4.23 | 2.03 |
| 2012Q2 | 4.70 | 0.38 | 3.32 | 10.43 | 4.77 | -2.19 | -1.81 | 6.76 | -5.12 | 12.83 | 4.13 | 6.10 | 3.01 |

| Nominal | SN1000 | SN010 | SN020 | SN030 | SN040 | SN050 | SN060 | SN070 | SN080 | SN090 | SN100 | SN110 | SN540 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011Q1 | 21.37 | 135.00 | 27.76 | 15.92 | 3.08 | -4.89 | -2.05 | 10.22 | 5.73 | 21.38 | 26.83 | -6.62 | 5.92 |
| 2011Q2 | -0.97 | -19.33 | 15.27 | -6.25 | -6.41 | -6.26 | 1.77 | 11.60 | 15.54 | 22.18 | -2.59 | 13.66 | 14.40 |
| 2011Q3 | 8.13 | -13.96 | -16.40 | 21.11 | 21.98 | -3.86 | 10.81 | 8.59 | 0.06 | 21.07 | 5.08 | 6.27 | 4.85 |
| 2011Q4 | -17.28 | -9.70 | 23.90 | -39.02 | -5.05 | -5.02 | 5.71 | -22.08 | -29.49 | 10.96 | 2.62 | 9.22 | 8.01 |
| 2012Q1 | 6.53 | 31.83 | 8.80 | -0.23 | 0.55 | 4.61 | 5.50 | -8.62 | 12.64 | 7.13 | 2.83 | 6.22 | 5.88 |
| 2012Q2 | 5.92 | -1.54 | 6.86 | 13.09 | 6.79 | -0.36 | 0.51 | 5.10 | -3.11 | 15.63 | 4.14 | 5.68 | 4.58 |

1000 GDP

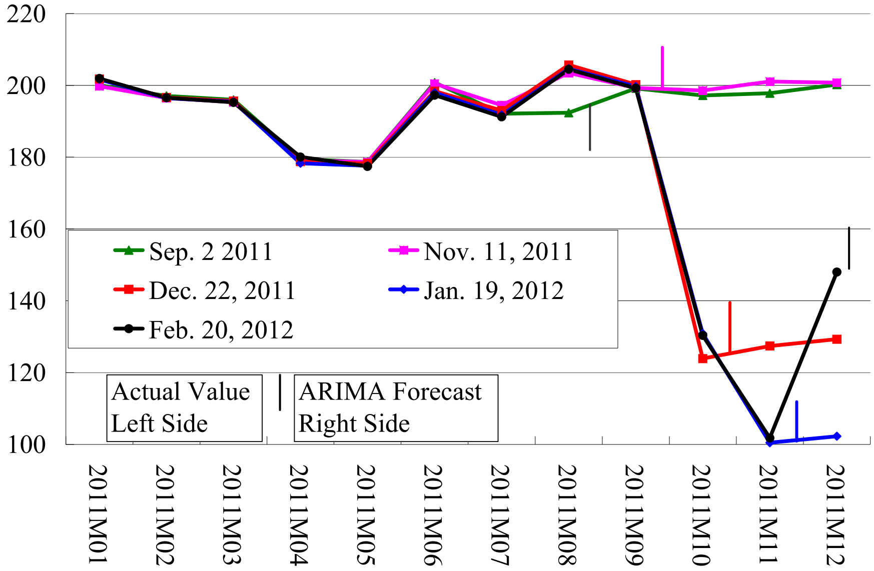
010 Agriculture
020 Mining and Quarrying
030 Manufacturing
040 Electricity, Gas and Water Supply
050 Construction

060 Wholesale and Retail Trade
070 Hotels and Restaurants
080 Transportation, Storage and Communication
090 Financial Intermediation
100 Real Estate, Renting and Business Activities
110 Public Administration and Defense
540 Others (Education, Health and Social Work, Other Community, Social & Personal Service Activity, and Private Households with Employed Persons)

*Source*: CQM as of December 22, 2011.

Figure 2, the estimated production value index of Thailand, explains how CQM adjusts the estimated values using available sources. After getting additional available data, CQM updates its estimations to more reliable values. On September 2 and November 11, CQM did not have data of the damage caused by the flood and it could not assess the possibility of decreasing production. On December 22, CQM got partial information on the damage and revised the estimation values. Also, on January 19 and February 20, CQM revised its values accordingly from additionally obtained information.

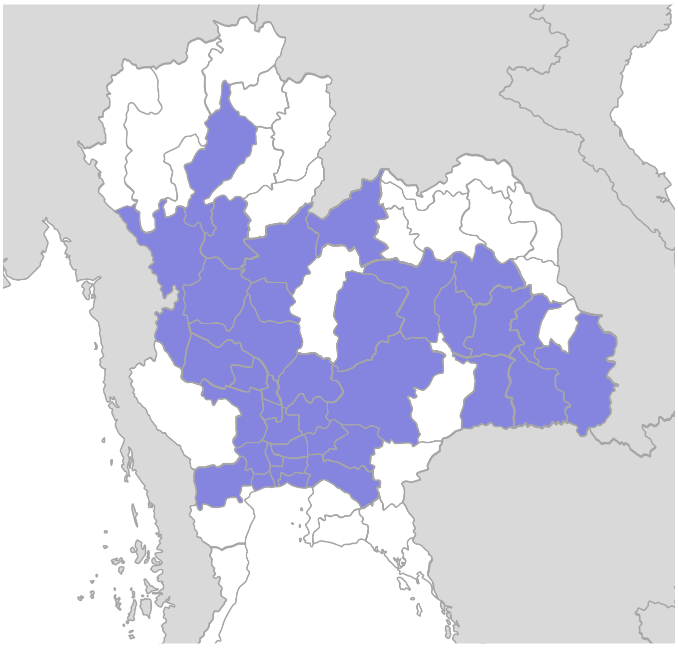
**Figure 2: Production Value Index by CQM**




*Source*: Kumasaka (forthcoming)

We assume that the damage shown in Table 9 in Q4 is proportionally distributed in the provinces affected by the flood, based on the total share of these provinces of the country in each industry. The affected provinces are shown in Figure 3. Finally, we get the value used in the assumptions of the simulations. We assume that each affected province has the same level of damage, as set out in Table 10.

**Figure 3: Affected Provinces**



*Source*: Compiled from JETRO's website as of November 11, 2011

**Table 10: Assumptions of Damage in the Technological Parameters in 2011**

| | |
|---|---|
| Agriculture | -17.6% |
| Automotive | -19.8% |
| Electronics & Electrical Appliances | -15.0% |
| Textiles & Garments | -11.1% |
| Food Processing | -13.6% |
| Other manufacturing | -13.6% |
| Services | -2.8% |

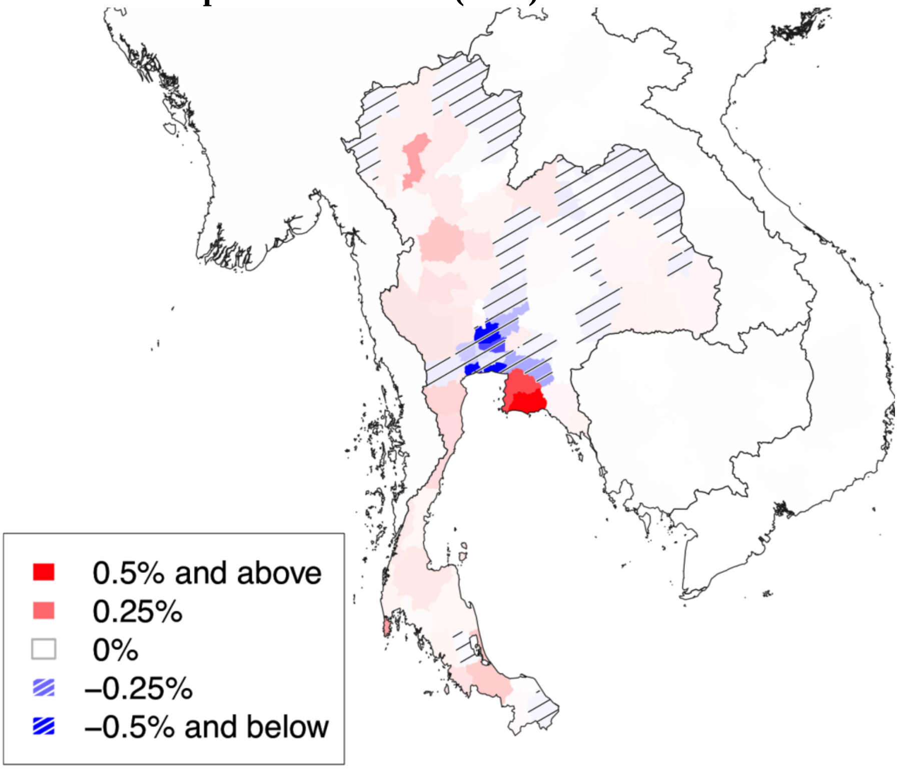
*Source:* Author derived based on CQM short-run forecasts.

In summary, Scenario 0 is described as follows:

Scenario 0:
**The flood in Thailand**
Technological parameters of affected provinces as shown in Figure 3 decrease by the percentage provided in Table 10 in 2011 and recover to the former value in 2012.

Figure 4 illustrates the economic impacts of the flood evaluated in the year 2020, compared with the baseline scenario. Red regions have positive impacts and blue or slashed regions have negative impacts. As explained in Figure 1, a negative impact does not necessarily mean a GDP below the present level. Samut Sakhon, Samut Prakarn and Ayutthaya provinces have larger negative impacts, because they have large scale electronics industries. Bangkok has a slight negative impact, reflecting the idea that service industries had less damage caused by the flood, and that services has a dominant share in the Bangkok economy.

**Figure 4: Economic Impacts of the Flood (2020)**




*Source*: IDE/ERIA-GSM 4.

Table 11 shows the top 7 negatively affected provinces and the top 4 positively affected provinces. Interestingly, there are many provinces positively affected, compared with the baseline scenario. This is because some households and firms move away from severely affected provinces to other areas, and thus some of these other areas will have more industrial activities than shown in the baseline scenario. Especially, Rayong and Chonburi are predicted to see 0.7% and 0.3% positive impacts, respectively. This can be interpreted as indicating that many companies move their production from Samut Sakhon, Samut Sakhon or Ayutthaya provinces to safer and better locations in other provinces. Lamphun, which has an electronics cluster, follows Rayong and Chonburi. Phuket also gets positive impacts from tourism shifting from Bangkok.

**Table 11: Top 7 Negatively affected Provinces and Top 4 Positively affected Provinces**

| Region | Impact in GRDP |
|---|---|
| Samut Sakhon | -0.5% |
| Samut Prakarn | -0.5% |
| Ayutthaya | -0.5% |
| Pathum Thani | -0.3% |
| Chachoengsao | -0.1% |
| Saraburi | -0.1% |
| Nakhon Pathom | -0.1% |

| Region | Impact in GRDP |
|---|---|
| Phuket | 0.1% |
| Lamphun | 0.1% |
| Chonburi | 0.3% |
| Rayong | 0.7% |

*Source*: IDE/ERIA-GSM 4.

As in Figure 4, other countries, such as Cambodia, Laos, Myanmar and Vietnam, have negligible impacts.[3] This means that replacement of the production lost in Thailand will be largely accomplished within Thailand, mainly led by Rayong and Chonburi provinces. In sum, Thailand as a country has almost 0% impact. China and Indonesia will have positive impacts though they are almost negligible. This can be supported by JETRO's interview survey of affected companies in January 2012; it reported that among 50 affected companies, 39 answered they would restart operations at their existing locations, while and the other 8 replied that they planned to relocate their production site to other areas of Thailand. The Japan Chamber of Commerce, Bangkok released another survey result showing that among 48 affected manufacturing companies, 41 answered that they would restart operations at their existing production sites and 12 reported they would restart in other areas in Thailand[4].

### 3.2. Recovery Scenario (1): MIEC and NSEC

At present Thailand, the Greater Mekong Sub-region and ASEAN have many

[3] We could not obtain flood damage data for Cambodia in terms of economic values, so we do not assume any damage for Cambodia.
[4] Multiple answers were allowed.

connectivity enhancement projects in hand. To assess the net effect of the negative impacts of the flood and the expected positive impacts from the connectivity enhancement, we run simulations including improving the Mekong-India Economic Corridor (MIEC, Scenario 1A) and the North-South Economic Corridor (NSEC, Scenario 1B). These scenarios are set as follows:

Scenario 1A:

**Mekong-India Economic Corridor (MIEC)**

A new bridge over the Mekong River at Neak Loueng in Cambodia is constructed. The speed of trucks along MIEC is raised in Cambodia and Vietnam to 60km/h. Dawei and Kanchanburi are connected by a road, and border crossing facilitation along the MIEC is introduced. Dawei and Chennai (India) are connected via a sea route that is equivalent to other international routes between equally important ports.

Scenario 1B:

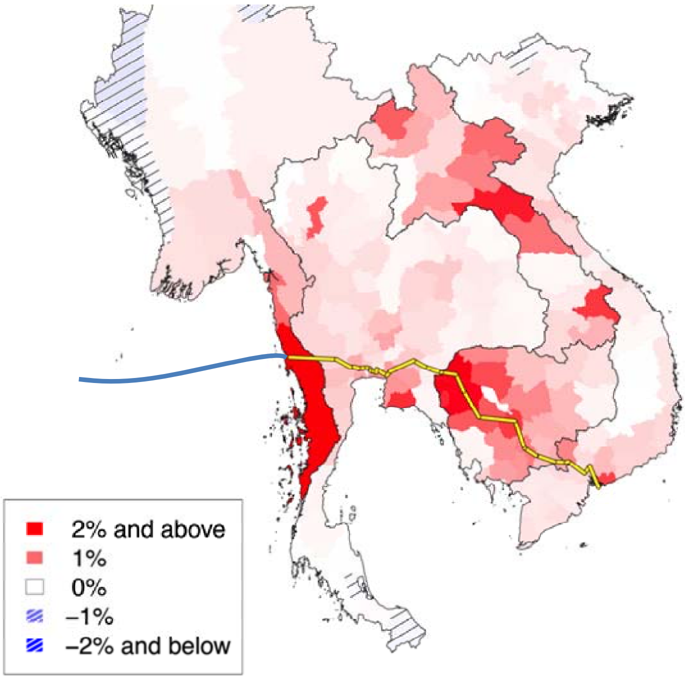
**North-South Economic Corridor (NSEC)**

The speed of trucks along the NSEC is raised in Lao PDR, Myanmar and Vietnam to 60km/h. Border crossing facilitation along the NSEC is introduced.

Figures 5 and 6 present economic impacts of the MIEC and the NSEC, given the impact of the flood in the last subsection, respectively. In these scenarios, we do not assume increasing speeds of trucks within Thailand, because Thailand already has good national road networks. Even though we recognize some negative impacts of the flooding in these simulations and have no speed enhancement in Thailand, Figure 5 shows that Thailand will overcome the negative shock of the flood through the MIEC development. By comparing Figure 5 with Figure 6, we find that the NSEC has a relatively smaller positive impact on Thailand, because connecting Ho Chi Minh City, Phnom Penh and Bangkok and providing a new gateway toward India, the Middle East and Europe yield much larger benefits to Thailand.[5]

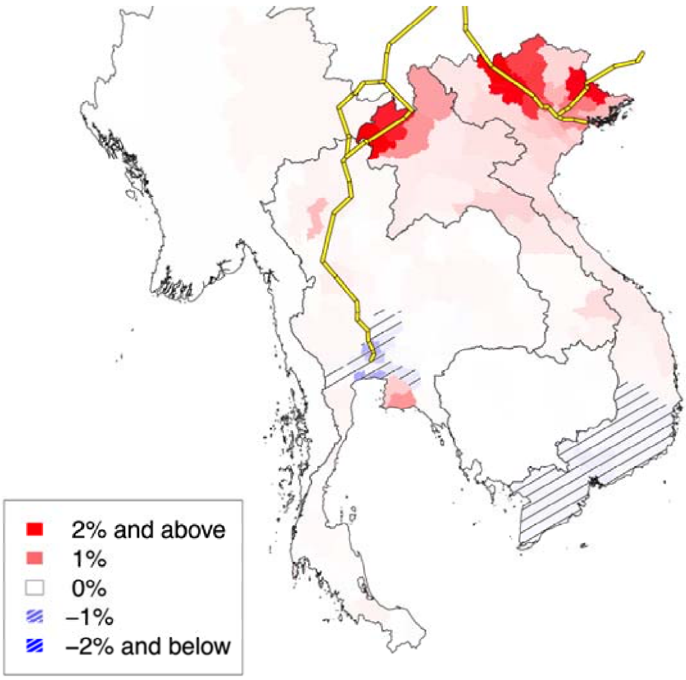
[5]The CADP report (ERIA, 2010) also compared the MIEC and the NSEC using IDE/ERIA-GSM version 3 and concluded that the MIEC has much larger economic impacts than the NSEC.

**Figure 5: Economic Impacts of MIEC (2020)**




*Source*: IDE/ERIA-GSM 4.

**Figure 6: Economic Impacts of NSEC (2020)**




*Source*: IDE/ERIA-GSM 4.

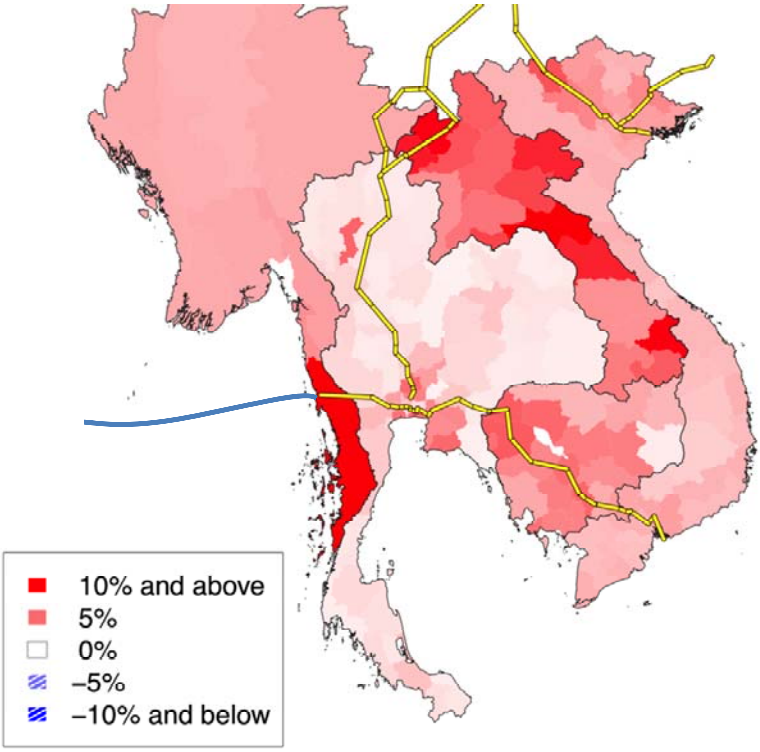
### 3.3. Recovery Scenario (2): MIEC, NSEC and Soft Infrastructure Development

We conduct another simulation of soft infrastructure development, together with the MIEC and the NSEC, given the impact of the flood. We assume Thailand, Cambodia, Lao PDR, Myanmar, Vietnam and India will reduce PCBs by 2% per year, presuming the situation that they are cooperatively improving institutional connectivity.

| |
|---|
| Scenario 2:<br>**Soft infrastructure improvement in addition to the other development and enhancement**<br>Countries involved in the MIEC and NSEC reduce Policy and Cultural Barriers (PCBs) by 2% per year, in addition to the other development and link enhancement mentioned above. |

Figure 7 illustrates the economic impacts of the MIEC, the NSEC and soft infrastructure development. These measures will help Thailand overcome the negative impact of the flood. Ayutthaya will have a 4.9% net positive impact, even allowing for the implicit negative impact of the flood. Samut Prakarn and Samut Sakhon have 4.8% and 4.6% positive impacts, respectively. Rayong, Chonburi and Lamphun which have relatively larger positive impacts caused by the flood will also see further economic benefit.

**Figure 7: Economic Impacts of MIEC, NSEC and Soft Infrastructure Development (2020)**




*Source*: IDE/ERIA-GSM 4.

## 4. Policy Recommendations and Concluding Remarks

Simulation results show that the long-run impact of the flood in Thailand may not be as great as previously thought. Positive impacts in Rayong or Chonburi, for example, can only be simulated by a model with CGE setting, including many provinces. At an early stage of the disaster, many partial observations or interviews are collected in severely damaged areas, which may lead to overestimating the long-run damage. Utilizing IDE/ERIA-GSM with an assumption from the Current Quarter Model (CQM) provides a solution to cope with this bias. In fact a preliminary report of this study, with the message that the long-run impact of the flood might not be as great as previously thought, was conveyed to the National Economic and Social Development Board (NESDB) and the Committee of Permanent Representatives (CPR) member of Thailand in January and February 2012.

We conclude with our findings, policy recommendations and some limitations or challenges.

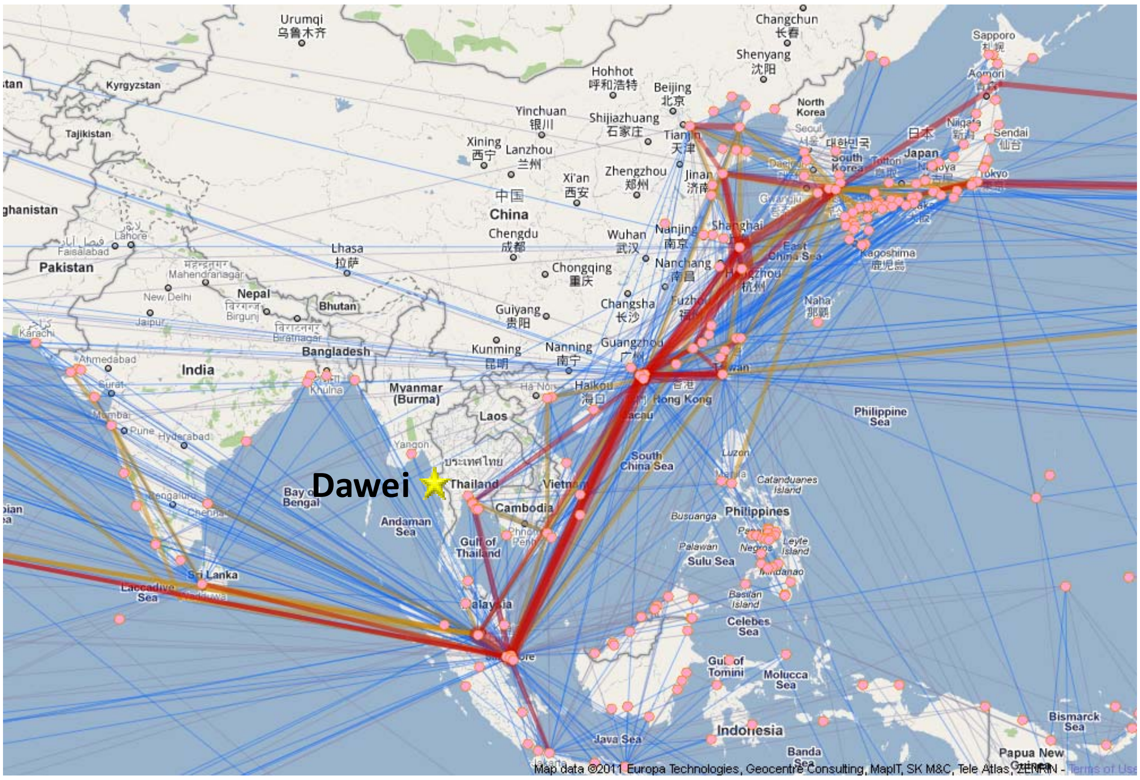
First, minimizing the damage arising from the flood and minimizing future risk are essential. We assume smooth recovery from the flood. If the Thai government had not offered good recovery measures, the flood's negative impacts would be larger. In fact many companies in JETRO's interview survey responded that they wanted to ask the Thai government to provide a good disaster insurance scheme and to develop tangible flood countermeasures.

Secondly, some facilitation measures to help firms move some production blocks from affected provinces to Rayong or Chonburi may contribute to Thailand's recovery. This does not mean, of course, that we recommend the forced relocation of firms. As reported in the media, many companies are already seeking production sites in industrial estates in Chonburi, Rayong and Lamphun, and developers are planning to establish new industrial estates. Our recommendation is that these movements should not be impeded, even though the government must be aiming for an equitable development of the country.

Thirdly, stimulating R&D activities and innovation is indispensable. In the simulations we assume full recovery of production infrastructure in 2012. However, if Thailand saw a delay in conducting R&D activities and other countries went ahead in 2011, possible negative impacts compared to the baseline scenario would be much larger.

Fourthly, even though we forecast a favorable result from the MIEC, several conditions are required to make it possible. There needs to be a smooth transaction flow between Dawei and the Kanchanburi border. Dawei port should be large and efficient enough to host international carriers, as in Laem Chabang or Tanjung Priok, because Dawei itself is located far from the major international sea lines (Figure 8).

**Figure 8: International Maritime Shipping Routes (2009)**




*Note*: Blue (narrow) lines: more than once/week. Yellow lines: more than once/day. Red (thick) lines: more than twice/day.
*Source*: Authors. Original Map is obtained from the Google Maps.

Fifthly, and finally, the assumptions used in this chapter need to be reviewed repeatedly in order to produce more reliable results. For example, we assumed that Samut Prakan was affected by the flood, based on information from JETRO as in November 2011. Actually Samut Prakan was affected by the flood, but no industrial estates in Samut Prakan were damaged. In this regard, the result for Samut Prakan in Figure 4 should be overestimated, even though some companies in Samut Prakan are in fact now seeking alternative sites considering their vulnerability to flooding. Similarly, the result as of January 2012 did not detect booming demand for construction in 2012. Nevertheless, IDE/ERIA-GSM can be a good tool for assessing the long-run effects of severe disasters and identifying possible remedies.

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# CHAPTER 12

# Mental Health Impacts of Disasters in India: Ex-ante and Ex-post Analysis

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*This paper aims to provide a qualitative analysis of a broad range of issues in disaster psychosocial support and mental health services often experienced and reported in India during the past two decades. The paper is limited to the analysis of the issues in disasters caused largely by natural hazards. The key objectives of the paper are to: (i) provide a desk review of the available global and Indian literature on disaster psychosocial support and mental health service, (ii) analyze the policy, legal and institutional framework related to the overall disaster psychosocial and mental health service provisions in India, and (iii) review the impact of disasters on the mental health of survivors affected by natural disasters in India, then to identify the gaps in support services. Accordingly some suggestions will be provided for India and for regional cooperation in disaster mental health research and service provision practices.*

# 1. Introduction

### 1.1. Overview: Disaster Profile of India

India, due to its location and geo-climatic conditions, is one of the most disaster-prone areas of the world. About 58.7 % of the total land mass is prone to earthquakes of moderate to very high intensity (12% is prone to very severe earthquakes, 18% to severe earthquakes and 25% to damaging earthquakes and the rest to non-damaging earthquakes). About 40 million hectares, or 12% of Indian land, is prone to floods, and 68 % of the land is vulnerable to drought. In addition, India has increasingly become vulnerable to tsunamis since the 2004 Indian Ocean tsunami. India's coastline of 7,516 kilometers is exposed to nearly 10 per cent of the world's tropical cyclones. About 8% of the land is vulnerable to cyclones of which coastal areas experience two or three tropical cyclones of varying intensity each year. In the hilly terrain of India, including the Himalayas (a total of 3% of land), landslides have been major and widely spread natural disasters that often strike life and property and occupy a position of major concern. Cold waves and heat waves are recurrent phenomena in different parts of India. Hundreds of people die of cold and related diseases every year, most of them living in poor urban areas in the northern parts of the country.

According to India's tenth Five Year Plan, natural disasters have affected nearly 6% of the population and 24% of deaths in Asia caused by disasters have occurred in India. Between 1996 and 2001, 2.5% of national GDP was lost because of natural disasters, and nearly 12% of government revenue was spent on relief, rehabilitation and reconstruction during the same period. A World Bank study in 2003 stated that natural disasters pose a major impediment on the path of economic development in India

The table below shows major disasters in India:

| SR. NO. | Name of Event | Year | Fatalities |
|---|---|---|---|
| • | Kangra earthquake | 1905 | 20,000 |
| • | Bihar earthquake | 1934 | 6,000 |

| SR. NO. | Name of Event | Year | Fatalities |
|---|---|---|---|
| • | Bengal cyclone | 1970 | 500,000 (include Pakistan and Bangladesh also) |
| • | Drought | 1972 | 200 million people affected |
| • | Andhra Pradesh cyclone | 1977 | 10,000 |
| • | Drought in Haryana & Punjab | 1987 | 300 million people affected |
| • | Latur earthquake | 1993 | 7,928 deaths and 30,000 injured |
| • | Orissa super cyclone | 1999 | 10,000 |
| • | Gujarat earthquake | 2001 | 25,000 |
| • | Indian Ocean tsunami | 2004 | 10,749 deaths 5,640 persons missing |
| • | Kashmir earthquake | 2005 | 86000 deaths (include Kashmir & Pakistan) |
| • | Kosi floods | 2008 | 527 |
| • | Cyclone Nisha in Tamil Nadu | 2008 | 204 |
| • | Sikkim earthquake | 2011 | 101 |
| • | Cyclone Thane | 2012 | 183 |

**1.2. Aim and Objectives**

Apart from the disaster risk and vulnerability profile of India in the introductory part, this paper has two parts. One part focuses primarily on providing a selective account of disaster psychosocial issues, major studies in this area and various mental health services in India. The other part commences with an overview of disaster management policies and agency responsibilities in India and their relationship to psychosocial and mental health service provision during disasters in India. This analysis also includes and proposes a broad perspective on regional collaboration in this field for the ASEAN region.

The paper aims to provide a qualitative analysis of a broad range of issues in disaster psychosocial support and mental health services often experienced and reported in India during last two decades. *The paper is limited to the analysis of the issues in disasters caused largely by natural hazards.* The key objectives of the paper are to: (i) provide a desk review of the available global and Indian literature on disaster psychosocial support and mental health service, (ii) analyze the policy, legal and institutional framework related to the overall disaster psychosocial and mental health service provisions in India, (iii) review the impact of disasters on the mental health of survivors affected by natural disasters in India, then to identify the gaps in support services. Accordingly some suggestions will be provided for India and for regional cooperation in disaster mental health research and service provision practices.

## 2. Impact of Disasters on Psychosocial and Mental Health in India: Ex ante and Ex post Review

### 2.1. An Overview of Disasters and Mental Health

The word "disaster" conjures up horrific images of humanity being affected in multifarious ways, economically, socially, physically and psychologically. In other words, a disaster is a complex multi-dimensional phenomenon having short and long-term ecological, political, economic, developmental, psychological and social impacts. There is adequate research evidence at national and international level regarding the mental health and psychosocial consequences of disasters. It has been recognized that most of the people affected by a disaster experience stress and emotional reactions after disaster as a 'normal response to an abnormal situation', and are able to cope well with a little psychosocial support.

Trauma after any disaster and the psychological reactions to it varies from ***individual to individual*** and ***from disaster to disaster*** in terms of *exposure, extent of* *loss, personal coping mechanism, and support system available at that time and more importantly the culture of that society, and country's socio-economic and political structure*. It has been seen that a significant proportion of people may not be able to cope effectively with the situation and experience significant signs and symptoms of mental health problems, thus requiring appropriate and adequate psychosocial support and mental health services.

### *2.1.1. Common Psychological Reactions or Responses to Disasters*

First of all one needs to understand that any psychological and emotional reaction is not itself all negative, for it can increase the chances of the survival of the victims. Stress becomes a threat to mental health when it overwhelms the capacity of the victims to cope with their new situations by mastering their reactions. A cauldron of emotional reactions can come to boil after a disaster. Although people react differently to traumatic events on the basis of their experiences and personality, and other important factors mentioned in the paragraph above, there are number of common responses that are experienced by the majority of those affected and involved. These common post-disaster responses include: ***emotional*** (panic attacks, shock, fear, irritation, anger, sadness and guilt feeling), ***psychosomatic*** (sleep disturbances, eating problems, physical problems such as muscle tension, palpitation, headaches, nausea, diarrhea or constipation, breathing difficulties, etc), ***cognitive*** (repeated thoughts and involuntarily triggering of memories, nightmares, confusion, flashbacks, difficulty in concentrating and making decisions, memory problems, shortened attention span, etc), and ***behavioral and attitudinal*** (disruptions in social relationship, habits, poor motivation and concentration, lethargy, hopelessness, loss of interest, etc) difficulties.

Normally, these reactions 'settle' over the first week. If, however, they remain protracted and intense and moreover, if symptoms persist for a period of more than a month or after that the person is very likely to suffer from various psychological disorders.

Although there is no general agreement on one single scale or classification (Beigel & Berren, 1985; Quarantelli, 1985), a broad classification of the reactions, specific reactions to specific disasters, and of the victims should help us to do an evaluation of the needs for the support activities intended for the target groups. The three main psychological disorders usually described and encountered among the affected population are: acute stress reactions/disorders, post- traumatic stress disorders (PTSD), an adjustment disorders

## 2.2. Literature Review

### *2.2.1. Global Research on Mental Health Impacts of Disasters*

The first systematic study on the psychological consequences of a disaster was done in Zurich after a mining disaster in 1906 and an earthquake in Messina, Italy in 1908 (Stierlin, 1909 and 1911). The study reported that the recovery was faster among the survivors who ventilated their grief. A study following the Coconut Grove night club fire disaster in Boston (Lindermann, 1944) corroborated the earlier findings. Early classical descriptions of post-disaster psychological problems revealed that the range of percentage of disaster survivors exhibiting typical disengaged behavior ("disaster syndrome") varied from 25% (Frederick, 1981) to 75 % (Duffy, 1988). Findings of psychological morbidity affecting 30-40% of the disaster population within the first week of the disaster (Raphael, 1986) also supported other studies in this area. A study investigating the 109 worst natural disasters occurring between 1960 and 1987 (Benz, 1989) revealed that developing countries suffered the most in terms of loss of life and property, disability, diseases, and damage to the public infrastructure. Interestingly, the psychopathological profile of war trauma survivors (Veeken, 1998; Baily, 1996) resembled that of survivors of disasters. The impact of a disaster is felt more in developing countries due to the economic status of the population, population density, and limited resources with limited accessibility (Juvva & Rajendran, 2000). Disasters increase the prevalence of psychopathology by approximately 17% on average compared to pre-disaster control groups (Rubonis & Bickman, 1991).

The past two and half decades have provided an increasing number of articles documenting the mental health effects of natural and man-made disasters. Disasters have been found to be associated with increased prevalence of severe psychiatric symptomatology, posttraumatic stress disorder, anxiety, depression, somatic complaints, and nightmares (Maj, *et al*. 1989; Madakasira & O'Brien, 1987; Escobar, *et al*. 1992; Bravo, *et al*. 1990; Shore, *et al*. 1986a; Shore, *et al*. 1986b; Wood & Bootzin, 1992; Murphy, 1984; Papadatos, *et al.* 1990). The long-term sequelae have been studied less extensively. However, reports do suggest that: 1) there may be a latency period or delayed onset of some symptoms (Green, *et al*. 1990); 2) that symptoms may wax and wane (Phifer, *et al*. 1988); 3) and that significant psychiatric symptomatology may remain for as long as 14 years (Green, *et al*. 1990).

In fact, the issue of mental health impacts following any disaster has gained attention across the globe during the recent decade only, peaking during the 2000-09 decade. The mental health and behavioral consequences of natural disasters have ranged from mild to very severe (Galea, *et al.* 2005). A lot of studies revealed that disasters involving exposure to the dead and dying, lingering social and community disruption, and massive destruction lead to severe and chronic psychological problems (Bodvarsdottir & Elklit, 2004; Norris, *et al.* 2004; Armenian, *et al*. 2000; Fukuda, *et al*. 1999; Bland, *et al*. 1996; Glesser, *et al.* 1981). Exposure to earthquakes has been found to be associated with increased psychological distress (Karanchi & Rustemli, 1995; Rubonis & Bickman, 1991; Papadator, *et al.,* 1990; Lima, *et al*. 1987; Lima, *et al.* 1993). Higher rates of prevalence of PTSD as a reaction to natural and technological disaster was also found (Acierno, *et al.* 2006). Studies examining the prevalence of psychological and psychiatric morbidity among disaster survivors reported long-term effects (Salcioglu, *et al.* 2007, Carr, *et al.* 1997a; Goenjian, *et al*. 2000) from these disasters. Some studies also suggested earthquake related psychological distress to be permanent (Bland, *et al.* 1996; Kato, *et al*. 1996). Posttraumatic stress disorder (PTSD) was found as a common mental health problem among victims of natural disasters both in western countries (Acierno, *et al*. 2007; Altindag, *et al.* 2005; Brown, *et al.* 2000; McMillen, *et al.* 2000) and Asian countries (Kumaret, *et al.* 2007; Lai, *et al.* 2004; Shinfuku, 2002; van Griensven, *et al*. 2006; Wang, *et al.* 2000; Wang, *et al.* 2009). Depending on assessment methodologies, instruments, and timing, the prevalence rate of PTSD related to natural disasters in this region was reported between 8.6% and 57.3% (Udomratn, 2008).

*Prevalence*

There is no consensus regarding the prevalence of psychological disorders after exposure to disasters. Some authors have indicated that not more than 25% of people exhibit psychological disorders after a disaster (Fredrick, 1981), while some indicated it to be not less than 75% (Duffy, 1988). Girolamo of the World Health Organization (WHO) Mental Health Division has found that the prevalence ranges between 20% to 35% after a natural disaster. The "disaster syndrome", characterized by stunned, apparently disengaged behavior, may vary between 25% to 75% of disaster survivors. Using a psychiatric victim status screening schedule it was found out that over 70% of survivors react in the first week. By 10 weeks, there is usually a significant drop, with gradual decrease over one year. However, according to Raphael (1986) psychological morbidity tends to affect 30-40 % of the population within the first year. A recent study has analyzed the relationship between disasters and subsequent psychopathology in 52 studies using quantitative measures. The study (Rubonis & Bickman, 1991) also reported the relationships between characteristics of the victim population, characteristics of the disaster, study methodology and type of psychopathology.

Following exposure to traumatic events, approximately 40-70% of the population is identified to be at risk of developing PTSD (Yule, *et al.* 1999). This indicates that not all people develop major stress reactions, influenced by individual differences and type of trauma. Approximately 13% of sexually assaulted adult women, 15-50% exposed to combat, and 50% exposed to natural disasters develop PTSD. These figures change across the year from 20-70% in the first week, 30-40% in the first year and 15-20% in the second year following a disaster (Canterbury & Yule, 1999).

A significant portion of people exposed to traumatic events go on to develop severe and prolonged psychological reactions (Canterbury & Yule, 1999), indicating the need for effective psychological interventions. In most of the comprehensive studies it has therefore been reported that the psychological morbidity after an exposure to disaster affects at least 30% of the exposed population in the first year following the impact. It is also now evident that post-traumatic stress disorder

(PTSD) and its associated co-morbid conditions such as depression and anxiety are becoming major issues in the disaster-affected communities.

*ASEAN Region*

There has been a great mismatch in the areas of mental health research, practice, policy and services in this region as compared to the developed countries. A number of studies have investigated major mental health problems prevailing in these countries after disasters, but research studies into the efficacy of psychological intervention are extremely few. Some of the key studies are mentioned below to provide a birds-eye view of the prevalence of psychological problems after disasters in this region.

Stress related disorders, acute stress reactions, anxiety, adjustment and panic disorders were the most common mental sufferings developed in the maximum number of diagnosed psychiatric victims after the massive earthquake in **Pakistan** in 2005. Around 20-40 % reported to have mild psychological distress, while 30-50 % was entrapped in moderate or severe psychological distress. Those with mild and moderate mental disorder amounted to 10 to 20% (Husain 2006).

The prevalence of PTSD, anxiety and depression among the natural disaster and exposed to traumatic events in **Thailand** has not been assessed previously (van Griensven, *et al*. 2006). The rapid mental health needs assessment after tsunami, 2004 (= 392 displaced and 323 non-displaced) was done by these researchers as a part of public health emergency response. The report revealed that while symptoms of PTSD were found among 12% of displaced and 7% of non-displaced persons, anxiety symptoms were found among 37% of displaced and 21% of non-displaced, and depression was reported by 30% of displaced and 21% of the non-displaced survivors. A study done (Chakrabhand, *et al*. 2006) with a sample of 7,130 tsunami affected revealed that 30% of the victims had mental health problems during the first two months of the tsunami. Assessment, referral, treatment, psycho-education and group activities were also provided as outreach services up to three months. Facilitating community resilience, addressing quality of life among the vulnerable groups, advanced mental health support to people suffering from various mental health problems, a mental health surveillance system, and establishing "mental health recovery centres” in communities and a “mental health operations centre” at the Department of Mental Health were very appropriate initiatives that were taken up by the Thailand Government in the recovery and rehabilitation phase (Chakrabhand, *et al*. 2006).

Adverse psychological and psychiatric impacts of various disasters on children (Arunakirinathan, *et al.* 1993; Sivashanmungarajah, *et al.* 1994; Vivo, 2005a; Vivo 2005b), women (Sivachandran, 1994) and family systems (Jeyanthy, *et al*. 1993; Kumerandran, *et al*. 1998) have been reported in the last few years in **Sri Lanka**. Development of a comprehensive and efficient psychosocial intervention at community level after a disaster should recognize the importance of dead body management as an integral part of the intervention (Sumathipala, *et al*. 2006). Management of post-disaster mental health problems is reported to be provided on the basis of a three-tier service model, with provision of trained workers at the community level, a multidisciplinary team at the primary health care level, and psychiatric care at the district level. Therapeutic interventions for disaster survivors included psycho-education, crisis intervention, psychotherapy, Cognitive Behavior Therapy (CBT), relaxation (both traditional and Jacobson’s), pharmacotherapy, group therapy, family therapy, and other emotive methods. However, research on the efficacy of these service provisions is rarely reported.

The profile of psychosocial distress found among the tsunami affected communities affected by the tsunami in the **Maldives** included emotional problems, such as, excessive crying, immense grief, survivors’ guilt, fear, hopelessness, nightmares, hyper vigilance and anger; and somatic problems such as headache, chest pain, loss of appetite, increased fatigue and insomnia (Ibrahim & Hameed 2006a).

A study after the Wenchuan earthquake in **China** (Zhang & Ho, 2011) reported that results showed that PTSD symptoms affected 84.8% of survivors one to two months after the earthquake. Significant risk factors associated with PTSD symptoms included: (1) being female; (2) being older; (3) higher exposure to traumatic events during the earthquake; and (4) negative effect in a personality disorder.

The low priority accorded to mental health by policy makers, the scarcity of trained and sustainable human resources, the lack of culture-specific study instruments, the inadequate number of empirical papers in scientific journals have been some of the impediments to mental health research in these countries. In addition, lack of community participation and absence of sound mental health policies have deprived the vast majority of people of the benefit of modern psychiatric treatments. Recently, with increase in collaboration in research, availability of treatment including low-priced psychotropic drugs, and a growing emphasis on the need for mental health policy in some low-income countries, the bleak scenario has begun to change (Isaac, *et al*. 2007).

A particular country's response to a disaster is based on a multitude of factors. Some of these factors operate at the national level, such as having a disaster management Act/Policy/Plan or a Mental Health Act/Policy/Plan and some factors operate at the affected community level in terms of service provision by the government along with reputable international organizations. The studies included in this paper varied greatly in terms of approach, objectives, methodology, and variables studied. However, given the need to consolidate existing mechanisms and initiatives in this field it is very important to understand the regional perspective on the application of disaster psychosocial support and mental health services in all these countries, so that regional cooperation in this area is clearly outlined.

### *2.2.2. Evidence Based Research on Mental Health Impact of Disasters in India*

This global trend of evidence-based research has also been seen in India. The first well-documented research study in this area in India was on the survivors of a fire disaster (Narayan, *et al*. 1987) and this revealed not only the symptoms of mental disturbances but also the reduced coping behavior of the families of the deceased. The Bhopal gas tragedy (1984) was the most important disaster to draw national attention due to its severe impact and the sensitivity of the politico-economic issues involved therein. The psychosocial impact was studied systematically although intervention programs were more psychiatric in nature. The Marathawada earthquake (1993) and the Andhra Pradesh super cyclone (1996) were disasters in which mental health professionals took an active part in terms of providing mental health services and undertaking research to study the psychosocial impact of these disasters. A review of Indian work on the psychosocial support and mental health services (PSSMHS) aspects of disasters in India in terms of service delivery, training and research activities carried out over more than the past two decades revealed a progressive shift in the nature and scope of services, the focus and objectives of training activities and in the issues pursued in the research activities. This shift is well reflected in the developments that have taken place during five major disasters viz. the Bhopal gas tragedy (1984), the Marathwada earthquake (1993), the Orissa super cyclone (1999), the Gujarat earthquake (2001), and the Indian Ocean tsunami (2004). The developments in the area of service, training and research have been occurring in parallel to each other as well as following a combined approach.

The studies on the Bhopal gas disaster (Sethi, *et al.* 1987; Srinivasa Murthy, 1990; Cullinan, *et al.* 1996) reported increased neuro-psychiatric symptoms among the survivors attending different health care facilities. A study by Srinivasa Murthy and Isaac within three months of the disaster reported a 22.6% prevalence rate for mental disorders such as anxiety neurosis (25%), depression (20%), and adjustment reaction with predominant disturbance of emotions (16%), mostly found among the females (81.1%) and those in their middle adulthood (under 45 years of age-74%) (Kar, 2000). More studies on this disaster (Srinivasa Murthy, 2004) also revealed additional health problems and disability found amongst the disaster survivors.

Increased psychiatric morbidity was also reported from the Bombay riots (Shetty and Chhabria, 1997), the Marathwada earthquake (Aghase, 2004), Orissa super cyclone (Sekar, 2004; Kar and Bastia, 2006)), the Gujarat earthquake (Vankar and Mehta, 2004; Ramappa and Bhadra, 2004). Some studies highlighted the importance of both mental health of workers (Juvva and Rajendran, 2000, and Davar, 2001) and the mental health of disaster affected people (Srinivasa Murthy, 2000). While, some studies reported peoples' needs and feelings of vulnerability (Parasuraman and Acharya, 2000) as important mental health indicators of people affected by disaster , other studies focused on the extent of poverty, homelessness and violence (Lohokare and Davar.2000), thus indicating the risk of mental health in people in disaster affected areas.

The psychosocial impact of the Orissa cyclone was reported by Sekar Kasi, Kar and Bastia, and some others. In fact, acceptance of the existence of psychological impacts and the need for focused services for the survivors became much clearer only after the cyclone. The emergence of this field as an independent area of research was widely recognized by various funding agencies after this disaster. Innovations in service provision, comprehensive community networked care service models, the nature and extent of mental health morbidity research, and capacity building programs were very promising, and perhaps laid a robust foundation for the growth of a distinct area of service provision and research after this disaster.

A study through a WHO-funded research project in Gujarat on the economic implications of health care use by comparing survivors who received psychosocial help and those who did not demonstrated a positive impact on overall well-being.

On the basis of the literature reviewed above, especially for ASEAN countries, it is evident that the magnitude and pattern of psychosocial and mental health problems in all these ASEAN countries are very similar, mainly highlighting the existence of largely stress-related disorders and common psychosocial problems, as well as incidences of anxiety-depressive disorders, PTSD and associated psychosomatic problems. The empirical research primarily focused on assessing the impact of a disaster on mental the health of the survivors and less on the efficacy of psychological interventions.

*Ex-ante and Ex-post Analysis: India*

The review of Indian research on the psychosocial and mental health aspects of disasters in terms of service delivery, training and research activities carried out during over more than two decades reveals a progressive shift in the nature and scope of services, the focus and objectives of training activities and the issues pursued in the research. This shift is well reflected in the developments that have taken place during some major disasters viz. the Bhopal gas tragedy (1984), the Marathwada earthquake (1993), the Orissa super-cyclone (1999), the Gujarat earthquake (2001), the Indian Ocean tsunami (2004) and Jammu and Kashmir Earthquake (2005). Although there are sufficient studies on the psychosocial and mental health impact (Srinivasamurthy, 1990; Sethi, *et al.* 1987; Narayanan, *et al.* 1987; Srinivasamurthy, 2004; Srinivasamurthy, 2004; Agashe, 2004; Vankar and Mehta, 2004; Ramappa and Bhadra, 2004; Desai, *et al.* 2002; and service provision (Srinivasamurthy and Isaac, 1987; Joseph, 2000; Prewitt-Diaz, *et al.* 2004; Chachra, 2004; Vijaykumar, 2006c) in the aftermath of disasters, these studies mainly covered 1) the natural disasters as compared to the manmade disasters, and 2) the mental health impacts. *The Indian studies on the mental health consequences of disasters have mainly covered the mental health impacts of large-scale natural disasters.* Very few studies have been reported from any small scale disasters in terms of impacts or psychopathology or service intervention (Desai, *et al.* 2004; Satapathy and Walia, 2006; Satapathy and Walia, 2007).

The interventions were primarily basic psychosocial services, psych-education, relaxation/meditation, individual therapy, child focused intervention (Vijaykumar, *et al.* 2006a, 2006b), behavioral therapies, group play therapies for children, yoga, meditation, religious discourse and psychiatric treatment. These services were provided in the community by trained community-level volunteers, and mental health professionals. While mental health professionals such as trained psychologists and psychiatric social workers took care of overall community volunteer training, monitoring and supervision of psychosocial service provisions along with the specified home-based therapies wherever needed, the trained community-level volunteers were responsible for delivering seven basic psychosocial support skills comprising ventilation, empathy, active listening, social support, relaxation, externalization of interest and spirituality. These seven primary psychosocial skills of the volunteers were feasible, culturally appropriate and well designed, therefore have been successfully implemented. However, more focused research on Randomized Control Trials of these interventions would be highly required so as to contribute the global research on effectiveness and efficacy of these culturally acceptable interventions.

The nature of psychosocial and mental health services provided after disasters has also undergone a significant change during the last two decades. After the Bhopal gas tragedy the focus was on identification and treatment of those who suffered from clinically diagnosable mental disorders and who visited the health clinics started after the disaster. Identification and treatment of psychiatric disorders by mental health professionals in the field, or identification and referral of persons with psychiatric disorders, continued as a major mental health service activity in the subsequent disasters. However, a number of non-disorder oriented interventions to restore mental health and psychosocial well being, including crisis intervention, emotional first aid, counseling for grief reactions, group therapy, play therapy for children, facilitating community self-help groups by the trained workers as well as mental health professionals were all started begun in subsequent disasters, especially after the Orissa super cyclone and the Gujarat earthquake. However, only a small fraction of the needy people in need could receive it the help in the absence of an institutionalized approach and appropriate coordination mechanisms. A beginning was made during after the Orissa super-cyclone in understanding the inter-relationship between mental health services (MHS) and psychosocial support (PSS) when a combined approach of delivering MHS and PSS through trained community workers with referral support of from mental health professionals was adopted.

After Tsunami the Indian Ocean tsunami, these interventions were provided in a more systematic and widespread manner as a result of greater institutionalization and well established coordination mechanisms between Government and non-government organizations (GO-NGOs collaboration). All organizations offered offering to work with the survivors had to register with the district administration and a standardized capacity building training was provided by the National Institute of Mental Health and Neurosciences (NIMHANS), WHO, the International Federation or Red Cross and Red Crescent Societies (IFRC), etc to these organizations for a coordinated and qualitative service provision. Group activities like including prayers and, religious discourses by leaders contributed to psychosocial well being and played a significant role in preventive and promotive mental health. Other indigenous practices and alternative medicinal system have also been utilized and have got obtained wide acceptance. In fact lot of many spiritual and Yoga institutions such as the Ramakrishna Mission, and the Vivekananda Yoga Institute were involved in helping the survivors for rebuilding their internal harmony through group meditation and yoga camps during the relief stage of disaster management. Prevention and treatment of substance abuse and alcoholism has also been one of the focuses of interventions after disasters, as research evidence supports such a need.

Nevertheless, the Government of India initiatives subsequent to the Orissa super cyclone, in terms of the high- power committee recommendations and the national disaster management plan (2000), provided impetus not only to the overall disaster management and mitigation plan but also to the varied stakeholders and disaster service provision agencies. Indian experience in the area of disaster mental health during more than the past two decades showed the evolutionary nature of psychosocial support and mental health services in disaster situations. From a mental disorder based approach after the Bhopal gas tragedy, the approach has been modified to community based mental health or psychosocial care in the cases of the Marathwada earthquake, the Orissa super Cyclone and the Gujarat earthquakes, and further broadened to psycho-social and mental health care following the Indian Ocean tsunami. *The pure clinic/hospital based planning and delivery of services has given way to community based services with active utilization of community resources. This helps to rebuild sustainable community resiliency.*

*The nature of the manpower involved in service delivery has also therefore undergone a significant change from psychiatrists alone to all mental health professionals (including clinical psychologists, psychiatric social workers, etc) to professionals, paraprofessionals and trained community-level workers/volunteers.* This mode of service provision not only addressed the problem of the ratio of disaster survivors and inadequate mental health professionals in the country but also received wider acceptance from the disaster affected communities, and hence became further institutionalized after The tsunami and the Jammu and Kashmir earthquake.

Besides service delivery, training and research activities have also evolved during the same period. *Development of appropriate training materials and tool kits and standardization of psychosocial care* and training in accordance with the phases of disasters was an outcome of such interventions.

Involvement and continuous support of Government agencies such as NIMHANS, the Indian Council of Medical Research, the WHO, the Institute of Human Behavior And Allied Sciences, the National Institute of Disaster Management, the Defence Research and Development Organization, etc; and the Ministries of Health, Women and Child Development, and Social Welfare; and

NGOs including Action-aid, Care India and the Red Cross emerged as a strong coordinated GO-NGO partnership.

The results of such a coordinated effort in the area of mental health in the country's disaster management framework will be discussed in the next section.

## 3. Disaster Risk Management Framework

The increasing frequency and ferocity, the rising extent as well as the mounting human and economic toll due to disasters has necessitated a reappraisal of institutional and policy frameworks and the development of new frameworks for holistic management of disasters. On the basis of the philosophy of sustainable development, a holistic **National Disaster Management Framework** was developed in 2004, which highlighted the interdependence of economy, environment, and development. This framework also linked the issues of poverty alleviation, capacity building, community empowerment and other structural and non-structural issues of prevention and preparedness, response and recovery for effective disaster risk mitigation and management.

### 3.1. Policy Responses towards Effective Disaster Risk Management in India

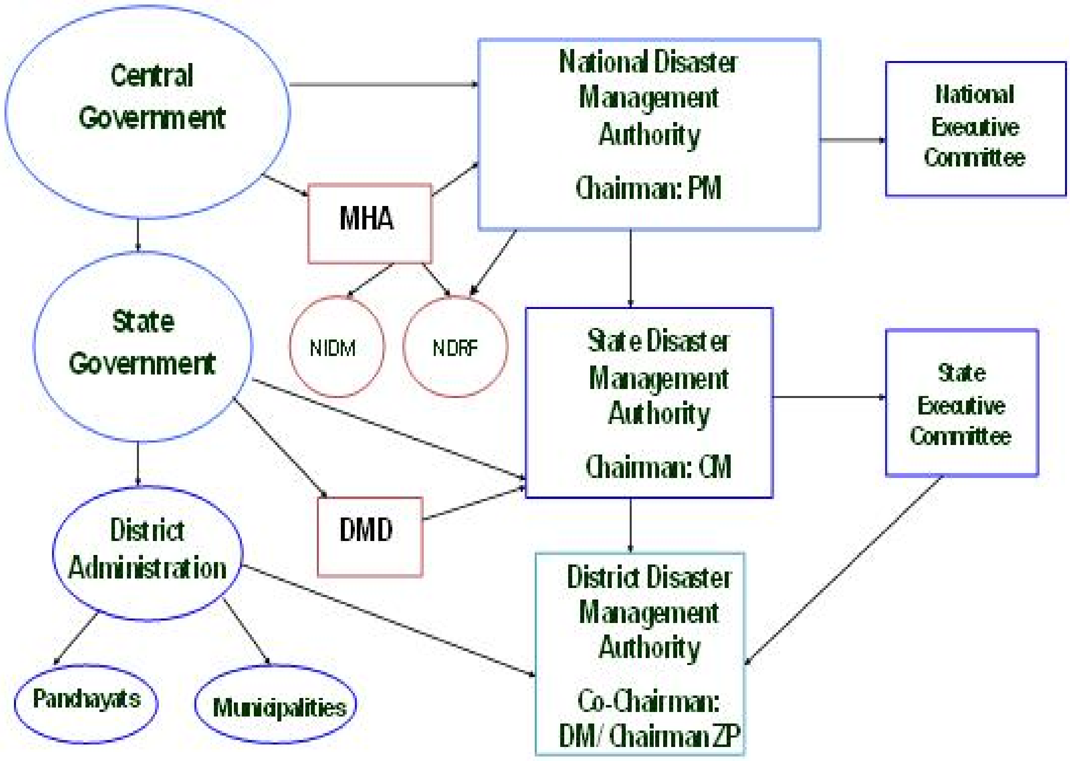
A comprehensive legal and institutional framework for disaster management has been set up through the **Disaster Management Act** passed by the Indian parliament in December 2005 and the **National Policy on Disaster Management** was approved in 2009.

**The Cabinet Committee for Management of Natural Calamity (CCMNC)** oversees all aspects relating to the management of natural calamities including assessment of the situation and identification of measures and programs considered necessary to reduce their impact, monitor and suggest long term measures for prevention of such calamities, formulate and recommend programs for public awareness so as to build up society's resilience to them. **The Cabinet Committee on Security (CCS)** deals with the matters relating to nuclear, biological and chemical emergencies. **The National Crisis Management Committee (NCMC)**

under the Cabinet Secretary oversees the command, control and coordination of the disaster response.

### 3.2. Institutional Mechanisms for Disaster Management

The Disaster Management Act, 2005 has created new institutions at the national, state, district and local levels. The new institutional framework for disaster management in the country is as under:




**The National Disaster Management Authority (NDMA)** under the chairmanship of the Prime Minister is the apex body responsible for laying down policies, plans and guidelines for disaster management, and for coordinating their enforcement and implementation throughout the country. The policies and guidelines will assist the Central Ministries, State Governments and district administration to formulate their respective plans and programs. NDMA has the power to approve the National Plans and the Plans of the respective Ministries and Departments of Government of India. The general superintendence, direction and control of the National Disaster Response Force (NDRF) are vested in and will be exercised by the NDMA.

**The National Executive Committee (NEC)** is mandated to assist the NDMA in the discharge of its functions and further ensure compliance with the directions issued by the Central Government. The NEC comprises the Union Home Secretary as the Chairperson, and the Secretaries to the GOI in the Ministries/Departments of Agriculture, Atomic Energy, Defense, Drinking Water Supply, Environment and Forests, Finance (Expenditure), Health, Power, Rural Development, Science and Technology, Space, Telecommunications, Urban Development, Water Resources and the Chief of the Integrated Defense Staff of the Chiefs of Staff Committee as members. Secretaries in the Ministry of External Affairs, Earth Sciences, Human Resource Development, Mines, Shipping, Road Transport & Highways and the Secretary, NDMA are special invitees to the meetings of the NEC. The National Executive Committee is responsible for preparing the National Plan and coordinating and monitoring the implementation of the National Policy and the guidelines issued by NDMA.

**The Ministry of Home Affairs (MHA)** in the Central Government has the overall responsibility for disaster management in the country. For a few specific types of disaster the concerned Ministries have the nodal responsibilities for management of the disasters, as under:

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| Drought | Ministry of Agriculture |
| Epidemics & Biological Disasters | Ministry of Health and Family Welfare |
| Chemical Disasters | Ministry of Environment & Forests |
| Nuclear Disasters | Ministry of Atomic Energy |
| Air Accidents | Ministry of Civil Aviation |
| Railway Accidents | Ministry of Railways |

**The National Institute of Disaster Management (NIDM)** has the mandate for human resource development and capacity building for disaster management within the broad policies and guidelines laid down by the NDMA. NIDM is required to design, develop and implement training programs, undertake research, formulate and implement a comprehensive human resource development plan, provide assistance in national policy formulation, assist other research and training institutes, state governments and other organizations in successfully discharging their responsibilities, develop educational materials for dissemination and promote awareness among stakeholders in addition to undertaking any other function as assigned to it by the Central Government

**The National Disaster Response Force (NDRF)** is the specialized force for disaster response which works under the overall supervision and control of the NDMA.

At the State Level the **State Disaster Management Authority (SDMA)**, headed by the Chief Minister, lays down policies and plans for disaster management in the State. It is also required to coordinate the implementation of the State Plan, recommend provision of funds for mitigation and preparedness measures and review the developmental plans of the different departments of the State to ensure integration of prevention, preparedness and mitigation measures.

In the district level the **District Disaster Management Authority (DDMA)** is headed by the District Magistrate, with the elected representative of the local authority as the Co-Chairperson. DDMA is the planning, coordinating and implementing body for disaster management at district level. It will, inter alia prepare the District Disaster Management Plan and monitor the implementation of the National and State Policies and the National, State and the District Plans. DDMA will also ensure that the guidelines for prevention, mitigation, preparedness and response measures laid down by the NDMA and the SDMA are followed by all departments of the State Government at the district level and the local authorities in the district.

The Local Authorities, are both the rural local self governing institutions (Panchayati Raj Institutions) and urban local bodies (Municipalities, Cantonment Boards and Town Planning Authorities) These bodies will ensure capacity building of their officers and employees for managing disasters, carry out relief, rehabilitation and reconstruction activities in the affected areas and will prepare DM Plans in consonance with guidelines of the NDMA, SDMAs and DDMAs.

### 3.3. Current Status of Psychosocial and Mental Health Support in Disaster Risk Management in India

As a part of the comprehensive disaster management framework of the country, The National Guidelines on Psychosocial Support and Mental Health Services (PSSMHS) in disasters were released in December 2009 so as to provide overall guidance for the efficient and effective qualitative service provision to the survivors. This document defined psycho-social support in the context of disasters as comprehensive interventions aimed at addressing a wide range of psychosocial and mental health problems arising in the aftermath of disasters. These interventions help individuals, families and groups to build human capacities, restore social cohesion and infrastructure along with maintaining their independence, dignity and cultural integrity. Psycho-social support will comprise the general interventions related to the larger issues of promoting or protecting psycho-social well-being through relief work, meeting essential needs, restoring social relationships, enhancing coping capacities and promoting harmony among survivors. Psycho-social support helps in reducing the level of actual and perceived stress and in preventing adverse psychological and social consequences amongst disaster-affected communities. In addition, psycho-social support interventions are aimed at promotion of mental health and psychological well-being, and prevention of psychological and psychiatric symptoms among disaster-affected communities.

Mental health services in disaster interventions are aimed at identification and management of stress related psychological signs and symptoms or mental disorders among disaster-affected persons and persons with pre-existing mental health problems.

The Psycho-Social Support and Mental Health Services are considered as a continuum of interventions as an important component of general health services in disaster situations. And the overall goal of the Psycho-Social Support and Mental Health Services is restoration of well-being of the disaster-affected community.

There are three important aspects of these guidelines: preparedness, response, and implementation, which will be very briefly described below.

*Preparedness for PSSMHS*

Preparedness for PSSMHS, as described in the national guidelines, includes proper planning and resource mapping at all levels, along with capacity development and up-grading of infrastructure and hospital preparedness. The need for creating a network of institutions has also been emphasized, with the intention of preparing adequate knowledge bases and modules for training a variety of workers at different levels. The need for activation of psycho-social support, enhancing manpower for psychiatry and psychology, psychiatric social work, psychiatric nursing, community level workers and other trained community level volunteers is outlined. Adequate emphasis has also been laid on proper documentation, international co-operation and the role of NGOs in providing PSSMHS. Appropriate attention to vulnerable groups and the necessity of creating proper referral systems for disaster-affected people have been highlighted.

*PSSMHS Response*

The critical role of response mechanisms for the PSSMHS at national, state and district levels, by various ministries and departments and all the other stakeholders including International Non- Government Organizations (INGOs), Non-Government Organizations (NGOs) and communities has been identified in the guidelines. Integration of PSSMHS in the general relief work, disaster health plans and community practices has also been stressed. Guidelines also highlight the important aspect of inclusion of long-term PSSMHS services in the recovery, rehabilitation and reconstruction phases of disasters. In addition, the importance of providing special care to the vulnerable groups, as well as to the care-givers, to enhance the quality of service delivery is stressed.

*Implementation of PSSMHS Guidelines*

These Guidelines provide a framework for action at all levels. The Ministry of Health and Family Welfare (MoH&FW) shall prepare an Action Plan to enable all sections of the government and administrative machinery at various levels to prepare and respond effectively. The PSSMHS plan shall be prepared during the pre-disaster phase which will be integrated, coordinated and monitored by nodal agencies at national, state and district levels. This shall cater to immediate and long-term needs of the affected communities.

The Government has initiated various programs, such as the National Mental Health Program and the District Mental Health Program as part of a national health plan to reach out to every citizen of the country. In order to strengthen PSSMHS in disasters it is imperative it be integrated into these programs to provide both short and longer-term psycho-social support and mental health care.

The time-lines proposed for the milestones for implementation of the various activities listed and explained in the PSSMHS preparedness and response mechanism are to be rolled out in three periods viz 3 years, 5 years and 8 years.

The Ministry of Health and Family Welfare (MoH&FW), the nodal ministry for medical preparedness, is mandated to formulate and implement national health policies and programs in the country, including mental health. All the other line ministries are required to follow the policies and plans laid down by the nodal ministry for any health plan activation for service provision for any type of disaster.

## 4. Policy Recommendations

### 4.1. National Level

There is an urgent need to address some issues of paramount importance in this area, at the policy level of the Govt. of India and also at the institutional level.

*Evidence Based Research and Development:*

The institutions working in this area should now focus on the long-term psychopathology of man-made and small scale natural disasters to understand the country profile of the epidemiology of the mental health impacts of disasters on survivors.

A randomized clinical control trial of various intervention packages should be undertaken to report the effectiveness of interventions scientifically.

Age specific psychopathology and interventions should be highlighted in all types of research initiative. Other risk factors should also be identified.

As a part of the concept of the economics of psychology and the psychology of economics, a cost-benefit analysis of these interventions should be recorded and reported to increase the applicability of these interventions in wider similar situations.

*Implementation of Guidelines*

There is also an immediate need to implement the national guidelines for the preparedness of PSSMHS. There is no clear institutional mechanism to implement the regular care services in this area during disasters. The service is entirely convenience driven by some organizations and is often based on an ad hoc approach.

Integration of psychosocial care and mental health services into general relief, recovery and rehabilitation is yet to be properly organized with adequate financial provisions.

**4.2. Regional Cooperation**

Psychosocial and mental health problems are particularly important for low-income countries, which face a high burden of illness due to infectious disease and greater socio-economic disparities, and have limited resources for mental health care. The psychosocial and mental health impacts of these disasters have been exacerbated by the multiple losses due disaster and subsequent stressful life events and consequent uncertainty of the future. The Inter Agency Standing Committee Guidelines on Mental Health & Psycho-Social Support in 2007 mentioned, “Emergencies create a wide range of problems experienced at the individual, family, community and societal levels. At every level, emergencies erode normally protective supports, increase the risks of diverse problems and tend to amplify pre-existing problems of social injustice and inequality”. Hence, the disaster management policies of the countries need to consider their own vulnerability factors in socio-economic situations and look for best alternatives to rebuild their support system at the earliest opportunity. Facilitating psychosocial support services therefore needs to be a continuous process within the developmental projects of the country.

*Research and Development*

A fairly comprehensive review study on psychosocial support and mental health services in eleven ASEAN countries has identified the following few important areas of research, which could be explored by future researchers (Satapathy and Bhadra, 2009):

The process and method of standardization of psychosocial and mental health need assessment tools in few or all countries.

Specific psychosocial and mental health intervention for more vulnerable groups and focusing on the pre and post intervention qualitative as well as quantitative studies.

The correlates of sustainable community-based mental health and psychosocial interventions such as mental health nurses in primary health care systems and mental health surveillance systems.

It was also found from the review that research and development in disaster related psychosocial support and mental health services is yet to focus on the role of cultural differences in service provision and in natural coping strategies/resources; indigenous practices to manage physical, social and psychological recovery from a disaster; and to develop a comparative picture of culture-specific psychopathology in these countries and variation during disasters.

This study also reported that in most of the South and South –East Asian countries the community-based structures at the grass-root level are quite strong through initiation of the women's groups and youth groups or through development of micro finance structures and income generation activities.

In addition to the above, other specific emerging areas of research could be:

**Research & Development**

More methodologically strong damage and loss assessment/cost analysis, especially developing indicators of cost of loss of productive life days and cost of mental health illness of survivors

Economic benefits of psychosocial intervention in terms of effectiveness of rehabilitation services. More specifically, quantifying the benefits of community-based PSSMHS service provision and other forms of psychological services after disasters.

Institutional networking/collaboration for a pilot project study on cross cultural differences in disaster psychopathology, expression of psychopathology, assessment tools for diagnosis, psychological interventions, social interventions, mechanism of treatment of psychiatric problems, financial arrangements for PSSMHS, etc should be looked at in ASEAN countries.

In fact, post-tsunami initiatives in research and service provision in the area of PSSMHS in many countries reported successful experimentation in the community-based approach with the support of the World Health Organization, the Red Cross & Red Crescent Society and other non-government organizations. Facilitating psychosocial care support at this level, therefore, could perhaps ensure the building of resiliency and preparedness for dealing with stress and disaster-related events at the individual, family and community levels. This, however, needs to be established by longitudinal studies. Empowering the existing community-based organizational structures and strengthening the existing mental health service delivery mechanism, and integrating these two in many countries, may ensure a continuous flow of services, which is essential for development of the resiliency among the people. The Government mental health care service delivery structures in many countries are reported to be over-burdened, which may become a bottleneck in the development of uninterrupted services to the disaster-affected communities. Hence, ensuring adequate resources in developing robust structures may be possible by integrating government and eligible non-government organizations and community-based organizations. This may be considered as an important matter, not only to meet the urgent PSSMHS needs but also to reduce the risk of long-term psychiatric disorders, and their financial and social burden among the survivors.

As mentioned earlier, psychosocial and mental health service provision after any disaster depends largely on factors such as existing government mechanisms for health care service delivery, the type and magnitude/severity of a disaster, the number of people affected, culture and community characteristics, trained manpower, religion, agencies responsible/interested, quality of community capacity building, impact and need assessment tools, well designed intervention packages, etc. Hence, it may be easier and feasible to adapt a particular service delivery system prevalent in some countries and verify if the adaptation brings required outcomes. Support of mental health professionals may make it implementable administratively and technically.

Regional experience-sharing platforms should be created for information exchange and lessons leaning from each other's experiences. Field practices and their cultural adaptation and effectiveness should be focused on. As the field practices in PSSMHS in major ASEAN countries are reported to be community-based with unique features and this is different from western psychological intervention practices and institutional mechanisms, this would contribute a lot to the global evidence-based research if pursued systematically.

## Conclusion

Any disaster resulting from either natural or manmade hazards will affect countries in multifarious way, resulting in undermining all major developmental measure and the financial stability of the countries. Apart from the quantifiable and tangible damage and loss, there is loss of quality and productivity of life in a disaster situation, which are still not measured or quantified. The impact of any disaster on the mental health of the survivors is enormous and affects a country's development directly and indirectly.

The psychological and mental health services and interventions are very much country and culture specific, therefore, any tailor-made intervention in one country may not be applicable in a similar disaster in other countries. For example, similar magnitudes of earthquake in India and Iran would be two different contexts all together, therefore, mental health and psychosocial services would certainly vary, although the core recovery objectives and principles may remain similar and constant in both the countries. *However, good intervention practices in one country may be adapted for the specific needs of another country's disaster affected population.* The severity of symptoms is directly related to the magnitude and extent of trauma experience, and the associated factors either aggravating life conditions or supporting the speedy recovery of the survivors in the aftermath of a disaster. And, due to these factors, service provision in this sector would also vary from place to place, community to community, hence country to country.

Evidence-based research in India reveals that to overcome the issues of inadequate mental health professionals, absence of institutional mechanisms for service provision and ambiguous financial provisions for the same, the existence of community- based psychosocial support and mental health services was successful in past large scale disasters . Such community-based services, therefore, would perhaps remain as a viable, more culturally approved and less stigmatized option available to the country. Nevertheless, the ASEAN countries are still evolving with their own successful models of mental health care service provision after a disaster. And learning from and adapting a good practice prevailing in one country may result in expediting their initiative in this regard. Regular experience-sharing platforms in this region would enable all the countries to overcome many challenges so as to achieve the objectives.

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# CHAPTER 13

# Impact of Disasters and Disaster Risk Management in Singapore: A Case Study of Singapore's Experience in Fighting the SARS Epidemic

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*Singapore is vulnerable to both natural and man-made disasters alongside its remarkable economic growth. One of the most significant disasters is the Severe Acute Respiratory Syndrome (SARS) epidemic in 2003. The SARS outbreak was eventually contained through a series of risk mitigating measures introduced by the Singapore government. This would not be possible without the engagement and responsiveness of the general public. This chapter begins with a description of Singapore's historical disaster profiles, the policy and legal framework in the all-hazard management approach. We use a case study to highlight the disaster impacts and insights drawn from Singapore's risk management experience with specific references to the SARS epidemic. We draw on the lesson-learning from Singapore's experience in fighting the SARS epidemic, and discuss implications for future practice and research in disaster risk management. The implications are explained in four aspects: staying vigilant at the community level, remaining flexible in a national command structure, the demand for surge capacity, and collaborative governance at regional level. This chapter concludes with a presence of the flexible command structure on both the way and the extent it was utilized. This helps to explain the success level of the containment of the SARS epidemic.*

***Key Words*: Disaster risk, SARS, Epidemics, Infectious disease, Singapore**

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# 1. Introduction

Situated in Southeast Asia yet outside the Pacific Rim of Fire, Singapore is fortunate enough to have been spared from major natural disasters such as typhoons, floods, volcanic eruptions, and earthquakes. However, this does not imply that Singapore is safe, or immune from being affected by disasters. Singapore houses a population of 5.2 million, a ranking of the third highest population density in the world. About 80 % of Singapore's population resides in high-rise buildings (Asian Disaster Reduction Center, 2005). A major disaster of any sort could inflict mass casualties and extensive destruction to properties in Singapore. Clearly, like its neighboring countries, Singapore is also vulnerable to both natural and man-made disasters alongside its remarkable economic growth. The potential risks may result from its dense population, intricate transportation network, or a transnational communicable disease. Moreover, Singapore can be affected by the situations in surrounding countries. For example, flooding in Thailand and Vietnam may affect the price of rice sold in Singapore.

Indeed, Singapore in her short history of 47 years has experienced a small number of disasters. Chief among these, the Severe Acute Respiratory Syndrome (SARS) epidemic in 2003 was the most devastating. The SARS outbreak brought about far-reaching public health and economic consequences for the country as a whole. Fortunately, the outbreak was eventually contained through a series of risk mitigating measures introduced by the Singapore government and the responsiveness of all Singaporeans. It is important to point out that these risk mitigating measures, along with the public's compliance, were swiftly adjusted to address the volatile conditions – such as when more epidemiological cases were uncovered.

In this chapter, we introduce Singapore's all-hazard management framework as well as the insights drawn from Singapore's risk management experience with specific references to the SARS epidemic. To achieve our research objective, we utilized a triangulation strategy of various research methodologies. For understanding the principles and practices of Singapore's approach to disaster risk management, the research methods employed here are an historical analysis of official documents obtained from the relevant Singapore government agencies as well as international organizations, literature reviews, quantitative analysis of economic impacts, qualitative interviews with key informants (e.g. public health professionals and decision-makers), and email communications with frontline managers from the public sector (e.g. the Singapore Civil Defense Force, the Communicable Disease Centre) and non-governmental organizations. The authors also employed the 'cultural insider' approach by participating in epidemic control against SARS[1]. In particular, we use the method of case study to illuminate Singapore's approach to disaster risk management. The rationale of doing a case study of SARS along with Singapore's all-hazard approach is that the case study can best showcase the contextual differences, those being political, economic, and social. This case study aims to highlight the lessons drawn from past experiences in a specific context and timeframe, through which we are able to focus more on the nature of the risks, and the processes and the impacts of the disaster risk management and policy intervention. We also examined relevant literature on risk mitigating measures against communicable diseases in order to establish our conclusions. We evaluated oral accounts provided by key health policy decision-makers and experts for valuable insights. It is our hope that through these rigorous methodological approaches we ensure our conclusions are valid and reliable.

The research contribution of this chapter is significant because it offers empirical evidence on the role of the whole-of-government approach to risk mitigation of the SARS epidemic. Applying the approach to a case study, our research enriches the vocabulary of risk management, adding to the body of knowledge on disaster management specific to the region of Southeast Asia. Indeed, the dominant perspective in this field holds that the state must be able to exercise brute force and impose its will on the population (Lai and Tan, 2012). However, as shown in our paper, this dominant perspective is incomplete as the exercise of authority and power from the government is not necessarily sufficient to contain the transmission of transnational communicable diseases. Success in fighting epidemics, as most would agree, is also contingent on a concerted effort of partnership between governmental authorities and the population at large.

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[1] One of the authors, Allen Lai, has been working on the rescue mission in fighting SARS in 2003.

This chapter has four main sections. Following this introduction, we provide an overview of Singapore's historical disaster profiles. Second, we introduce the policy and legal framework, and budgetary allocations for risk mitigation in Singapore. Third, we detail a case study of Singapore's experience in fighting SARS, as well as the impact of SARS on Singapore in its economic, healthcare, and psychosocial aspects. In the fourth section, we discuss the implications for practice and future research in disaster risk management, followed by conclusions.

## 2. Singapore's Historical Disaster Profile

Singapore has experienced a small number of disasters since it was founded in 1965 (Table 1). In this section, we briefly provide an historical account of Singapore's disaster risk profiles including earthquakes, floods, epidemics, civil emergencies, and haze. According to the Centre for Research on the Epidemiology of Disasters (CRED) EM-DAT,[2] an emergency event is classified as a disaster if it meets at least one of the following criteria: 10 or more people reported killed, 100 people reported affected, the declaration of a state emergency, and the call for international assistance. However, to provide an overview of Singapore's disaster profiles, this paper lists all major public emergencies in the city-state from 1965 onwards.

**Table 1: A Chronological Profile of Singapore's Major Disaster Events from 1965-2011**

| Year/Event | Nature of Disaster | Number of People Affected | Number of People Killed |
|---|---|---|---|
| 1978/Greek tanker Spyros explosion | Industrial | 182 | 76 |
| 1978/Floods | Natural | >100 | 7 |
| 1986/ Hotel New World Collapse | Technological | 50 | 33 |
| 1997/Southeast Asian Haze | Natural | >100 | Nil |
| 2000/Hand Foot Mouth Disease | Natural | 3790 | 3 |
| 2003/SARS | Natural | 238 | 33 |
| 2006-07/Southeast Asian floods | Natural | >100 | Nil |
| 2009/H1N1 avian influenza | Natural | 1,348 | 18 |

*Source*: various from government report.

[2] EM-DAT is one of the most exhaustive sources of data available in the global emergency events database on disasters (natural and technological hazards).

### 2.1. Risk of Earthquake and Tsunami

Singapore has a low risk of earthquakes and tsunamis. Geographically, Singapore is located in a low seismic-hazard region. However, the high-rise buildings that are built on soft-soil in Singapore are still vulnerable to earthquakes from far afield (ADRC, 2005). This is because Singapore is at a distance (nearest) of 600 km from the Sumatran subduction zone and 400 km away from the Sumatra fault both of which have the potential of generating large magnitude earthquakes. This geographic vicinity may produce a resonance like situation within high-rise buildings on soft-soil. Recent tremors from the September 2009 Sumatra offshore earthquake were experienced in 234 buildings located mainly in the central, northern and western parts of Singapore. On the front of potential tsunamis, Singapore has developed a national tsunami response plan which is a multiagency government effort comprising of an early warning system, tsunami mitigation and emergency response plans, and public education.

### 2.2. Risk of Flooding

Though Singapore does not suffer from flood disasters due to the continuous drainage improvement works by the local authorities, the country has a risk of local flooding in some low-lying parts. The floods take place due to heavy rainfall that aggregates over short periods of time. The worst floods in Singapore's history took place on 2 December 1978. The floods claimed seven lives, forced more than 1,000 people to be evacuated, and the total damages reached SGD10 million (Tan, 1978). The swift and sudden floods in 1978 were caused by a combination of factors including torrential monsoon rains, drainage problems, and high incoming tides. Over the following years, Singapore saw a series of flash floods hit various parts of the city-state. For example, 2006-07 Southeast Asian floods hit Singapore on 18 December 2006 as a result of 366 mm rainfall in 24 hours. From 2010 onwards, Singapore has experienced a series of flash floods due to the higher-than-average rainfall. One severe episode occurred on16 June 2010 that flooded shopping malls and basement car parks in its most famous shopping area – Orchard Road.

### 2.3. Risk of Epidemics/Pandemics

As per the reported historical disaster data from the CRED International Disaster Database, Singapore has suffered only two disaster events caused by epidemics. In 2000, Singapore experienced its largest known outbreak of Hand-Foot-Mouth Disease (HFMD) which affected more than 3,000 young children, causing 3 deaths. Later in 2003, SARS hit Singapore and it was Singapore's most devastating disaster to date. The SARS virus infected around 8,500 people worldwide and caused around 800 deaths. In Singapore, SARS infected 238 people, 33 of whom died of this contagious communicable disease. In 2009, novel avian influenza H1N1 struck Singapore, which affected 1,348 people with 18 deaths.

### 2.4. Risk of Civil Emergencies

Civil emergencies are defined as sudden incidents involving the loss of lives or damage to property on a large scale. They include 1) civil incidents such as bomb explosions, aircraft hijacks, terrorist hostage-taking, chemical, biological, radiological and explosive (CBRE) agents and the release of radioactive materials by warships, and 2) civil emergencies, for example major fires, structural collapses, air crashes outside the airport boundary, and hazardous material incidents. In Singapore, the Singapore Civil Defence Force (SCDF) is responsible for civil emergencies. Since 1965, Singapore has experienced several episodes of civil emergencies. For example, the Greek tanker Spyros explosion at the Jurong Shipyard in 1978 was Singapore's worst industrial disaster in terms of lives lost (Ministry of Labour, Singapore, 1979). In 1986, the six-storey Hotel New World collapse was Singapore's deadliest civil disaster claiming 33 lives. The collapse was due to structural faults. The SCDF, together with other rescue forces, spent 7 days on the whole relief operation. After the collapse, the government introduced more stringent regulations on construction building codes, and the SCDF went through a series of upgrades in training and equipment (Goh, 2004).

### 2.5. Risk of Haze

Singapore experienced its first haze in the period of the end of August to the first week of November 1997 as a result of prevailing winds. The haze in 1997, called the

Southeast Asian haze, was caused by slash and burn techniques adopted by farmers in Indonesia. The smoke haze carried particulate matter that caused an increase of acute health effects including increased hospital visits due to respiratory distress such as asthma, pulmonary infection, as well as eye and skin irritation. The haze also severely affected visibility in addition to increasing health problems. As a result, Singapore's health surveillance showed a 30% increase in outpatient attendance for haze-related conditions (Emmanuel, 2000). Apart from healthcare costs, other costs associated with the haze included short-term tourism and production losses. A study by environmental economists of the 1997 Southeast Asian haze indicated a total of USD$74.1 million in economic losses in Singapore alone. Singapore is actively involved in various regional meetings to deal with trans-boundary smoke haze pollution in order to reduce the risk (Singapore Institute of International Affairs, 2006).

## 3. Disaster Risk Management in Singapore

### 3.1. Policy Framework for Disaster Risk Mitigation

The Singapore government adopts a cross-ministerial policy framework – a Whole-of-Government Integrated Risk Management (WOG-IRM), for disaster risk mitigation and disaster management (APEC, 2011). This is a framework that aims to improve the risk awareness of all government agencies and the public, and helps to identify the full range of risks systematically. In addition, the framework identifies cross-agency risks that may have fallen through gaps in the system. This framework also includes medical response systems during emergencies, mass casualty management, risk reduction legislation for fire safety and hazardous materials, police operations, information and media management during crises and public-private partnerships in emergency preparedness.

The WOG-IRM policy frame work in Singapore functions in peacetime and in times of crisis. It refers to an approach that all relevant agencies work together in an established framework, with seamless communication and coordination to manage the risk (Pereira, 2008). In peacetime, the home team comprises of four core agencies at central government level. These four agencies are the Strategic Planning Office, the Home front Crisis Ministerial Committee (HCMC), the National Security Coordination Secretariat, and the Ministry of Finance at the policy layer (see Figure 1). Among them, the Strategic Planning Office provides oversight and guidance as the main platform to steer and review the overall progress of the WOG-IRM framework. During peacetime, the Strategic Planning Office convenes meetings quarterly for the permanent secretaries from the various ministries across government. In a crisis, the Home front Crisis Management system provides a 'ministerial committee' responsible for all crisis situations in Singapore.

In the WOG-IRM structure, the HCMC is led by the Ministry of Home Affairs (MHA). In peacetime, MHA is the principal policy-making governmental body for safety and security in Singapore. In the event of a national disaster, the MHA leads at the strategic level of incident management. The incident management system in Singapore is known as the Home front Crisis Management System (HCMS). Under the HCMS, the SCDF is appointed as the Incident Manager, taking charge of managing the consequences of disasters and civil emergencies. Reporting to the HCMC is an executive group known as the Home front Crisis Executive Group (HCEG), which is chaired by the Permanent Secretary for MHA. The HCEG is in charge of planning and managing all types of disasters in Singapore. Within the operation allayer, there are various functional inter-agency crisis management groups with specific responsibilities, integrated by the various governmental crisis-management units. At the tactical layer, there are the crisis and incident managers who supervise service delivery and coordination. The Singapore government holds relevant ministries accountable in accordance to the nature and scope of the disaster. Among those ministries and government agencies, the SCDF is the major player in risk mitigation and management for civil emergencies. Now, let us look into the SCDF in more detail.

For civil security and civil incidents, the Singapore Civil Defence Force (SCDF)[3] is Singapore's leading operational authority – the Incident Manager for the management of civil emergencies. The SCDF is responsible for leading and

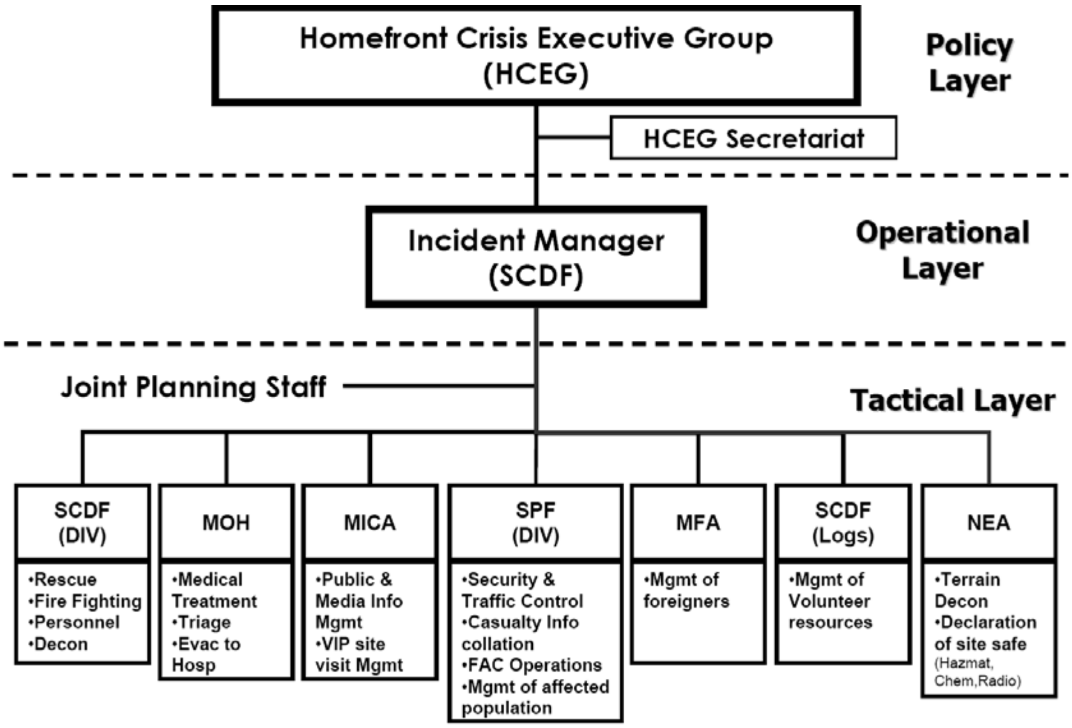
[3]According to 2006 data, SCDF has a workforce of about 5,100 staff comprising of 1,700 regular uniformed staff, 200 civilian staff and 3,200 full-time National Servicemen. The budget size for SCDF on a national level is about SGD$300 million per annum.

coordinating the multi-agency response under the Home front Crisis Management Committee. The SCDF operates a 3-tier command structure, with Headquarters (HQ) SCDF at the apex commanding 4 Land Divisions. These Divisions are supported by a network of Fire Stations and Fire Posts strategically located around the island. The SCDF also serves the following pivotal functions. The SCDF provides effective 24-hour fire fighting, rescue and emergency ambulance services. The SCDF developed the Operations Civil Emergency (Ops CE) Plan – a national contingency plan. When Ops CE is activated, the SCDF is vested with the authority to direct all response forces under a unified command structure, thus enabling all required resources to be pooled. However, the WOG-IRM policy framework only came to existence when Singapore encountered SARS.

The SARS epidemic in 2003 was an institutional watershed for Singapore's approach to risk mitigation and disaster management (Pereira, 2008). Prior to the SARS epidemic, Singapore's Executive Group[4] mainly focused on crises or disasters that were civil defense in nature. These emergencies were merely conceived to be well managed by a solitary incident manager, supported by other relevant agencies. A specific multi-sectoral governance structure was not considered necessary to handle the crisis. The SARS epidemic challenged the prevailing Home front Crisis Management structure as the epidemic transcended just managing civil defense incidents. The policymakers realized the necessity to adopt a comprehensive disaster management framework, an all-hazard approach that includes a mechanism for seamless integration at both the strategic and operational levels among various government agencies. To this end, Singapore revamped its Home front Crisis Management framework to produce the current inter-agency structure.

[4] Prior to SARS in 2003, the Executive Group in the Homefront Crisis Management System was the key executive body charged with managing peacetime crises in Singapore.

**Figure 1: Whole-of-Government Integrated Risk Management Policy Framework**




*Source*: Asian Conference on Disaster Reduction (2010)

### 3.2. Legal Framework in Disaster Reduction

The main legislation supporting emergency preparedness and disaster management activities in Singapore are the Civil Defence Act of 1986, the Fire Safety Act of 1993, and the Civil Defence Shelter Act of 1997. The Civil Defence Act provides the legal framework for, amongst other things, the declaration of a state of emergency and the mobilization and deployment of operationally-ready national service rescuers. The Fire Safety Act (1993) provides the legal framework to impose fire safety requirements on commercial and industrial premises, as well as the involvement of the management and owners of such premises in emergency preparedness against fires; and The Civil Defence Shelter Act provides the legal framework for buildings to be provided with civil defense shelters for use by persons to take refuge during a state of emergency. To tackle disease outbreak, Singapore had earlier promulgated the Infectious Disease Act in 1977. This legislation is jointly administered by the MOH and the National Environment Agency (NEA).

### 3.3. Budgetary Allocations

Unlike most governments that make regular national budgetary provision for potential disaster relief and early recovery purposes, the Government of Singapore makes no annual budgetary allocations for disaster response because the risks of a disaster are low (Global Facility for Disaster Reduction and Recovery, 2011, p.24). However, the Singapore government can swiftly activate the budgetary mechanisms or funding lines in the event of a disaster and ensure these lines are sufficiently resourced with adequate financial capacity.

## 4. Case Study: Singapore's Experience in Fighting SARS Epidemic

To illuminate Singapore's approach to disaster management, we now use a case study of Singapore's fight against SARS to highlight policy learning and lesson-drawing in a specific context and timeframe. This case study has three sections. We first introduce the epidemiology of SARS in Singapore. In the second section, we describe the impact caused by SARS epidemics on Singapore in the economic, healthcare, and psychosocial aspects. In the third section, we demonstrate Singapore's risk mitigating management, and detail the government's risk mitigating measures to contain the epidemic.

### 4.1. Epidemiology of SARS in Singapore

SARS hit Singapore in early 2003. But what began as a few isolated cases swiftly turned into a major public health emergency within a few short weeks. In early March 2003 the first Singaporean to contract SARS was hospitalized upon her return from Hong Kong. As it turned out, she had contracted SARS from a super-carrier while both were staying on the same floor of the M Hotel. That super-carrier – a physician from China – was later identified by the World Health Organization (WHO) to be the primary source of infection for multiple cases of SARS worldwide (Centers for Disease Control and Prevention, 2003). Back in Singapore, this first SARS victim quickly infected 21 others. In late July 2003, among all SARS affected countries, Singapore reported 238 probable cases (see

Table 2). By the time, Singapore was removed from the WHO advisory list on 31 May 2003, 205 (86%) had recovered while 33 (14%) had died. A further breakdown reveals that 8 cases (3%) were infected while abroad whereas 97 cases (41%) were healthcare workers (WHO, 2003a).

**Table 2: SARS Numbers Worldwide (as of the 31 December 2003)**

| Country | Number of Cases | Number of death (fatality rate) |
|---|---|---|
| Singapore | 238 | 33 (13.8%) |
| Taiwan | 346 | 37 (10.6%) |
| Hong Kong | 1,755 | 299 (17%) |
| Vietnam | 63 | 5 (7.9%) |
| China | 5,327 | 349 (6.5%) |
| Canada | 251 | 43 (17%) |

*Source*: WHO (2003b)

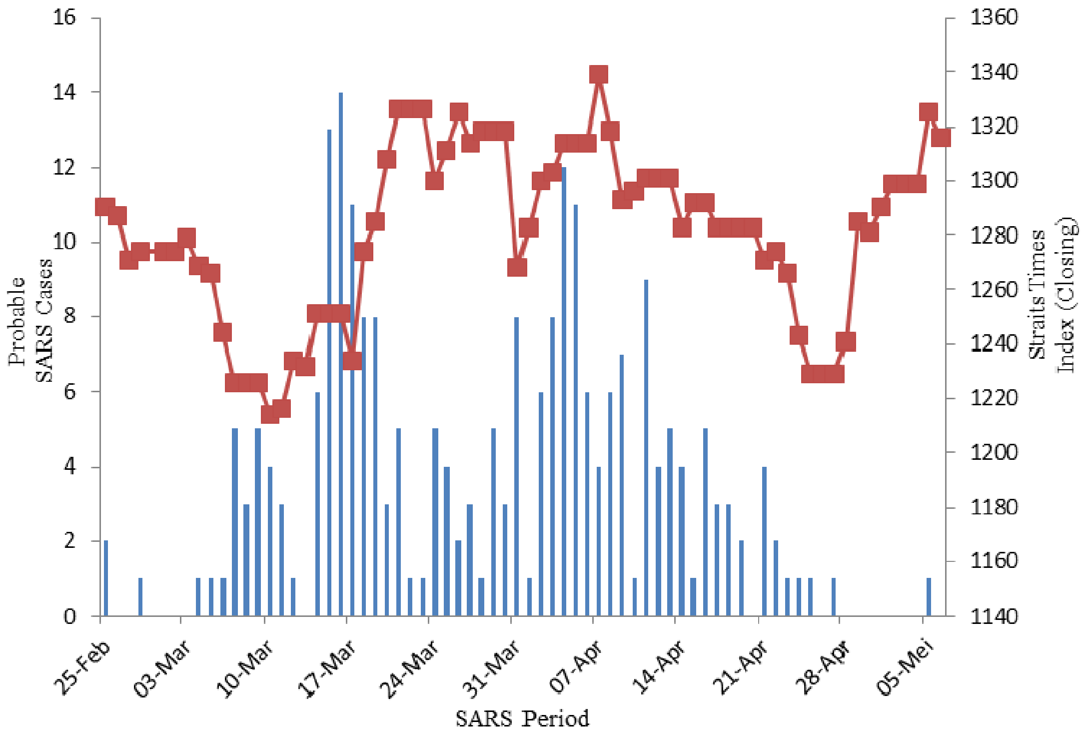
### 4.2. SARS's Impact on Singapore

*Economic Impact*

Singapore is a small open economy. External shocks can result in high levels of volatility resonating across the domestic economy. These shocks in turn would bring about higher levels of risk and uncertainty in Singapore. At the beginning of 2003, Singapore's economic outlook was clouded by the Iraq War and its impact on oil prices (Attorney-General's Chambers, 2003). The unexpected outbreak of SARS led to greater uncertainty in the Singapore economy. Singapore's financial markets were severely affected due to the loss of public confidence and reduced floor trading. The impact of SARS on the stock market reflected in the Straits Times Index (STI) (see Figure 2). The market did not react well to the SARS epidemic. In the first fortnight of the epidemic, the STI closed down 76 points. Even though more cases were reported, the STI climbed progressively up 86 points over the next fortnight, eclipsing the earlier falls. This could be attributed to the strict measures which the Singapore government introduced. The STI remained relatively stable over the immediate fortnight as new cases were reported. However, it started a downward plunge over the following fortnight as the number of cases peaked once more. The

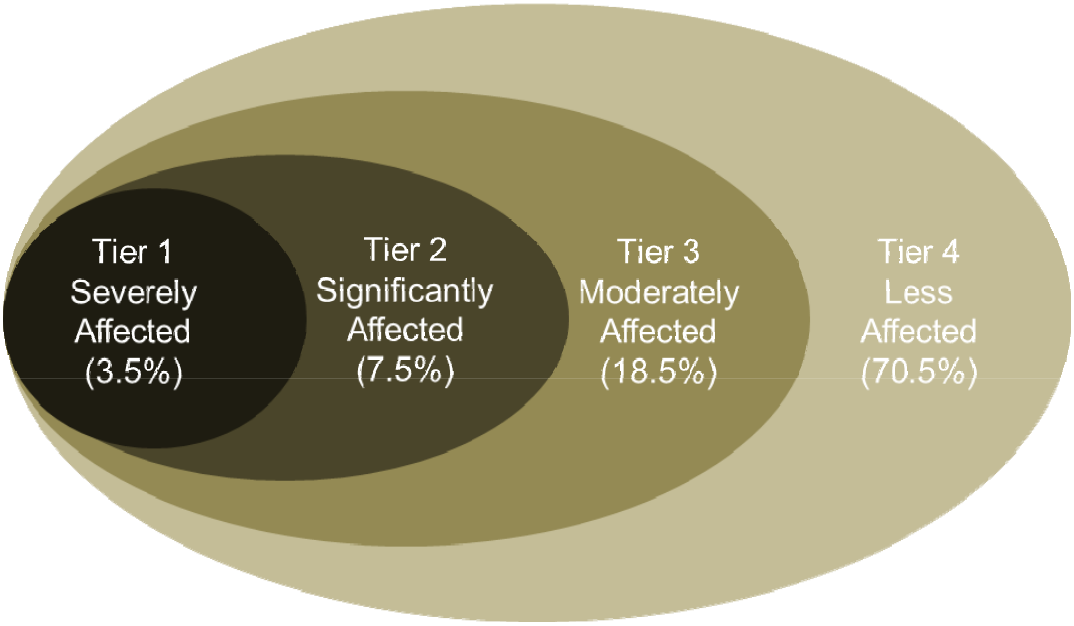
STI plunged 96 points. However, the resilience of the STI was shown when it climbed back up, surpassing the level reported at the beginning of the SARS period. The volatility of the STI demonstrates the vulnerability of a small open economy from exogenous forces – in this case, the SARS epidemic.

**Figure 2: SARS Probable Cases and Straits Times Index (Closing) (25th February to 6th May 2003)**




*Source*: Straits Times Index available at http://quotes.stocknod.com(accessed April 15, 2012); Ministry of Health (2003a)

**Figure 3: Impact of SARS on Singapore's Domestic Economy***




*Note*: *MAS internal estimates
*Source*: Monetary Authority Singapore, Annual Report 2003/2004

**Table 3: Impact of SARS on Singapore's Domestic Economy**

| Tier | Industry | Percentage in GDP |
|---|---|---|
| **1 (Severely)** | Hotels, Air-Transport | 3.50% |
| **2 (Significantly)** | Restaurants, Retail Trade, Land Transport | 7.50% |
| **3 (Moderately)** | Real Estate, Financial Services | 18.50% |
| **4 (Less)** | Manufacturing, Construction, Post and Communications, Wholesale Trade, Sea Transport, Service Allied to Transport | 70.50% |

*Source*: Monetary Authority Singapore, Annual Report 2003/2004

SARS was the one single activity which contributed to the volatility of Singapore's Gross Domestic Product (GDP) in 2003. The Ministry of Trade and Industry (MTI) revised the forecast for Singapore's annual GDP growth down from 3% to 0.5%. This forecast was later revised upwards to 2.5%. There were a number of channels by which the SARS epidemic affected the economy. The economic impacts will be discussed from the positions of demand and supply shocks. The main economic impact of the SARS outbreak was on the demand side, as consumption and the demand for services declined (Henderson, 2003). The economic consequence caused fear and anxiety among Singaporeans and potential tourists to Singapore. The hardest and most directly hit were the tourism, retail, hospitality and transport-related industries, for example airline, cruise, hotel, restaurant, travel agent, retail and taxi services, and their auxiliary industries (see Figure 3 and Table 3). Visitor arrivals fell by one third in March 2003, and two thirds in April 2003. This had a direct impact on hotel occupancy rates, which declined sharply to 30% in late April 2003. Cancellation or postponement of tourism events increased by about 30-40%. Revenues of restaurants dropped by 50% while revenues of the travel agents decreased by 70%. SARS had an uneven impact on various sectors of the economy. A four-tiered framework to assess the impact on the respective sectors showed that Tier 1 industries, such as the tourism and travel-related industries were most severely hit. Tier 1 industries account for 3.5% of GDP. The Tier 2 industries, such as restaurants, retail and land transport industries were significantly hit, which account for 7.5% of GDP. The next two tiers were less directly affected by the SARS outbreak. Tier 3 industries include real estate and stock broking, which account for close to 19% of GDP. The remaining 70% of the domestic economy in Tier 4 includes manufacturing, construction and communications. These industries were not directly impacted by the outbreak of SARS. All in all, the estimated decline in GDP directly from SARS was 1%, equaling SGD875 million.

Singapore experienced a significant drop in tourist arrivals where visitors usually stay for up to three days and transit onto their next destination. The trend for visitor inflow is that visitor inflows fall sharply. This is especially true in the case of Singapore, when visitor stays tend to be shorter and the high-end visitors stayed away. As a result, tourism and other related industries were nearly crippled due to a significant reduction in both leisure and business travel. For example, tourist arrivals saw a significant drop of 15% in March 2003. The drop in tourist arrivals was 67% in April 2003, and 65% for the month of May 2003 until the first week of June 2003. The outcome was low visitor numbers relative to other months in 2003. See Figure 4 below.

**Figure 4: Singapore Visitors Numbers for the Year 2003**


*Source*: Singapore Tourism Board (2003), "Annual Report on Tourism Statistics"

Visitors from around the world cancelled or postponed their trips to Singapore, causing a drastic decrease of total expenditure from visitors. (See Table 4) Plummeting visitor arrivals directly impacted hotel occupancy rates, which declined sharply to 30% in late April (See Table 5). The hotel occupancy rate plummeted from 72% to 42%, compared to the normal level of 70% or above. The annual averages for hotel occupancy rates were 74.4% in 2002, 67.3% in 2003, and 80.6% in 2004. Singapore's national carrier, Singapore Airlines (SIA), faced a record-breaking low passenger capacity of 29% in April and May 2003.SIA cancelled approximately 30% of its weekly schedules (Henderson, 2003). SIA laid off 414 employees, of which 129 were ground staff, as a consequence of a USD200 million loss in June 2003.

**Table 4: Change of Expenditure of Visitors and Incoming Flights from 2002 to 2004**

| Year | Annual Total Expenditure of visitors (SGD) | Number of incoming flights (per week) | Number of seats on incoming flights (per week) |
|---|---|---|---|
| **2002** | 5,425,800 | 1,569 | 417,952 |
| **2003** | 4,315,600 | 1,490 | 408,606 |
| **2004** | 6,278,300 | 1,728 | 452,221 |

*Source*: Singapore Tourism Board, "Annual Report on Tourism Statistics" (2002-2004)

**Table 5: Hotel Statistics, First to Fourth Quarter 2003**

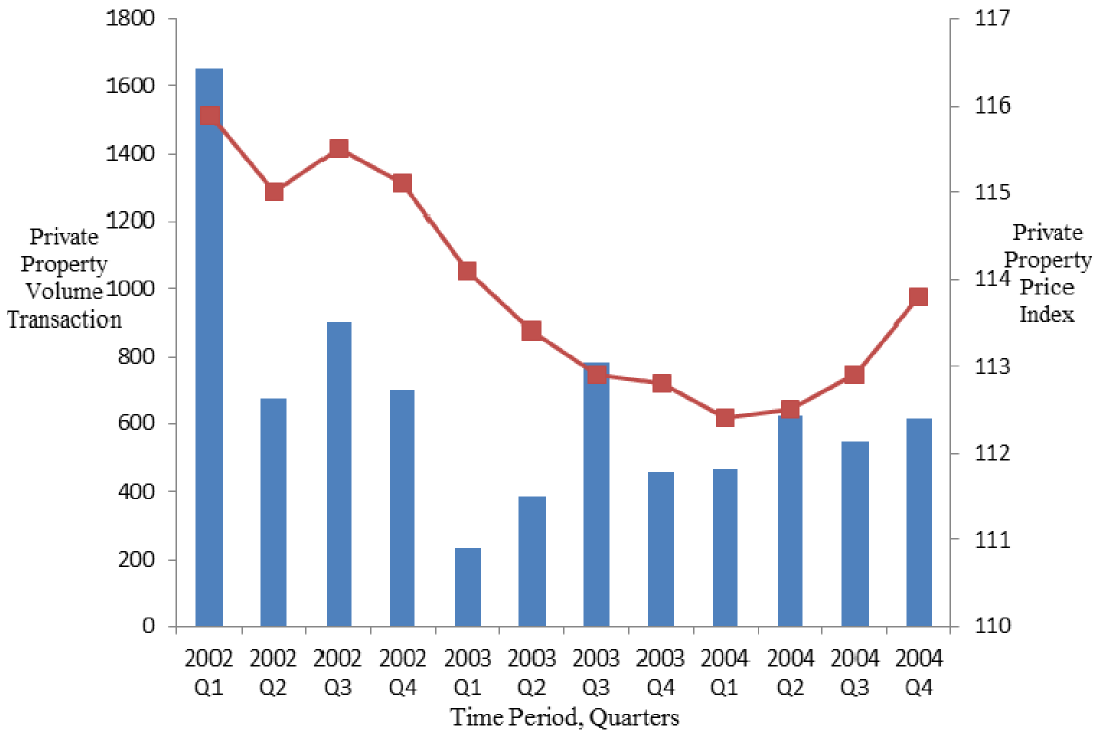
| Quarter | Average occupancy rate (%) | Average room rate (SGD) | Hotel room revenue (million SGD) | Food and beverage revenue million SGD) |
|---|---|---|---|---|
| **First** | 72 | 121.5 | 221.7 | 374.3 |
| **Second** | 42.1 | 106.7 | 92.6 | 284.8 |
| **Third** | 73.6 | 107.3 | 191.8 | 357.7 |
| **Fourth** | 76.9 | 117.4 | 220.2 | 399.6 |

*Source*: Economic Survey of Singapore 2003, Singapore Department of Statistics, http://www.singstat.gov.sg/ (Accessed April 15, 2012)

The hospitality industry had to resort to cutting budgets, which led to a steep plunge in the number of employed in the service sector. Out of a total of 12,100 made unemployed, hotels and restaurants went through the biggest cut, that being 5,800 employees. The breakdown of total job losses showed 47% in the service sector, 28% in construction, and 25% in manufacturing. Additionally, transactions in the retail sector were dropped by 50%.

The private property volume transactions for condominiums and private property price index are also good proxies on the impact of the economy from SARS. Based on quarterly figures between 2002 and 2004, the volume transactions dipped to a low in the first quarter of 2003. Also, there was a corresponding decline in the price index. Transactions recovered steadily by the third quarter boosted by confidence in market sentiments (See Figure 5). The STI and private property price index seemed to display fairly similar trends, albeit with some observed lag. Note also that there is a lagged effect of consumer's deferred purchases after the outbreak of SARS in Singapore.

**Figure 5: Private Property Volume Transactions (Condominiums), Private Property Price Index (Quarterly 2002-2004)**




*Source*: Singapore Real Estate, available at http://www.singaporerealestate.info/blog/property-tools/spsf-chart-d09-10/ (Accessed April 15, 2012), http://www.h88.com.sg/property_stats/property_price_index.php (Accessed April 15, 2012)

Demand creates its own supply. Therefore, a fall in demand of goods and services is likely to bring about a fall in the supply of such goods and services. Also, the loss of consumer and business confidence would reduce the level of aggregate demand. These effects were observed as the manufacturing industry experienced supply chain disruptions as the Singaporean economy and employment market continued to weaken. Singapore was taken off the WHO's list of SARS affected countries on 31st May 2003 – one of the first countries to be removed from the list. With the "fear-factor" managed, normal daily activities slowly resumed. SARS affected industries and sectors started to show signs of recovery towards the end of the second quarter in 2003. A more comprehensive analysis of the economic costs of

SARS will need to consider the direct impact on consumer spending and indirect repercussions of the shock on trade and investment (Asian Development Bank Outlook, 2003). The economic costs from a global disease, such as SARS, go beyond the immediate impacts incurred in the affected sectors of disease-inflicted countries. This is not just because the disease spreads quickly across countries through networks related to global travel, but also because any economic shocks to one country spread quickly to other countries through the increased trade and financial linkages associated with globalization. However, just calculating the number of cancelled tourist trips, the declines in retail trade, and some of the factors discussed earlier do not provide a complete picture of the impact of SARS. This is because there are close linkages within economies, across sectors, and across economies in both international trade and international capital flows. Thus, analyzing the tourism sector alone may not be sufficient in analyzing the overall financial impact of SARS. SARS inflicted a heavy toll on businesses and immediately impacted severely the viability of business. Businesses lost employees for long periods of time due to factors such as illness, the need to care for family members and fear of infection at work, or retrenchment. As the workforce shrunk due to absenteeism, business operations, for example supply chain, flow of goods worldwide and provision of services, were all affected both locally and internationally. In terms of retrenchment, the job prospects of employees in affected companies appeared miserable. A survey performed during the SARS period showed that the jobless rate increased more than 5.5%, the highest for the last decade in Singapore (Ministry of Manpower, Singapore, 2003). In absolute numbers, overall employment diminished by 25,963 in the second quarter of 2003, the largest quarterly decline since the mid-1980s recession. Unlike previous retrenchment that affected mainly blue-collar labor, SARS also affected white-collar employees too. The implementation of workplace SARS control measures added to operational and administrative costs. For example, the policy of temperature taking was implemented at workplaces in the private sector. Numerous private establishments installed thermal-scanners in their entrances from day one. However, such precautionary measures were necessary to contain the disease. This helped to restore business confidence and investment potential (a lower level of investments will lead to slower capital growth). But the reduction in an economy's capacity may linger on for a few quarters before it is restored to pre-SARS levels. The loss of productive working days from quarantine, and implementation costs incurred to monitor movements of employees contributed to the reduction in the aggregate supply front. Some of these economic effects may have worsened the public health situation if strategic planning was not in place.

*Healthcare System Impact*

SARS reduced levels of service and care in Singapore's healthcare system as the system mobilized its medical resources to deal with the SARS epidemic. The influx of influenza patients to hospitals and clinics crowded out many other patients with less urgent medical problems for treatment. This particularly affected those seeking elective operations that had to be postponed until the epidemic ended in Singapore. SARS also severely impacted Singapore's healthcare manpower. During the peak of SARS from mid-March 2003 to early April 2003, there was a shortage of medical and nursing professionals because 1) the demand for care of influenza patients substantially increased, and 2) the supply of healthcare manpower decreased as somewere also affected by the epidemic. Like other business sectors, hospitals, clinics and other public health providers also faced a high staff-absenteeism rate and encountered difficulties in maintaining normal operations. This resulted in a further reduction in the level of service capacity.

*Psychosocial Impact*

Psychosocial impact from SARS was mainly caused by limited medical knowledge of SARS when it began its insidious spread in Singapore. Such uncertainty of contracting a highly contagious disease actually deteriorated the fear of security breaches, and the panic of overexposure (Tan, 2006). Responding to the uncertainty of disease transmission, the Singapore government instituted many draconian public policies, such as social distancing, quarantine and isolation, as risk mitigating measures. All of these control measures created an instinctive withdrawal from society for the general population. This brought about a behavior which resulted in the public avoiding crowds and public places with human interaction. On

24 March 2003, the MOH invoked the Infectious Disease Act (IDA) to isolate all those who had been exposed to SARS patients. After IDA was invoked, on 25 March 2003, schools and non-essential public places were closed. Public events were cancelled to prevent close contact in crowds. Singaporeans with contact history were asked to stay home for a period of time to prevent transmission. Harsh penalties, such as hefty fines of more than USD4,000 or imprisonment, were imposed on those who defied quarantine orders. In a drastic move reminiscent of a police state, closed-circuit cameras were installed in the houses of those ordered to stay home to monitor their compliance with the quarantine order (ABC News Online, 2003). At the height of SARS, 12,194 suspected cases were ordered to stay home, all of whom were monitored either by cameras or in less severe cases, by telephone calls. Quarantine, regardless of its effectiveness, received strong criticism from the general public during the outbreak of SARS due to the invasive nature of that measure (Duncanson, 2003). Impact of social distancing remains unclear, but WHO has recommended such control measures depending on the severity of the epidemic, risk groups affected and epidemiology of transmission (WHO, 2005). Singapore's MOH advocated the practice of social distancing during the outbreak of SARS. The sole intention of social distancing was to limit physical interactions and close contact in public areas to slow the rate of disease transmission. Additionally, social distancing measures in particular have a psychological impact. The practice of social distancing led to a social setback in businesses that suffered economic losses as a result (Duncanson, 2003). The psychological impact of SARS is longer lasting. The most immediate and tragic impact was the loss of loved ones.

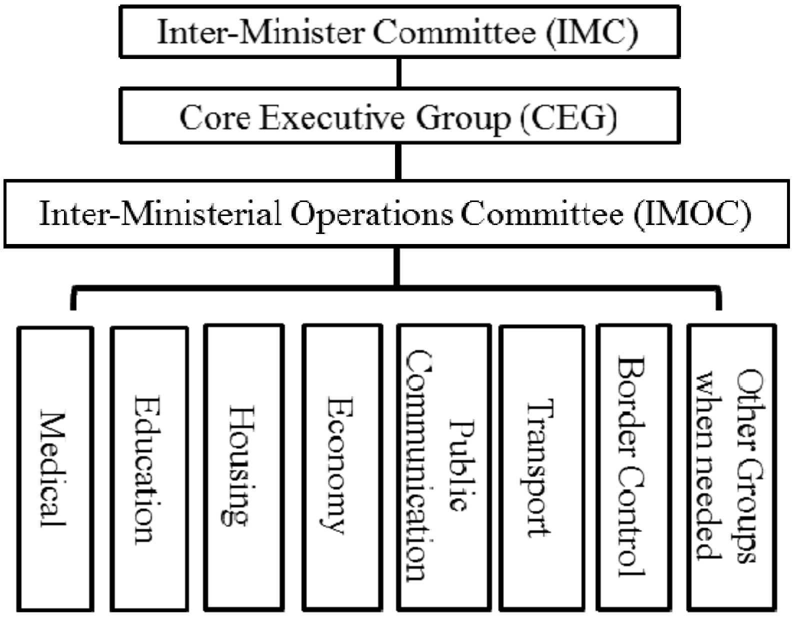
### 4.3. Singapore's Risk Mitigating Measures

In this section, we detail Singapore's command structure, legal framework in fighting SARS, as well as risk mitigating measures in economic, healthcare, and psychosocial perspectives.

#### *4.3.1. Command Structure and Legal Framework*

One of the most important lessons the Singapore government learned from the SARS epidemic was the crucial role played by the bureaucracy in disaster management. The bureaucratic structure in place then was severely inadequate in terms of handling a situation that was both fluid and unprecedented; indeed, fighting SARS required more than a medical approach because resources had to be drawn from agencies other than the MOH. Accordingly, a three–tiered national control structure was created in response to SARS – these tiers were individually represented by the Inter-Ministerial Committee (IMC), the Core Executive Group (CEG) and the Inter-Ministry SARS Operations Committee (IMOC) (TayandMui, 2004). The nine-member IMC was chaired by the Minister of Home Affairs (MHA) and it fulfilled three major functions: 1) to develop strategic decisions, 2) to approve these major decisions, and 3) to implement control measures (Figure 6).[5]

**Figure 6: Singapore's Organizational Structure for Fighting SARS**



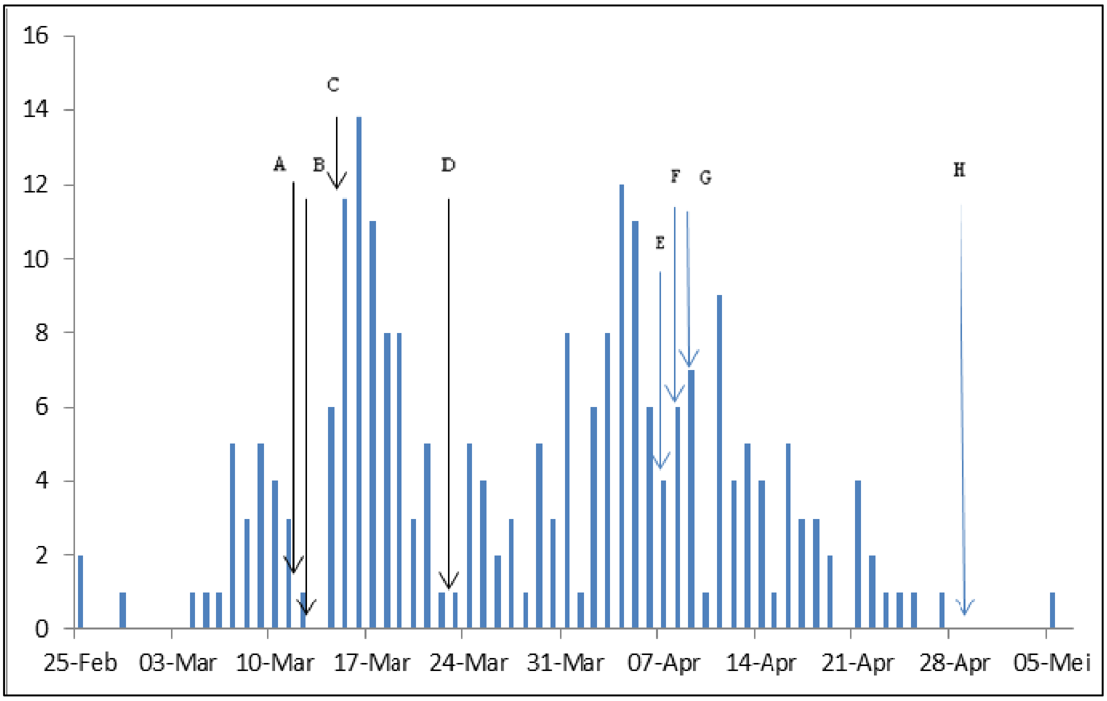

*Source*: Adapted from Tay and Mui (2004, p. 35)

Notably, the IMC also played the role of an interagency coordinator overseeing the activities of other ministries and their subsidiaries. On 7 April 2003 (five weeks after the first case of SARS was reported), the CEG and a ministerial committee was formed. The CEG was chaired by the Permanent Secretary of Home Affairs and consisted of elements from three other ministries: the MOH, the Ministry of Defense (MOD) and the Ministry of Foreign Affairs (MFA). In particular, the role of the

[5] Other than Ministries of Home Affairs and Health, the Inter-Ministerial Committee comprised other eight ministries: Foreign Affairs, Defence, Education, National Development, Manpower, Environment, Transport and Information, Communications and the Arts.

CEG was to manage the SARS epidemic by directing valuable resources to key areas. The IMOC, meanwhile, was seminal in carrying out health control measures issued by the IMC (Figure 7). The MOH, at the operational layer, formed an Operations Group responsible for the planning and coordination of health services, and operation in peacetime. During SARS, it commanded and controlled all medical resources and served as the main operational linkage between the MOH and all the healthcare providers.

**Figure 7: Chronology of Singapore's Control Measures**




*Note:* A: (*13 March*) WHO's global alert on SARS, MOH's directive to isolate all cases of atypical pneumonia; B: (*14 March*) MOH advisory to the public to avoid travel to SARS-affected countries; C: (*16 March*) triage at Emergency Departments to separate out febrile patients from other types of patients and unprotected staff and members of the public; D: (*22 March*) Tan Tock Seng Hospital designated as the SARS hospital. Home quarantine and daily telephone surveillance of contacts with suspected SARS cases; E: (*7 April*) formation of the Ministerial Committee on SARS chaired by the Minister for Home Affairs; F: (*8 April)* MOH directive under the Private Hospitals and Medical Clinics Act requiring all hospitals and nursing homes to ensure effective implementation of detailed procedures on triage, isolation, use of personal protective equipment and infection control; G: (*9 April*) passengers of all inbound flights required to complete a Health Declaration Card. Thermal scanners deployed at airport; H: (*30 April*) Mandatory temperature screening of children in schools.

*Source*: Tan (2006)

On 15 March 2003, when the epidemiological nature of SARS was still unclear, the MOH initiated a SARS taskforce to look into the mysterious strain. Only two days later, after more SARS cases were reported and a better epidemiological understanding of the strain was developed, the Singapore government swiftly declared SARS a notifiable disease under the Infectious Disease Act (IDA) (Ministry of Health, 2003b). In the case of a broad outbreak, IDA made it legally permissible to enforce mandatory health examination and treatment, exchange of medical information and cooperation between healthcare providers and the MOH, and the quarantine and isolation of SARS patients (Infectious Disease Act, 2003). In particular, the government amended the IDA on 24 April 2003 requiring all those who had come into contact with SARS patients to remain indoors or report immediately to designated medical institutions for quarantine (Ministry of Health, Singapore, 2003b). Asa legacy of Singapore's British colonial past, the Singapore legislature is unique and well-known for passing laws in a swift and efficient manner. The uniqueness in Singapore's legal framework allows Singapore to swiftly amend the IDA during health crises to suit volatile conditions, for instance when more epidemiological cases were uncovered and the virus was better understood. All in all, the IDA played an adaptive role in terms of facilitating a swift response to the outbreak of this particular epidemic. On 22 March 2003, the CEG designated the restructured public hospital – Tan Tock Seng Hospital (TTSH) as the SARS hospital (James, *et al*. 2006; Tan, 2006). That is, once a suspected SARS patient was detected at a local clinic or emergency department, he or she would then be transferred to TTSH immediately for further evaluation and monitoring. The national healthcare system prioritized life-saving resources such as medicine and medical equipment to allocate manpower and protective equipment to the TTSH. To ease the flu-like patient influx into the TTSH, the government diverted non-flu patients away from TTSH so that the sudden surge in the number of flu cases at TTSH did not paralyze its service delivery.

#### *4.3.2. Economic Measures*

The full impact of SARS on the economy by and large depended on how quickly SARS was contained, as well as the course of the SARS outbreak in the region and beyond. To mitigate SARS impact on Singapore's economy, the government took every precaution and spared no effort to contain the SARS outbreak in Singapore. Two aspects of SARS warranted government intervention to mitigate economic impact. First, the information that needs to be collected and disseminated to effectively assess SARS displays the characteristics of public good. Second, there are negative externalities related to contagious diseases in the sense that they affect third parties in market transactions. Public good and negative externalities are typical areas where government action is needed (Fan, 2003). There are three major factors which can explain why some economies are more vulnerable and susceptible to the effect of SARS than others (Asian Development Bank Outlook, 2003). These factors are structural issues (e.g. shares of tourism in GDP and the composition of consumer spending), initial consumer sentiments, and government responses. As the research shows, the Singapore government implemented a USD 132 million (SGD 231 million in 2003) SARS relief package to reduce the costs for tourism operators and its auxiliary services. On the other hand, an economic relief package worth USD 131m (SGD 230m) was created to aid businesses hit by SARS.[6] In addition, the government incurred USD$109m (SGD 192m) in direct operating expenditure related to SARS, and committed another USD 60m (SGD105m) development expenditure of hospitals for additional isolation rooms and medical facilities to treat SARS and other infectious diseases. The government's economic incentives worked when seeking cooperation of other healthcare providers (such as public hospitals and local clinics) so that they would absorb additional cases of non-flu illnesses.

To help SARS affected firms tide over the plight and minimize job losses, Singapore's National Wage Council widely consulted the private sector, and recommended SARS-struck companies adopt temporary cost-cutting measures to save jobs[7]. The measures adopted by the private sector included the implementation of a shorter working-week, temporary lay-offs and the arrangement for workers to take leave or undergo skills training and upgrading provided by the Ministry of

[6] Singapore government dispensed a total of SGD 300m to battle SARS directly and SGD230m to help business, on 1 July 2003.

[7] These measures were agreed by the tripartite partners who issued a tripartite statement on 15 April 2003. The tripartite approach reflects the willingness and ability of the three social partners to work together to face the crisis (Source: NWC Recommendations for 2003/2004).

Manpower and associated agencies. When these measures failed to preserve jobs, the last resort was temporary wage cuts.

### *4.3.3. Public Health Control Measures*

#### *Surveillance and Reporting*

Surveillance and reporting is critical in combating pandemics because it serves to provide early warning and even detection of impending outbreaks. The surveillance process involves looking out for possible virulent strains and disease patterns within a country's borders as well as at major border-crossings (Jebara, 2004; Ansell, *et al.* 2010; Narain and Bhatia, 2010). When SARS first surfaced, the nature of this virus was largely unknown. As a consequence, health authorities worldwide were mostly unable to detect and monitor suspected cases. Health authorities in Singapore encountered this same problem. But with the aid of WHO technical advisors, Singapore managed to establish in a timely manner identification and reporting procedures. Furthermore, the MOH also expanded the WHO's definitions for suspected cases of SARS (to include any healthcare workers with fever and/or respiratory symptoms) in order to widen the surveillance net (Goh, *et al*. 2006). As the pace of SARS transmission quickened, the Singapore Parliament amended the IDA on 25 April 2003 requiring all suspected SARS cases to be reported to the MOH within 24 hours from the time of diagnosis.

Although these control measures were laudable, SARS also exposed the weaknesses of Singapore's fragmented epidemiological surveillance and reporting systems (Goh, *et al*. 2006). As a major part of lesson-drawing in the post-SARS era, a number of novel surveillance measures were introduced to integrate epidemiological data and to identify the emergence of a new virulent strain faster. One of the most notable was the establishment of an Infectious Disease Alert and Clinical Database system to integrate critical clinical, laboratory and contact tracing information. Today, the surveillance system has four major operational components that include community surveillance, laboratory surveillance, veterinary surveillance, external surveillance, and hospital surveillance.

*Hospital Infection Control*

To limit the risk of transmission in healthcare institutions once the SARS epidemic had broken out, the MOH implemented a series of stringent infection-control measures that all healthcare workers (HCWs) and visitors to hospitals visitors had to adhere to. The use of personal protective equipment (PPE)[8] was made compulsory. Visitors to public hospitals were barred from those areas where transmission and contraction were most likely. The movements of HCWs in public hospitals were also heavily proscribed. Unfortunately, except for TTSH, these critical measures were not enforced in all healthcare sectors until 8 April 2003, and this oversight resulted in a number of intra-hospital infections (Goh, *et al*. 2006). In addition, the policy of restricting the movements of HCWs and visitors to hospitals was taken further. More specifically, their movements *between* hospitals were now restricted. Patient movement between hospitals, meanwhile, was strictly restricted to medical transfers. The number of visitors to hospitals was also limited and their particulars recorded during each visit. It is also important to point out that these somewhat draconian control measures required strong public support and cooperation. Indeed, their implementation would not have been successful had these two elements been missing.

*Public Education and Communication*

Public education and communication are two indispensable components in health crisis management (Reynolds and Seeger, 2005; Reddy, *et al.* 2009). Communication difficulties are prone to complicate the challenge, especially when there is no established, high-status organization that can act as a hub for information collation and dissemination. Therefore, it is necessary to disseminate essential information to the targeted population in a transparent manner. During the SARS outbreak, the MOH practiced a high degree of transparency when it shared information with the public. Indeed, the clear and distinct messages from the MOH contributed significantly to lowering the risk of public panic.

[8] Personal protective equipment includes N95 masks, disposable gloves, gowns, and goggles or visors.

The MOH worked closely with the media to provide regular, timely updates and health advisories. This information was communicated to the public through every possible medium. In addition to the media (e.g. TV and radio), information pamphlets were distributed to every household and the MOH website provided constant updates and health advisories to the general public. Notably, a government information channel dedicated to providing timely updates was created on the same day – 13 March 2003 – when the WHO issued a global alert. A dedicated TV Channel called the SARS Channel was launched to broadcast information on the symptoms and transmission mechanisms of the virus (James, *et al*. 2006). The importance of social responsibility and personal hygiene was a frequent message heard throughout the SARS epidemic. As an example, when Tan Tock Seng Hospital was designated as the SARS hospital at the peak of SARS epidemics, the government undertook many efforts in public communication and education to seek cooperation and support from other healthcare providers, such as public hospitals and local clinics, so that they would absorb the additional cases of non-flu illnesses. Many organizations displayed prominent signs in front of their building entrances that reminded their staff as well as visitors to be socially responsible. School children were instructed to wash their hands and take their body temperature regularly. The public was told to wear masks and postpone non-essential travel to other countries.

*Social Distancing*

The MOH advocated the practice of social distancing during the outbreak of SARS. The sole intention of social distancing was of course to limit physical interactions and close contact in public areas thereby slowing the rate of transmission. As a result, all pre-school centers, after-school centers, primary and secondary schools, and junior colleges were closed from 27 March to 6 April 2003. School children who had stricken siblings were advised to stay home for at least 10 days. Moreover, students who showed flu-like symptoms or had travelled to other affected countries were automatically granted a 7-day Leave of Absence and home-based learning program were instituted for those affected. Extracurricular activities were also scaled down to minimize social contact. Meanwhile, the MOH also advised businesses to adopt social distancing measures such as allowing staff to work from home and using split-team arrangements. Those who were most at higher risk of developing complications if stricken were moved and removed from frontline work to other areas where they were less likely to contract the virus. As mentioned earlier, the practice of social distancing also drew strong criticisms from those businesses that suffered economic losses as a result. Apart from providing economic compensation, measures to mitigate psychosocial impacts are also important.

#### *4.3.4. Psychosocial Measures*

The government's measures of public health control, as mentioned above, drew strong criticisms from businesses and the public during the outbreak of SARS due to the invasive nature of those actions. Besides these, the economic slowdown affected overall employment and personal income. Some households required financial assistance. In response to the public complaints, authorities in Singapore provided economic assistance to those individuals and businesses who had been affected by home quarantine orders through a "Home Quarantine Order Allowance Scheme" (Tay and Mui, 2004; Teo, *et al.* 2005).

At the same time, the MOH worked together with various ministerial authorities to provide essential social services to those affected by the quarantine order. For example, housing was offered to those who were unable to stay in their own homes (because of the presence of family members) during their quarantine, ambulance services were freely provided by the Singapore Civil Defence Force to those undergoing quarantine at home to visit their doctors, as well as high-tech communication gadgets such as webcams, for those undergoing quarantine to stay in touch with relatives and friends. Impacts on social welfare in large part relate to economic outlook, especially in the area of consumption patterns. All these risk mitigating measures were not only effective in containing the epidemic, but also valid for implications in disaster risk management.

## 5. Implications for Practice and Research

In this section, we draw on the lesson-learning from Singapore's experience in fighting the SARS epidemic, and discuss implications for future practice and research in disaster risk management. The implications are explained in four aspects: *staying vigilant at the community level, remaining flexible in a national command structure, demand for surge capacity,* and *collaborative governance at regional level*.

*Staying Vigilant at the Community Level*

It remains questionable that Singapore's draconian health control measures may not be applicable or replicable in other countries, for example setting a camera to monitor the public's compliance during home quarantine. The evidence suggests that draconian government measures, such as quarantine and travel restrictions, are less effective than voluntary measures (such as good personal hygiene and voluntarily wearing of respiratory masks), especially over the long term (Bruine, *et al.* 2007). However, reminding the public to maintain a high level of vigilance and advocate individual social responsibility can be a persuasion tactic by an authority to influence and pressure, but not to force individuals or groups into complicity with a policy (Aledort, *et al*. 2007; Aimone, 2010; Barrett, 2007). Therefore, promoting social responsibility is crucial in terms of slowing the pace of infection through good personal hygiene and respiratory etiquette in all settings.

To achieve this goal, public education and risk communication are two indispensable components in health crisis management (Reddy, *et al*. 2009; Reynolds and Seeger, 2005). The community must be aware of the nature and scope of disasters. They have to be educated on the importance of emergency preparedness and involvement in exercises, training and physical preparations. At the community level, institutions and capacities are developed and strengthened which in turn systematically contribute to vigilance against potential risks.

This is best illustrated in the Singapore government's communication strategy to manage public fear and panic during the outbreak of SARS (Menon and Goh, 2005). Throughout the epidemic, the Singapore government relentlessly raised the level of vigilance of personal hygiene and awareness of social responsibility. This, in large part, has to rely on public education and risk communication. To effectively disseminate the idea of vigilance across the public, political leaders were seen as doing and initiating a series of countermeasures to reassure the public. By showing the people that government leaders practiced what they preached, the examples served to naturalize and legitimize the public discourse of social responsibility for all Singaporean citizens (Lai, 2010).

The need to stay vigilant is never overemphasized, but being vigilant does not equate to a panacea that ensures all government agencies work together. To be well prepared for the unexpected, we need a clear and swift national command structure that can flexibly respond to, and even more promptly than in the case of disease transmission, the changing situation.

*Remaining Flexible in a National Command Structure*

All local agencies responding to an emergency must work within a unified national command structure to coordinate multi-agency efforts in emergency response and management of disasters. On top of facilitating close inter-agency coordination, the strength of this flexible structure is in its ability to ensure a swift response to an epidemic outbreak by implementing risk mitigating measures more effectively and efficiently. Structural flexibility involves swift deployment of forces to mitigate the incident at the tactical level, and to provide expert advice at the operational level, in order to minimize damage to lives and property. Among other things, the flexibility endemic to this command structure facilitates the building of trust between the state and its people (Lai, 2009). This in turn ensures that government measures are quickly accepted by the general public.

As shown in this chapter, the MOH has been entrusted by the Singapore government and pre-designated to be the Incident Manager for public health emergencies. When a sudden incident involves public health or the loss of lives on a large scale, the MOH is responsible for planning, coordinating and implementing an assortment of disease control programs and activities. During the outbreak of SARS, the Singapore government established a national command and control structure that was able to adapt to rapidly changing circumstances that stemmed from the outbreak.

Specifically, the MOH set up a taskforce within that ministry even when the definition of SARS remained unclear. As more SARS cases were uncovered and better epidemiological information became available, the government quickly created the Inter-Ministerial Committee (IMC) and Core Executive Group (CEG) – both of which were instrumental in the design and implementation of all risk mitigating measures – to coordinate the operation to combat the outbreak (Pereira, 2008). While this overarching governance structure is more or less standard worldwide ('t Hart, *et al.* 1993; La Porte, 2007), the case of Singapore is unique in that the city-state was able to overcome bureaucratic inertia and adapt this governance structure.

From Singapore's experiences during the SARS crisis, we have learnt that the strength of a national command structure lies in its flexibility to link relevant ministries on the same platform. These linkages ensure a timely, coordinated response and service delivery. Having a flexible structure was not the only reason behind the successful defeat of SARS. In Singapore's case, we also notice the success of containing an uncertain, high-impact disaster has to rely on surge capacity.

*The Demand for Surge Capacity*

In the context of this paper, surge capacity refers to the ability to mobilize resources (such as PPEs, vaccines and HCWs) to combat the outbreak of a pandemic. Singapore's response to SARS in 2003 illustrates the importance of being able to increase surge capacity swiftly to deal with an infectious disease outbreak. In the Asia Pacific region, this problem continues to hamper many countries' ability to combat infectious diseases (Putthasri, *et al*. 2009). For many public health organizations in Asia, it is a matter of fact that they are unable to deal with pandemics because the resources to do so are simply absent (Balkhy, 2008; Hanvoravongchai, *et al*. 2010; Lai, 2012b; Oshitani, *et al*. 2008). Meanwhile, there are evidences which suggest that surge capacity alone is not the full answer. For example, during the SARS outbreak, abundant resources contribute an important but not all-encompassing element in the fight against these pandemics. As it turned out, when different stakeholders brought to the task-at-hand their unique skill sets and resources, they actually complicated the fight due to their lack of synergy. In fact, abundant resources without synergy might even undermine collaborative efforts.

Therefore, it is essential that the ability to link up various stakeholders must be complemented by some type of synergy between them. Such ability can be enhanced through close collaboration. This brings us to the third implication for disaster management: collaborative governance at regional level.

*Collaborative Governance at Regional Level*

The trans-boundary nature of the disasters calls for a planned and coordinated approach towards disaster response for efficient rescue and relief operations (Lai, *et al.* 2009; Lai, 2012a). Combating epidemics requires multiple states and government agencies to work together in close (Shalala, 1997; Webby and Webster, 2003). Therefore, it is clear that collaborative capacity of various stakeholders is central to the fight against transboundary communicable diseases (Lai, 2011; Lai, 2012b; Leung and Nicoll, 2010; Voo and Capps, 2010). While member states that are of advanced economic development typically lead such efforts, the inclusion of other developing countries, non-traditional agencies, and organizations (including non-governmental ones) is necessary and ultimately, inevitable. Indeed, major countermeasures such as border control and surveillance are often made possible with the aid of regional collaboration. Take the Association of Southeast Asian Nations (ASEAN) as an example.

ASEAN countries take regional, national and sub-national approaches to disaster risk management (Lai, *et al.* 2009). The ASEAN Committee on Disaster Risk Management (ACDM) was established in 2003 and tasked with the coordination and implementation of regional activities on disaster management. The Committee has cooperated with United Nations bodies such as the United Nations International Strategy for Disaster Reduction (UNISDR) and the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA). The ASEAN Agreement on Disaster Management and Emergency Response (AADMER) provides a comprehensive regional framework to strengthen preventive, monitoring and mitigation measures to reduce disaster losses in the region. In recent years, Singapore has been active in providing training and education for disaster managers from neighboring countries. Singapore has an ongoing exchange program with a number of Asia Pacific nations and Europe. For example, to partner with APEC to increase emergency preparedness in the Asia-Pacific region, Singapore's SCDF provides short-term courses on disaster management in the Civil Defence Academy (Asia Pacific Economic Cooperation, 2011).

## 6. Conclusions

The world today is far more inter-connected than ever before. International travel, transnational trade, and cross-border migration have drastically increased as a consequence of globalization. No country is spared from being influenced directly or indirectly by disasters. Singapore is no exception. Singapore is vulnerable to both natural and man-made disasters alongside its remarkable economic growth. In response, the Singapore government adopts an approach of Whole-of-Government Integrated Risk Management, a concerted, coordinated effort based on a total national response.

We have witnessed in the case study Singapore's all-hazard management framework with specific references to the SARS epidemic. In fighting SARS, Singapore's health authority was responsive enough to swing into action when they realized that the existing bureaucratic structure was inadequate in terms of facilitating close cooperation between various key government agencies to tackle the health crisis on hand. Therefore, a command structure was swiftly established. The presence of a flexible command structure, the way and the extent it was utilized, explains how well an epidemic was successfully contained. Flexibility actually enhanced organizational capacities by making organizations more efficient under certain conditions.

Epidemic control measures such as surveillance, social distancing, and quarantine require widespread support from the general public for them to be effective. Singapore's experiences with SARS strongly suggest that risk mitigating measures can be effective only when a range of partners and stakeholders (such as government ministries, non-profit organizations, and grass-roots communities) become adequately involved. This is also critical to disaster risk management. Whether all of these aspects are transferrable elsewhere needs to be assessed in future research. Nonetheless, this unique discipline certainly has helped Singapore come out of public health crises on a regular basis. Singapore's response to the outbreak of SARS offers valuable insights into the kinds approaches needed to combat future pandemics, especially in Southeast Asia.

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# CHAPTER 14

# Impacts of Disasters and Disaster Risk Management in Malaysia: The Case of Floods


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*Malaysia lies in a geographically stable region, relatively free from natural disasters, but is affected by flooding, landslides, haze and other man-made disasters. Annually, flood disasters account for significant losses, both tangible and intangible. Disaster management in Malaysia is traditionally almost entirely based on a government-centric top-down approach. The National Security Council (NSC), under the Prime Minister's Office, is responsible for policies and the National Disaster Management and Relief Committee (NDMRC) is responsible for coordinating all relief operations before, during and after a disaster. The NDMRC has equivalent organizations at the state, district and "mukim" (sub-district) levels. In terms of floods, the NDMRC would take the form of the National Flood Disaster Relief and Preparedness Committee (NFDRPC). Its main task is to ensure that assistance and aid are provided to flood victims in an orderly and effective manner from the national level downwards. Its approach is largely reactive to flood disasters. The NFDRPC is activated via a National Flood Disaster Management Mechanism (NFDMM). Members of the NFDRPC include Government departments/agencies and social organizations which provide shelter, rescue and food supplies in case of disaster. The NFDRPC meets at least once a year, normally before the onset of the northeast monsoon. The meeting is between all organizations involved with flood disaster management, and is focused on the need to get ready before the monsoon arrives (bringing floods with it). Its purpose is to ensure that its machinery will run smoothly. At the national level, the NSC is the secretariat for the NFDRPC which comprises members from the Ministries of Information, Finance, National Unity and Social development, Transport, the Federal Chief Secretary, the Federal Police Department and the Federal Armed Forces. The NFDRPC coordinates all relief operations from the Malaysian Control Centre in Kuala Lumpur. The NFDMM is basically a mechanism responding to disasters, as its name suggests. As such, its approach towards disaster management/reduction is largely reactive. Because Malaysia's main risk is flooding, the NFDMM is largely targeted towards handling monsoon flooding. Consequently, this mechanism is less than effective and should be re-modeled into something more pro-active. In terms of flood management, the Drainage and Irrigation Department (DID) is the responsible agency. However, being an engineering-based organization, DID's approach is largely focused on structural measures in controlling floods. It needs to embrace a more holistic approach towards flood management via a multi-disciplinary effort. Non-structural measures are easy to implement, less expensive and community-friendly, and need to be employed more widely. There is also a need for greater stakeholders participation, especially from NGOs at all levels in the disaster cycle. Capacity building for NGOs, local communities and disaster victims is also necessary. The disaster management mechanism should also adopt more non-structural measures, bring in state-of-the-art technology and cooperate internationally with other countries for addressing transboundary disasters. However, the politicization and mediatization of disasters should be controlled while disaster insurance should be introduced and disaster legislation strengthened.*



***Keywords*:** Disaster Risk Management, Flood Management, Malaysia, Flood Damage, Politicization of Disaster



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# 1. Introduction

This chapter opens with a general discussion on the background and history of disaster occurrence and risk management in Malaysia. As floods are the single most severe of all disasters in Malaysia, the chapter specifically focuses on flood disaster management. This is followed by an emphasis on ex post and ex ante analysis of the past and potential socioeconomic impacts of flood disasters in Malaysia. It then reviews and assesses the effectiveness of Malaysia's flood disaster management system with respect to "Risk Identification, Emergency Preparedness, Institutional Capacity Building, Risk Mitigation, and Catastrophe Risk Financing". A detailed discussion on the current constraints that prevent people from engaging in post-disaster supports follows. Finally, the chapter ends with policy recommendations for reforms at the national level and explores the prospects for regional cooperation framework in disaster management.

## 1.1.Overview of Disasters in Malaysia

Malaysia lies in a geologically stable region which is free from earthquakes, volcanic activities, and strong winds such as tropical cyclones which periodically affect some of its neighbors. It lies geographically just outside the "Pacific Ring of Fire". Hence, it is free from volcanic eruptions and earthquakes. It also lies too far south of the major typhoon paths, although tail-ends of tropical storms have occasionally hit it. However, that does not mean Malaysia is totally "Free" from natural disasters and calamities, as it is often hit by floods, droughts, landslides, haze, tsunamis, and human-made disasters (Parker, *et al*. 1997). Annually, disasters such as floods account for a significant number of casualties, disease epidemics, property and crop damage and other intangible losses (Chan, *et al*. 2002a).

In the past few decades, the country has experienced various extreme weather and climatic events, including El Nino in 1997 (which led to severe droughts), La Nina in 2011 and 2012 (which brought floods), freak thunderstorms almost every year (which brought wind damage, flash floods and landslides), monsoonal floods (which brought about heavy losses, including loss of life in many parts of the country exposed to monsoon winds), and haze (which brought about poor air quality, extreme heat and drought). Monsoonal floods are an annual occurrence which varies in terms of severity, place and time of occurrences with a recent 2010 flood in Kedah and Perlis being among the worst flood ever experienced by the country. The total economic loss and the financial burden on the government were enormous. When two or more of these events coincide such as the “Terrible twins” (La Nina and the monsoon season) that hit the federal capital of Kuala Lumpur and Selangor in December 2011, the damage is compounded (The Star, 2011). The haze phenomenon in 1997/98 also caused significant problems due to losses in tourist income, health effects and hospitalization costs, and mitigation losses (Kunii, *et al*. 2002) More recently, the 2005 haze episode in Malaysia was a week-long choking haze (at its worst on August 11) that affected mostly the central part of Peninsular Malaysia. The air quality in Kuala Lumpur was so poor that health officials advised citizens to stay at home. A state of emergency was declared in Port Klang and Kuala Selangor. The event also led to crisis talks with Indonesia and caused widespread health effects and inconvenience (Ahmad and Hashim, 2006). The Asian Tsunami which hit in December 2004 was also very severely felt on the coasts of Peninsular Malaysia, most notably in Penang, Kedah, Perlis and Langkawi (Chan, 2009). Due to Malaysia’s wet equatorial climate regime with frequent heavy rain storms of high rainfall intensities, landslide disasters are common. In recent decades, landslide disasters in the Klang Valley Region and elsewhere have caused significant loss of life, property and infrastructure damage, environmental destruction and anxiety (Chan, 1998a; Periasamy, 2011). In addition, the country is also regularly hit by man-made disasters such as fires, accidents and the collapse of structures and buildings, which cause considerable damage to property and loss of life (Hussin, 2005).

In terms of human-made and human-enhanced disasters, Abdul Malek (2005) listed the following major disasters: fire and explosions at the Bright Sparklers factory in Sungai Buloh in 1991 which claimed 22 lives; fire and explosions at South Port Klang in 1992 which claimed 10 lives; collapse of the Highland Towers apartment blocks in Hulu Kelang in 1993 which claimed 48 lives; massive landslide at the Genting Highlands in 1995 which claimed 20 lives; mudslides in Pos Dipang, Perak, on 29 August 1996 which claimed 44 lives; severe haze episodes in 1997 and 1998 which caused loss in tourist revenues in the millions of dollars and hospitalized thousands of people; landslide at Sandakan, Sabah, in February 1999 due to heavy downpour which claimed 17 lives; luxury home collapsed on 21 November 2002 in the Ulu Kelang area killing eight people.

Arguably, of all the disasters in Malaysia, floods are most frequent and bring the greatest damage annually. Floods are therefore considered as the most severe type of disaster experienced in Malaysia. Historically, there have been big flood events in 1886, 1926, 1931, 1947, 1954, 1957, 1965, 1967, 1970/1971, 1988, 1993, 1996, 2000, 2006/2007, 2008, 2009, and 2010. Of these floods, the 1926 flood was known as "The storm forest flood" because it destroyed hundreds of square kilometers of lowland forest on the floodplains of the Kelantan and Besut rivers. Records show that the flood was accompanied by gale force winds (Drainage and Irrigation Department, Undated). According to the Drainage and Irrigation Department (DID), this flood was considered "the biggest flood in living memory" in Malaysia as it affected almost the entire length and breadth of Peninsula Malaysia, causing extensive damage. In 1996, floods brought by Tropical Storm Greg in Keningau (Sabah State), claimed 241 lives, caused more than USD 97.8 million damage to infrastructure and property and destroyed thousands of houses. In 2000, floods caused by heavy rains killed 15 people in Kelantan and Terengganu, and caused more than 10,000 people to flee their homes in northern Peninsular Malaysia. The December 2006/January 2007 floods in Johor caused 18 deaths and USD 489 million in damage. In 2008, floods occurred in Johor again, killing 28 people and causing damage estimated at USD 21.19 million. In 2010, the floods affected transportation in and around Kedah and Perlis, shutting down rail, closing roads including the North-South Expressway (The Star, 2010c) and the airport in Kedah's capital city of Alor Setar leaving helicopters as the only mode of aerial transport into Kedah and Perlis (The Star, 2010d). Water supply in Kedah and Perlis was contaminated, forcing these two states to seek supplies from their neighbor Perak (*Bernama*, 5 November 2010a). Kedah and Perlis are the "Rice Bowl" of Malaysia, and the floods destroyed an estimated 45,000 hectares of rice fields with the government pledging USD8.476 million in aid to farmers (in both states (*Bernama*, 2010c). The floods killed four people, with more than 50,000 evacuated. In Perlis, the floods submerged over two-thirds of the state's land. Table 1 gives a list of some of the major disasters that have occurred in Malaysia.

## 1.2. Literature Review

The literature review on disaster management in Malaysia is largely based on a review of government reports from disaster management agencies such as the National Security Council (NSC), the Public Works Department (PWD), the Drainage and Irrigation Department (DID), the Welfare Department (WD), the Statistics Department (SD), State Governments, the Malaysian Medical Relief Society (MERCY), Red Crescent Society (RCS), Red Cross Society (RCS) and other NGOs, and other agencies/organizations. The literature review also covers research reports, academic theses, journal papers, newspaper reports and websites of reputed organizations.

### *1.2.1. The Top-down Government-centric Model*

Historically, disaster management in Malaysia has commonly been considered as a government function and is largely based on top-down government-centered machinery (Chan, 1995). At the very top, the Government Agency responsible for disaster management (all sorts) is the National Security Division (NSD) under the Prime Minister's Department. The NSD is therefore responsible for coordinating activities related to the preparation for, prevention of, response to and handling of disasters, basically referring to natural and technological disasters. The NSD is bound by the National Security Council (NSC) Directive No. 20 on "Policy and Mechanism on National Disaster and Relief Management", issued on 11$^{th}$ May 1997. The NSC Directive No. 20 is an Executive Order from the Prime Minister aimed at outlining policy on disaster and relief management according to the level and complexity of disaster. The directive is also aimed at establishing a management mechanism whereby the roles and responsibilities of the various agencies involved in handling disasters are outlined/identified. Currently, the handling and resolving of disasters in Malaysia are managed via the Committee System which emphasizes the concept of coordination and mobilization of agencies involved, in an integrated and coordinated manner. At the highest Federal level, the National Disaster Management and Relief Committee (NDMRC) is in charge of managing and handling national-level disasters. Lower down the scale, state-level disasters are managed by the State Disaster Management and Relief Committee (SDMRC). At the third level, district-level disasters are managed by at the District Disaster Management and Relief Committee (DDMRC). At the lowest village level, village-level disasters are managed by the DDMRC with inputs from the village committee (though there is, strictly speaking, no official disaster management and relief committee at the village level).

**Table 1: Disaster Incidents in Malaysia**

| Date/Year | Incident | Natural, Human-made or Combination | Property, Material, Crop or Other Losses (USD) | Number of Deaths |
|---|---|---|---|---|
| 1926 | Flood known as "The storm forest flood" | Natural | Thousands of hectares of forests destroyed | NA |
| 19 October 1968 | Collapse of Four-Story Building – The Raja Laut Tragedy | Human-made | NA | NA |
| 1988 | Sultan Abdul Halim Ferry Terminal–Royal Inquiry | Human-made | Injured 1,634 people | 32 |
| 1991 | Bright Sparklers-1991(Royal Inquiry) | Human-made | Millions | 22 |
| 21 June 1992 | Choon Hong III oil tanker explodes and burns (Royal Inquiry) | Human-made | NA | 13 |
| 1992 | Fire and explosions at South Port Klang | Human-made | Millions | 10 |
| December 1993 | Collapse of Highland Towers apartments | Human-made | Tens of Millions | 48 |
| June 1993 | Genting Highlands Landslide | Combination | Millions | 20 |
| 29 August 1996 | Pos Dipang landslide-mudslide | Combination | NA | 44 |

| Date/Year | Incident | Natural, Human-made or Combination | Property, Material, Crop or Other Losses (USD) | Number of Deaths |
|---|---|---|---|---|
| December 1996 | Floods brought by Tropical Storm Greg in Keningau (Sabah State) | Combination | 300 million | 241 |
| 1997 | El Nino in 1997 which led to severe droughts, forest fires & haze | Combination | Millions in lost tourist revenue, health costs & business losses | NA |
| June 1999 | Japanese Encephalitis Virus Outbreak | Combination | Millions | 60 |
| February 1999 | Landslide at Sandakan, Sabah | Combination | Millions | 17 |
| 2000 | Floods caused by heavy rains in Kelantan and Terengganu | Combination | Millions | 15 |
| December 2004 | Asian Tsunami | Natural | Millions | 68 |
| November 2002 | A luxury home collapsed in Ulu Kelang area | Combination | Millions | 8 |
| November 2002-May 2003 | Severe Acute Respiratory Syndrome (SARS) | Combination | Millions | NA |
| 2003-2007 | Avian Influenza 2003 - 2007 | Combination | Millions | NA |
| 2005 | Haze | Combination | NA | NA |
| December 2006 & January 2007 | Floods in Johor State | Combination | 489 million | 18 |
| 2008 | Floods in Johor State | | 21.19 Million | 28 |
| 2010 | Floods in Kedah and Perlis | Combination | 8.48 Million (Aid alone) | 4 |
| 2011 & 2012 | La Nina in 2011 and 2012 (which brought floods) | Natural | NA | NA |

All these committees at various levels are integrated via “Vertical Coordination” (e.g. between FDMRC and SDMRC) as well as via “Horizontal Coordination” (e.g. between the State Police Department and the State Drainage & irrigation Department). Through NSC Directive No. 20, the Government hopes that the handling and resolving of disasters could be carried out in a more coordinated manner with the integrated involvement and mobilization of related agencies. All these will in turn ensure that suffering and losses as a result of disasters can be minimized.

The above disaster management mechanism has been widely applied in flood disasters which is the major type of disaster affecting the country (Chan, 2011). Before the country went through modernization and industrialization, there were also meteorological disasters, strong winds, rain-induced monsoon floods, and other natural disasters. However, since independence in 1957, other kinds of disaster have been experienced, such as fires, explosions, structural collapse, landslides, biological/disease-related disasters, flash floods and landslides caused by slope disturbance resulting from human activities. According to Yusof (n.d.), Malaysia has transformed radically from an agrarian economy to a modern industrialized nation. This rapid process of development and transformation has given rise to the occurrence of a range of man-made disasters that are considered as "landmark" disasters whereby various safety and emergency acts and regulations were proposed, amended or formulated, resulting also in the formation of specialized teams in disaster management. This government-centric approach is employed to address both the physical/natural (Sham, 1973) as well as the human aspects of flood management (Leigh and Low, 1983). In Malaysia, the National Security Council (NSC) defines a disaster under NSC D20 (National Security Council Malaysia, 1997) as *"An incident that occurs in a sudden manner, complex in nature, resulting in the loss of lives, damages to property or the environment as well as affecting the daily activities of local community. Such incident requires the handling of resources, equipment, frequency and extensive manpower from various agencies as well as effective coordination and the possibility of demanding complex actions over a long period of time."* The types of disaster defined under NSC D-20 are classified as follows: (1) Natural disasters such as floods and landslide; (2) Industrial and technological disasters; (3) Accidents involving dangerous or hazardous materials (4) Collapse of high rise buildings and special structures (5) Aviation accidents in public areas; (6) Railway accidents; (7) Major fire incidents; (8) Collapse of hydroelectric dams or reservoirs; (9) Nuclear and radiological accidents; (10) Release of poisonous and toxic gases in public places; and (11) Air and environmental disasters such as haze. In recent years, Aini, *et al.* (2001) have discussed the evolution of emergency management in Malaysia with the authorities trying to keep up with the rest of the world.

### *1.2.2. The Technocentric Model*

In terms of flood disasters, which are, as previously stated, the major type of disaster affecting Malaysia, much of the relevant research literature reflects a technocentric approach which strongly emphasizes the use of structural/engineering methods in addressing floods (Chan, 1995). Consequently, it is not surprising to find that the bulk of the literature on flood studies in Malaysia is largely focused on the field of engineering and hydrology. Some notable examples are Volker (1971), Drainage and Irrigation Department (1973, 1974, 1976), Japan International Cooperation Agency (1989, 1991), Syed Mohammad, *et al.* (1988), Julien *et al.* (2010) and Ab. Ghani, *et al*. (2012). Such an approach is central within the "Society over Nature" school of thought, or technocentricism, which asserts that science can solve all flood problems. This cannot be further from the truth in an ever-changing world, especially in the context of rapidly developing Malaysia. Despite the fact that technology plays an important role in flood hazard management, it is a fallacy that it can provide the means of total protection against all floods. In fact, Jones (1991) has observed that technology can increase vulnerability to floods.

### *1.2.3. The Natural Science Perspective*

Against the background of the technocentric approach is the "natural science perspective", which is essentially the natural scientist's explanation to the occurrence of flood hazards. Alexander (1993) states that this approach focuses on how natural processes in the "Earth-Atmosphere System" create hazards. This approach also takes into account the importance of society in altering the physical processes, but the flood hazard is principally attributed to the natural causes (e.g. monsoon winds and rains). As such, it is of paramount importance to monitor and understand the natural processes. It is also important for the natural scientist to measure and monitor these processes in order to classify them. The natural processes can also be modified by humans and this makes them more complicated and difficult to study. Natural scientists often believe that natural processes can be controlled by technological solutions, which is similar to the technocentric approach. This perspective is strongly advocated by natural and physical scientists who employ the hard sciences (e.g. geology, geomorphology, hydrology and engineering) to flood hazard management. Some good examples of the natural scientist's approach to flood hazards in Malaysia are Chan (1998b) and Lim (1988). The natural science perspective is essentially a "tech-fix" approach, although in recent years it has incorporated ecological, biological, environmental and sustainability considerations. Because of its emphasis on technology as a means of alleviating hazards, it has often been criticized as being too narrow an approach. No field of science can predict the occurrence of hazard events with any level of certainty. Furthermore, artificial structures with high protection levels may still be "over-topped" by an extreme event. For example, the 100-year flood protection structures in the Federal capital of Kuala Lumpur were over-topped by a more than 1:100 year event in 1971, causing widespread flooding that lasted for weeks. Furthermore, the environment is ever-changing in the context of a rapidly developing Malaysia. Studies by others have also shown that disasters occur because of other factors such as the misapplication of technology, institutional ineffectiveness, warning ineffectiveness, and hazard generating socio-political systems (Winchester, 1992).

*1.2.4. The Organizational Perspective*

Another flood disaster management approach is that of the organizational perspective, originally an approach used by organizational analysts in explaining hazards. This approach focuses upon the ways in which organizations such as government agencies, private companies, NGOs and other civil society voluntary bodies tackle hazards. Disaster managers in the field of economics, geography, systems analysis, planning and sociology who are concerned with "collective behavior" and "collective decision-making" are probably responsible for this perspective (Parker, 1992). The role played by organizations cannot be underestimated because they are powerful and influential. The argument is that organizations may contribute in one way or another to the creation or worsening of hazards. Turner (1978) examined hazards arising out of organizational inefficiencies. Reasons for failures include organization inefficiencies (within and outside), existence of organizational "sub-cultures" which lead to "collective blindness" to the hazard, "organizational exclusivity", poor information dissemination and others. Handmer and Parker (1991) have documented the tendency for organizations to "groupthink", resulting in the narrowing of options, and noted the existence of a high level of secrecy amongst the bureaucracy of government organizations, all of which hinder emergency planning. In Malaysia, the organizational approach has been studied by Chan (1997a), who found that organizations tend to protect and safeguard self-interest rather than expose their weaknesses.

*1.2.5. The Vulnerability Model and the Structural Paradigm*

Vulnerability to flood disasters in Malaysia is another approach (Chan, 2000). The study of disaster vulnerability originated from the "Structural Paradigm" in which disasters were believed to be subject to cultural, social, economic and political forces (Torry, 1979). In developing countries and poor countries, it was discovered that broader structural forces (local and national) were more powerful and pervasive than local factors in affecting the outcome of hazards and disasters (Wadell, 1983; Hewitt, 1983). This radical view gave a new insight that went beyond the conventional geophysical cause of hazards and disasters. More recently, the recognition that structural forces at the international level can strongly affect local vulnerability has resulted in an expanded version of the structural paradigm, known as the "political economy paradigm" or the "political ecology perspective of hazards" (Blaikie, *et al*., 1994; Varley, 1994). All these approaches to disasters are essentially a "structuralist" view that links social relations to disasters and is rooted in Marxist political economy. Although basically a social/structuralist perspective of hazards emphasizing vulnerability and lack of access to resources, Blaikie, *et al*. (1994) avoided using a purely deterministic approach rooted in political-economy, notions of equating vulnerability with poverty or some other specific conditions, and definitions of vulnerability that focus exclusively on the ability of a system to cope with risk or loss. They advanced the political economy perspective by explaining vulnerability as a progression from "root causes" to "dynamic pressures" and "unsafe conditions", that coincide with hazards, leading to disasters. In Malaysia, Chan (2000) has used this paradigm to study flood hazards, and has proposed measures to reduce the exposure of people to flood hazards and also to reduce people's vulnerability to floods. Chan (1996) has found that vulnerability to flood disasters in Malaysia is not solely influenced by poverty, but more importantly by awareness, perception, attitude, experience, length of residence and social relations (Jamaluddin, 1985).

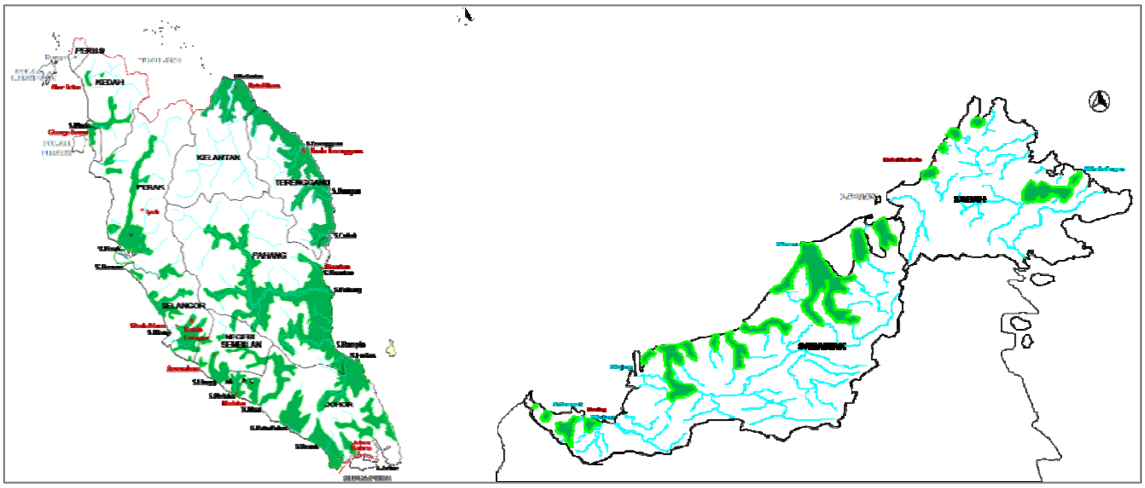
## 2. Flood Disaster Risk in Malaysia

Malaysia is a country very prone to flood risks, mostly by nature of its physical (e.g. topography and drainage) as well as its human geography (e.g. settlement and land use patterns). The combination of natural and human factors has produced different types of floods, viz. monsoon, flash and tidal (Chan, 1998b). Malaysians are historically a riverine people, as early settlements grew on the banks of the major rivers in the peninsula. Coupled with natural factors such as heavy monsoon rainfall, intense convection rain storms, poor drainage and other local factors, floods have become a common feature in the lives of a significant number of Malaysians. Monsoon and flash floods are the most severe climate-related natural disasters in Malaysia, with a flood-prone area of about 29,000 $km^2$ affecting more than 4.82 million people (22% of the population) and inflicting annual damage of USD 298.29 million (Asian Disaster Reduction Centre (2005) *Mitigation and Management of Flood Disasters in Malaysia.* Kobe: Asian Disaster Reduction Centre http://www.adrc.asia/publications/TDRM2005/TDRM_Good_Practices/PDF/PDF-005e/Chapter3_3.3.6.pdf accessed May 14 2012) (Figure 1). With annual heavy monsoon rains averaging more than 3000mm and such a large flood-prone area, flood risk is indeed high, most notably in riverine areas and coastal flat lands. With such a large population living in flood-prone areas, flood exposure is high as well. Because of such high flood risks and exposure, the Malaysian Government is forced to spend a huge amount of its annual budget to mitigate against floods. Under Malaysia's five-yearly Plans for development, the allocations for design and construction of flood mitigation projects account for USD 4.564 (1st Malaysia Plan 1966-1970), USD 9.78 million (2nd Malaysian Plan 1971-1975), USD 32.6million (3rd Malaysia Plan 1976-1980), 65.2 million (4th Malaysia Plan 1981-1985), USD 97.8 million (5th Malaysia Plan 1986-1990), USD 228.2 million (6th Malaysia Plan 1991-1995), USD306.44 million (7th Malaysia Plan 1996-2000), USD 3.97 billion (8th Malaysia Plan 2001-2005), USD1.25 billion (9th Malaysia Plan 2006-2010) and USD 1.17 billion (10th Malaysia Plan 2011-2015).

According to Hj Ahmad Hussaini, the Director General of the Drainage and Irrigation Department of the government of Malaysia, there are two major water-related problems affecting this country. These are excess water (floods) and water shortage (droughts). Both these problems have disrupted the quality of life and economic growth in the country and can result in severe damage and loss of property, and occasionally loss of human lives, as can be seen in the December 2006 and January 2007 floods in Johor (Hussaini, 2007). Floods occur annually in Malaysia, causing damage to property and loss of life. It is useful to distinguish "normal" from "major" flood events. "Normal floods" are seasonal monsoon floods (November to March) whereby the waters do not normally exceed the stilt height of traditional Malay houses. Thus, people living in stilt houses in the rural areas are well adapted to normal floods. It is the major floods, which are "unusual" or "extreme" events that render people helpless. "Major floods" also have their origins in the seasonal monsoon rains but statistically occur once every few years. These floods are extensive, severe and unpredictable and result in significant loss of life, damage to crops, livestock, property, and public infrastructure (Winstedt, 1927). In a major flood, people's coping mechanisms are totally ineffective and they are forced to rely on government relief for recovery. During major floods, a flood depth of 3 meters is not uncommon, and hundreds of thousands of people are often evacuated. Other classifications such as "flash flood", "tidal flood", "river flood" and "monsoon flood" may be considered as normal or major depending on the severity (Chan, 1995).

Historically, Malaysia experienced major floods in the years 1926, 1963, 1965, 1967, 1969, 1971, 1973, 1979, 1983, 1988, 1993, 1998, 2005 and most recently in December 2006 and January 2007. This latter flood occurred in Johor. The years 2009 and 2010 also saw major floods occurring in Kedah and Perlis, two northern Peninsular Malaysia states that are considered relatively dry. The January 1971 flood was a massive disaster affecting nearly the whole of Peninsular Malaysia, with Kuala Lumpur the most badly hit. This flood resulted in a loss of more than USD 65.2 million and 61 deaths. Since then floodplains in the country have undergone a rapid transformation into large urban cities with dense population and mega structures, thereby increasing flood damage potentials. As a comparison, during the 2006-2007 flood disasters in Johor, the estimated total cost was in excess of USD 0.49 billion. These two events are ranked as the most costly flood events in Malaysian history. Recent urbanization amplifies the cost of damage in infrastructures, bridges, roads, agriculture and private commercial and residential properties. At the peak of the most recent Johor flood, around 110,000 people were evacuated to relief centers, and 18 people died. (Hussaini, 2007).

**Figure 1: Flood-prone Areas in Malaysia**




*Source*: Drainage and Irrigation Department Malaysia [Online] (2012).

In the past, natural causes such as heavy intense rainfall (monsoon or convective) and low-lying flat terrain were the main causes of flooding. However, deforestation reduces the role of forests as natural flood attenuation systems (Chan, 2003; Chan, *et al.*, 2002b). As a result of deforestation, a very high proportion of rainfall becomes surface runoff, and this causes breaching of river capacity resulting in floods. Yet development has continued unabated. In more recent years, rapid development within river basins has further increased runoff and reduced river capacity, resulting in an increase in both flood frequency and magnitude. Urban areas are the most susceptible to flooding, and with more than 60% of the Malaysian population now urban, flash flooding in urban areas has become a very serious problem (surpassing the monsoon floods) since the mid 1990s. This is reflected in flood frequency and magnitude, social-economic disruption, public outcry, media coverage and the government’s escalating allocation of funds for flood mitigation.

Coastal areas are also subject to tidal floods. Tidal floods are often exacerbated when high tides coincide with heavy rains or strong wind. In 2004, the Asian Tsunami also flooded many coastal areas in northern Peninsular Malaysia, resulting in huge losses and deaths (Chan, 2009). In the last decade, largely due to development on the slopes of hills, there has been an increased occurrence of other flood-related disasters, such as debris flood flow, mud flow and landslides. Flood risks are therefore ever increasing in Malaysia, despite the huge amount of effort and funds invested to mitigate them (Chan, 1997b).

## 3. Methodology

This chapter is based on research employing the "triangulation" strategy of combining various complementary research methods. For understanding the fundamental ethics, beliefs, and practices of human society related to disasters (especially flood disasters), the research methods employed are; historical analysis, analysis of traditional response strategies and practices, literature review, qualitative interviews with key informants (e.g. flood managers), social impact assessment, and the use of secondary data. In examining the political-economy of disasters, the federal-state dichotomy and institutional arrangements, the research looks at archives (letters, agreements, reports, government documents, etc.) institutional analysis using the "criteria approach" was employed to study and analyze institutions involved in the disaster sector. In-depth qualitative interviews with Federal and State government officers, NGO managers, and private sector consultants, and disaster victims were also carried out. As an involved party, the author also employed the "cultural insider" approach by working as a volunteer in disaster organizations and living in flood-prone areas. This is to get a feel of the actual world of the insider. This is the greatest merit of the insider approach. Without insider knowledge, the researcher has to go to great lengths before beginning to study the insider's world. Davis (1981) recognized the dangers of cultural detachment which face research workers from western developed countries working in the developing world. These researchers often fail to grasp the realities of local cultures and are too ready to project western values, often resulting in a vast gulf in terms of academic elitism, language barriers, geographical remoteness and income levels of consultants *vis-a-vis* local families. In the case of the current research, there is no such problem. As an informed member of the culture under study the author uses this advantage to effect in the analysis of many aspects of the flood hazard in the contexts of the historical, socio-cultural, political economy and institutional forces. Living amongst the flood victims certainly helped to deepen his understanding of how individuals in the peninsula perceive and respond to the flood hazard. This “observer-participant” role is made more relevant in the context of this research as it draws upon 33 years of academic experience with numerous publications on disaster research, including an MA thesis on drought hazards (Chan, 1981) and a PhD thesis in flood hazard management in Malaysia (Chan, 1995).

## 4. Socioeconomic Impacts of Flood Disasters

Floods are the disasters causing the most damage in Malaysia. The annual costs incurred by the Malaysian Government in rescue and flood relief operations, as well as rehabilitation of public works and utilities, are substantial. It is estimated that the costs of damage for an annual flood, a 10-year flood and a 40-year flood are USD 0.98 million, USD 5.87 million and USD 14.34 million respectively. The 1926 flood was perhaps the biggest flood in living memory in Malaysia. During this flood most parts of the country were affected. The 1971 flood was so serious that it was declared a national disaster by the Prime Minister. Total flood loss was estimated at USD 65.2 million then and there were 61 deaths. The 1967 flood damage estimated for the Kelantan River Basin alone was USD 25.43 million. A summary of flood damage for selected floods is shown in Table 2.

## Table 2: Official Flood Loss Estimates for Major Flood Events in Malaysia

| Flood Event (Year) | (Place) | Damage (USD million at 1996 prices) | Deaths | No.of Victims Evacuated |
|---|---|---|---|---|
| 1886 | Kelantan & Besut Rivers ("Storm Forest Flood") | Several hundred square kilometers of forest destroyed | NA | NA |
| 1926 | Most of Peninsular Malaysia | Damage to natural environment | NA | NA |
| 1954 | Johor, Terengganu | Hundreds of acres of padi | 2 | Thousands |
| 1965/66 | Besut, Kelantan-Terengganu | >30,000 acres of padi destroyed | NA | Thousands |
| 1966 | Perlis | NA | 1 | NA |
| 1967 | Kelantan River Basin | 72.31 | 38 | 320,000 |
| 1967 | Perak River Basin | 56.04 | 0 | 280,000 |
| 1967 | Terengganu River Basin | 14.57 | 17 | 78,000 |
| 1971(December) | Kuala Lumpur | 30.71 | 24 | NA |
| 1971(December) | Pahang River Basin | 33.77 | 24 | 153,000 |
| 1979 | Peninsular Malaysia | NA | 7 | 23,898 |
| 1981 | Kelantan State | NA | 8 | 2,740 |
| 1982 | Peninsular Malaysia | NA | 8 | 9,893 |
| 1983 | Penang State | 0.20 | 0 | NA |
| 1983 | Other Peninsular Malaysia | NA | 14 | 60,807 |
| 1984 | Batu Pahat River Basin | 7.37 | 0 | 8,400 |
| 1984 | Kelantan dan Terengganu States | NA | 0 | Thousands |
| 1986 | Peninsular Malaysia | 11,96 | 0 | 40,698 |
| 1988 | Kelantan River Basin | NA | 19 | 36,800 |
| 1988 | Other Peninsular Malaysia | NA | 37 | 100,755 |
| 1989 | Johor State | NA | 1 | Thousands |
| 1989 | Kuala Lumpur/Petaling Jaya | 0.03 | 0 | 220 |
| 1991 | Other Peninsular Malaysia | NA | 11 | NA |
| 1992 | Peninsular Malaysia | NA* | 12 | NA |
| 1993 | Peninsular | NA | 22 | 17,000 |
| 1993 | Sabah State | 72.57 | 5 | 5,000 |
| 1995 | Shah Alam/Kelang Valley | 1.76 | 1 | 8,970 |
| 1995 | Klang Selangor | NA | 3 | 0 |
| 1995 | Other Peninsular Malaysia | NA | 4 | 14,900 |
| 1996 | Sahab (June) | >100 houses destroyed | 1 | 9,000 |
| 29.8.1996 | Pos Dipang, Perak | 97.8** | 44 | Hundreds |
| 1996 | Sahab (December) | NA | 241*** | 23,000 |
| 30.12.98 | Kuala Lumpur | NA | 5 | 0 |
| 5-9.1.99 | Penampang, Sabah | NA | 6 | 4,481 |
| 11.1.99 | Sandakan Sabah | NA | 3 | 0 |
| 23.11.2000 | Kg. La | NA | 6 | 0 |
| Dec. 2001 | Kelantan, Pahang, Terengganu | Crop loss & property damage in millions USD; USD 0.65 million texts destroyed | 6 | >10,000 |
| 27.12.2001 | Gunung Pulai, Johor | Mudslide swept away 4 houses | 5 | 4 families |
| 31.12.2001 | Benut Marang, Terengganu | Crop loss & property damage | 4 | Thousands |
| Dec 2006 – Jan | Johor State | USD 489 million Property Damage | 18 | 110,000 |
| 2007 | Kelantan State | USD 17.28 Damage to Infrastructures | | |
| 2008 | Johor State | 65 (Relief Costs) | 28 | 34,000 |
| November 2010 | Kedah & Perlis States | Alor Setar Airport closed, railway line flooded, USD 8.48 million padi crop damage | 4 | 50,000 |

*Note*: NA = Not Available

* = In the state of Kelantan, 200 schools were closed resulting in 113, 000 students missing school between 6 to 11 days.

** = Damage to infrastructure and public utilities estimated at USD 42.38 million (The Star, 1st January 1997). Destruction of properties (more than 4,553 houses were destroyed), crops and livestock loss estimated at USD 55.42 million.

*** = Another 108 people are still missing more than a month after the even (The Star, 27 January 1997)

*Source*: Drainage and Irrigation Department Malaysia, Malaysian National Security Council and major newspaper.

The socio-economic impacts of floods in terms of flood damage are varied. However, there is now a considerable volume of literature on flood damage assessment (Chan and Parker, 1996). Flood damage in terms of losses can be direct or indirect, and both categories include tangible and intangible losses. While the assessment of tangible losses is fairly straightforward, the evaluation of intangible losses can be problematic. Despite this, there have been attempts to quantify intangible flood damages so that they can be included in cost-benefit analysis (Green, *et al*. 1988). In Northern Peninsular Malaysia, the 2004 flood resulted in tidal flooding that caused considerable damage to residential and commercial properties located on or near the eastern and northern coasts of the area. While the damage in rural areas was largely confined to residential properties (largely farms and fishermen's properties) resulting in the loss of livestock and crops, farm machinery, fishing vessels and equipment, and damage to building structure and contents, tsunami flooding in coastal urban areas involved damage to residential and commercial properties, vehicles, materials, machinery, goods and loss of business. And because of the high density of residential and commercial properties, infrastructure and public utilities in urban areas, the urban damage toll is expected to be much higher than in the rural areas. Though commercial properties suffered much greater damage in monetary terms, the households suffered the most in terms of damage in kind (intangible losses) and affected members of households are usually the victims that carry with them the trauma and mental damage for life. Jamaluddin (1985) suggests that victims need to respond positively and appropriately to flood disasters if they hope to have any chance of quick recovery.

In the flood damage assessment literature, damage or losses have been categorized as direct or indirect. Such damage is further categorized as tangible or intangible (Parker, *et al*. 1987). A typology of flood damage is given in Figure 2. According to Chan (1995), tangible flood damage refers to those effects of flooding which can be assigned monetary values. They can be direct as in the case of damage to building structures or indirect as in the case of the loss suffered as a result of drop in business volume. Direct flood damage results from the contact of flood water and its contents (sediment, oil etc.) with buildings and their contents, vehicles, livestock and crops, humans, memorabilia, etc. For residential properties, the pressure and contact of flood water may give rise to adverse effects on building structure (walls, floors, stilts etc.), damage to garden and house contents such as furniture, electrical appliances, household utensils, carpets, wiring systems and sockets, etc. In the case of commercial properties, additional effects may include damage to shop fittings, goods, raw material, machinery, etc. The costs of clean-up after a flood may also be included as direct damage. In contrast, indirect damages usually occur at the time of, or in a period after, a flood. In Peninsular Malaysia, as flood events can last for several weeks, such damage may be substantial. Also, the post-flood period can extend for several weeks or months. In the case of residential properties, indirect damage includes the cost of alternative accommodation, costs of transportation (of family members and household contents), loss of income through disruption to work, costs of treatment for illness resulting from floods (especially children and the elderly being exposed to the cold waters), loss of schooling and subsequent costs of extra lessons to catch up with the syllabus, etc. In the case of commercial properties, such damage may include loss of production, reduced output due to inability of workers to commute to working premises, transportation of goods and raw materials to alternative locations, loss of trade due to temporary closure of business outlets, loss of business orders, increases in costs of transportation caused by disruption to usual traffic, the devaluation of the property value in the market, etc. Intangible flood damage refers to those effects of flooding to which it is not currently possible to assign acceptable monetary values (Pearce, 1976). The only common property shared by “intangibles” is that they cannot be evaluated for one reason or another (Parker, *et al*. 1987). As with tangible damages, it is possible to have both direct and indirect intangible damages. The damage of historical buildings by flooding is a direct effect but it would be difficult to evaluate the loss in monetary terms. This is then an intangible direct loss. On the other hand, the inconvenience caused by a flood is difficult to measure in monetary terms. This is then termed an intangible indirect loss.

**Figure 2: A typology of Flood Damage (After Parker, *et al*., 1987)**

A TYPOLOGY OF LOSSES DUE TO FLOOD DISASTERS

| | | Types of Losses due to Tsunami | |
|---|---|---|---|
| | | Tangible Losses | Intangible Losses |
| Types of Losses | Direct Losses | Damage to Building & Contents | Mental/Psychological & Loss of Life (Stress) |
| | Indirect Losses | Loss of Work & Production | Discomfort, Stress & Sufferings due to Tsunami & Cutting Off of Water, Electricity, Transport, Food Supplies, Healthcare, etc |

According to findings by Green, *et al*. (1988), the non-monetary (intangible) impacts of flooding are far more important to the households affected than the cost of the damage done. Physical damage to buildings and their contents are the most visible but not always the most serious effects of flooding (Green, *et al*. 1983). Among the notable intangible damage is disruption to the household's life caused by a flood and the stress of the flood event itself; subsequent health damage; loss of memorabilia or of other irreplaceable and non-monetary goods; and possible evacuation. Furthermore, stress and worry about the risk and consequences of future flooding may also damage a person's health. Chan and Parker (1997) have evaluated the socio-economic aspects of flood disasters in Peninsular Malaysia and found that non-monetary and intangible effects are just as significant as monetary impacts.

## 5. Flood Disaster Risk Management

### 5.1.Background

In Malaysia, the Drainage and Irrigation Department's Flood Mitigation Policy and Strategy consists of both structural measures (for example dams and embankments to control flood flows) and non-structural measures (for example land use planning and flood forecasting and warning systems to mitigate the impact of flooding). Hence policy guidelines for implementing flood mitigation measures include the following: (i) implementation of structural flood mitigation in terms of engineering and socio-economic environment; (ii) implementation of complementary non-structural measures; (iii) implementation of non-engineering measures where there is no engineering solution; and (iv) continuation of strengthening flood forecasting and warning systems (Hussaini, 2007).

In terms of flood mitigation and management, Malaysia conducted a National Water Resources Study in 1982 on structural and non-structural measures for flood mitigation and management (Japan International Cooperation Agency, 1982). The government also conducted a number of flood mitigation projects but these were mostly structural mitigation measures such as canalization of rivers, raising river embankments and the building of multi-purpose dams. Interestingly, despite their high costs compared to non-structural measures, structural measures continue to this day to be favored. The financial allocations for such projects have consequently increased significantly in every one of Malaysia's subsequent five yearly development plans. Such escalating expenditures put a heavy strain on the government, and there have been suggestions that strategies be re-examined with the objective of developing a more proactive approach in finding ways and means to address the flood disasters in a holistic manner. The current Government machinery allows the Economic Planning Unit of the Prime Minister's Department to coordinate all aspects of planning, design and implementation of water resources (including flood management) in the country.

### 5.2.Malaysian Flood Disaster Relief and Preparedness Machinery

The Malaysian Flood Disaster Relief and Preparedness Machinery (MFDRPM) was set up after the disastrous flood of 1971 when the National Disasters Management and Relief Committee (NDMRC) was formed. This committee was entrusted with responsibility for planning, coordinating and supervising relief operations during floods. Unfortunately, this was an entirely top-down approach as most of the organizations in the committee were governmental departments/agencies and social organizations that are able to provide shelter, rescue, food and medical supplies. Through the various government levels, the NDMRC, SDMRC and DDMRC committees coordinate between government departments and various voluntary organizations. In terms of early warning, the Flood Forecasting and Warning Systems have been upgraded. By 2007, the following infrastructure for flood forecasting and warning systems had been installed: 233 telemetric rainfall stations; 190 telemetric water level stations; 256 manual stick gauges; 84 flood warning boards; 217 flood sirens; real-time flood forecasting and warning systems in nine river basins. The Department of Irrigation and Drainage Malaysia is responsible for providing flood forecasting and warning service to the public. It has established an Internet-based National Flood Monitoring System known as Infobanjir (http://infobanjir.moa.my), enabling rainfall and water level data can be collected for the whole country. The government has been working closely with the Canadian government to establish the GEOREX Monsoon Flood System for the Kelantan River Basin, a flood monitoring system integrating remote sensing, hydrological modeling and geographical information systems (GIS). This system allows the merging of hydrological data, such as river water levels and potential flooded areas, with geographical data on demography and transportation infrastructure.

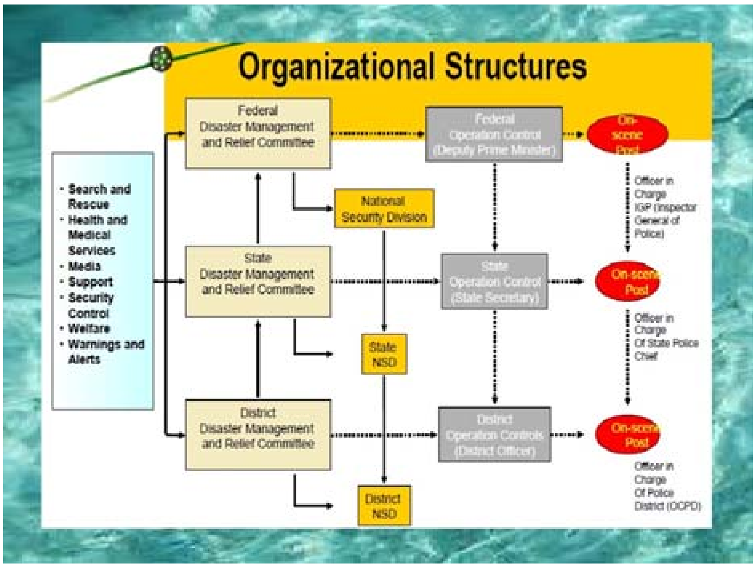
Flood management activities undertaken include the following: (i) the National Water Resources Study; (ii) development of infrastructure for flood forecasting and warning systems; (iii) "Infobanjir" (the National Flood Monitoring System); (iv) "Flood Watch" (a flood forecasting and warning system); and (v) the Urban Storm-water Management Manual for Malaysia (MSMA) (Hj Ahmad Hussaini, 2007). All these flood management activities are basically a combination of structural methods aimed at "controlling" floods and non-structural methods aimed at reducing flood impacts. One famous example of a structural method is the Storm-water Management and Road Tunnel (also known as the SMART Project), developed by the Drainage and Irrigation Department to alleviate flash flood problems in the Federal capital of Kuala Lumpur (Umar, 2007). The 9.7 kilometers long, 11.83 meters diameter tunnel integrates both storm water management and a motorway in the same tunnel. In contrast, an example of a non-structural method is the flood forecasting and warning system (Drainage and Irrigation Department, 1988).

In Malaysia, disaster management is almost entirely based on a top-down approach. At the very top is the NDMRC running a National Crisis and Disaster Management Mechanism (NCDMM). According to Chia (2004), this machinery was established with the objective of co-coordinating relief operations at the Federal, state and district levels so that assistance can be provided to flood victims in an orderly and effective manner. In the case of floods, the NCDMM would be called the National Flood Disaster Relief Machinery (NFDRM). The NFDRM is basically a reactive system, as it reacts to major floods when they occur. The coordination of flood relief operations is the responsibility of the National Flood Disaster Management & Relief Committee (NFDMRC), headed by the Minister of Information with its secretariat at the National Security Council (NSC). The committee is empowered, among other things, to declare any district, state or even the whole nation to be in a state of disaster so as to be eligible for financial assistance from the Federal Government. Members of this committee include government departments/agencies and social organizations which provide shelter, rescue and food supplies in case of disaster. On a positive note, the FFDMRC meets at least once a year, normally before the onset of the northeast monsoon. The meeting is between all organizations involved with flood disaster management on the need to get ready before the monsoon arrives (bringing with it floods). It is to ensure that its machinery will run smoothly. The entire organizational structure of the NFDRM is shown in Figure 3.

The NFDRM is theoretically responsible for all operations at the national, state, district, *mukim* and village levels. In reality, however, it coordinates operations at the national level and overseas operations at the state level. Much of the activity in each state is left to be run by the respective state authorities. Its main task is to ensure that assistance and aid are provided to flood victims in an orderly and effective manner from the national level downwards. As a result, its approach to disaster mitigation is largely reactive (Chan, 1995). For example, this body meets annually just before the onset of the northeast monsoon season to organize flood disaster preparedness, evacuation and rehabilitation work. It is also more of a welfare body than it is a flood management organization. At the federal level, the National Security Council (NSC) is the secretariat for the Disaster Relief and Preparedness Committee (DRPC) which comprises members from the Ministries of Information, Finance, National Unity and

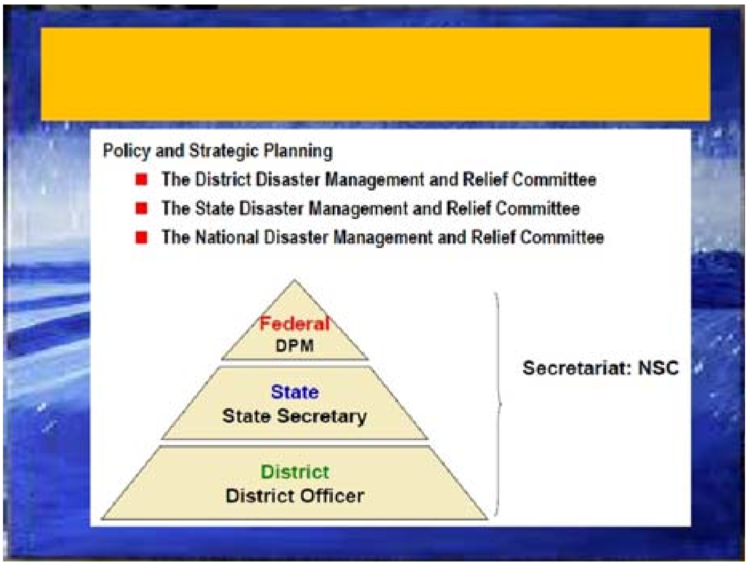
Social development, Transport, the Federal Chief Secretary, the Federal Police Department and the Federal Armed Forces. The DRPC coordinates all relief operations from the Malaysian Control Centre in Kuala Lumpur. At the state level, there are 13 State Disaster Relief and Preparedness Committees (SDRPC) for Malaysia. Each state is given funds by the Federal Government every year to enable it to run its own disaster relief operations. At the district level, there are several district committees under each state, depending on the number of districts in a particular state. Each district will have its own District Disaster Relief and Preparedness Committees (DDRPC) which receives funds and directives from the SDRPC. Below the district level, there are several *mukim* Disaster Relief and Preparedness Committees (MDRPC), again depending on the number of *mukim* in each district. Each MDRPC is headed by a penghulu (County Head). Finally, there are many Village Disaster Relief and Preparedness Committees (VDRPC) under each *mukim*. Each VDRPC is headed by a ketua kampong (village Head) (Figure 4). The National Disaster Response Mechanism (NDRM) is basically a system responding to disasters, as its name suggests. As such, its approach towards disaster management/reduction is largely reactive. Because Malaysia's main type of disaster is flooding, the NDRM is largely targeted at handling monsoon flooding. Consequently, this mechanism is less than effective and should be re-modeled into something more pro-active. There is also a serious lack in terms of stakeholder participation, although the authorities have recognized the important role of NGOs, particularly that of MERCY, the Red Cross, the Red Crescent and other NGOs. This is likely due to heavy the dependence of communities on government, and the reluctance of government to relinquish responsibilities to the public. Public apathy may also be a reason for low public participation in disaster management. Capacity building is therefore necessary. NGOs and other stakeholders should be involved right from the beginning, from pre-disaster preparedness to rescue and reconstruction. NGOs would be particularly effective in creating awareness and education on disasters. The disaster management mechanism should also adopt more non-structural measures, use state-of-the-art technology and cooperate internationally with other countries for addressing transboundary disasters.

**Figure 3: The Organizational Structure of the National Disaster Relief and Preparedness Committee (NDRPC) in Malaysia**




*Source*: Yusof, (n.d.)

**Figure 4: The National Disaster Relief and Preparedness Committee (NDRPC) in Malaysia**




*Source*: Yusof, (n.d.)

### 5.3.Limitations of the Malaysian Flood Disaster Management Model

As a country which is almost annually affected by flooding, there are countless measures and strategies employed to reduce floods in Malaysia. While many of these strategies have been responsible for reducing some of the impacts of flooding, they have not been entirely successful in the overall management of floods. As discussed above, this is largely due to an outdated reactive approach based on evacuation, relief and rehabilitation, the low salience of floods on government agendas, the lack of interaction and cooperation amongst government agencies dealing with floods, the bureaucratic nature of government agencies, and the victims' reluctance to relocate. In fact, floodplain encroachment has even exacerbated flood hazards, as more and more people are forced to occupy floodplains due to the shortage of land, high rents and rural-urban migration. Urban floodplains have also extensively developed as a result of rapid urbanization leading to greater flood damage potentials (Chan, 1996; Chia, 2004).

In Malaysia, flood forecasting and warning systems have also not developed as quickly as expected (Drainage and Irrigation Department, 1988). Currently, two flood forecasting models have been developed and used by the Drainage and Irrigation Department Malaysia, viz. the Linear Transfer Function Model (LTFM) at Pahang River and the Tank Model at Kelantan River (Umar, 2007). The agencies involved in flood relief have used information from the models to decide when they should mobilize their staff and equipment to the areas that are potentially to be hit. The flood warning system consists of dissemination systems such as automatic warning sirens, the Short Messaging System (SMS), telephone, fax and the website (http://infobanjir.water.gov.my Retrieved 16/5/12). The current system being used is not state-of-the-art technology, as it does not have radar or satellite rainfall forecasts as inputs into computer models. Rather, it uses river levels as inputs. The number of automated telemetric rain gauges and river level recorders is also short of the required number. As a result, the advantages of flood forecasting and warnings have not been maximized and the current system appears cumbersome and ineffective. This has led to a lack of confidence amongst floodplain users and flood victims in flood forecasts and warnings (Chan, 1997c). While every effort is made by relevant authorities to improve formal (official) FWESs, there has been little attempt to incorporate traditional (informal) FWESs into them. Traditional FWESs are an integral part of the Malaysian cultural heritage and are closely knitted into the fabric of rural societies. Due to years of responding to flood hazards, traditional FWESs are based on practical knowledge of adaptation and have served people well. As such, the authorities should incorporate them into formal FWESs in order to maximize the effectiveness of overall flood warning and evacuation response from the people.

As a developing country, Malaysia's flood mitigation policy can be described as commendable. Since the First Malaysia Plan (1971-1975), the country's expenditure on flood mitigation has increased substantially. From a mere USD 4.56 million in this plan, it has shot up to a massive USD 228.2 million for the Sixth Malaysia Plan (1991-1995), a 50 fold increase over a 20 year period. During the 10th Malaysia Plan, the budget allocated for flood management was USD 1.17 billion, a 256 fold increase. Even after discounting inflation, the real increase is still substantial. With the many structural and non-structural measures being implemented for flood control and for flood relief, the country is moving in the right direction towards a comprehensive program of flood mitigation. Yet, there are many areas which can still be improved. While the total number of telemetric stations for rainfall and river flow in the country seems large enough, a closer scrutiny would expose the inadequacies of uneven distribution. Most telemetric stations are located in populated areas while the sparsely populated areas, especially highland watershed areas, do not have enough telemetric stations. The Malaysian Meteorological Department and the Drainage and Irrigation Department have also not utilized remotely sensed rainfall (i.e. using radar and satellite systems) as an input in its forecasting models. This could have been deliberately overlooked because of the high cost involved, but real-time flood forecasting cannot be detached from the usage of such techniques, especially in terms of flash flooding.

Legislation related to flood control is indirect as there is no flood legislation. Existing legislation is also sector-based and outdated. While there are currently some laws governing the regulation of river use (e.g. the Waters Enactment 1920, the Mining Enactment 1929, the Drainage Works Ordinance 1954, and the Land Conservation Act 1960, and others) and have some bearing on flood mitigation, they are not sufficiently clear or forceful enough as measures for flood mitigation. These laws were formulated mainly for the purpose of regulating and managing single sectoral water use. More stringent and clear-cut laws must be passed to enable the authorities to have direct control in all aspects of water use which may affect flooding. This includes laws that clearly specify water rights administration, water resource development, flood plain management and all aspects of flood mitigation. Alternatively, the existing laws should be updated with a stronger emphasis on flood mitigation.

Finally, flood hazard management in Malaysia has not kept up in the context of its rapid development. Malaysia is a newly-industrializing country in which the pace of social, economic and political change is fast, as is the pace of physical and environmental change. Other things being equal, these are the contexts in which flood hazards can be magnified and mismanaged. The contexts themselves are also changing, and changing physical systems have given rise to increased risk, exposure and vulnerability to flood hazards. Other contexts, largely structural, such as persistent poverty, low residential and occupational mobility, landlessness, and ethnic culture have also contributed to increased vulnerability to flood hazards amongst specific communities, mainly the poor. Thus, in order to better manage floods and move towards greater flood loss reduction, flood management must be given a higher salience on official agendas. In a country where poverty reduction and income equity amongst all races are targets of policy, the reduction of flood losses appears to be an important vehicle towards achieving those targets. This is because the poor are the most vulnerable to flooding in Malaysia, and any substantial increase in flood protection and flood loss reduction will reduce the income gap between the rich and the poor. The government should also adopt a more pro-active and dynamic approach towards flood management, rather than adhere to a reactive approach.

Finally, the current flood management model lacks a multi-disciplinary approach that should include a well balanced mixture of structural and non-structural measures. In this respect, the employment of legislation to control floodplain encroachment, the development of hill land, and urbanization is vital if Malaysia is to successfully develop at a sustainable pace and yet protect and conserve its environment, and at the same time manage flood hazards effectively. If not, flood hazards will continue to put a tremendous strain on the country's economy, exacerbate poverty and income inequity, and delay its efforts as a newly industrializing country (NIC) by the year 2020 (Chan, 2011).

## 6. Constraints in Post-Flood Disaster Supports

### 6.1. Politicization of Flood Disasters

Notwithstanding the limitations and weaknesses in the current Malaysian flood disaster management system, there are other constraints which hinder the effectiveness of the system. In Malaysia, almost all facets of life, be it political, social, economic or cultural, are closely linked to politics. Hence, it is not unusual that disaster management is also closely linked to politics. Basmullah Yusuf (n.d.) calls this linkage 'the politicization of disasters". Disaster managers have been cautioned that future disasters will be best depicted as a context for framing and blaming, as politicians with some skill may turn disaster from a threat into an opportunity/political asset (Boin, *et al*. 2009). In the case of Malaysia, politicians are quick to politicize disasters. This is all the more apparent when the Federal Government and State Governments are formed from different political parties. Disaster management research has largely ignored one of the most pressing challenges the ruling government is confronted with in the wake of a disaster, viz. how to cope with what is commonly called the blame game. In order to ensure an effective response to any disaster, political leaders must understand opposition parties' responses in pointing fingers and blaming the ruling government for mishaps in the disaster. It is vital that leaders properly manage the political aspects of disasters and their inquiries. On 12 April 2012, an opposition party leader led some 200 Klang residents to stage a protest in front of the Selangor State Secretariat building, demanding that their flood damage compensation money to be increased to USD 260.8. The group claimed that the USD 163 received from the Selangor government was far too little to compensate for the damage residents suffered in the recent floods. While this claim was beneficial for the flood victims, one cannot hide the fact that previous Selangor State Governments had not previously paid flood victims any compensation at all. This case is in fact a example of the politicization of floods.

In another incident in 2007 when Johor was ravaged by floods, Johor *Mentri Besar* (Chief Minister) Datuk Abdul Ghani Othman had claimed that the devastating floods (18 deaths, USD 0.49 billion damage and 110,000 people evacuated) may have been caused by Singapore's land reclamation at its Pulau Tekong island in a narrow sea lane between Malaysia and Singapore. The *Mentri Besar* blamed Singapore based on its land reclamation at the island which had effectively plugged the mouth of the Sungai Johor, resulting in the river overflowing its banks and inundating the town of Kota Tinggi (The Star, 2007). But Singapore's Ministry of National Development responded with the statement "The comments are unfounded" as results from technical studies commissioned separately by both the Malaysian government and the Singapore government had not proven this claim. In another incident, Selangor United Malays National Organization (UMNO) deputy chief Datuk Seri Noh Omar has blamed the Selangor State's ruling Pakatan Rakyat's (PR) poor flood mitigation works for the recent spate of flash floods in the state (Chieh, 2012). He alleged that PR-led Selangor Government had failed to set aside sufficient funds to improve drainage and reduce the risk of flooding in the nation's wealthiest state. Respondents in the study by Chan (1995) also mentioned that political parties had their own agendas, as they helped only those flood victims (in their constituencies) who supported them. For example, the UMNO Member of Parliament would pay more attention and channel more aid to the Malay majority areas. Similarly, the Malaysian Chinese Association leaders would give priority to help the Chinese victims, and the Malaysian Indian Congress would favor helping the Indians. Choosing to help victims by their political convictions or support goes against all the rules of disaster management, but it is a real problem. More recently, floods have triggered further political fallout. The Federal Minister for Housing and Local Government and Alor Setar MP criticized the Kedah State government (led by the opposition Pan-Malaysian Islamic Party (PAS), an opponent of the MP's National Front coalition) for what he considered a slow response to the floods and the government's inexperience (Bernama, 5 November 2010b; Foong, 2010). Deputy Prime Minister Muhyiddin Yassin then claimed the State government had a responsibility to assist victims of the flood (The Star, 2010a). In response, Kedah's Chief Minister Azizan argued that his government's response had been "quick" and that 300,000 ringgit in aid had been committed to the affected areas (New Straits Times, 2010). Fortunately, Kedah's Sultan Abdul Halim called publicly for politics to be set aside for the purposes of dealing with the floods (The Star, 2010b).

### 6.2. Mediatization of Flood Disasters

Another obvious constraint in effective flood disaster management is that of mediatization. In any account, the media are a potent force. This is a factor that significantly affects disaster management. So powerful is the role of the media that they can either help a nation address a disaster or make the country look bad. According to the Thomas Theorem: “If the media define a situation as a disaster or a crisis, be sure that it will indeed be a disaster or a crisis in all its consequences” (Thomas and Thomas, 1928). Yusof (n.d.) contends that mediatization would be one of the driving forces in the world of future disasters. The media can either use a disaster for outright sensationalism, or it can self-impose censorship on the event making it “unimportant”. The media can also apply pressure on politicians and decision makers to explain and justify the occurrence and impacts of the disaster to the public.

### 6.3. Lack of Awareness and Volunteerism

Lack of awareness towards donating and volunteering to flood disasters is another constraint that impedes advancement of disaster management, especially towards engaging the public and giving the public a more active role. Generally, Malaysians are very private people who have developed the conception that disasters are the responsibility of the government. Few Malaysians would volunteer in social work. This is a constraint that limits the effectiveness of volunteer groups such as MERCY, and the Red Cross and Red Crescent. Asking Malaysians to donate money or even clothes/food to disaster organizations is a difficult task. That is not to say Malaysians are poor, nor are they miserly/stingy. Malaysians do not donate towards flood disaster aid simply because they feel that is not their responsibility. They feel that it is the responsibility of the government, be it at the Federal or State level.

### 6.4. Climate Change

In Malaysia, floods occur throughout the country and throughout the year, although certain states and certain times experience more floods than others. Over the years, monsoon floods have normally affected the east coast of Peninsular Malaysia and Sabah and Sarawak, but only flash floods affect the west coast of the peninsula. Hence, there is a detachment from disasters of people living on the west coast. For example, residents in the city of Kuala Lumpur would not perceive floods as dangerous. This is because floods in this city are not so frequent and occur with low magnitudes. Hence, there is a false sense of security about flooding amongst city folks.

### 6.5. Short Memory Span

Malaysians are a forgetful lot and have short memories when it comes to floods. Hence there is a general misconception of the relative unimportance of disasters, especially floods. It is therefore not unusual to find flood victims moving back into their flooded houses even before the flood waters have subsided. It is therefore difficult to ensure safety and healthcare when the victims expose themselves to the filth from the aftermath of a flood. In fact, there have been many incidents in which flood victims have refused to heed the call of the police or other warning authorities to evacuate their properties, and by the time the victims evacuate, they have been caught by the flood waters. Many victims think they are well in control based on their experience of flooding, but a big flood may catch them unawares.

### 6.6. Erosion of Social Capital

Aldrich (2010) has found that recovery from disasters is very much dependent on social capital, especially in post-crisis resilience. Hossain and Kuti (2010) similarly highlighted the importance of disaster response, preparedness and coordination through social networks. In the case of flood disasters in Malaysia, social capital as manifested by kinships and family bonds have been found to be a strong factor in helping victims cope with and recover from flood disasters. This factor is all the more important when government aid is not forthcoming to the victims. However, out-migration from families due to the search for jobs in cities has, among other reasons, broken down the extended families. Consequently, families have lost the one thing that protects them from being totally devastated by flood disasters, i.e. the social bonding and self-reliance that has made them resilient in the past. For example, in the 1990s Makcik (Aunty) Mabee never had any problems when her house near the Sungai Pinang in Penang was flooded every month as she could call upon her own children (ten of them) to help her cope with the floods. More than that, she could rely on help from her relatives living in adjacent houses. But now in 2012, she is no longer able to rely on her own children (only two girls have stayed behind) or her relatives as they have all moved out to Kuala Lumpur or other cities looking for jobs.

## 7. Policy Recommendations: Towards Effective Flood Disaster Risk Management in Malaysia

Disaster preparedness is one aspect of disaster management that clearly needs to be improved, especially in the context of flood disasters. While the NDRM appears to work in the east coast flood-prone areas whereby preparations get under way during the month of October/November just before the monsoon season, residents living on the west coast of the peninsula, in the southern state of Johor and the northern states of Kedah and Perlis are not exposed to this kind of preparedness. That is because in the past the north-east monsoon seldom affected these rain-shadowed areas. Now, there is global climate change and weather systems are changing and becoming highly unpredictable. In recent years, massive floods are now not affecting the usual east coast states such as Kelatan, Pahang and Terengganu, but have moved south towards Johor and north towards Kedah and Perlis. The major floods in Johor in 2006-2007 and the massive floods in Kedah and Perlis in 2010 are indications that this trend is happening. Hence, residents in Johor, Kedah and Perlis, or for that matter in Kauala Lumpur (subjected to frequent flash floods) should also be sensitized by exposing them to awareness via flood preparedness campaigns.

Flood Disaster Risk Management in Malaysia has traditionally been over-focused on a top-down government-centric approach. This was workable in the past when population was sparse and the public largely made up of poorly educated citizens, and the role of NGOs and civil society was limited in scope. It is time for a radical change towards a more people-friendly “horizontal” or “bottom-up” approach. People, especially disaster victims, need to be engaged and empowered to be more resilient. If not, they remain highly dependent on government aid and this is not what the Malaysian Government wants. According to Mohd Radzi Jamaludin, MERCY Malaysia Head of Human Resources and Volunteer Management and their training course coordinator, *"We must involve communities in disaster management as our focus is to rebuild communities after a disaster and educate them on how to prevent the next one"* (http://www.mercy.org.my/main/pressreleases/2009/drrandcommunitybaseddrmtrainingcourse4.html Retrieved15/5/12). When the public (who are the victims) are actively engaged and involved, their ability to respond to flood or other disasters effectively and appropriately will be enhanced. The general principles of preparedness that should be adopted are as follows: (i) preparedness is a central foundation of disaster/emergency management; (ii) preparedness is not static but a dynamic and continuous process whereby managers and victims learn; (iii) preparedness is an educational activity to increase awareness and understanding; (iv) preparedness is not just about drills but is based on knowledge (which is evolving all the time); and (v) preparedness evokes appropriate actions (from both disaster managers and victims).

Providing disaster services up to international standard should be one of the objectives of disaster managers. The authorities must introduce standards that would serve as the guiding principles for flood disaster managers and other humanitarian workers during disasters. Malaysia should try its best to adopt the new crisis assistance standards in the country. These standards, widely known in the humanitarian sector as the SPHERE Standards, are comprehensive and stress quality as well as quantity in order to achieve the best practice in providing aid during/after a disaster. These standards specify, among others, the minimum amount of uncontaminated water with which a victim should be provided per day (7.5 litres), the minimum sizes for shelters, average distances to water distribution points, specifications for toilets, healthcare, etc in the aftermath of a disaster. The SPHERE Standards have been widely adopted by disaster managers, especially managers working in the humanitarian sector. Government must ensure that all NGOs and humanitarian organizations working in a disaster area adhere to the specified quality and accountability practices (www.sphereproject.org Retrieved 15/5/12).

Other policy recommendations proposed for the Malaysian Government are as follows: (i) Develop disaster/emergency plans. Such plans should be reviewed and improved from time to time. Ensure that early warnings reach and are understood by the most vulnerable people as they need to know what to do, where to go, and how to protect themselves. Hence, the plans must include education and preparedness; (ii) Constantly improve existing flood forecasting and warning systems. Incorporate traditional systems into the official systems so that people can make the adjustment quickly. Employ state-of-the-art technology in such systems; (iii) Provide flood-prone areas/communities with emergency materials such as torch lights, batteries, water purification tablets, stretchers, chain saws, plastic sheeting, first aid supplies, generators, etc.; (iv) Identify and gazette more emergency sites/shelters such as community halls, schools, mosques, etc and assembly areas such as parks or fields when evacuating people; (v) Construct shelters/houses and infrastructure to withstand future disasters (for example, the Malay stilt house has stood the test of time but this unique flood-proof architectural design is fast disappearing due to changing needs); (vi) Healthcare centers such as hospitals and clinics should be made flood-proof (for example, the ground floor can be used only as a car park or recreational space), roads should be built on the highest ground, water supply mains should be waterproof, and electricity wires should be on high poles; (vii) Relocation should be used as a last resort, considering its negative effects on people. However, if need be, relocation should be carried out and people should be well compensated for it. Alternatively, people should get alternative housing nearby, not in an alien place that is far away from their social networks. During relocation or temporary resettlement, social networks should be preserved; (viii) Government should provide livelihood opportunities, introduce victims to suitable alternatives, and where possible, help people to be responsible for their own reconstruction; (ix) Subsidies in the form of cash or food vouchers can be provided, not as a long term subsidy but as a short-term aid. Cash is a suitable choice as it allows people to purchase their own needs rather than receive items in kind which they might already have; (x) Government must ensure that evacuation centers are always safe and well maintained. A crumbling structure may precipitate another disaster; (xi) Government must consider gender differences when giving out aid and support, as disasters often affect men and women differently.

## 8. Emerging Threats of Disasters at the National Level

At the national level, many factors impinge on the success or failure of flood disaster management. One of the most influential factors is politicization. In Malaysia, almost everything is political. For example, the issue of water is politically motivated (Chan, 2011), river management is politically inclined (Ujang, 2010), the business sector has political influence (Chooi, 2012) and even education is not free from politics (Thenh, 2011). It is therefore no surprise that disasters are also political. The floods in Kedah State in 2010, for example, triggered immediate political fallout. The Federal Minister for Housing and Local Government (National Front Coalition) criticized the Kedah State government (led by the opposition Pan-Malaysian Islamic Party) for what he considered a slow response to the floods and the government's inexperience (Bernama, 5 November 2010). Deputy Prime Minister Muhyiddin Yassin claimed the State government had a responsibility to assist victims of the flood (The Star, 2010a). In reply, Kedah's Chief Minister Azizan argued that his government's response had been "quick" and that 300,000 ringgit in aid had been committed to the affected areas (New Straits Times, 2010). Fortunately, the politicization was stopped when Kedah's Sultan Abdul Halim called publicly for politics to be set aside for the purposes of dealing with the floods (The Star, 2010b).

Alarmingly, disasters in the modern world are a complex mixture of natural and human-made inputs. Often, when two or more disasters collide, they change into “Compound Disasters” or can evolve into a totally different category of disaster. A good example is when the Asian Tsunami not only flooded the west coast of Penang but also caused contamination of water supplies. This is a challenge that the Malaysian Government needs to be aware of. Related to this is the mutation of disasters, as if disasters were something “alive”. Disasters mutate in form in response to population growth and urbanization, economic growth, globalization of commerce, and technological advancement. The challenge is how to contain individual disasters and stop them from evolving and mutating.

Flood disasters continue to impoverish the government coffers. During the 10$^{th}$ Malaysia Plan period (2011-2015), a total of USD 1.17 billion was allocated for flood disaster management. This figure is expected to increase exponentially as it has done so during the last nine Malaysian plans. This is a challenge that the Malaysian Government has to address. Raising tax rates to increase government revenue would not be an acceptable move, given the fact that the citizenry expects the government to foot the bill when it comes to disaster spending. Perhaps a workable alternative would be to involve the private sector and help people become more flood resilient and self reliant. Even so, damaged public structures need to be repaired.

Flood losses are difficult to measure. How much is a life worth indeed? Tangible and intangible losses are complicated by direct and indirect losses. Flood loss profiles are ever changing as a result of population growth, changing needs and changing lifestyles. Technological advancement and the use of sophisticated equipment (for forecasting and warning) may see a drop in the loss of lives, but dense construction may see an increase in property losses and indirect economic losses such as loss of business. These will become major societal vulnerability.

Global warming brings with it unexpected changes in the hydrological regime. What was a 100-year flood in the past may be in fact only a 1:50 year flood in the future. This means that a mega-flood would be a distinct possibility in the near future as temperature rises, evaporation rates increase, storms get bigger, and monsoons get stronger. In addition, the rapid growth of cities and population will see the emergence of mega-cities and mega-populations, i.e. conditions that will foster the emergence of a mega-flood.

Another major challenge is Malaysia's inability to use new scientific and technological advances to mitigate flood disasters. Currently, the flood forecasting system has just started to use radar and satellite images as inputs in forecasting rains, a necessary input for flood forecasting. Warning systems using short text messages also have problems.

Another challenge is that hydro-meteorological hazards are not easily forecastable on an extended time scale, since weather can change abruptly. But today's societies require extended forecasting to increase the time available for evacuation. Sadly, evacuation clearance time has in fact increased due to increased population densities. Hence, road systems need to be markedly improved to ensure swift evacuation.

The pace of engineering advances is not in keeping with their implementation in practice. For example, building codes are not keeping pace with current engineering practice. The Environmentally-friendly Drainage Manual, for instance, is not user-friendly and contractors see it as cumbersome and costly to implement compared to the conventional open drainage system. The challenge here is to educate contractors and house buyers into buying the system.

In the future, floods and other disasters are likely to evolve into new forms yet unheard of. One of the characteristics and conditions of future disasters will be transnationalisation. For example, the original source of flooding may occur in Malaysia, but the immediate and long term impact of the disaster may be spread into neighboring countries such as Thailand or Singapore. It is therefore imperative that Malaysia and its immediate neighbors come to some sort of agreement and establish cooperation in managing disasters, especially those that can cross borders or are transboundary. Regional cooperation is also needed in the light of the effects of globalization on all countries. For example, disasters are said to have a globalization effect when a country affected by a major disaster can no longer export the goods it exports to other countries worldwide. Thus the Kobe earthquake in 1995 affected a large fraction of Japanese shipping, and forced closures of subcontractors' facilities worldwide, including in Malaysia. This affected world trade and many national economies suffered.

## 9. Conclusion

After more than half a century of flood management, Malaysia is still subject to severe floods. Indeed, Malaysia will never be flood-free. Floods and other disasters will continue to impact upon the people and bring negative effects on life, properties and infrastructure. This is unavoidable. However, what is avoidable is that Malaysians must not forget past disasters. Past disasters present opportunities for us to learn from past mistakes. Just like mistakes from history which we must remember and avoid, disasters are no different. Once we forget them and let our guard down, they will strike us hard. This is attested by the evolution of various safety and emergency laws, acts and regulations since independence. The current NDRM appears rather outdated as it is based on a reactive approach. This machinery needs to be revamped and repackaged, not just with cosmetic changes but with real changes for the better. Institutional arrangements also need to be vastly improved for effective implementation of the national disaster management program. The NSC needs to be revamped to give it a fresh mandate, more funds to operate, and more qualified personnel. Malaysia is constantly revamping ministries and government agencies. This is where the role of the NSC can be better positioned. Putting the NSC under the Prime Minister's Department gives it more clout, but it also marginalizes it as the Prime Minister has other more immediate agendas. Flood management will not feature highly on the Prime Minister's agenda. However, the future looks optimistic as there are signs of cooperation between various relevant disaster agencies as well as between government agencies and NGOs. Disaster practitioners and scholars are also doing more research to bridge the gap. The NSC also needs to provide better coordination between the council and NGOs working in disaster areas. Currently, the lack of coordination makes it difficult for NGOs to bring aid where it is most needed, thus hampering the effectiveness of relief work.

Flood Disaster Risk Management in Malaysia has traditionally been over-focused on a top-down government-centric approach. This was workable in the past when population was sparse, the public largely lowly educated, and the role of NGOs and civil society limited in scope. It is time for a radical change towards a more people-friendly "horizontal" or "bottom-up" approach. People, especially disaster victims, need to be engaged and empowered so as to become more resilient. If not, they will remain highly dependent on government aid and this is not what the Malaysian Government wants. When the public (who are the victims) are actively engaged and involved, this will enhance their ability to respond to flood or other disasters effectively and appropriately. The general principles of preparedness that should be adopted are as follows: (i) preparedness is a central foundation of disaster/emergency management; (ii) preparedness is not static but a dynamic and continuous process whereby managers and victims learn; (iii) preparedness is an educational activity to increase awareness and understanding; (iv) preparedness is not just about drills but is based on knowledge (which is evolving all the time); and (v) preparedness evokes appropriate actions (from both disaster managers and victims).

Providing disaster services up to international standard should be one of the objectives of disaster managers. The authorities must introduce standards that would serve as the guiding principles for flood disaster managers and other humanitarian workers during disasters. Malaysia should try its best to adopt the new crisis assistance standards in the country. These standards, widely known in the humanitarian sector as the SPHERE Standards, are comprehensive and stress quality as well as quantity.

The Malaysian flood authorities should not ignoring local leadership, as they have rich experience that can be tapped into. Local leaders such as village heads can provide information and cooperation on the ground. Moreover, these leaders can advise the authorities when distributing relief goods, reconstruction material, or other benefits, especially those which help the poor, women, children, and the elderly. Some things to avoid include rushing in with reconstruction without recycling useful materials from the disaster site, bulldozing over what could be valuable building materials, and rushing in quickly to implement ad-hoc plans. For example, establishing new institutions in short time frames or developing complex and inflexible project designs are not encouraged. The authorities should always use familiar disaster management plans and systems with the local officials/leaders. Another thing to avoid is relocation of people away from their jobs and social contacts. This is useless as they would eventually return. In the case of farmers, care must be taken so that they do not miss the next planting season. Hence, distribution of seeds should be timely. The authorities should also be sensitive, for example not imposing grief counseling where it is found to be inappropriate, especially in the context of multi-ethnic Malaysia with multi-cultural beliefs.

Because Malaysia’s main disaster is flooding, the NDRM is largely targeted for handling monsoon flooding. Consequently, this mechanism is less than effective and should be re-modeled into something more pro-active. Stakeholder participation is also seriously lacking, although the authorities have recognized the important role of NGOs, particularly MERCY, the Red Cross, Red Crescent and other specific NGOs. These stakeholders need to be involved during every stage of the disaster cycle. Capacity building is necessary. The disaster management mechanism should also adopt more non-structural measures, and state-of-the-art technology, and cooperate internationally with other countries for addressing transboundary disasters.

In terms of flood warning, there are many areas which can still be improved. While the total number of telemetric stations for rainfall and river flow in the country seems large enough, a closer scrutiny would expose inadequacies in terms of uneven distribution. Most telemetric stations are located in populated areas while the sparsely populated areas, especially highland watershed areas, do not have enough telemetric stations. The Malaysian Meteorological Department and the Drainage and Irrigation Department have also not utilized remotely sensed rainfall (radar and satellite sensed rainfall) as an input in its forecasting models. This could have been deliberately overlooked because of the high cost involved, but real-time flood forecasting cannot be detached from the usage of such techniques, especially in terms of flash flooding.

Legislation related to flood control should also be improved. While there are currently some laws governing the regulation of river use (e.g. the Waters Enactment 1920, the Mining Enactment 1929, the Drainage Works Ordinance 1954, the Land Conservation Act 1960, and others) and which have some bearing on flood mitigation, they are not sufficiently clear or forceful as measures of flood mitigation. These laws were formulated mainly for the purpose of regulating and managing single sectoral water use. More stringent and clear-cut laws must be passed to enable the authorities to have direct control in all aspects of water use which may affect flooding. This includes laws that clearly `specify water rights administration, water resource development, flood plain management and all aspects of flood mitigation. Alternatively, the existing laws should be updated with a stronger emphasis on flood mitigation.

Flood insurance is poorly developed in Malaysia, despite the country been flood-prone. In developed countries, flood insurance is an integral part of overall flood management. The Government should seriously consider introducing an insurance scheme for flood victims to help them get back on their feet after suffering huge losses. In recent years, there have been cases where victims in Johor and Kedah suffered through two major floods and ended up with a total loss twice over. Under a normal scheme to protect properties in Malaysia, insurance companies will not compensate flood victims since it is considered a natural disaster. One could purchase a special flood insurance to protect one’s property, but the premium would be very high.

Nevertheless, there should be a move by the authorities to introduce an insurance scheme so that the victims can get some compensation.

Another point is the need to create a data management system (i.e.. a data bank), which would display data spatially and temporally, and underpin a more systematic communication system in flood disaster management (Lawal, *et al*. 2006). This disaster data bank could be managed in a geographical information system environment and be put on the NSC website for all disaster organizations to access. Currently, disaster information is often treated as "confidential" and seldom released to the public. This should not be the case as the public has a right to know all the statistics related to disasters. A case in mind is the holding back of the Air Pollution Index (API) during the 1997/98 haze episodes. The excuse given was that such statistics may "frighten" tourists and drive them away, resulting in the country losing foreign revenue. But surely the health of its own citizens should be given the highest priority. Here again, the confidentiality of disaster statistics is yet another manifestation of politicization. It must be stressed that politics should not mix with disaster management, or else the disaster will just get worse. Politicians must refrain from using disasters as ammunition. All parties must put aside political differences when it comes to disaster management. After all, it is the people's lives that are at stake. Unlike political parties, floods are the same to everyone and would affect anyone.

Finally, flood hazard management in Malaysia must be viewed in the context of its rapid development. Malaysia is a newly-industrializing country in which the pace of social, economic and political change is fast, as is the pace of physical and environmental change. Other things being equal, these are the contexts in which flood hazards can be magnified and mismanaged. The contexts themselves are also changing, and changing physical systems have given rise to increased risk, exposure and vulnerability to flood hazards. Other contexts, largely structural, such as persistent poverty, low residential and occupational mobility, landlessness, and ethnic culture have also contributed to increased vulnerability to flood hazards amongst specific communities, mainly the poor. Thus, in order to better manage floods and move towards greater flood loss reduction, flood management must be given a higher salience on official agendas. In a country where poverty reduction and income equity amongst all races are targets of policy, the reduction of flood loss appears to be an important vehicle towards achieving those targets. This is because the poor are the most vulnerable to flooding in Malaysia and any substantial increase in flood protection and flood loss reduction will reduce the income gap between the rich and the poor. The government should also adopt a more pro-active and dynamic approach towards flood management, rather than adhere to a reactive approach. Finally, a multi-disciplinary approach encompassing a well balanced mixture of structural and non-structural measures should be adopted. In this respect, the employment of legislation to control floodplain encroachment, the development of hill land, and urbanization is vital if Malaysia is to successfully develop at a sustainable pace and yet protect and conserve its environment, and at the same time manage flood hazards effectively. If not, flood hazards will continue to put a tremendous strain on the country's economy, exacerbate poverty and income inequity, and delay its efforts in becoming a newly industrialising country (NIC) by the year 2020.

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# CHAPTER 15

# Impacts of Natural Disasters on Agriculture, Food Security, and Natural Resources and Environment in the Philippines

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*This study quantitatively and qualitatively analyzed the impacts of natural disasters (particularly typhoons, floods and droughts) on agriculture, food security and the natural resources and environment in the Philippines. It aimed to propose recommendations as to how best to respond to the impacts of natural disasters and to suggest further studies that can be undertaken. In general, the study found that: a) typhoons, floods and droughts have an insignificant impact on overall agricultural production at the national level, yet typhoons may have a significant negative impact on paddy rice production at the provincial level; b) typhoons, as exemplified by Ondoy and Pepeng in 2009, have a significant negative impact on the food security of the households in the affected areas; c) households have varying consumption and non-consumption strategies to cope with the impacts of typhoons; and d) the different impacts of typhoons, floods and droughts on the natural resources and environment have not been quantitatively assessed in detail, however available evidence suggests that these are also substantial. Based on its results and findings, the study recommends the following: a) Since typhoons may have significant negative impacts on rice production at the local level as opposed to the national level, assistance for rice farmers and the agriculture sector as a whole should be made more site-specific, zeroing in on the affected areas that actually need it; b) Those assisting affected households and areas in overcoming the resulting ill-effects of natural disasters should consider not only consumption strategies, such as the provision of emergency food aid, but also non-consumption strategies, such as the provision of post-disaster emergency employment; and c) While the available evidence suggests that the natural resources and environment sector is significantly affected by natural disasters, it is currently less considered, as attention is presently focused on agriculture. It may now be high time to provide concrete assistance to this sector, in particular the provision of defensive investments and rehabilitation expenditures to cope with these natural disasters.*

***Keywords***: Natural disasters, Typhoons, Floods, Droughts, Agriculture, Food security, Natural resources and the environment, Agricultural Multi-Market Model for Policy Evaluation (AMPLE)

# 1. Introduction

In Southeast Asia, the Philippines is among the hardest hit by natural disasters, particularly by typhoons, floods and droughts. These natural disasters have negative economic and environmental impacts on the affected areas and the people who live there. Furthermore, the agriculture and natural resources sectors are highly vulnerable because they are continuously exposed to natural disasters and their unwelcome consequences.

An analysis of the impacts of typhoons, floods and droughts on agriculture, food security and the natural resources and environment of the Philippines will help bring further to light the nature and extent of these effects. For an economy largely dependent on agriculture and its natural resources and environment, the data and information as well as overall knowledge gained from the study may prove useful in developing strategies to address the ill-effects of natural disasters. Moreover, the results and findings may assist in identifying new studies that can soon be undertaken in relation to natural disasters, an important research concern which still lacks the necessary level of focus in the Philippines.

The main objective of this study is to quantitatively and qualitatively analyze, to the extent possible with available secondary data and information, the impacts of typhoons, floods and droughts on agriculture, food security and the natural resources and environment in the Philippines. The specific objectives are to: a) present an overview of agriculture, natural resources and environment, disaster management, and the occurrences of typhoons, floods and droughts in the country; b) evaluate the impacts of typhoons, floods and droughts on agriculture at both the national and provincial level; c) assess the impacts of these disasters on food security; and d) analyze the effects of these disasters on the natural resources and environment.

The ultimate aim for doing so is to recommend measures that can be undertaken in response to the unwelcome impacts of natural disasters on the agriculture and natural resources and environment sectors and to propose relevant studies that can be undertaken in the future.

## 2. Methodology

### 2.1. Definitions

Put simply, a natural disaster is a natural event with catastrophic consequences for living things in the vicinity (Sivakumar, 2005). From an economic perspective, a natural disaster can be taken as a natural event that causes a perturbation to the functioning of the economic system, with significant negative impact on assets, production factors, output, employment, or consumption (Hallegatte and Przyluski, 2010).

In the Philippines, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), which is the institution that provides meteorological, astronomical, climatological and other specialized data and information and services, defines a disaster as "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts which exceeds the ability of the affected community or society to cope using its own resources". On the other hand, it defines a hazard as "a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihood and services, social and economic disruption, or environmental damage".

Natural disasters are generally meteorological, hydrological, geological or biological. Examples of meteorological and hydrological disasters include typhoons, floods and droughts. A typhoon is the name given to a storm system that occurs in and around the Philippines and Southeast Asia (elsewhere commonly known as a cyclone or hurricane, depending on the location). According to PAGASA, a typhoon is a "tropical cyclone with winds that exceed 118 kilometres per hour that occurs in the western Pacific". A flood is defined as "an abnormal progressive rise in the water level of a stream that may result in the overflowing by the water of the normal confines of the stream with the subsequent inundation of areas which are not normally submerged". On the other hand, a drought is defined as "abnormally dry weather in a region over an extended period of time".

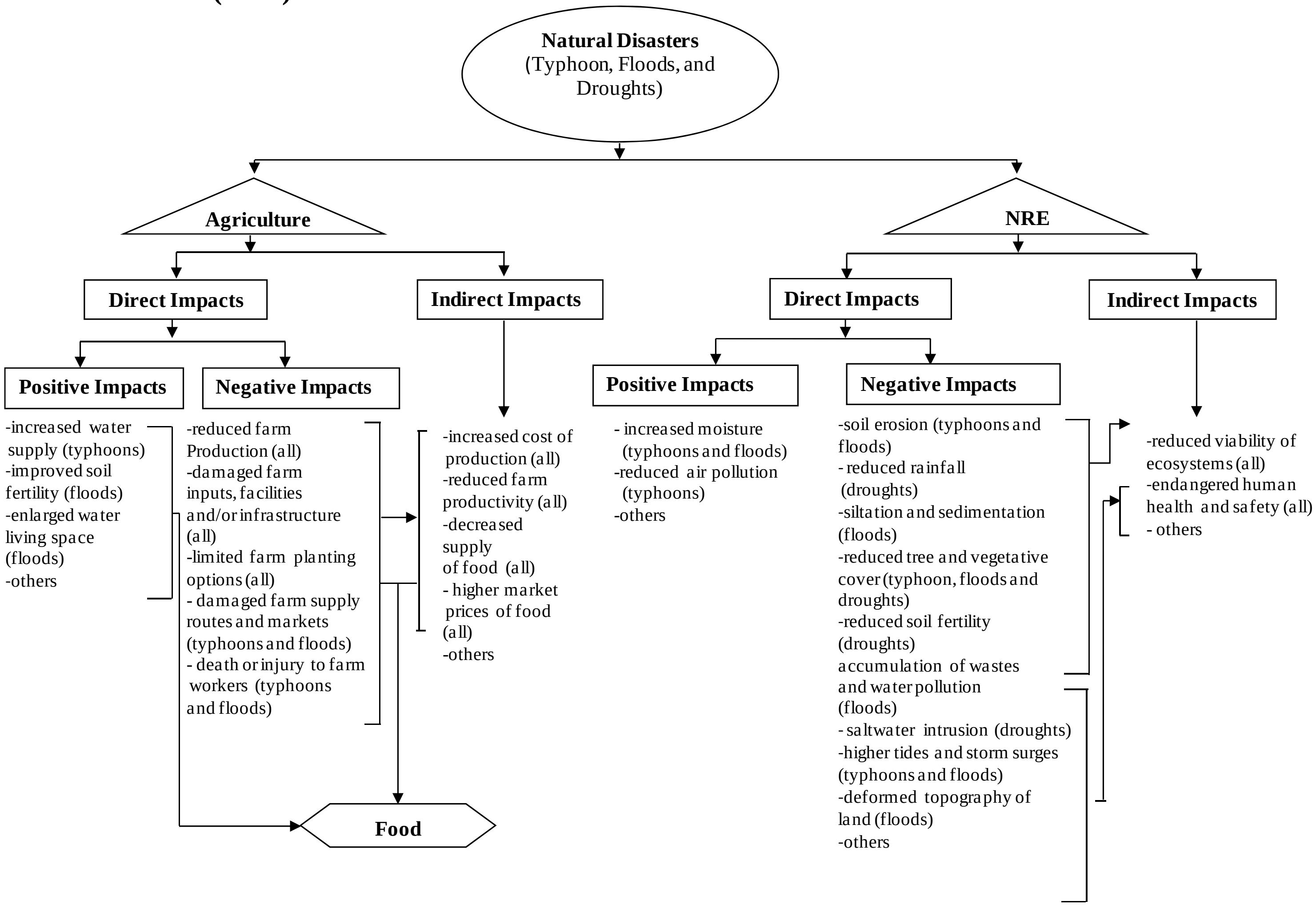
Food security is "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2002; 1996). The basic features of food security are accessibility, affordability and absorption (Kurien, 2004). This means that, firstly, food should not only be in sufficient quantity, it must also be actually accessible to people of all economic classes and in all locations. Secondly, its supply should also be stable so that it is affordable in both the short and long term. Thirdly, and equally importantly, food should be absorbable and safe for people to consume.

## 2.2. Framework of Analysis

Theoretically, the impacts of natural disasters on agriculture and the natural resources and environment sectors can be direct or indirect as well as positive or negative (Figure 1). In the case of agriculture, the direct and positive impacts are actually readily identifiable. Typhoons increase the supply of water for agriculture as they usher in rain. Floods improve soil fertility as they deliver nutrients from the uplands to the lowlands. In addition, floods temporarily create a larger water habitat for inland fish and other aquatic animals. Together with other yet-to-be-identified factors, these impacts of typhoons and floods are viewed as positive because, ceteris paribus, they facilitate an increase in agricultural production in the affected areas and help improve the food security situation.

In contrast to the above, there are direct and negative impacts of natural disasters on the agriculture sector as well. Typhoons, floods and droughts have the potential to reduce farm productivity; damage farm inputs, facilities and/or infrastructure, and limit farm planting options. Furthermore, individually, typhoons and floods can damage farm supply routes and cause death or injury to farm workers. As a consequence, these direct and negative factors can further lead to indirect and negative impacts on agriculture and the economy as a whole. Specifically, as a result of typhoons, floods and droughts, the overall cost of agricultural production increases; agricultural production output declines; food supply falls and, as a result, food prices rise. Taken together, the direct and indirect negative impacts on agriculture threaten food security in the affected areas.

**Figure 1: Framework of Analysis on the Impacts of Natural Disasters on Agriculture, Food Security, and the Natural Resources & Environment (NRE)**



As in the case of agriculture, natural disasters impact the natural resources and environment sector. On the positive side, typhoons and floods directly increase the moisture content in the air, resulting in a temporary cooler temperature for the local people to enjoy. Typhoons also clear the air of pollution to the benefit of the population residing in congested urban areas. On the negative side, typhoons, floods and droughts can reduce the impact area's total vegetative cover; typhoons and floods lead to soil erosion, higher coastal tides and storm surges; floods result in siltation and sedimentation, accumulated waste, polluted water and deformed land topography; while droughts reduce rainfall, lower soil fertility and increase saltwater intrusion. Taken together, all three of these phenomena indirectly reduce the viability of both land and water ecosystems as suppliers of ecosystem services and endanger human health and safety with the proliferation of natural disaster-related diseases.

In the above framework, it should be pointed out that while there are both positive and negative impacts on agriculture and the natural resources and environment sectors, it is assumed that the net impact is negative. Also, it should be emphasized that beyond the aforementioned framework, not only do natural disasters affect the natural resources and the environment but the latter influences the former as well (For instance, forests block the force of incoming winds and limit the damage caused by typhoons, while watersheds store rainwater and reduce the incidence of flooding). Although important, these and other reverse relationships are not covered in this study. Thirdly, while it would be interesting to quantitatively measure all the actual impacts of previous natural disasters on agriculture and the natural resources and environment, this would not be possible given the limited data available.

### 2.3. Econometric Methods

For quantitatively analysing, using econometric methods, the impacts of natural disasters, in particular, typhoons, floods and droughts on agriculture, the Agricultural Multi-market Model for Policy Evaluation (AMPLE) is used in this instance. AMPLE is an 18-production sector partial equilibrium model covering crops, livestock, poultry and aquatic products which generates projections of output, area, consumption, imports, exports, and prices. In common with other supply-demand models, AMPLE is suitable for understanding the evolution of underlying economic fundamentals, as opposed to actually predicting market movements. A full description of AMPLE is presented in Briones and Parel (2011) and Briones (2010) and the sets, variables, and equations of the model are listed in the annexes of these two papers. The model is programmed and solved with the use of the Generalized Algebraic Modelling System (GAMS). Another econometric approach used here in analysing the impacts of natural disasters is regression analysis, the specifics of which are explained in the relevant section below.

### 2.4. Data and Data Sources

This study used secondary data from institutional sources. Data on the annual occurrence of typhoons at the national, regional and provincial levels were taken from the unpublished records of the PAGASA. There were no data available at the time of writing on the annual occurrence of floods and droughts, but national and regional data for the areas affected by them were available; generated from the unpublished records of the Department of Agriculture (DA). Data on the annual damage by agricultural commodity in terms of production in metric tons, cost of production in million pesos, and area in hectares caused by typhoons, floods and droughts were available only for the national level, except those for rice, which were also available for the regional level. These data were also taken from the unpublished records of the DA. Data on the provincial quantities and prices of paddy rice were generated from the Bureau of Agricultural Statistics (BAS). All the aforementioned data utilized were supplemented by secondary quantitative and qualitative data, as well as information taken from the related literature.

## 3. Review of Related Literature

Some recent empirical studies on the impacts of natural disasters on economic growth have been conducted. Cavallo, *et al*. (2010) found that only extremely large disasters have a negative effect on output both in the short and long term. Cavallo and

Noy (2010) asserted that, on average, natural disasters have a negative impact on short-term economic growth. Toya and Skidmore (2005) found that countries with higher incomes, higher educational attainments, greater openness, more complete financial systems and smaller governments experience fewer losses from natural disasters. Loayza, *et al*. (2009) argued that natural disasters affect economic growth, but not always negatively, and the effects are different across disasters and economic sectors; although moderate disasters can have a positive growth effect in some sectors, severe disasters do not; and growth in developing countries is more sensitive to natural disasters with more of their economic sectors being significantly affected.

Some empirical works on the impacts of natural disasters on agriculture have also been conducted. Loayza, *et al*. (2009) found that, in contrast to the weak effects on overall GDP growth, droughts and storms have negative impacts on agriculture while floods have a positive effect. Sivakumar (2005) explained that the predominant impacts of natural disasters on agriculture are negative. Long (1978) argued that the negative effects are a powerful partial explanation of the lack of agricultural self-sufficiency in a large number of low income countries and consequently go some way towards explaining the occurrence of hunger and poverty in these countries.

The impacts of natural disasters on natural resources and the environment have also been investigated in the literature. Sivakumar (2005) explained that natural disasters cause environmental degradation which in turn contributes to the disaster vulnerability of agriculture, forestry and rangelands. NRC (1999) mentioned that not all natural disasters result in significant ecosystem impacts and that some extreme events actually have positive impacts. However, many of these impacts are non-market related and are exceptionally difficult to quantify and/or monetize.

Recent studies have been carried out on the impacts of natural disasters in the Philippines and selected neighboring countries. Israel (2011) reviewed the occurrence of disasters caused by weather and climate-related disasters in Cambodia, Indonesia, The Lao PDR, the Philippines and Viet Nam and explained that in the 1990s and 2000s, these disasters occurred on a regular basis in all of these countries, with the Philippines being the most affected. Israel (2010) studied the occurrence of weather and climate-related natural disasters in the Philippines in the last two decades and found that this phenomenon has indeed increased and that the monetary damage caused by such disasters has been substantial. Both studies argued for the importance of improving and integrating the national meteorological systems (NMHS) of Southeast Asian countries in order to address natural disasters.

Lastly, qualitative studies on the impacts of natural disasters on agriculture and the natural resources and environment in the Philippines have been conducted previously, and these will be cited in the relevant sections below.

## 4. Review of the Agriculture and Natural Resources and Environment Sectors of the Philippines

### 4.1. Agriculture

From 2004 to 2010, agriculture and fisheries contributed an average of 18.4 % to gross domestic product (GDP) and grew at an average rate of 2.6 % annually in the Philippines (NEDA 2011). Among the regions, the top contributors to output in 2009 were Region IV-A (CALABARZON) and Region III (Central Luzon). The agriculture sector during this period employed an average of 11.8 million people, which accounted for almost 35.1 % of the total work force of the country. Between 2004 and 2010, the agriculture and fisheries sector exports increased in monetary value from USD 2.5 billion to USD 4.1 billion. The top agricultural exports in terms of value were coconut oil, fresh banana, tuna, pineapple, tobacco, and seaweed. It is worth noting that in 2010 as well as in some years in the past, although the country recorded an overall balance of trade deficit in the agriculture sector, it had positive trade balance in fishery products.

Among the main challenges facing the agriculture sector in the Philippines is its vulnerability to the inherent climate volatility within the region, as well as global climate change. In response to this, an important development goal for the country is an increased resilience to climate change risks of the agriculture sector. With a rapidly increasing population and demand for food, another major development goal is improved food security. To attain these two goals and other objectives within the Philippines' agricultural sector, the strategies promoted by the government are: a) to raise the productivity and incomes of agriculture and fishery-based households and enterprises; b) to increase the investment and employment level across an efficient value chain; and c) to transform agrarian reform beneficiaries into viable entrepreneurs.

### 4.2. Natural Resources and Environment

The natural resources sub-sector of the Philippines includes land, forest and fisheries resources while the natural environment sub-sector refers to the quality of its land, water and air resources. In general, the natural resource and environment sector is facing the twin problems of overexploitation and depletion of natural resources and the deterioration of the overall environmental quality. In recent years, little progress has been made in arresting the worsening pace of these problems even as new challenges have emerged (EC, 2009).

Similar to agriculture, among the important challenges facing the natural resources and environment sector of the Philippines are natural hazards and disasters. In response, a major development goal in this sector is the enhanced resilience of natural systems and improved adaptive capacities of human communities to cope with natural hazards and disasters including climate-related risks (NEDA, 2011). To reach this goal, the following strategies are pursued by the government: a) strengthening the institutional capacities of national and local governments for climate change adaptation and disaster risk reduction and management; b) enhancement of the resilience of natural systems; and c) improvement of the adaptive capacities of communities.

## 5. Review of Disaster Risk Management in the Philippines

### 5.1. Laws, Institutions, and Recent Initiatives

The history of disaster risk management (DRM) in the Philippines began during the Commonwealth period with Executive Order 355 which created the Civilian Emergency Administration (CEA). Thereafter, other laws were passed and agencies were established for DRM in the country (Table 1). In 2010, the Republic Act (RA)

10121, otherwise referred to as the Philippine Disaster Risk Reduction and Management Act, was passed reconstituting the National Disaster Risk Reduction and Management Council (NDCC) into the National Disaster Risk Reduction and Management Council (NDRRMC). This current agency is empowered with policy-making, coordination, integration, supervision, monitoring and evaluation functions related to disaster risk management. It is headed by the Secretary of the Department of National Defense (DND) as Chairperson with Secretaries of other selected departments as Vice Chairpersons.

The Philippine Congress also passed RA 9729 otherwise known as The Climate Change Act of 2009. This law aims to mainstream climate change into the formulation of government policy by setting up a National Framework Strategy and Program on Climate Change. It has also created the Climate Change Commission (CCC) which is tasked with the coordination, monitoring and evaluation of the programs and actions of the government in order to mitigate and adapt to the effects of climate change.

**Table 1: Periods, Laws, Agencies and Their Functions Related to Disaster Risk Management in the Philippines**

| Periods | Laws | Agencies and their functions |
|---|---|---|
| Commonwealth to Post-Commonwealth | Executive Order No. 335 | This law created the Civilian Emergency Administration (CEA) which was tasked primarily through the National Emergency Commission (NEC) to formulate and execute policies and plans for the protection and welfare of the civilian population under extraordinary and emergency conditions. |
| Japanese Occupation | Executive Order No. 36 | This law created the Civilian Protection Service (CPS) which was empowered to formulate and execute plans and policies for the protection of civilian population during air raids and other national emergencies. |
| 1954-1968 | Republic Act 1190, otherwise known as | This law created the Civil Defense Administration (NCDA) which was |

| Periods | Laws | Agencies and their functions |
|---|---|---|
| | the Civil Defense Act of 1954 | tasked primarily to provide protection and welfare to the civilian population during war or other national emergencies of equally grave character. To support the NCDA in carrying out its mission, this law also provided for the establishment of civil defense councils at the national and local levels. namely: the National Civil Defense Council (NCDC) and the provincial, city and municipal civil defense councils, Respectively. |
| 1970s | | In 1970 a Disaster and Calamities Plan prepared by an Inter-Departmental Planning Group on Disasters and Calamities, was approved by the President. The Plan provided, amongst other things, the creation of a National Disaster Control Center (NDCC). In 1973, The Office of Civil Defense (OCD) was created with the mission of ensuring the protection and welfare of the people during disasters or emergencies. |
| | Presidential Decree 1566 | This law was issued in 1978 to strengthen the Philippine disaster control capability and to establish a community disaster preparedness program nationwide. It also created the National Disaster Coordinating Council (NDCC) as the highest policy-making body for disasters in the country. |
| 2000s | | In February 2010, the NDCC was renamed, reorganized, and subsequently expanded into the National Disaster Risk Reduction & Management Council (NDRRMC), an agency responsible for ensuring the protection and welfare of the people during disasters or emergencies. |
| | Republic Act No. 10121 or the | This law acknowledges the need to adopt |

| Periods | Laws | Agencies and their functions |
| --- | --- | --- |
| | Philippine Disaster Risk Reduction and Management Act of 2010 | a disaster risk reduction and management approach that is holistic, comprehensive, integrated, and proactive in lessening the socio-economic and environmental impacts of disasters including climate change, to promote the involvement and participation of all sectors and all stakeholders concerned, at all levels and especially the local community. |

Other recent DRM-related initiatives have been conducted in the Philippines. On June 7 2010, Executive Order No. 888 was signed, adopting the Strategic National Action Plan (SNAP) for the years 2009 to 2019. The SNAP serves as the road map for the Philippines to strategically implement disaster risk reduction (DRR) programs and projects both at the national and local levels. Furthermore, the SNAP contains a strategy that focuses on safety and well-being enhancements that aims to increase capacity, reduce vulnerability, and achieve improved public safety and well-being and build resilience to disasters in the country.

Administrative Order No. 1 Series of 2010 was also issued directing the local government units (LGUs) to adopt and use the DRR Guidelines to enhance natural disaster risk reduction efforts in the local development planning process. The National Economic and Development Authority (NEDA) is directed to conduct capacity-building activities for planning offices at local, regional and national levels towards DRR Guidelines. Moreover, the NDRRMC and the CCC have signed a Memorandum of Understanding (MOU) to harmonize the Local Climate Change Action Plans (LCCAP) and the Local Disaster Risk Reduction Management Plans (LDRRMP) by local government units (LGUs).

### 5.2. Regional Participation in Disaster Risk Management

At the level of the Association of Southeast Asian Nations (ASEAN), the Philippine Senate ratified the ASEAN Agreement on Disaster Management and Emergency Response (AADMER) in September 2009. AADMER binds member states together to promote regional cooperation and collaboration in reducing disaster losses and intensifying joint emergency response to disasters in the ASEAN region. It contains provisions on disaster risk identification, monitoring and early warning systems, prevention and mitigation, preparedness and response, rehabilitation, technical cooperation and research, mechanisms for coordination, simplified customs and immigration.

The Philippines is also an active member of the ASEAN Committee on Disaster Management (ACDM). At present, the regional cooperation is underway to fully establish an operational ASEAN Coordinating Centre for Humanitarian Assistance in disaster management (AHA Centre), as mandated by AADMER. Simultaneously, under the AADMER Work Programme 2010-2015, regional systems for risk identification and assessment, early warning, and monitoring systems are in the process of being established by the ACDM.

Furthermore, the PAGASA has collaborated with the Asian Disaster Preparedness Center (ADPC) and Regional Integrated Multi-Hazard Early warning System for Africa and Asia (RIMES) as well as with neighboring countries with respect to typhoon monitoring. The Philippine Institute of Volcanology and Seismology (PHIVOLCS) is also already a part of the tsunami warning system for the Pacific region.

### 5.3. Constraints and Issues Facing Disaster Risk Management

The following are the identified constraints and issues facing the DRM in the Philippines (NDRRMC 2011): a) ineffective vertical and horizontal coordination among its member agencies; b) existing DRM efforts of governmental and partner organizations are still limited in coverage due to limited available resources; c) ineffective institutional capacities of LGUs such as the lack of managerial and technical competencies; d) limited funds, equipment and facilities for monitoring and early warning; e) Insufficient hazard and disaster risk data and information; f) inadequate mainstreaming of DRM in development planning and implementation; g) poor enforcement of environmental management laws and regulations, and other relevant regulations; and h) inadequate socioeconomic and environmental management programs to reduce the vulnerability of marginalized communities. Overall, the current state of the DRM in the Philippines has been rated as low to very low in the ladder of accomplishments and progress in implementation.

## 6. Results and Analysis

### 6.1. Occurrence of Typhoons

From 2001 to 2010, the country had a total of 171 typhoons; an average of 17 typhoons per year (Table 2). The occurrence of typhoons decreased from 2001 to 2002, rose in 2003, fell from 2004 to 2007, increased again in 2008 and 2009, and fell again in 2010. On a yearly basis, the greatest number of typhoons occurred in 2002, and the least in 2011.

Regionally, from 2001 to 2010, the highest number of typhoons in the Philippines occurred in Luzon, particularly in the Cagayan Valley, Ilocos Region, Cordillera Administrative Region (CAR), Central Luzon, and the Bicol Region. Luzon was followed by Visayas, including its three regions: Eastern Visayas, Central Visayas, and Western Visayas. Mindanao had the least number of typhoon occurrences with the CARAGA region having the most number.

At the provincial level, from 2001 to 2010 the highest number of typhoons occurred in Cagayan Province in Region II. Some provinces within Mindanao and all the ARMM provinces in particular have not been visited by typhoons at all. Mindanao provinces had fewer occurrences of typhoons compared to Luzon and the Visayas. The World Bank Group (2011) stated that while the trends in the occurrence of typhoons in the Philippines in the future are still a subject of much debate, they are likely to increase in intensity, and with greater consequent damage.

**Table 2: Number of Occurrences of Typhoons in the Philippines, by Region and Province, 2001-2010**

| Region | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| National Capital Region | 3 | 1 | 2 | 6 | 1 | 1 | 2 | 3 | 4 | 2 | 25 |
| I - Ilocos Region | 14 | 5 | 11 | 9 | 11 | 5 | 7 | 19 | 16 | 7 | 104 |
| Ilocos Norte | 5 | 4 | 6 | 5 | 6 | 1 | 4 | 11 | 8 | 3 | 53 |
| Ilocos Sur | 4 | 4 | 3 | 3 | 6 | 2 | 3 | 10 | 8 | 4 | 47 |
| La Union | 6 | 3 | 8 | 4 | 4 | 3 | 4 | 9 | 8 | 3 | 52 |
| Pangasinan | 5 | 2 | 10 | 4 | 4 | 3 | 3 | 8 | 8 | 3 | 50 |
| II - Cagayan Valley | 15 | 6 | 25 | 20 | 16 | 9 | 16 | 21 | 20 | 8 | 156 |
| Batanes | 7 | 3 | 11 | 6 | 7 | 4 | 6 | 9 | 8 | 3 | 64 |
| Cagayan | 11 | 5 | 21 | 12 | 7 | 5 | 5 | 13 | 9 | 4 | 92 |
| Isabela | 6 | 3 | 5 | 7 | 4 | 3 | 5 | 8 | 12 | 5 | 58 |
| Nueva Vizcaya | 3 | 1 | 8 | 5 | 5 | 1 | 1 | 4 | 8 | 3 | 39 |
| Quirino | 2 | 3 | 8 | 5 | 4 | 1 | 4 | 8 | 6 | 3 | 44 |
| III - Central Luzon | 9 | 4 | 18 | 11 | 6 | 5 | 9 | 13 | 16 | 6 | 97 |
| Aurora | 3 | 4 | 10 | 6 | 5 | 1 | 6 | 11 | 10 | 4 | 60 |
| Bataan | 5 | 2 | 4 | 4 | 1 | 3 | 2 | 5 | 5 | 2 | 33 |
| Bulacan | 1 | 2 | 4 | 5 | 2 | 1 | 4 | 4 | 6 | 2 | 31 |
| Nueva Ecija | 3 | 2 | 5 | 4 | 5 | 1 | 3 | 6 | 6 | 3 | 38 |
| Pampanga | 1 | 2 | 3 | 4 | 2 | 1 | 3 | 6 | 6 | 2 | 30 |
| Tarlac | 1 | 2 | 4 | 4 | 3 | 2 | 3 | 6 | 6 | 2 | 33 |
| Zambales | 2 | 2 | 6 | 4 | 2 | 3 | 3 | 7 | 7 | 2 | 38 |
| IVA – CALABARZON | 10 | 5 | 12 | 15 | 5 | 4 | 6 | 6 | 9 | 3 | 75 |
| Batangas | 2 | 3 | 3 | 6 | - | 2 | 3 | 4 | 3 | 2 | 28 |
| Cavite | 3 | 3 | 3 | 6 | - | 2 | 2 | 3 | 3 | 2 | 27 |
| Quezon | 8 | 6 | 9 | 10 | 5 | 4 | 5 | 5 | 7 | 3 | 62 |
| Rizal | 3 | 3 | 2 | 7 | 1 | 1 | 3 | 4 | 4 | 2 | 30 |
| Laguna | 4 | 3 | 3 | 5 | - | 2 | 3 | 4 | 3 | 2 | 29 |
| IV-B – MIMAROPA | 9 | 5 | 7 | 11 | 4 | 2 | 4 | 7 | 4 | 1 | 54 |
| Marinduque | 4 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 2 | 1 | 29 |
| Occidental Mindoro | 7 | 3 | 4 | 7 | 2 | 2 | 2 | 4 | 3 | 1 | 35 |
| Romblon | 3 | 4 | 5 | 6 | 2 | 2 | 2 | 3 | 1 | - | 28 |
| V - Bicol | 11 | 5 | 9 | 14 | 10 | 5 | 6 | 6 | 11 | 3 | 80 |

| Region | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Region | | | | | | | | | | | |
| Albay | 5 | 4 | 4 | 5 | 4 | 2 | 3 | 4 | 4 | 1 | 36 |
| Camarines Norte | 2 | 1 | - | 2 | 1 | 1 | 3 | 4 | 4 | 1 | 19 |
| Camarines Sur | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 4 | 4 | 1 | 19 |
| Catanduanes | 5 | 4 | 4 | 5 | 5 | 2 | 4 | 5 | 4 | 2 | 40 |
| Masbate | 3 | 4 | 4 | 6 | 3 | 2 | 2 | 4 | 3 | - | 31 |
| Sorsogon | 4 | 4 | 5 | 4 | 3 | 3 | 3 | 4 | 3 | - | 33 |
| VI - Western Visayas | 11 | 6 | 10 | 11 | 7 | 3 | 4 | 9 | 3 | 0 | 64 |
| Aklan | 3 | - | 1 | - | 2 | 2 | 2 | 4 | 1 | - | 15 |
| Antique | 2 | - | 2 | 2 | 2 | 2 | 1 | 6 | 1 | - | 18 |
| Capiz | 1 | - | 1 | 2 | 2 | 2 | 2 | 7 | 1 | - | 18 |
| Guimaras | - | - | 3 | 2 | 2 | 1 | 1 | 4 | 1 | - | 14 |
| Iloilo | 3 | 1 | 6 | 5 | 2 | 2 | 1 | 6 | 1 | - | 27 |
| Negros Occidental | 1 | 6 | - | 1 | 3 | 2 | 2 | 4 | 1 | - | 20 |
| Palawan | 9 | 2 | 9 | 6 | 3 | 2 | 1 | 5 | 2 | - | 39 |
| VII - Central Visayas | 5 | 1 | 7 | 5 | 4 | 3 | 2 | 7 | 3 | 0 | 37 |
| Bohol | 2 | 1 | 3 | 4 | 1 | - | 1 | 5 | 2 | - | 19 |
| Cebu | 3 | 1 | 6 | 5 | 2 | 2 | 1 | 7 | 2 | - | 29 |
| Negros Oriental | 3 | - | 1 | - | 3 | - | 2 | 3 | 2 | - | 14 |
| Siquijor | 1 | 1 | 2 | - | 1 | - | 1 | 3 | 1 | - | 10 |
| VIII - Eastern Visayas | 7 | 3 | 10 | 10 | 5 | 6 | 3 | 8 | 4 | 0 | 56 |
| Biliran | 4 | 4 | 5 | 7 | 2 | 2 | 1 | 4 | 2 | - | 31 |
| Eastern Samar | 6 | 4 | 5 | 3 | 2 | 3 | 1 | 3 | 3 | - | 30 |
| Leyte | 2 | 4 | 6 | - | 2 | 3 | 2 | 5 | 4 | - | 28 |
| Northern Samar | 5 | 3 | 4 | 2 | 3 | 3 | 1 | 4 | 4 | - | 29 |
| Samar | 5 | 3 | 9 | 4 | 2 | 2 | 1 | 4 | 3 | - | 33 |
| Southern Leyte | 3 | 4 | 4 | - | 1 | 3 | 1 | 3 | 3 | - | 22 |
| Tacloban City | - | - | - | - | - | - | - | - | - | - | 0 |
| IX -Zamboanga Peninsula | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| Zamboanga City | - | - | - | - | - | - | - | - | - | - | 0 |
| Zamboanga del Norte | 1 | - | - | - | - | - | - | 1 | - | - | 2 |
| Zamboanga del Sur | - | - | - | - | - | - | - | - | - | - | 0 |
| Zamboanga Sibugay | - | - | - | - | - | - | - | - | - | - | 0 |

| Region | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| X - Northern Mindanao | 3 | 4 | 1 | 2 | 1 | 0 | 1 | 5 | 2 | 0 | 19 |
| Bukidnon | - | 1 | - | - | - | - | - | 1 | - | - | 2 |
| Cagayan de Oro City | - | - | - | - | - | - | - | - | - | - | 0 |
| Camiguin | 3 | 3 | 1 | 2 | 1 | - | 1 | 5 | 2 | - | 18 |
| Iligan City | - | - | - | - | - | - | - | - | - | - | 0 |
| Lanao del Norte | - | - | - | - | - | - | - | 1 | - | - | 1 |
| Misamis Occidental | - | 1 | - | - | - | - | - | 1 | - | - | 2 |
| Misamis Oriental | - | 3 | - | 2 | - | - | - | 2 | - | - | 7 |
| XI - Southern Mindanao | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 3 |
| Compostela Valley | - | - | - | - | - | - | - | - | - | - | 0 |
| Davao City | - | - | - | - | - | - | - | - | - | - | 0 |
| Davao del Norte | - | - | - | - | - | - | - | 1 | - | - | 1 |
| Davao del Sur | - | - | - | - | - | - | - | 1 | - | - | 1 |
| Davao Oriental | - | 1 | - | 1 | - | - | - | 1 | - | - | 3 |
| XII - Central Mindanao | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Cotabato | - | - | - | - | - | - | - | 1 | - | - | 1 |
| Cotabato City | - | - | - | - | - | - | - | - | - | - | 0 |
| General Santos City | - | - | - | - | - | - | - | - | - | - | 0 |
| Sarangani | - | - | - | - | - | - | - | - | - | - | 0 |
| South Cotabato | - | - | - | - | - | - | - | 1 | - | - | 1 |
| Sultan Kudarat | - | - | - | - | - | - | - | - | - | - | 0 |
| XIII - Caraga | 7 | 5 | 6 | 7 | 2 | 3 | 1 | 6 | 3 | 0 | 40 |
| Agusan del Norte | 3 | 3 | 1 | 3 | 1 | - | - | 3 | 2 | - | 16 |
| Agusan del Sur | - | 1 | - | 2 | - | - | - | 2 | 3 | - | 5 |
| Butuan City | - | - | - | - | - | - | - | - | 3 | - | 0 |
| Dinagat Islands | 5 | 5 | 5 | 4 | 1 | 3 | 1 | 5 | 3 | - | 32 |
| Surigao del Norte | 5 | 5 | 2 | 4 | 1 | - | 1 | 5 | 3 | - | 26 |
| Surigao del Sur | 3 | 2 | 1 | 3 | - | - | - | 4 | 3 | - | 16 |
| CAR | 9 | 5 | 15 | 10 | 11 | 5 | 7 | 17 | 14 | 6 | 99 |
| Abra | 5 | 3 | 8 | 3 | 5 | 3 | 5 | 11 | 7 | 2 | 52 |
| Apayao | 6 | 3 | 11 | 6 | 6 | 3 | 4 | 10 | 8 | 2 | 59 |
| Baguio City | - | - | - | - | - | - | - | - | - | - | 0 |

| Region | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Benguet | 4 | 3 | 7 | 4 | 5 | 3 | 3 | 9 | 9 | 3 | 47 |
| Ifugao | 4 | 3 | 7 | 5 | 4 | 3 | 3 | 8 | 9 | 3 | 49 |
| Kalinga | 5 | 2 | 9 | 5 | 4 | 3 | 5 | 9 | 7 | 2 | 51 |
| Mountain Province | 5 | - | 3 | 2 | 4 | 3 | 3 | 9 | 8 | - | 37 |
| ARMM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Basilan (excluding Isabela City) | - | - | - | - | - | - | - | - | - | - | 0 |
| Lanao del Sur | - | - | - | - | - | - | - | - | - | - | 0 |
| Maguindanao | - | - | - | - | - | - | - | - | - | - | 0 |
| Sulu | - | - | - | - | - | - | - | - | - | - | 0 |
| Tawi-Tawi | - | - | - | - | - | - | - | - | - | - | 0 |
| | - | - | - | - | - | - | - | - | - | - | 0 |
| National | 17 | 13 | 25 | 23 | 16 | 13 | 12 | 19 | 22 | 11 | 171 |

*Note*: Here and in the rest of the tables, **-** also means 0.
*Source of data*: PAGASA

### 6.2. Occurrence of Floods

Flooding occurred yearly in the Philippines from 2007 to 2011 (Table 3). More regions were affected by floods in 2008, followed by 2011, 2007, 2009, and 2010. On a regional and annual basis, the region most often visited by floods was Region VI while those with no incidence of floods included CAR, Region I, Region IV-A, and Region VII. The World Bank Group (2011) stated that over time in the Philippines, heavy rainfall associated with typhoons and other weather systems may increase in both intensity and frequency under a changing climate and exacerbate the incidence of flooding in existing flood-prone areas and introduce a risk of flooding to new areas.

### 6.3. Occurrence of Droughts

During the 2007 to 2011 period, droughts occurred in the Philippines only in 2007 and 2010 (Table 4). More regions in 2010 were affected by droughts than in 2007. In 2007, all regions in Luzon except Region IV-A and Region VI were affected while no regions in the Visayas and Mindanao were affected. In 2010, on the other hand, most regions in Luzon, Visayas and Mindanao were affected except CAR, Region VII, Region VIII, and CARAGA. The World Bank Group (2011) reported that prolonged droughts are associated with the El Niño phenomenon and that these natural events will likely intensify in the future in the Philippines.

**Table 3: Regions Affected by Floods in the Philippines, 2007-2011**

| Region | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| CAR | - | - | - | - | - |
| Region I | - | - | - | - | - |
| Region II | - | ✓ | - | ✓ | ✓ |
| Region III | - | ✓ | - | ✓ | - |
| Region IV-A | - | - | - | - | - |
| Region IV-B | - | ✓ | - | ✓ | ✓ |
| Region V | ✓ | ✓ | ✓ | - | ✓ |
| Region VI | ✓ | ✓ | ✓ | ✓ | ✓ |
| Region VII | - | - | ✓ | - | - |
| Region VIII | ✓ | ✓ | ✓ | - | ✓ |
| Region IX | ✓ | ✓ | - | - | ✓ |
| Region X | ✓ | ✓ | ✓ | - | ✓ |
| Region XI | ✓ | ✓ | ✓ | - | ✓ |
| Region XII | ✓ | ✓ | ✓ | - | - |
| CARAGA | ✓ | ✓ | ✓ | - | ✓ |
| ARMM | - | ✓ | ✓ | - | - |

*Source of data*: DA

**Table 4: Regions Affected by Droughts in the Philippines, 2007-2011**

| Region | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| CAR | ✓ | - | - | - | - |
| Region I | ✓ | - | - | ✓ | - |
| Region II | ✓ | - | - | ✓ | - |
| Region III | ✓ | - | - | ✓ | - |
| Region IV-A | - | - | - | ✓ | - |
| Region IV-B | ✓ | - | - | ✓ | - |
| Region V | ✓ | - | - | ✓ | - |
| Region VI | - | - | - | ✓ | - |
| Region VII | - | - | - | - | - |
| Region VIII | - | - | - | - | - |
| Region IX | - | - | - | ✓ | - |
| Region X | - | - | - | ✓ | - |
| Region XI | - | - | - | ✓ | - |

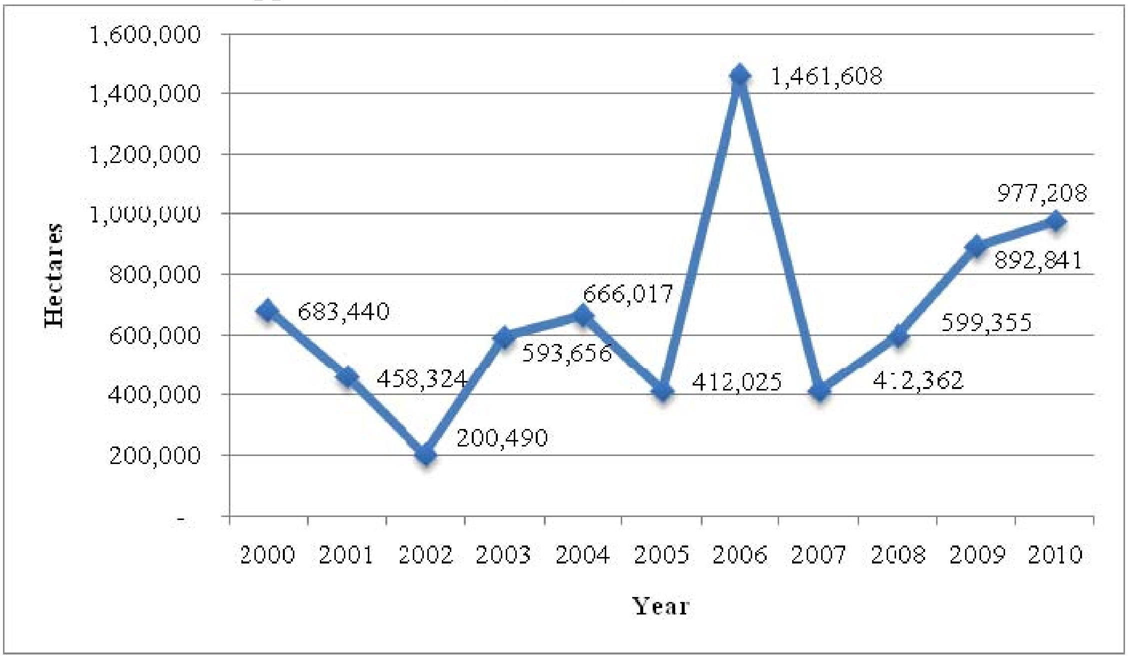
| Region | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| Region XII | - | - | - | ✓ | - |
| CARAGA | - | - | - | - | - |
| ARMM | - | - | - | ✓ | - |

*Source of data*: DA

**6.4. Impacts of Natural Disasters on Agriculture: Descriptive Analysis**

From 2000 to 2010, the national agricultural area affected by typhoons, floods and droughts in the Philippines has been trending upwards. The total area increased from 683,440 hectares in 2000 to 977,208 hectares in 2010 (Figure 2). The affected area was at its lowest in 2002 at 200,940 hectares and at its highest in 2006 at 1,461,608 hectares. There are neither available data at the regional nor the provincial levels with respect to the agricultural area affected by typhoons, floods and droughts in the Philippines

**Figure 2: Total Agricultural Area Affected by Typhoons, Floods and Droughts in the Philippines 2000-2010 (hectares)**




*Source of data*: DA.

There are few available economic studies which have investigated the effects of typhoons, floods and droughts on agriculture in the Philippines. Thus, most of the variables representing both positive and negative impacts of said disasters based on the framework of analysis presented earlier cannot be discussed at length in this paper. Of the available literature, one study (Medina, *et al*. 2009) stated that the flashfloods and mudflows due to heavy torrential rains in November 2004, particularly in the towns of Real, Infanta and General Nakar in Quezon Province, in addition to Dingalan in Aurora Province, resulted in 300,000 hectares of prime agricultural land, mainly lowland rice cultivation land, being seriously affected. In another study, Godilano (2004) identified 790,000 hectares in the Philippines which are potential sites for natural disasters and asserted that approximately 80 % of these areas fell under the jurisdiction of the agriculture sector.

From 2000 to 2010, the total value of agricultural damage, by commodity, affected by typhoons, floods and droughts in the Philippines amounted to a total of USD 2,234.21 million (Table 5). The crops with the most damage were rice, corn and high value cash crops. Other commodities recording damage included vegetables, coconut, abaca, sugarcane, tobacco, fisheries products, and livestock. While generally increasing, the total damage to agriculture decreased from 2000 to 2002, increased in 2003 to 2004, fell in 2005, rose in 2006, declined in 2007, increased in 2008 and 2009, and decreased again in 2010. The total damage to agriculture due to typhoons, floods and droughts were lowest in 2002 and highest in 2009.

Aside from agricultural commodities, agricultural facilities and irrigation incurred damage due to typhoons, floods and droughts. Damage incurred from 2000 to 2010 for agricultural facilities was valued at USD 102.39 million while those for irrigation were estimated at USD 203.31 million (Table 6). The highest level of damage for agricultural facilities occurred in 2008 while that for irrigation occurred in 2009. There was no recorded damage in 2005. There were no regional and provincial data on damage to agricultural facilities and irrigation.

Nationally, NEDA (2008) assessed the direct damage due to natural disasters and found that the average cost of direct damage from natural disasters from 1970 to 2006 to be P15 billion at 2000 prices (or USD 339.44 million), including the damage to agricultural crops, public infrastructure and private homes. GOP (2009) estimated the impacts of typhoons Ondoy (Ketsana) and Pepeng (Parma) which hit several parts of

Philippines within a span of two weeks in September and October 2009. The typhoons and the floods they caused created havoc in both the urban and rural parts of northern Luzon, particularly affecting Regions I, CAR, II, III, NCR and IVA. The study estimated that these typhoons resulted in approximately P36.2 billion (or USD 759.87 million) in immediate damage to the agriculture, fisheries, and forestry sectors in the affected areas.

**Table 5: Total Value of Damage to Agriculture due to Typhoons, Floods and Droughts in the Philippines, by Commodity, 2000-2010 (USD million)**

| Year | Rice | Corn | HVCC | Vege-tables | Coconut | Abaca | Sugar-cane | Tobac-co | Fisher-Ies | Live-stock | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 36.09 | 1.30 | 7.97 | 2.05 | 1.07 | 1.23 | 0.92 | 0.92 | 8.10 | 0.18 | 59.84 |
| 2001 | 15.79 | 10.71 | 7.04 | 1.28 | 0.00 | 0.01 | 1.45 | - | 5.01 | 1.86 | 43.14 |
| 2002 | 10.62 | 6.40 | 2.23 | 0.24 | 0.00 | - | - | - | 2.47 | 0.31 | 22.27 |
| 2003 | 24.36 | 31.29 | 7.83 | 2.29 | 0.02 | 0.01 | - | - | 4.46 | 0.90 | 71.16 |
| 2004 | 30.30 | 25.63 | 20.62 | 13.17 | 7.84 | 0.31 | - | 2.54 | 34.01 | 0.78 | 135.19 |
| 2005 | 35.26 | 44.40 | 0.59 | 0.36 | - | - | - | - | 0.11 | 0.01 | 80.73 |
| 2006 | 66.28 | 22.97 | 61.94 | 4.54 | 21.74 | 6.36 | - | 5.37 | 21.06 | 4.35 | 214.62 |
| 2007 | 40.78 | 60.30 | 8.16 | 3.85 | 0.00 | - | - | - | 1.92 | 0.06 | 115.07 |
| 2008 | 112.75 | 40.60 | 51.32 | - | 25.48 | 0.28 | 0.81 | - | 70.87 | 5.52 | 307.63 |
| 2009 | 500.47 | 29.76 | 52.57 | - | - | 1.35 | - | 0.10 | 33.53 | 1.85 | 619.62 |
| 2010 | 344.91 | 188.13 | 24.56 | - | - | - | - | - | 6.71 | 0.62 | 564.94 |
| Total | 1,217.61 | 461.50 | 244.82 | 27.77 | 56.14 | 9.53 | 3.19 | 8.93 | 188.26 | 16.45 | 2,234.21 |

*Note*: The data in pesos were converted into US dollars using average annual exchange rates taken from NSCB (2011). The average exchange rates for $1 were P44.19 in 2000, P50.99 in 2001, P51.61 in 2002, P54.20 in 2003, P56.04 in 2004, P55.09 in 2005, P51.31 in 2006, P46.15 in 2007, P44.48 in 2008, P47.64 in 2009, and 45.11 in 2010.
*Source of basic data*: DA

**Table 6: Total Value of Damage to Agricultural Facilities and Irrigation due to Typhoons, Floods and Droughts in the Philippines, 2000-2010 (USD million)**

| Year | Agricultural Facilities | Irrigation |
|---|---|---|
| 2000 | 0.01 | 0.01 |
| 2001 | 17.26 | 17.26 |
| 2002 | 0.61 | 0.61 |
| 2003 | 0.22 | 0.22 |
| 2004 | 11.35 | 11.35 |
| 2005 | - | - |
| 2006 | 25.09 | 25.09 |
| 2007 | 0.11 | 0.11 |
| 2008 | 41.94 | 38.16 |
| 2009 | 4.09 | 80.93 |
| 2010 | 1.73 | 29.59 |
| Total | 102.39 | 203.31 |

*Note*: The data in pesos were converted into US dollars.
*Source of basic data*: DA

### 6.5. Impacts of Natural Disasters on Agriculture: Econometric Analysis

In this section, the impacts of agricultural damage or losses due to natural disasters by commodity are estimated using AMPLE. As mentioned earlier, this model is capable of simulating changes in quantities of supply, imports, consumption, and exports, together with producer and consumer prices for 18 commodities. The baseline data used in the estimation is a 3-year average for the 2008 – 2010 period. In this study, AMPLE is used to simulate a counter-factual scenario in which crop losses arising from disasters are avoided at two different levels: a) complete or 100 % avoidance and b) 50 % avoidance. The differences between the counter-factual scenario and baseline data are the estimated impacts of natural disasters. Crop losses are measured as a percent of output in volume (metric tons) and, where this was not available, this was proxied by cost of production in value (Pesos) or area affected (hectares); whichever was possible based on data availability (Table 7). The crop loss counter-factual is assumed to cause an exogenous, proportional supply shift, the size of which is stated in Table 7.

**Table 7: Average Losses as a Percent of Output or Area Measure in the Philippines, by Commodity (1995-2010)**

| Item | Annual Average Loss | Annual Average Production/Cost of Production/Area | Loss (%) |
|---|---|---|---|
| Rice (Production in M.T.) | 570,531 | 13,441,901 | 4.2 |
| Corn (Production in M.T.) | 305,690 | 5,175,980 | 5.9 |
| HVCC (Cost in million P) | 2,801 | 94,267 | 3.0 |
| Vegetables (Cost in million P) | 202 | 63,721 | 0.3 |
| Coconut (Cost in million P) | 562 | 49,473 | 0.1 |
| Sugarcane (Area in Ha.) | 7,097 | 373,442 | 1.9 |
| Banana (Cost in Million P) | 84 | 46,066 | 0.2 |
| Mango (Area in Ha.) | 1,750 | 152,066 | 1.2 |
| Fisheries (Cost in Million P) | 619 | 47,655,202 | 0.0 |
| Livestock (Cost in Million P) | 90 | 139,560 | 0.0 |

*Note*: The model specifies the use of peso values.
*Source of Data*: Department of Agriculture

The results of running the counter-factual using AMPLE are shown in Tables 8 and 9, showing changes in quantity and price respectively. Since the losses as a proportion of output are small, it is not surprising that changes in quantity of output, imports, exports, and also that of prices, are commensurately minor. There are few large changes in percentage terms, but this is only due to a small base, e.g. cassava output and consumption. Thus, based on these results, it is argued that agricultural damage or losses have insignificant impacts on agricultural production and prices at the national level. The result appears to support the notion that natural disasters have little bearing when the production of the agriculture sector at the national level is taken into consideration.

It should be pointed out that the figures shown in Tables 8 and 9 may alternatively be viewed as a variation of the elasticity concept because the shocks are also stated in percentage changes (in this case, 100 % and 50 % reduction in crop losses). Unlike standard elasticities which are evaluated along a given functional relationship (e.g. a supply or demand function), however, the figures generated here may be seen as comparative static elasticities which take into account the entire set of market interactions.

**Table 8: Changes in Quantity by Commodity and Supply-Demand Component (%)**

| Item | Complete reduction | | | | 50 % reduction | | | |
|---|---|---|---|---|---|---|---|---|
| | Output | Import | Export | Demand | Output | Import | Export | Demand |
| Rice | 1.7 | 0.1 | 1.7 | 1.1 | 0.1 | 0.9 | 0.1 | 0.4 |
| White corn | 4.2 | Na | na | 4.2 | 1.9 | Na | na | 1.9 |
| Yellow corn | 2.9 | -21.4 | 19 | Na | 1.8 | -8.6 | 7.8 | Na |
| Coconut | 1.1 | Na | 0.9 | 1.5 | 2.7 | na | 3.7 | 1.2 |
| Sugar | 1.7 | -5.7 | 2.1 | 1.6 | 0.8 | -3.5 | 1.1 | 0.8 |
| Banana | 2.3 | Na | 9.1 | 0.8 | 0.4 | na | 1.8 | 0.1 |
| Mango | 0.7 | Na | 3.1 | 0.5 | 0.3 | na | 1.7 | 0.2 |
| Other fruit | 2.6 | 0 | 5.3 | 1.6 | 0.2 | 0 | -0.9 | 0.6 |
| Cassava | 7.1 | 8.3 | -9.8 | 8.6 | 6.1 | 7 | -8.4 | 7.3 |
| Vegetables | 1.5 | 1.6 | -1.4 | 1.5 | 0.8 | 0.9 | -1 | 0.8 |
| Poultry | 0.5 | 2 | -1.4 | 1.6 | 0.6 | 2.4 | -1.6 | 1.9 |
| Swine | 0.1 | 0.5 | na | 0.1 | 0.1 | 0.3 | na | 0.1 |
| Other livestock | 0.1 | 0.2 | 0 | 0.1 | -0.4 | -1.6 | 0 | -0.7 |
| Freshwater fish | -2.5 | Na | na | -2.5 | -1.8 | na | na | -1.8 |
| Brackish-water fish | -4.5 | -20.7 | -3.6 | -4.5 | -3.2 | -15.1 | -2.6 | -3.2 |
| Seaweed | 0 | Na | 0 | Na | 0 | na | 0 | Na |
| Marine fish | 1 | 3.4 | -3 | 1.1 | 0.6 | 2.1 | -1.9 | 0.7 |

*Note*: Demand denotes household food consumption; "na" or not applicable denotes items of negligible quantity.

**Table 9: Changes in Price by Commodity and Market Level (%)**

| Item | Complete reduction | | 50 % reduction | |
|---|---|---|---|---|
| | Producer | Consumer | Producer | Consumer |
| Rice | -0.4 | -0.3 | 0.2 | 0.1 |
| White corn | -7.9 | -7.9 | -4.9 | -4.9 |
| Yellow corn | -7.0 | Na | -2.9 | Na |
| Coconut | 0.0 | 0.1 | -0.2 | -0.5 |
| Sugar | -3.6 | -3.6 | -2.1 | -2.1 |
| Banana | -1.3 | -1.6 | -0.3 | -0.3 |
| Mango | -0.5 | -0.5 | -0.3 | -0.3 |
| Other fruit | -0.5 | -0.7 | 0.2 | 0.3 |
| Cassava | 9.0 | 8.7 | 7.6 | 7.4 |
| Vegetables | 1.5 | 1.3 | 0.9 | 0.9 |
| Poultry | 1.0 | 0.3 | 1.1 | 0.3 |
| Swine | 0.2 | 0.2 | 0.1 | 0.1 |
| Other livestock | 0.1 | 0.1 | -0.9 | -0.7 |
| Freshwater fish | -7.9 | -7.9 | -5.8 | -5.8 |
| Brackishwater fish | -8.7 | -8.9 | -6.3 | -6.4 |
| Seaweed | 0.0 | Na | 0 | Na |
| Marine fish | 2.0 | 2.1 | 1.3 | 1.3 |

### 6.6. Impacts of Natural Disasters on Rice Farming: Descriptive Analysis

From 2007 to 2011, the total monetary value of damage to rice farming due to typhoons in the Philippines amounted to USD1,075.28 million (Table 10). The damage increased in 2008 and 2009, decreased in 2010 and rose again in 2011. Regionally, during the same period, the highest level of damage occurred in Region III while the lowest was in the CARAGA region. Region XI did not register any damage to rice farming due to typhoons during the period. There are no available data at the provincial level.

**Table 10: Value of Damage to Rice Farming due to Typhoons in the Philippines, by Region, 2007-2011 (USD million)**

| Region | 2007 | 2008 | 2009 | 2010 | 2011 | Total |
|---|---|---|---|---|---|---|
| Philippines | 21.23 | 66.44 | 484.63 | 109.94 | 393.05 | 1,075.28 |
| CAR | 1.53 | 0.34 | 26.88 | 16.03 | 7.94 | 52.71 |
| Region I | 0.73 | 4.44 | 154.70 | 3.98 | 13.93 | 177.77 |
| Region II | 9.87 | 17.63 | 65.46 | 50.47 | 72.13 | 215.55 |
| Region III | 6.11 | 5.20 | 176.40 | 38.84 | 224.72 | 451.28 |
| Region IV-A | - | 0.50 | 19.30 | 0.26 | 3.15 | 23.22 |
| Region IV-B | 1.18 | 2.13 | 8.68 | 0.30 | 15.31 | 27.60 |
| Region V | 1.52 | 0.03 | 33.19 | 0.06 | 42.43 | 77.23 |
| Region VI | 0.01 | 24.03 | 0.00 | - | 0.06 | 24.10 |
| Region VII | 0.28 | 0.03 | - | - | - | 0.31 |
| Region VIII | - | 0.64 | - | - | - | 0.64 |
| Region IX | - | 2.46 | 0.01 | - | - | 2.47 |
| Region X | 0.00 | - | 0.02 | - | 0.66 | 0.68 |
| Region XI | - | - | - | - | 0.22 | 0.22 |
| Region XII | - | 3.96 | - | - | 7.35 | 11.31 |
| Caraga | 0.01 | - | - | - | 0.00 | 0.01 |
| ARMM | - | 5.05 | - | - | 5.15 | 10.19 |

*Note*: The data in pesos were converted into US dollars. The average annual exchange rate for $1 in 2011 was P43.30.
*Source of basic data*: DA

From 2007 to 2011, the total value of damage to rice farming due to floods in the Philippines amounted to USD115.32 million (Table 11). The damage increased in 2008, decreased in 2009, rose in 2010 and fell in 2011. Regionally, the highest level of damage occurred in Region II while the lowest was in Region VII. CAR, Region I and Region IV-A did not register any damage to rice farming due to floods during the period. There are presently no available data at the provincial level.

**Table 11: Value of Damage to Rice Farming due to Floods in the Philippines, by Region, 2007-2011 (USD million)**

| Region | 2007 | 2008 | 2009 | 2010 | 2011 | Total |
|---|---|---|---|---|---|---|
| Philippines | 5.27 | 42.64 | 15.52 | 31.00 | 20.89 | 115.32 |
| CAR | - | - | - | - | - | - |
| Region I | - | - | - | - | - | - |
| Region II | - | 5.68 | - | 25.52 | 1.85 | 33.05 |
| Region III | - | 0.16 | - | 0.49 | - | 0.66 |
| Region IV-A | - | - | - | - | - | - |
| Region IV-B | - | 0.83 | - | 2.68 | 0.89 | 4.40 |
| Region V | 0.83 | 17.52 | 2.29 | - | 3.33 | 23.97 |
| Region VI | 1.70 | 4.95 | 1.80 | 2.30 | 1.27 | 12.02 |
| Region VII | - | - | 0.00 | - | - | 0.00 |
| Region VIII | 0.62 | 5.77 | 0.09 | - | 9.55 | 16.02 |
| Region IX | 0.01 | 3.85 | - | - | 1.59 | 5.45 |
| Region X | 0.03 | 0.01 | 0.17 | - | 0.86 | 1.07 |
| Region XI | 1.00 | 0.03 | 0.45 | - | 0.74 | 2.21 |
| Region XII | 0.58 | 0.83 | 5.02 | - | - | 6.43 |
| Caraga | 0.52 | 1.76 | 3.06 | - | 0.82 | 6.15 |
| ARMM | - | 1.26 | 2.64 | - | - | 3.90 |

*Note:* The data in pesos were converted into US dollars.
*Source of basic data*: DA

From 2007 to 2011, the total value of damage to rice farming due to droughts in the Philippines amounted to USD 217.52 million (Table 12). The damage increased in 2008 and 2009, increased in 2010, and fell again in 2011. Regionally, the highest level of damage occurred in Region II while the lowest was in Region IX. CAR, Region VII, Region VIII and the CARAGA Region did not register any damage to rice farming due to droughts during the 2007-2011 period. There are no available data at the provincial level.

**Table 12: Value of Damage to Rice Farming due to Droughts in the Philippines, by Region, 2007-2011 (USD million)**

| Region | 2007 | 2008 | 2009 | 2010 | 2011 | Total |
|---|---|---|---|---|---|---|
| Philippines | 13.84 | - | - | 203.68 | - | 217.52 |
| CAR | 1.59 | - | - | - | - | 1.59 |
| Region I | 1.68 | - | - | 3.57 | - | 5.26 |
| Region II | 8.43 | - | - | 74.33 | - | 82.76 |
| Region III | 1.15 | - | - | 18.74 | - | 19.89 |
| Region IV-A | - | - | - | 11.16 | - | 11.16 |
| Region IV-B | 0.57 | - | - | 23.87 | - | 24.44 |
| Region V | 0.42 | - | - | 17.23 | - | 17.65 |
| Region VI | - | - | - | 32.73 | - | 32.73 |
| Region VII | - | - | - | - | - | - |
| Region VIII | - | - | - | - | - | - |
| Region IX | - | - | - | 0.48 | - | 0.48 |
| Region X | - | - | - | 4.51 | - | 4.51 |
| Region XI | - | - | - | 1.78 | - | 1.78 |
| Region XII | - | - | - | 14.11 | - | 14.11 |
| Caraga | - | - | - | - | - | - |

| Region | 2007 | 2008 | 2009 | 2010 | 2011 | Total |
|---|---|---|---|---|---|---|
| ARMM | - | - | - | 1.17 | - | 1.17 |

*Note*: The data in pesos were converted into US dollars.
*Source of basic data*: DA

### 6.7. Impacts of Typhoons on Rice Farming: Econometric Analysis

Data on the occurrence of typhoons at the provincial level in the Philippines between the years 2001 and 2010 are available and together with provincial data on palay (unprocessed rice) production and palay prices, a regression analysis was conducted to assess the impact of typhoons on provincial rice production. The first deterministic equation employed is as follows:

$$QS_{i,t} = \beta_0 + \beta_1 QS_{i,t-1} + \beta_2 p_{i,t-1} + \beta_3 typh_{i,t} + \beta_4 t$$

Where *i*, *t* are indices for the provinces and years covered, respectively; *QS* denotes palay output; *p* denotes palay price; *typh* denotes number of typhoons; *t* denotes technological change and the $\beta$'s denote coefficients. Effectively, the aforementioned is a supply equation incorporating response lags for output and price; the *t* incorporates technological change. Of interest is the coefficient $\beta_4$, which shows the effect of typhoons on quantity of provincial palay production. Given the panel nature of the data for 2001-2010, both the random and fixed effects regressions were estimated (Table 13).

Under the random effects regression, the coefficient for number of typhoons is negative and significant at the 1 to 5 % level. Each typhoon, on average, controlling for other supply conditions, reduces provincial output by over one thousand tons of palay. Under the fixed effects regression, on the other hand, the coefficient for the number of typhoons is insignificant even at the 1 to 5 percent level. Nonetheless, the results, particularly those based on the assumption of random effects, indicate that at the provincial level, typhoons may have significant and negative impacts on palay production which appears to be consistent with past studies (Loayza, *et al*. 2009, Sivakumar, 2005).

**Table 13: Results of Panel Regression on Provincial Palay Production in the Philippines**

| | Random effects | | Fixed effects | |
|---|---|---|---|---|
| | Coefficient | z-value | Coefficient | t-value |
| Lagged quantity | 1.02** | 171.7 | 0.6** | 17.6 |
| Lagged price | -3,006.7* | -2.5 | -4,224.1** | -2.9 |
| Number of typhoons | -1.111.1* | -1.8 | -409.1 | 0.6 |
| Year | 964.1 | 1.02 | 4,915** | 4.6 |
| Constant | -1,897,108 | -1.02 | -,728,307** | -4.6 |

*Note*: * means t-value or z-value is between 0.01 to 0.05 level of significance and ** means t-value or z-value is below 0.01 level of significance.

Another alternative equation is estimated to take typhoon intensity into account. The deterministic form the equation is as follows:

$$QS_{i,t} = \beta_0 + \beta_1 A_{i,t} + \beta_2 p_{i,t-1} + \beta_3 typh2_{i,t} + \beta_4 typh3i,t + \beta_5 t$$

where *A* is a control variable for level of production input, *p* denotes paddy price averaged over the last quarter of the year, *typh2* denotes a dummy variable for incidence of at least one typhoon with an intensity of signal number 2 or more; *typh3* denotes a dummy variable for incidence of at least one typhoon with an intensity of signal number 3 or more and the other variables are defined as before. The dummy variable representation of typhoons specified above places greater emphasis on intensity of typhoons (a higher signal number denoting higher intensity) rather than the simple incidence or number of typhoons hitting a particular province in a particular year. Effectively, the aforementioned is a supply equation incorporating response lags for price, together with a control variable for level of production input (in this case reduced to land). The lagged last quarter price is used based on adaptive expectations, i.e. the farmer uses the previous quarter's price as an estimate of the current cropping season price, as a basis for planting decisions. Of interest is the coefficients $\beta_3$ and $\beta_4$ which show the effect of typhoons on quantity of provincial palay production. Again, given the panel nature of the data for the period 2001-2010, both random and fixed effects regressions were estimated (Table 14).

Under the random effects regression, the coefficient for signal number 2 dummy is negative and significant at the 1 to 5 percent level. This implies that the incidence of at least one typhoon with an intensity of signal number 2 or more, controlling for other supply conditions, reduces provincial output by over eight thousand tons of palay. Similar results are obtained under the fixed-effects regression. Somewhat anomalous is the sign of the coefficient for signal number 3 dummy for either regression method although the coefficients are not significant. These results again indicate that, at the provincial level, typhoons may have significant and negative impacts on palay production.

### 6.8. Impacts of Natural Disasters on Food Security

It was indicated in the foregoing analysis that at the national level, typhoons, floods and droughts do not significantly impact agricultural production and prices. Hence, based on food affordability alone, these disasters may have little effect on food security at that level. On the other hand, it was also estimated beforehand that typhoons have a significant and negative effect on rice production at the provincial level. Therefore, based on rice availability alone, typhoons may have diminished food security at that level.

**Table 14: Results of Panel Regression on Provincial Palay Production in the Philippines**

| | Random effects | | Fixed effects | |
|---|---|---|---|---|
| | Coefficient | z-value | Coefficient | t-value |
| Area | 0.0** | 2.80 | 0.0** | 3.17 |
| Lagged last quarter price | -3.6** | -5.26 | -3.5.** | -5.13 |
| Dummy: Signal 2 | -8.3* | -2.11 | -8.4* | -2.13 |
| Dummy: Signal 3 | 6.7 | 1.65 | 6.6 | 1.63 |
| Year | 7.0** | 11.12 | 6.9** | 10.89 |
| Constant | -13,843.5** | -11.02 | -3,597.9** | -10.79 |

*Note*: * means t-value or z-value is between 0.01 to 0.05 level of significance and ** means t-value or z-value is below 0.01 level of significance.

At present, there is a paucity of research actually quantifying the impacts of natural disasters on food security in the Philippines. An exception is the WFP (2009) which conducted a study on typhoons Ondoy (Ketsana) and Pepeng (Parma) including their impacts on food security at the household level. The study found that as a coping strategy to adapt to the effects of Ondoy and Pepeng, the most frequently reported consumption coping mechanism, used by 79 % of the households surveyed, was to rely less on preferred or expensive food (Table 15). The least used consumption coping strategy, adopted by 5 % of the households, was sending family members outside for food. On the other hand, the most common non-consumption coping mechanism, used by 15.1 % of households, was selling labor in advance, while the least utilized was the selling of household and agricultural assets for food, a mechanism used by just 5.2 % of households.

The results of the aforementioned study indicate that, particularly at the household level, natural disasters may have a significant impact on food security. They also show that households differ in their consumption and non-consumption strategies to cope with their difficult food security situation. They further indicate that non-consumption strategies to address their food needs were practiced by households, although not as commonly as consumption strategies.

**Table 15: Consumption and Non-consumption Negative Coping Strategies Adopted by Households Affected by Typhoons Ondoy and Pepeng, 2009 (% of households)**

| Coping Strategies | Northern regions (I, CAR, II) | Region III | NCR | Region IV-A | Overall |
|---|---|---|---|---|---|
| *Consumption coping strategies* | | | | | |
| Eating less preferred food | 42 | 95 | 94 | 82 | 79 |
| Borrowing food from neighbours/friends | 44 | 33 | 55 | 34 | 37 |
| Buying food on credit | 53 | 46 | 50 | 54 | 51 |
| Eating wild/gathered food | 45 | 39 | 10 | 21 | 33 |
| Reducing meal portions | 31 | 34 | 32 | 50 | 39 |

| Coping Strategies | Northern regions (I, CAR, II) | Region III | NCR | Region IV-A | Overall |
|---|---|---|---|---|---|
| Reducing number of meals by children | 4 | 10 | 33 | 16 | 12 |
| Reducing number of meals by adults | 13 | 45 | 46 | 35 | 34 |
| Skipping meals for the whole day | 7 | 20 | 26 | 13 | 15 |
| Sending family members outside for food | 3 | 2 | 15 | 9 | 5 |
| *Non Consumption Coping Strategies* | | | | | |
| Out-migration | 5.2 | 4.3 | 18.2 | 15.3 | 9.1 |
| Selling Labour in Advance | 18.5 | 2.4 | 26.3 | 23.4 | 15.1 |
| Taking children out of school | 2.2 | 0.5 | 20.6 | 10.7 | 5.7 |
| Selling of household assets for food | | 1.0 | 13.3 | 12.8 | 5.2 |
| Selling Agricultural Assets for food | 10.4 | 5.3 | | 2.5 | 5.2 |

*Source*: WFP (2009)

## 6.9. Impacts of Natural Disasters on the Natural Resources and Environment

Limited available data and information also preclude a quantitative evaluation of the negative impacts of natural disasters on the natural resources and the environment of the Philippines. Thus, a descriptive and generally qualitative assessment is instead conducted below based on past research.

### *6.9.1. Soil Erosion*

The water-related natural factors that influence the rate of soil erosion are rainfall, vegetative cover, slope of the land, and soil erodibility (Asio, *et al*. 2009). Due to its wet tropical climate, the Philippines has a comparatively high average annual rainfall. It also has a rugged and mountainous topography with large sections having a gradient of more than 18 %. These and other natural factors such as wind, and man-made factors such as slash and burn agriculture, all contribute to soil erosion. The little available evidence on the actual impact of natural disasters on soil erosion in the

Philippines is site-specific and anecdotal. In particular, Medina, *et al*. (2009) mentioned that in 2004, flashfloods and mudflows resulting from heavy torrential rains induced mountain soil erosion, landslides and the overflowing of river systems in the provinces of Quezon and Aurora in Luzon.

*6.9.2. Reduced Rainfall*

Typhoons increase rainfall while droughts decrease it, but on the net it has been projected that there will be decreases in the average annual rainfall by the year 2020 in most parts of the Philippines, except in Luzon where either an increase or no change in rainfall is projected (MO-COMSTE, 2010) It was also foreseen that by 2050, Visayas and Mindanao will be drier than normal, as will most of the western part of Luzon. Clearly then, typhoons may increase rainfall at the times they occur and places they affect, but over time and for the country as a whole, average rainfall is expected to decrease. An important water resources-related negative effect of reduced rainfall is a concomitant reduction in the country's hydropower supply.

*6.9.3. Siltation and Sedimentation*

Silts and sediments caused by floods tend to clog rivers, lakes, drainage systems, reservoirs, dams, irrigation canals and other inland water bodies. This in turn reduces the viability of these water resources for economic activities such as fishing, aquaculture, water storage, irrigation, water recreation, water transportation and many others. Similarly, siltation and sedimentation of coastal areas damage mangroves, coral reefs, sea grasses, estuaries, beaches and other marine ecosystems, rendering them less viable as providers of ecosystem goods and services for the population.

No study, however, has quantified the impacts of floods in terms of inland and coastal siltation and sedimentation in the Philippines, although the impacts of siltation and sedimentation have been investigated. GOP (2009a) mentioned that the existing infrastructure that protects Manila and other populated areas in nearby Laguna Lake has been inadequate and has not been properly maintained. As a result, the siltation and sedimentation and other unwelcome impacts of the floods generated by Ondoy in 2009 had severe consequences for people living near the Marikina River and adjacent areas.

*6.9.4. Reduced Tree and Vegetative Cover*

Because of the strong winds and water currents they carry, typhoons and floods typically flatten or uproot trees. The siltation and sedimentation produced by floods also cover grasslands and other ground-level and below-water vegetation. In a similar vein, because of the length of time that it is exposed to intense sunlight, ground vegetation withers or dies during droughts. No study has quantitatively measured the effects of typhoons, floods and droughts on trees and other vegetation in the Philippines. Mjoes (2005) mentioned that in 2004, the Philippines experienced two typhoons and two tropical storms which resulted in considerable damage including a significant number of trees being brought down.

*6.9.5. Reduced Soil Fertility*

Droughts reduce soil fertility because higher temperatures reduce soil moisture, water storage capacity and overall soil quality. There is also no study that has quantified the effects of droughts on soil fertility in the Philippines. Mitin (2009) mentioned that Ilocos Norte was one of the provinces worst hit by the drought in Northern Luzon in 2007 along with Ilocos Sur, La Union and Pangasinan. It further explained that before the dry spell hit, Ilocos Norte in particular had high sufficiency levels of rice, corn, garlic, and onions.

*6.9.6. Accumulation of Wastes and Water Pollution*

Flood water currents carry all sorts of wastes that are then dumped into catchment areas. These wastes in turn pollute surface and ground water, including that used for drinking and sanitation. There is also no available study at present that quantifies the impact of floods on waste accumulation and water pollution in the Philippines. ADPC (2008) stated that while the riverbanks in Marikina City, Metro Manila used to be a site of religious celebrations in the past the river has been seen only as a site of filth and stench at present. Uncontrolled encroachment on the riverbanks by informal settlers, structures within the river, and the indiscriminate disposal of both domestic and industrial wastes have worsened the impacts of annual flooding from the Marikina River. GOP (201) also mentioned that about 50 % of the wells monitored by the Environmental Management Bureau (EMB) in 2005 were found to be contaminated with fecal coli forms and that Regions II and Region VI, which were seasonally-arid and drought-prone areas, had the highest number of contaminated sites.

*6.9.7. Saltwater Intrusion*

Demand for freshwater during periods of drought is higher than normal and this in turn may lead to higher rates of groundwater withdrawal. If the withdrawal rate is faster than the replenishment rate in a coastal area, seawater may be pulled into the freshwater aquifer resulting in the increased salinity of the groundwater. On a more temporary scale, high tides and storm surges caused by typhoons may also cause saltwater intrusion. The World Bank Group (2011) mentioned that during El Niño events, among the significant pressures on the freshwater resources in the coastal areas of the Philippines is saltwater intrusion. Citing past studies, GOP (2010) reported that saltwater intrusion in the country was evident in nearly 28 % of coastal municipalities in Luzon, 20 % in the Visayas and 29 % in Mindanao.

*6.9.8. Higher Coastal Tides and Storm Surges*

Floods and typhoons bring in a lot of rain that may raise coastal tides beyond normal levels, whilst strong winds from typhoons potentially drive huge wave surges into the coastal areas. The effects of rising coastal tides and strong storm surges have been devastating at times to people residing close to the water's edge. The World Bank Group (2011) stated that the Philippines is particularly vulnerable to rises in sea level and storm surges as about 60 % of its municipalities and 10 of its largest cities are located along the coasts. Four Philippine cities also ranked among the top 10 East Asian cities likely to be affected by sea level rises and storm surges. In particular areas, it has been projected that a 1.0 meter rise in sea level will inundate more than 5,000 hectares of land in 19 municipalities of Manila, Bulacan and Cavite (Capili, *et al*. 2005). The worst-case scenario of a 2.0 meter rise is expected to aggravate riverine flooding in most of the tributaries of Manila Bay, especially the Pampanga and Pasig rivers.

*6.9.9. Deformed Land Topography*

Below water level, floods deposit silts and sediments, thus raising the elevation of the soil beds and making the affected rivers and water bodies shallower than before. Above ground, floods level land areas and reduce their economic and aesthetic value.

Because they deposit so much soil both under water and on land, floods elevate the level of the soil, thus requiring substantial excavation or dredging to bring the area back to its original state. There has been no study conducted in the Philippines that quantitatively evaluates the impacts of floods on the land topography and the subsequent effects on land value.

*6.9.10. Reduced Viability of Ecosystems*

Typhoons, floods and droughts also constitute a threat to the health and survival of forests and other terrestrial ecosystems. It has been projected, for instance, that if the climate projections showing drier conditions in most regions of the Philippines actually materialize, the size of dry forests will decrease (MO-COMSTE, 2010). In line with this loss of forest cover will be the loss of existing and possibly yet to be discovered flora and fauna that constitutes the terrestrial biodiversity of the Philippines.

As well as negative aboveground effects, droughts also tend to negatively impact marine ecosystems. Rising temperatures coupled with the rising carbon dioxide levels in the atmosphere cause coral reef bleaching, or the chalky appearance coral takes on when it dies (MO-COMSTE, 2010). The destruction of coral reefs reduces marine biodiversity which is critically important for the ecological balance and productivity of marine ecosystems. It has been reported that the El Niño episode which occurred in1997 and 1998 in the Philippines, decreased the coral cover ranging from 46% to 80% in Bolinao, Pangasinan (GOP, 2010). Other areas affected included Batangas, other parts of Northern Luzon, West Palawan, and parts of the Visayas. In addition to droughts, floods could inundate mangrove, coral reef and sea grass areas along the coast, making them less viable as important providers of ecosystem goods and services to both the economy and environment.

The total value of the ecosystem goods and services provided by coral reefs, mangroves and seagrass nationally in the Philippines was estimated at about USD116.2 million in 2006 (Table 16). Although the exact level of damage directly caused by previous typhoons, floods and droughts on coastal ecosystems has not been measured as yet, it is clear that the marine resources provide significant economic and social benefits to the country as a whole.

**Table 16: Value of Net Benefits from Coral Reefs, Mangroves and Sea Grass Ecosystems in the Philippines, 2006**

| Coastal Ecosystem | Net Benefits Per Hectare (USD) | Total Net Benefits (USD million) |
|---|---|---|
| Coral Reefs | 28.98 | 78.25 |
| Mangroves | 172.66 | 36.11 |
| Seagrass | 17.95 | 1.76 |
| Total | 219.59 | 116.12 |

*Note*: The data in pesos were converted into US dollars.
*Source of data*: Padilla (2009)

*6.9.11. Endangered Human Health and Safety*

Overcrowding, inadequate water supply and sanitation, and poor access to health services following the sudden displacement of an affected population after the occurrence of natural disasters increase the risk of communicable transmission of diseases (WHO, 2006). These diseases include water borne diseases such as diarrhea, hepatitis, and leptospirosis; diseases associated with overcrowding such as measles, meningitis, and acute respiratory infections; vector-borne diseases such as malaria and dengue fever; and other diseases like tetanus, coccidiomycosis and mental health problems. Other health and safety-related impacts, particularly with respect to typhoons and floods, include injuries or even death due to falling trees and debris, electrical exposure and similar accidents.

It is projected that the displacement of families living in natural disaster-prone areas in the Philippines will be a public health challenge that will become more frequent in the coming years (MO-COMSTE, 2010). A decline in the volume of groundwater will heighten water-related disputes and increasingly expose the population to water-borne diseases. In addition, health-related facilities and infrastructure could be severely damaged under increased frequency and intensity of severe weather events (PAGASA, 2011). Studying the flood hazards in Metro Manila, Zoleta-Nantes (2000) asserted that the economic losses due to floods escalated through time and health-related risks such as dengue fever, diarrhea-related diseases, unsanitary conditions, and water contamination levels were high.

## 7. Summary and Conclusion

This study quantitatively and qualitatively analyzed the impacts of typhoons, floods and droughts on agriculture, food security and the natural resources and environment in the Philippines using available secondary data. In general, the study found that: a) typhoons, floods and droughts have an insignificant impact on overall agricultural production at the national level, yet typhoons may have a significant negative impact on paddy rice production at the provincial level; b) typhoons, as exemplified by Ondoy and Pepeng in 2009, have a significant negative impact on the food security of the households in the affected areas; c) households have varying consumption and non-consumption strategies to cope with the impacts of typhoons; and d) the different impacts of typhoons, floods and droughts on the natural resources and environment have not been quantitatively assessed in detail, however available evidence suggests that these are also substantial.

## 8. Recommendations

### 8.1. Recommendations

Recent studies undertaken in this field have provided strategies to address the impacts of: climate change on agriculture and the natural resources and environment (The World Bank Group 2011, MO-COMSTE 2010); climate change on the coastal natural resources and environment (Capili, *et al*. 2005); natural disasters on overall and sub-national development (NEDA, 2008, WB and NDCC, n.d .); typhoons on agriculture and the natural resources and environment (GOP, 2009, 2009a); typhoons on food security (WFP, 2009); and droughts on agriculture and the natural resources and environment (GOP, 2010). The recommendations made by these works should be seriously reviewed and considered by the government.

Based on its results and findings, the study recommends the following: a) Since typhoons may have significant negative impacts on rice production at the local level as opposed to the national level, assistance for rice farmers and the agriculture sector as a whole should be made more site-specific, zeroing in on the affected areas that actually need it; b) Those assisting affected households and areas in overcoming the resulting ill-effects of natural disasters should consider not only consumption strategies, such as the provision of emergency food aid, but also non-consumption strategies, such as the provision of post-disaster emergency employment; and c) While the available evidence suggests that the natural resources and environment sector is significantly affected by natural disasters, it is currently less considered, as attention is presently focused on agriculture. It may now be high time to provide concrete assistance to this sector, in particular the provision of defensive investments and rehabilitation expenditures to cope with these natural disasters.

### 8.2. Areas for Future Research

Based on the results and findings of the study, the potential topics for future economic research on the impacts of natural disasters on agriculture, food security and the environment in the Philippines are as follows: a) economic analysis of the impacts of natural disasters in disaster-prone local areas such as the identified typhoon belts; b) economic analysis of the defensive investments and rehabilitation expenditures needed for the natural resources and environment in ecologically sensitive and disaster-prone areas; c) analysis of the health and other social impacts of natural disasters in disaster-prone local areas; and d) detailed analysis of the impacts of natural disasters on food security at the household, local and national levels.

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# CHAPTER 16

# Emerging 'Agricultural Involution' in Indonesia: Impact of Natural Hazards and Climate Extremes on Agricultural Crops and Food System

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*The nature of does nothing in itself to stimulate the growing of agricultural crops but it can insure the non-growing of them (Geertz, 1963). The non-growing and loss of crops due to biophysical and geophysical processes have been interpreted as risks and catastrophes that human being need to anticipate. This paper asks: what were the impacts of natural catastrophes on Indonesian agricultural crops during the last four decades? And what are the options available to mitigate future agriculture loss and safeguard food production in Indonesia? The quantitative analysis is based on two national datasets from Indonesia, namely the Disaster Loss data from Agricultural Statistics produced by the Ministry of Agriculture in 2009 and an online disaster database from the National Disaster Management Office updated in March 2012. This research concludes that Indonesia can achieve better food production by adopting multi-loss mitigation scenarios. The chapter further highlights the impact of climate change on Indonesian agriculture, and existing policy instruments concerning disaster risk reduction in agricultural sectors. In addition, it makes policy recommendations for the Indonesian government and the international community regarding alternative solutions towards agricultural resilience.*

***Keywords***: Agricultural crop, Rice, Corn, Risk management, Disasters, Climate change, Indonesia, Agricultural resilience, Food system.

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# 1. Introduction

The Indonesian population has increased from 94 million people in 1960 to about 239 million people in 2010 (FAO 2012). The United Nations estimates that the Indonesian population will be about 293 million people in 2050.[1] The question is: "How can Indonesia feed its population in the next 50 years?" This question had been partly posed 50 years ago. Fortunately, a Malthusian crisis did not really happen (or has not yet happened) mainly because of two factors: First, Indonesia has been adopting the technological changes required for better yields year-on-year during the last 50 years. Secondly, it has been expanding production areas significantly over the last five decades.

In retrospect, Indonesia has been expanding its agricultural land area to anticipate the increasing need for food. The island of Java, as the largest contributor of rice production in the country has reached its limit for agricultural expansion. Therefore the government has recognized the need to open up new areas for food production. The total area of rice cultivation In Indonesia in 1960 was 6.4 million hectares (ha). It had reached 13.2 million ha in 2010.

Over the last 50 years, the average annual growth rate of harvested areas was 2%, while the population grew on average by 3% (calculated from 1960 to 2010 – however, over the last decades, it has been consistently growing at 1.5%). In absolute terms, the Indonesian agricultural population has moved from 80.8 million (54%) in 1980 to 89.6 million (37%) in 2010. Over the past five decades, however, rice yields increases significantly from 1.76 (1960) to 5.01 ton/ha in 2010 – with an average annual rate of 4%. A similar trend occurred in maize production, which grew from 2.45 million ha of cultivated land in 1960 to 4.1 million in 2010 (or a 1% annual rate). Positive progress was also seen in the maize yield, which increased from 0.93 ton/ha in 1960 to 3.51 ton/ha (or an 8% annual rate - See Figure 1).

Agricultural land covers 26.4% of Indonesia's area (Förster, *et al*. 2011) of which, in 2012, rice and corn areas are respectively 7% and 2%. Geertz (1963) made a classical division of Indonesian agriculture into two types of ecosystem. The first is the sawah system (or rice system) and the second is the swidden system of

[1]See http://esa.un.org/unpd/wpp/unpp/panel_population.htm [last access 21 Mar 2012]

agriculture. The first is mainly located in the islands of Java and Madura. Swidden agriculture is seen in the 'outer islands' such as Sumatra, Kalimantan, Sulawesi, Nusa Tenggara, Papua and Maluku. In 1956, 63% of Indonesia's rice and 74% of its maize were produced in Java (Geertz 1963:13). Today, Java still maintains its domination in the main crops by producing 60% of Indonesian rice and 51% of maize. Sumatra, Kalimantan and Sulawesi respectively accounted for 24%, 8%, and 12% of Indonesia's total rice production in 2008.

What should be noted is that Java's domination in rice production is led by higher yields. Java's share of Indonesia's overall cultivated area is only 47% in the case of rice, and 58% in maize. Lower yields occur in Sumatra, Kalimantan and Sulawesi where the areas of rice cultivation in 2008 were 26%, 11%, and 11% respectively of Indonesia's total (Ministry of Agriculture, 2009).

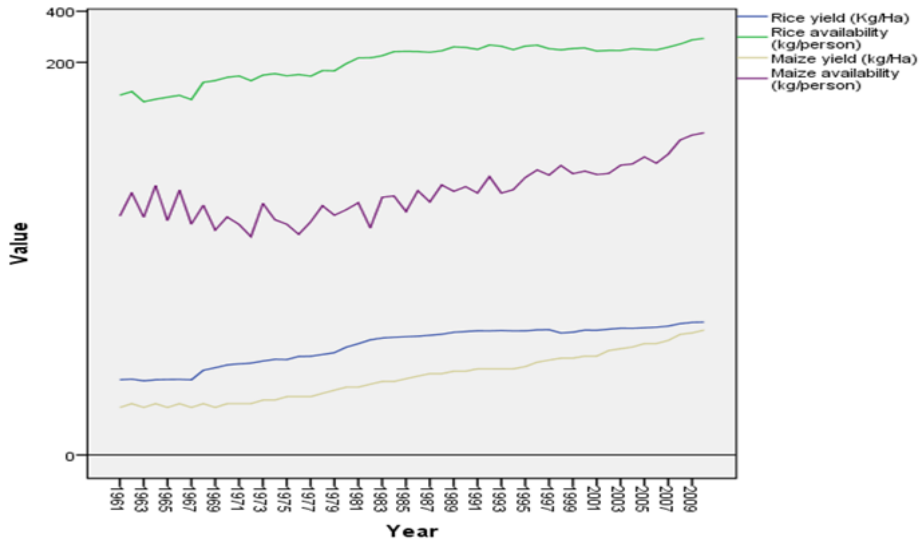
The question posed is whether expanding the agricultural area and raising rice yields are the only ways to increase production, given the fact that the yield growth may have its limit. There are gaps in yields between Java Island and the 'outer islands', where increasing yield in the 'outer islands' may always be a legitimate option. Land expansion may not always be the best alternative, but it has been government's key policy in boosting agricultural production.

What, therefore, are the conditions for future sustainability of Indonesian agriculture, especially in the context of changing climate and increasing catastrophic risks? Academic work on conditions for agricultural growth has barely considered the mitigation of natural catastrophe risk. For instance, Boserup's (1965) "conditions for agricultural growth" hardly considered natural hazards in agriculture. This paper argues for the need to face the challenges of the second wave of "agricultural involution" in Indonesia. The first phase of agricultural involution is defined by Geertz (1963) as Indonesian's reluctance to adopt technological change which eventually led to stagnation in production (as compared with Japan from the late 19th century and prior to the 1960s). In other words, there had been huge production opportunity loss as a result of late adoption of technology offering increased production.

Geertz (1963) defines 'agricultural involution' as a phenomenon where Indonesian agricultural growth was once dominated by high labor intensiveness (driven by population change) rather than the adoption of technological change (innovation) addressing market demands for agricultural crops. Geertz predicted that Indonesia's rice production would decline as a result of delays in adopting necessary agricultural innovation. Later on, researchers found that Geertz's prediction was not accurate (See Booth 1989). However, this paper argues that Geertz (1963) has shed light on the impact of hazards and risks on the conditions for sustainable growth of agriculture. Geert's emphasis on ecological change has its merits in today's discourse around risk management and natural catastrophes, as he highlighted some flood problems in regards to agriculture and irrigation management.

When natural hazards hit an agricultural area, the livelihoods of the people will be at risk. Recent experiences from Jogjakarta, Aceh, Nias Island and West Sumatra (Indonesia), where geological processes such as earthquakes, tsunamis and volcanoes have significantly affected agricultural production, exemplify this point. For instance, the 2005 earthquakes in Nias Island (North Sumatra, Indonesia) caused damage to the local irrigation infrastructure. Sisobambowo community in Nias called this phenomenon 'drought' not because there was less rainfall, but because of the disruption in rice production during the last 7 years due to the damage caused to irrigation systems during the earthquakes. Personal observation from Sisobambowo in 2011 suggests that the rate of production has been declining since 2005. Similar experiences have also recently been seen in the post disaster areas in many Indonesian islands.

**Figure 1: Rice and Maize Production and Availability in Indonesia: 1980-2010**




*Source*: Author. Data from Agricultural Statistics 2003-2008 and FAO Statistics.

The Indian Ocean Tsunami of 2004 that hit Aceh Province (Indonesia) claimed about 170,000 lives. The reported impact of the tsunami on the agricultural sector (FAO 2012) was that "92,000 farms and small enterprises have been partially or wholly destroyed. Prior to the disaster, these enterprises provided employment for approximately 160,000 people."[2] About 600,000 men and women in Aceh and Nias (or about one quarter of the total working population), lost their livelihoods as a result of the disasters. On the West Coast of Aceh, about 17,500 ha experienced high damage where reorientation of land use is suggested. In addition, about 2,900 ha agricultural land on the West Coast of Aceh was permanently lost to the sea.

Climate change may have also adversely affected agricultural crops such as rice. Naylor, *et al*. (2002) predicts that for every 1°C change in May-August SSTAs (sea surface temperature anomalies), Indonesia rice production varies on average by 1.4 million tons. Research at the International Rice Research Institute in the Philippines suggests that for every 1°C increase in the minimum temperature, rice yields decrease by 10% (Naylor, *et al*. 2007; Peng, *et al*. 2004).

There is a lack of long term agricultural loss data arising from the impact of natural hazards. Data are either unavailable or inadequate to suggest sound policy prescriptions for risk/loss reduction in the agricultural sector. The impact of natural hazards on the agriculture sector is not comprehensively covered in the literature. It is therefore timely to assess the impact of disasters on agricultural sectors in Indonesia, in order to understand how to reduce losses in agriculture.

This chapter asks: what are the impacts of disasters and climate hazards on Indonesian agricultural and food crops? And what are the options available to mitigate future agriculture losses so as to safeguard food security? The objectives of this research include: First to understand the impact of natural catastrophes on food crops and crop production in Indonesia. This involves loss assessment at the national scale. Second, it is to highlight the impact of climate change on Indonesia agriculture, based on existing literature and data. This chapter highlights existing policy instruments concerning disaster risk reduction in agriculture sectors. In addition, it suggests policy recommendations for the Indonesian government and

[2] See http://www.fao.org/ag/tsunami/assessment/assess-damage.html [last access 19 Mar 2012].

international communities regarding alternative solutions towards less risky and more resilient production of agricultural crops.

The rest of the chapter is structured as follows. The next section discusses the conceptual frameworks of agricultural development and risk management. Section 3 provides methods for data collection. Section 4 discusses the results of loss assessment of disaster impacts on Indonesian agriculture since the 1970s. Section 5 briefly highlights the impact of climate change on Indonesian agriculture, based on a recent literature survey and secondary data. Section 6 provides the overall institutional and disaster risk management policy setting, and highlights institutional gaps in managing agricultural risks (ex-ante and ex-post scenario) in Indonesia. Section 7 concludes the chapter.

## 2. Conceptual Framework: Agricultural Development and Disasters

### 2.1. Agricultural Development and Risk Management

Mitigation of natural catastrophe is one of the conditions for the sustainability of agricultural development elsewhere in the planet under pressure. Nature (e.g. the physical climate and environmental processes) does nothing in itself to assist the growing of agricultural crops but it can ensure the non-growing of them (Geertz, 1963). This implies that physical climate does nothing to sustain agricultural crops but it can render the growing of the crops unsustainable.

Rainfall, temperature and wind force are among the climate variables that may transform the biophysical world into hazards such as drought (when it is too hot and dry) or floods (when it is too wet). Risk is embedded in climate variability and agriculture is prone to certain climate risks. The climate dependency of an agricultural crop makes it is more likely to be impacted by the increased warming, sea level rise and changing precipitation patterns (Naylor and Mastrandrea 2010; Förster, *et al*. 2011). In addition, depending on the risk context, the agriculture sector may have been exposed to multiple hazards and risks may accumulate over the years.

Literature concerning the impact of natural catastrophes on the agricultural sector has highlighted the differences in risk reduction between nations. Developed countries have reduced their agricultural risks more effectively than developing nations. The latter have been struggling with the mitigation of agricultural risks. A previous exploratory study on this topic was pioneered by Frank Long (1978) who argues that the attempts to provide food self-sufficiency in developing nations have hit the brick wall of natural disasters. Long (1978) contextualizes the theoretical framework of disaster planning for risk sensitive agricultural planning. He suggests that developing countries draw up plans for controlling disaster risk in their national agricultural sectors. Long also suggests that governments create a rational institutional framework to deal with the physical aspect of natural hazards in their national development plans. Unfortunately the literature concentrates on ideas concerning the protection of agriculture from market shocks such as price shocks, barriers to imports and/or exports, increasing incentives/disincentives for farmers and so on (see Fane and Warr, 2008) including improving technology.

In the early 1900s, 31 out of 43 million Indonesians lived on the island of Java, where transportation and communication were still undeveloped, and agricultural productivity was still poor due to lack of technology and infrastructure. The increase in agriculture's importance in the Indonesian economy during the 1929-1940 periods (compared with prior periods) was considered as an indirect outcome of the colonial government's investment in railways, the road network, the construction of bridges and flood control structures (and to some degree 'flood mitigation' - See Van der Eng 1992). During this period, agriculture contributed 60.8% of Indonesian economic growth. It later fell to 17.2% during the period 1973-1989 (Van der Eng, 1992). Nevertheless, agriculture has remains strategic to overall economic growth during the last decades. The Ministry of Finance (2010) reports agriculture as one of the three main sectors that contributed to gross domestic product (GDP), to the tune of 15.3%. The other two sectors are processing industry (24.8%) and trade and tourism (13.7%).

Classical works such as Geertz's 'agricultural involution' in fact suggest that the relatively unsuccessful Javanese agricultural production (especially before the 1960s) could be attributed to a failure to adopt technological change. One of the outcomes of the involution was the relatively low production per worker compared with yields (ton/ha). In terms of today's risk management concern, Geertz (1963) is right about the ability to manage floods as one of the prerequisite in sustainability of agricultural production. He therefore argues for the need to develop flood control systems.

This rest of this chapter argues that Indonesia may have been trapped into a second wave of 'agricultural involution' due to failure to adopt multiple-risk management strategies in sustaining agricultural crop production.

**2.2. Agricultural Crop Loss Assessment Framework**

Hypothetically, the impact of natural hazards on agricultural production can be assessed by at least three approaches: First, the direct impact can be measured by direct losses and damage to crops, infrastructure and land. This depends on loss assessment models. Second, the indirect impact can be measured by loss of agricultural labor (e.g. deaths as a result of catastrophe) and disruption to production (e.g. delays in planting caused by long delays in reconstruction of irrigation systems and dams). These approaches utilize ex-post event records to measure relative vulnerability and the exposure of agriculture and food crops production to natural hazards. The third assessment method is the future projection of hazards impacting on agriculture which can either be built on the past loss data records, or on scenario building given the lack of past data. The latter practice is common in climate change studies.

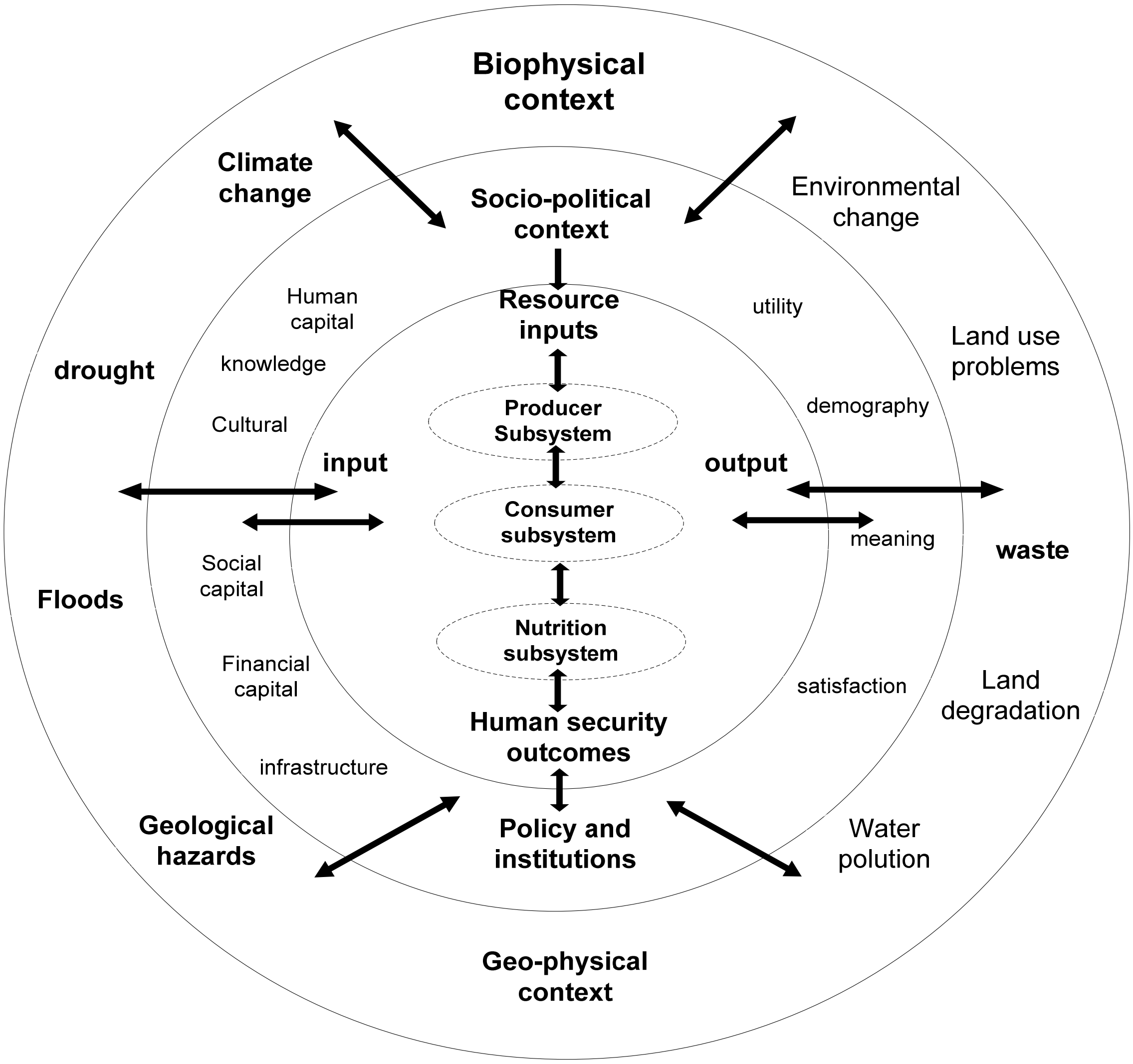
There is enough literature in the field of disaster studies to explain the causation of material/economic/ livelihood loss in regards to the impact of natural hazards on development infrastructure and outcomes. Burton, *et al*. (1993) suggest disaster risk as an outcome of interaction between human systems and natural systems. Today, it has become obvious that when natural hazards such as floods, tropical cyclones, tsunamis and earthquakes (the natural system) hit vulnerable infrastructure and human systems, disasters are likely to occur. Smith and Petley (2009) coined the idea of 'risk as a double helix' to illustrate the 'DNA code' of risks as joined and intertwined strands of DNA that underpin disasters. One strand represents the human system (vulnerability) and the other represents natural systems (hazards). The two elements- hazards and vulnerability- are interwoven and interlinked like a DNA double helix, where disasters arise from the complex interaction between them (Smith and Petley 2009: 43).

One of the old but still relevant disaster risk (R) models is R = E.V.H; where E is the level of exposure of elements at risk (e.g. valuable agricultural and livelihood assets). V is a vulnerability function such as economic, social and environmental vulnerability. H is a natural hazard function which can be manifested in floods, tropical cyclones, tsunamis and earthquakes (Alexander, 1993: 7).

This paper approaches the task of assessing the impact of natural hazards to agriculture by looking at the different sub-systems of the agriculture and food system. The elements at risk are the sub-components of agricultural systems. The author assumes that natural hazards affect different layers of agriculture and the food system (hereinafter AFS). AFS consists of three sub-systems, namely production, consumption and nutrition sub-systems. Figure 2 shows the natural hazard and agriculture-food system nexus. The core comprises the agricultural sub-systems (production, consumption and nutrition) that are situated in the larger context of both the biophysical and geophysical environments (natural hazards, climate change, land degradation, environmental change and processes). Each sub-system has its own input-throughput-output process (see Figure 2 and also Sobal, *et al*. 1998; Lassa, 2009). The intermediary between the core and the biophysical/geophysical context is the human system (social-economic-cultural and built environment, including the demographic context) that modify the human security outcomes. The sustainability of the sub-systems depends very much on the intermediaries, namely the socio-political and governance and institutional context. In disaster studies, these intermediaries are the vulnerability and agricultural resilience driving forces.

Barbier (1989) proposes a definition of 'agricultural sustainability' as the ability of an agricultural system to 'maintain its productivity when subject to stress or shock and disturbances. These include regular shocks such as land degradation, soil salinity or indebtedness and the 'irregular, infrequent, relatively large and unpredictable disturbance' such as drought or flood or a new pest.' Unfortunately, reality seems to suggest that the irregular and infrequent shocks are becoming more frequent and routine risks.

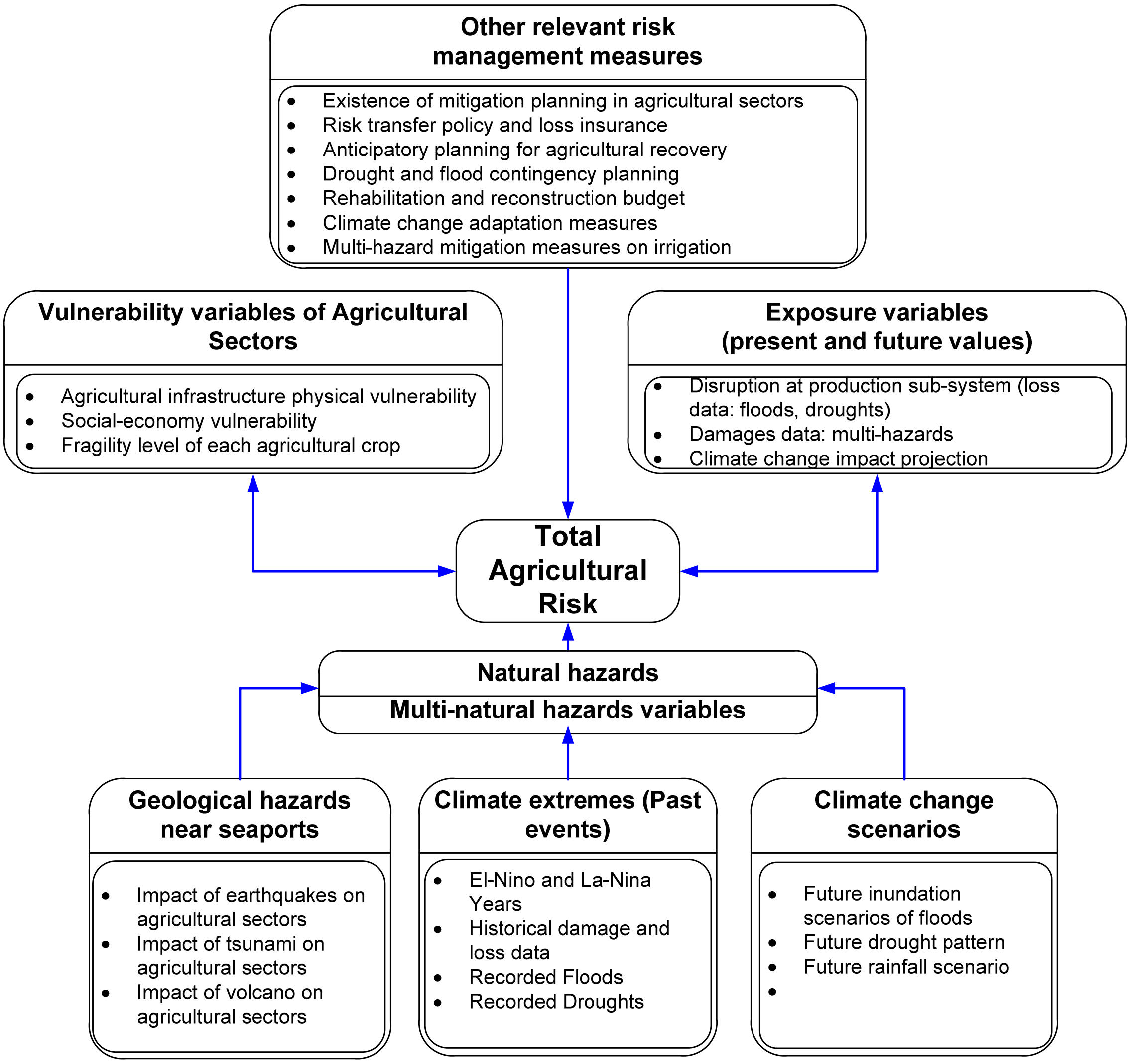
**Figure 2: Natural Hazards and Agriculture-Food System Nexus**




*Source*: Author, modified from Sobel, *et al*. 1998 and Lassa 2009.

Figure 2 suggests that disasters occur when hazards hit vulnerable agricultural infrastructure, which leads to direct/indirect loss and disruption in production, processing and distribution (including damaged roads and disrupted transportation). Disruption in production affects the whole chain of sub-systems. Vulnerable infrastructure (human factors) includes poorly designed irrigation infrastructures, poor drainage and bad site selection, poor maintenance, poor flood planning (Zwahlen, 1992) and other bad practices such as the uncontrolled expansion of wet-agricultural land into the flood plain areas. In short, in between the geophysical and biophysical world and AFS, there are mediating factors such as the socio-political context and the context of policy and institutions. Inside these two broad categories include knowledge, culture, human capital, social capital, financial capital, infrastructure, satisfaction, meaning, demography, utility, satisfaction and so on.

**Figure 3: Assessment Framework for Total Agricultural Risks**




*Source*: Author's

Total agricultural risk (Figure 3) is a derivative of Figure 2. It provides the overall step by step assessment framework for this research. It suggests that natural hazards such as floods, cyclones, drought, tsunamis, earthquakes and volcanoes often cause disruption to different food systems, measured by *ex-post* loss and damage and projected loss and damage (ex-ante). The lower half of Figure 3 shows the hazard components and the upper half the vulnerability components of the framework. At the production sub-system level, earthquakes (geological factors) can damage irrigation systems and crop fields, eventually leading to harvest failures due to shocks in water availability. This assessment framework includes mitigation planning and policy in agricultural sectors, risk transfer policy and loss insurance, anticipatory planning for agricultural recovery, drought and flood contingency planning, rehabilitation and reconstruction budgets, climate adaptation measures and the different fragilities of each agricultural crop.

## 3. Research Methods and Data Sources

### 3.1. Research Methods

Mixed methods are used. Table 1 lists selected methods that guide the research process. The Ministry of Agriculture's Agricultural Statistics 2009 released a database relating the impact of floods and drought on 23 agricultural crops (measured by losses and damage) from 2003-2008 at provincial levels. This paper mainly uses two main crops namely rice and maize.

**Table 1: Selected Methods**

| **Methods** | **National data** | **Central Bureau of Statistics** | **Agricultural Statistics** | **Disaster policy documents** | **Formal reports** | **Local data** | **Climate data** |
|---|---|---|---|---|---|---|---|
| Desk reviews | X | X | X | X | X | X | X |
| Literature survey | X | X | X | X | X | X | X |
| Open-ended interviews | | | | | | X | |
| Media reports | | | | | | X | |
| Past interviews in Padang, Aceh, East Nusa Tenggara, West Nusa Tenggara and Papua | | | | | | X | |
| Email correspondence/ informal communication | | | | | X | X | X |

The author also conducted field observations primarily but not limited to July-November 2011 field trips to disaster affected areas such as West Sumatra, West Papua,

Papua, East Nusa Tenggara, West Nusa Tenggara, North Sumatra and Central Java provinces. Field observations after the Indian Ocean Tsunami 2004 in Aceh and the Jogjakarta earthquakes in 2006 and volcano eruption in 2010 are also considered useful tools for reflection of the quantitative analysis.

### 3.2. Data Sources

Different data sources are used. Quantitative data is collected from the Indonesian Statistical Office, Agricultural Statistics of the Ministry of Agriculture 2004-2009, FAO Statistics Online 2012, and a national disaster database managed by the Indonesian National Disaster Management Office (BNPB). There have been difficulties in integrating the different data sources, especially the dataset on the impact of disasters on agriculture. Indonesia has recently established a disaster data and information source, namely DIBI. DIBI is indexed according to the Desinventar system, a UN-supported open-sourced disaster management system. It captures disaster events and codes each event into sets of data cards. One interregional event can be split into two cards or more. In total, there have been more than 10,000 data cards and events included in the online portal at DIBI BNPB. DIBI covers both man-made and natural hazards since 1850. Due to its broad coverage in terms of time period and region, one should be cautious about the level of accuracy of data. The author does not include all the events prior to 1970because there is lack of consistency in the quality of the data. The weaknesses of DIBI data are: first, it coded creeping hazards such as drought as a set of single events occurred at a particular date. Secondly, it is not commodity and crop specific data. Therefore the analysis cannot suggest crop specific policy and inter-crop considerations. Additionally, as of June 2012 not all the provinces' loss data have been included in the DIBI database.

However, overall, the DIBI data system can be informative and very locality-specific (event specific) which is beneficial for local policy makers. However, this study is only interested in macro analysis at the national scale. In addition, DIBI provides information concerning the damage and loss of transportation networks (measured in km). This is a good proxy for the impact of hazards on the food production sub-system (Figure 2) in a limited way, such as the impact of the transportation damage on the food supply chain. Finally, the data provide a broad overview of the different impacts of natural hazards, from geological hazards (earthquakes, tsunamis and volcano) to climatic hazards (floods, storm surges, drought etc.).

Another data source (See Table 2) is Indonesia Agricultural Statistics 2009. This records the loss of specific commodities or crops in every province in Indonesia during 2003-2008. It also provides data concerning different types of risk, ranging from floods and droughts to different types of pest attacks. The data provides clues to agricultural vulnerability based on crop sensitivity for different types of crops. It is also more consistent in showing the aggregative impact of floods and drought in every province annually.

**Table 2: Data Sources**

| Variables | Periods | Data Source | Remarks |
|---|---|---|---|
| Demographic and agriculture production areas | 1960-2010 | Agricultural Statistics Indonesia and FAO | Online/CD (aggregate and provinces) |
| Rice production | 1960-2010 | Agricultural Statistics Indonesia and FAO | Online/CD (aggregate and provinces) |
| Maize production | 1960-2010 | Agricultural Statistics Indonesia and FAO | Online/CD (aggregate and provinces) |
| Selected flood loss data on 21 food crops | 2003-2008 | Agricultural Statistics Indonesia 2009 | CD/book (aggregate and provinces) |
| | 1970-2011 | DIBI BNPB | Online dibi.bnpb.go.id |
| Selected drought loss data on 21 food crops | 2003-2008 | Agricultural Statistics Indonesia 2009 | CD/book(aggregate and provinces) |
| | 1970-2011 | DIBI BNPB | Online dibi.bnpb.go.id |
| Other historical data | Colonial period | Previous research | Literature review |
| Policy data | 1970-2011 | Formal documents and previous research | Literature review |
| Climate change | 1 m and 2 m SLR | Förster et. al. 2011 | Literature review (Secondary data) |

Demographic data and gross agricultural production during the period 1960-2010 are based on the Indonesian Agricultural Statistics report from 2000-2009 and the FAO Statistics Online dataset from 1960-2010. The different data systems can be complementary to each other because each data source its their own strengths and weaknesses. Each dataset may thus validate and fine tune findings from the other dataset.

This paper follows the Ministry of Agriculture's (2009) definition of floods as conditions where agricultural fields are inundated, lead to crop damage that may cause crop loss (or failures) that reduce agricultural production overall. Factors that cause floods include hydrological, improper land use and climatological factors. In this paper, all data concerning all crop loss (in ha) is included in the data of affected agricultural fields (in ha). However, not all affected areas are included in the loss data. The definition of flood loss is based on the national term *puso*, which means harvest failures. While 'affected agricultural fields' or 'affected crop fields' means inundated areas. For a projection of agricultural exposure to sea level rise (SLR), as a result of climate change, Förster, *et al*. (2011) use the term 'loss' to mean an estimated inundated crop fields.

## 4. Results 1: Natural Catastrophe Impact on Indonesian Agriculture

The assessment framework (Figure 3) guides this research by paying attention to the impact of natural hazard events on crops and agricultural related infrastructure. Table 3 provides a general overview on the impacts of natural hazards and plagues (i.e. including pest attacks) on general crops. It shows that floods, droughts and landslides are the dominant hazards. The data suggest that during the period 1970-2010, a total of 3,446,708 ha of crops were damaged as a result of 7576 hazard events. Interestingly, the data claim that more than 100,000 km of road (or 20 times the length of Indonesia from the Westernmost to the Eastern most borders) have been damaged as a result of more than 7500 events (mainly earthquakes and floods).

**Table 3: General Crop and Infrastructure Damage Assessment**

| Type of hazards | ∑ events | ∑ of crop damages (ha) | ∑ of road damages (km) | Crop damage probability (ha/event) | Road damage probability (km/event) |
|---|---|---|---|---|---|
| Floods 1970-2011 | 3,980 | 1,187,349 | 65,026 | 298 | 16 |
| Drought 2003-2011 | 1,411 | 1,667,766 | - | 1,182 | - |
| Earthquake-Tsunamis 1970-2010 | 268 | 60,673 | 37,041 | 227 | 138 |
| Landslides 1999-2011 | 1,596 | 52,273 | 1,324 | 33 | 1 |
| Landslides+Floods 1970-2011 | 305 | 287,046 | 1,135 | 941 | 4 |
| Plague 1990-2009 | 17 | 191,601 | - | 11,271 | - |
| Total | 7,576 | 3,446,708 | 104,526 | 455 | 14 |

*Source:* Author, based on data from DIBI BNPB.go.id. This data does not include Indian Ocean Tsunami in Aceh as in the original dibi.bnpb.go.id as of 1 March 2012.

Damage is highly associated with *puso* or harvest failure. The data shows that at least 3.44 million ha of general food crop loss occurred during 1970-2010, as a result of more than 7,500 events. Overall, the average crop damage probability was 455 ha per any hazard. Floods have a damage probability event of 298 ha/flood event. Combined floods and landslides have significant damage probability of 941 ha/event. While drought obviously has a higher crop damage probability at the rate of 11.182 ha/drought event). In terms of road infrastructure, earthquake-tsunamis dominated the damage probability with 138 km/event. One of the reasons could be that roads are often built in hazard-exposed areas such as coasts, to link food consumers in cities with food producers in rural areas. However, earthquakes can also have significant effects on road damage, especially in areas where soil liquefaction takes place, and roads near coasts are likely to be affected by this phenomenon.

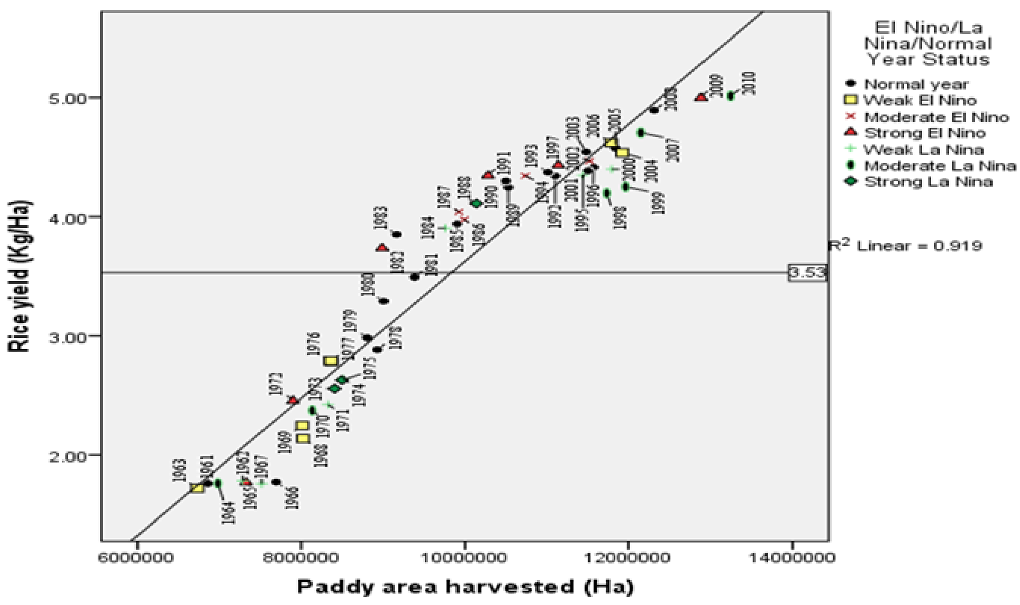
Plague (pest attacks) shares the highest loss probability of all, as Table 3 shows. Even though plague is the least recorded event (with a very high crop damage probability rate), readers should be cautious with this data, especially when calculated based on the DIBI recorded events. Closer investigation suggests the data do not cover some significant events during the period 1990-2009. In this case, the Agricultural Statistics 2009 publication provides more reliable data concerning plague, especially during 2003-2008, which suggest that plague is a much more routine event which needs to be explored in a different study. Data from Table 3 is simply a gross analysis, as it does not tell the readers the types of crops affected by floods, droughts, earthquakes/tsunamis and so on.

Figure 4A shows a high correlation between increased yield and expansion of rice field as shown by correlation test (r=.96). A separate exercise was also carried out to test the correlation between production and field expansion, and the result shows that they are almost identical (r=0.99). However, there were apparently shocks which impacted annual production over the years. For instance, the 1998-1999 rice production rate was lower than the levels of 1989 and 1996.Intuitively, one may assume that a strong El-Nino combining with a moderate La-Nina in 1998 were the causal events. It is clear from Figure 4 that the worst shock to production was associated with the El-Nino event. However, it is also clear that not every strong El-Nino or strong La-Nina creates shocks in yield. There is, nevertheless, a clear indication that they are likely to create shocks, and this indicates the need for a food crisis early warning system. For instance 2009 was considered as a strong El-Nino year. In fact, the 2009 yield was higher than the prior years. However, given the fact that there was a significant increase in the area of rice field in 2010, the yield in 2009 is relatively 'stagnant' compared to 2010, a strong La-Nina year.

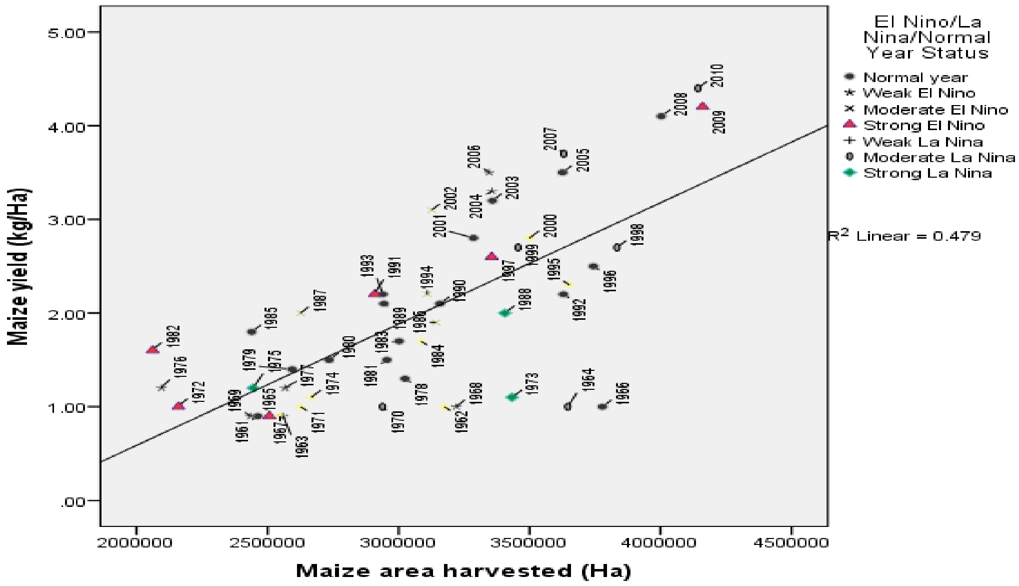
The rather S-shaped yield year-on-year scatter plots in Figure 4A begs for more in-depth research and data collection in the regression function of the yield. Natural and social political economic variables could be carefully considered to build a firmer yield prediction model (nonlinear multiple regression analysis) in comparison to the observation above.

**Figure 4: Scatter Plots of Indonesian Rice and Maize Yields and Areas Cultivated 1960-2010**

**A)**



**B)**




*Source*: Author's based on Indonesia Agricultural Statistics 2000-2009 and FAO Stat online; El-Nino and La-Nina years is based on NOAA approximate.

Unlike rice, the correlation between maize yield and maize area is relatively modest (Figure 4B). The regression line demonstrates a weaker predictive power, especially when increased maize yield is moderately associated with the increase of area harvested. The maize yield is very volatile. On average, as far as the macro data at the national scale are concerned, strong El-Nino years do not necessarily lead to shocks. However, some strong La-Nina years (e.g. 1978, 1998) indeed brought down the yield. It is also clear that during the course of the 1960s, increases in area harvested gave little yield increase. Some of the main reasons could be due to low productivity (Figure 1) as noted by Geertz's agricultural involution insight.

For future work, especially when data allows, a more detail study could be done on the seasonal scale rather than using an annual calculation.

### 4.1. Impact of Drought and Floods on Maize and Rice Crops

Agricultural statistics show an increase in crop loss in Indonesia due to drought and floods (Table 4). The total accumulation of rice area affected by floods in the period 2003-2008 equals 15% of the 2009 total area under cultivation (about 1.8 out of 12 million ha). During the same period, drought has affected 17% of the 12 million ha of rice field. Floods and drought combined have affected 32% of the total cultivated areas.

The total rice loss (termed locally as *puso*, or absolute quantity of harvest failure) caused by floods during 2003-2008 was about 564k ha and by drought about 424k ha. The total loss from both hazards was about 988kha (Table 4). The calculation was rather conventional and data collection is still focused on both drought and floods. The total affected area is equivalent to 4 million ha. In addition, existing data also contain a comprehensive list of primary to secondary crop loss (which will not be discussed in detail in this draft due to time and space limitation).

**Table 4: Maize and Rice Loss due to Flood and Drought**

| No | Region | Crop area '000 ha (2008) | Total flood and drought during 2003-2008 | | | | Avg Yield (t/ha) 2008 | Direct monetary loss ($) |
|---|---|---|---|---|---|---|---|---|
| | | | Crop affected (Ha) | Crop loss (Ha) | % crop affected | % crop loss | | |
| A | Rice/PaddyCrop | | | | | | | |
| | Sumatra | 3,184,493 | 848,168 | 247,346 | 0.27 | 0.08 | 3.97 | 156,527,959 |
| | Java | 5,712,172 | 2,261,715 | 545,351 | **0.40** | **0.10** | 5.42 | 471,992,674 |
| | Kalimantan | 1,282,931 | 357,536 | 59,702 | 0.28 | 0.05 | 3.30 | 31,398,589 |
| | Sulawesi | 1,284,999 | 313,399 | 85,735 | 0.24 | 0.07 | 4.65 | 63,586,323 |
| | Bali | 144,756 | 3,309 | 177 | 0.02 | 0.00 | 5.84 | 165,060 |
| | NTT | 168,412 | 50,935 | 38,729 | 0.30 | 0.23 | 3.06 | 18,920,495 |
| | NTB | 327,791 | 91,680 | 11,221 | 0.28 | 0.03 | 4.86 | 8,710,799 |
| | Papua | 27,859 | 13,463 | 46 | 0.48 | 0.00 | 2.98 | 21,841 |
| | Maluku's | 32,075 | 289 | 28 | 0.01 | 0.00 | 3.73 | 16,673 |
| | National | 12,165,488 | 3,940,494 | 988,335 | 0.32 | 0.08 | 4.26 | 671,252,801 |
| B | Maize/corn crop | | | | | | | |
| | Sumatra | 802,817 | 115,830 | 22,631 | 0.14 | 0.03 | 3.39 | 19,727,275 |
| | Java | 2,012,027 | 214,667 | 20,493 | 0.11 | 0.01 | 3.78 | 19,894,963 |
| | Kalimantan | 68,414 | 5,514 | 872 | 0.08 | 0.01 | 3.57 | 800,443 |
| | Sulawesi | 657,349 | 58,669 | 14,275 | 0.09 | 0.02 | 3.69 | 13,534,354 |
| | Bali | 27,069 | 12,018 | 1,625 | 0.44 | 0.06 | 2.71 | 1,131,764 |
| | NTT | 271,791 | 8,193 | 70 | 0.03 | 0.00 | 2.48 | 44,651 |
| | NTB | 55,374 | 12,027 | 887 | 0.22 | 0.02 | 3.25 | 741,779 |
| | Papua | 6,853 | 4 | 0 | 0.00 | - | 2.39 | - |
| | Maluku's | 19,775 | 955 | 549 | 0.05 | 0.03 | 2.03 | 286,772 |
| | National | 3,921,469 | 427,877 | 61,402 | 0.11 | 0.02 | 3.34 | 52,746,417 |

During 2003-2008, the accumulation of rice loss was 3.9 million ha (8% of 2008 total rice field) and maize loss was 427k ha or 2% of the total maize cultivation area in 2008. Monetary value of these losses equals USD 618 million.

The main areas of rice loss include the islands of Java and Sumatra. The combined Java and Sumatra rice loss amounted to 80% of total losses. Rice but Sumatra and Java together account for only 73% of Indonesia's rice-growing area. There is therefore an urgent need to mitigate losses within the wet-agricultural system in Java and Sumatra. The annual growth rate of rice loss was on average 5% during 2003-2008. This is obviously far above the annual rate of rice field expansion promoted by central governments during past decades.

Total monetary losses during 2003-2008 as shown in Table 4 were USD 723 million. This amounts to 81% of the total national budget earmarked for the Ministry of Agriculture in 2010. It is also about 115% of the government budget for irrigation in fiscal year 2010.[3] It is 29 times the overall disaster recovery budget managed by the National Disaster Management Office (BNPB) in 2010 (Ministry of Finance 2010).

Table 5 shows that the government's promotion of rice field expansion to boost production was countered by high annual loss rates during 2003-2010. For instance, the rice field expansion in 2008 was reported to be 1.3%. Unfortunately, evidence suggests that there was a rice loss equivalent to -1.6% rice in 2008. Therefore, the net balance was actually -0.3% (Table 5).

**Table 5: Rice Filed versus Loss data**

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|
| Rice area (Ha) | 11,477,400 | 11,923,000 | 11,839,100 | 11,786,400 | 12,147,600 | 12,309,200 | 12,883,600 | 13,244,200 |
| Rice loss (Ha) | 183,844 | 110,972 | 125,214 | 211,272 | 157,680 | 199,353 | 116,461 | 113,566 |
| Rice area (Ha) – Corrected | 11,293,556 | 11,812,028 | 11,713,886 | 11,575,128 | 11,989,920 | 12,109,847 | n/a | n/a |
| Rice innundated (Ha) | 831,800 | 475,169 | 529,165 | 668,087 | 783,534 | 652,739 | 183,844 | 110,972 |
| Rate of annual rice area % | -0.4% | 3.9% | -0.7% | -0.4% | 3.1% | 1.3% | 4.7% | 2.8% |
| Rate of annual rice loss % | 1.6% | 0.9% | 1.1% | 1.8% | 1.3% | 1.6% | 0.9% | 0.9% |
| Rate of annual rice area % (corrected by loss) | -2.0% | 3.0% | -1.8% | -2.2% | 1.8% | -0.3% | 3.8% | 1.9% |
| Rate of annual innundated | 7.2% | 4.0% | 4.5% | 5.7% | 6.5% | 5.3% | n/a | n/a |

*Source*: Author. Data 2003-2008 is taken from Ministry of Agriculture 2009; Data from 2009-2010 is adjusted from DIBI.

[3] See Fiscal Data from Ministry of Finance:www.fiskal.depkeu.go.id/webbkf/download/datapokok-ind2010.pdf

The mission to expand the rice land turns out to be less effective when the government were unaware of and unable to mitigate rice loss. Similar trends may have occurred in other crops at lower rates, especially in the case of maize. This phenomenon begs the question of whether the government should strategically seek the systematic prevention of crop loss without expanding the rice and maize areas of cultivation? Or should the government creatively increase the level of production efficiency through combining both expansion and loss prevention?

### 4.2. Agricultural Loss and Poverty

The agriculture/food system framework recognizes the consumption sub-system to be affected by natural hazards. In approaching consumption, this paper uses proxy data such as poverty levels by province. The Indonesian Central Bureau of Statistics differentiates two types of poverty as seen in Table 6. P1 is the poverty depth index and P2 is the poverty severity index at the rural level.

Correlation tests at provincial scale show insignificant correlation between the rate of agricultural losses (drought and flood combined) and the level of poverty (based on BPS 2008 data on poverty). However, it is interesting to note that exposure data (measured by flood inundated and drought affected agricultural areas) shows significant correlation with the rural poverty level (at 0.371 with sig. 2-tailed 0.033).

Even though there is no correlation between the loss and poverty (the sum of P1 and P2) based on Table 6, the exposure data is still consistent with qualitative observations from the field, and also observations in the literature. In addition, crop loss seems to be ' locally specific. At the micro level, evidence provides richer data concerning the impact of natural hazards on agriculture. For instance in Nias (North Sumatra) and Padang Pariaman (West Sumatra ), earthquakes in 2005 and 2009 destroyed the existing irrigation infrastructures. The Indian Ocean Tsunami of 2004 affected thousands of hectares of agricultural land, including aquaculture land.

**Table 6: Correlations Tests: Drought, Flood and Poverty**

| | | % Total production loss by flood | % Total production loss by drought | % Total drought & flood affected land (Exposure) | % Total production loss by drought and flood |
|---|---|---|---|---|---|
| Rural Poverty Level P1P2 | Pearson Correlation | .338 | .150 | .371* | -.041 |
| | Sig. (2-tailed) | .055 | .405 | .033 | .823 |
| | N | 33 | 33 | 33 | 33 |

*Note*: * Correlation is significant at the 0.05 level (2-tailed). P1 and P2 subsequently represent Depth Poverty Index and Severity Poverty Index at rural level. Poverty lines varies between regions however, national poverty line at rural level in 2008 is Rp.161,831/month (or USD17).

Agricultural losses suffered by poor farmer households and vulnerable communities, due to frequently occurring extensive disasters such as floods and drought, which have a huge aggregate effect, are often under-recorded and are increasing rapidly (UNISD 2011: 18). The economic implication of such losses cannot simply be calculated by the total production loss but should include a comprehensive account of the opportunity loss caused by meteorological and geological hazards. The Bengkulu earthquakes in September 2007 destroyed the irrigation infrastructure and led to 'localized drought' at the downstream rice areas.

A damage and loss assessment (DALA) report suggests that the Sumatran earthquakes in 2009 had an impact on the agriculture sector especially damage to irrigation systems and fishponds. The earthquakes of 2009 affected the livelihoods of many rural and coastal villages, however agriculture sectors have been much less affected than other sectors such as housing.[4] This means that the poverty-disaster relationship should be explored more deeply, especially when the drivers of poverty come from non-agricultural sectors (such as the impact on housing, non-natural based livelihoods and so on).

Cases from Bali and West Nusa Tenggara Province suggest that high (or rather extreme) rainfall often leads to the breakdown of irrigation. This leads to a lack of the water required for crop production. Recent flooding in West Nusa Tenggara province

[4]West Sumatra and Jambi Natural Disasters: Damage, Loss and Preliminary Needs Assessment A joint report by the BNPB, Bappenas, and the Provincial and District/City Governments of West Sumatra and Jambi and international partners, October 2009 Public. http://www.gfdrr.org/gfdrr/sites/gfdrr.org/files/documents/GFDRR_Indonesia_DLNA.2009.EN_.pdf

collapsed some small bridges that disrupted inter-village transportation and the local food supply chain.

In Nias Island, for example in Sisobambowo village, rehabilitation of dams has not fully taken place after seven years of disasters.

In addition, the collapse of small dams (either earth dams or ones made of wire mesh gabion) often take years to be repair/reconstructed. This is due to lack of financial capacity and anticipatory disaster recovery planning knowledge routinized within the local government system. The consequence is clear – long delays in recovery will cause delays in production and hence opportunity cost increases (for inter-regional comparison, please see Annex 1).

### 4.3. Loss Pattern of Primary and Secondary Crops

Table 7 presents findings on the sensitivity of specific crops to different types of hazard. Cucumber, watermelon, potato, eggplants, cabbage and long bean are more sensitive to floods. A high loss rate is very probable (between 75-100%) once they are affected by floods. Onion and durian are more sensitive to drought. Overall, secondary crops are more sensitive to floods rather than drought. This should be read cautiously because the observation period is limited to 2003-2008. However, this does suggest that hazard mitigation should also be crop specific.

**Table 7: Flood and Drought Crop Loss Pattern during 2003-2008**

| Commodity | Drought | | Flood | | Crop loss rate | |
|---|---|---|---|---|---|---|
| | Affected (ha) | Loss (ha) | ha affected | Loss (ha) | Drought | Flood |
| Tomato* | 16 | 1 | 149 | 22 | 0.06 | 0.15 |
| Coccumber* | 2 | - | 260 | 248 | - | 0.95 |
| Eggplants* | 36 | - | 245 | 183 | - | 0.75 |
| Watermelon* | 16 | - | 599 | 465 | - | 0.78 |
| Potato* | 125 | - | 1,228 | 1,218 | - | 0.99 |
| Chili* | 793 | 3 | 2,659 | 1,537 | 0.00 | 0.58 |
| Onion* | 11 | 11 | 96 | 1 | 1.00 | 0.01 |
| Banana* | 290 | 1 | 2,502 | 986 | 0.00 | 0.39 |
| Cabbage* | 27 | - | 9 | 9 | - | 1.00 |
| Soybean** | 45,931 | 1,600 | 37,185 | 11,111 | 0.03 | 0.30 |
| Groundnut** | 76,714 | 4,236 | 12,610 | 1,735 | 0.06 | 0.14 |
| Longreen bean* | 18 | - | 643 | 553 | - | 0.86 |
| Orange* | 209 | 1 | 9,305 | 1,609 | 0.00 | 0.17 |

| Commodity | Drought | | Flood | | Crop loss rate | |
|---|---|---|---|---|---|---|
| | Affected (ha) | Loss (ha) | ha affected | Loss (ha) | Drought | Flood |
| Durian* | 140 | 58 | 96 | 1 | 0.42 | 0.01 |
| Salak* | 318 | 1 | 327 | 2 | 0.00 | 0.01 |
| Rambutan* | 5 | - | 92 | 39 | - | 0.42 |
| Manggo* | 1 | 0 | 308 | 16 | 0.17 | 0.05 |
| All secondary crops | 124,676 | 5,912 | 68,328 | 19,745 | 0.05 | 0.29 |
| Maize (primary crops)** | 331,697 | 23,661 | 96,180 | 37,741 | 0.07 | 0.39 |
| Rice (primary crops)** | 2,128,044 | 423,667 | 1,812,450 | 564,668 | 0.20 | 0.31 |

*Note*: *Total value 2004-2007; **. Total value 2003-2008.
*Source*: Author, data from Ministry of Agriculture 2009.

Very often, smaller scale agriculturally disastrous events receive less attention (as can be seen from the scale of losses versus national spending in 2010). Deeper analysis of the data shows that the loss depends on type of crop, time and place. For instance, during 2003-2008, overall tomato loss to drought in 2006 occurred in North Sulawesi while tomato loss to flooding occurred mainly in 2005 in Aceh. The potato crop was affected by drought mainly in Central java in 2006 while flood loss occurred almost exclusively in East Java in 2006. Banana loss to floods was significantly concentrated in Sumatra (Riau, South Sumatra and Jambi province) in 2004. 80% of groundnut losses were concentrated in Jogjakarta and Central java in 2006. The ‘drought’ in Jogjakarta during 2006 may be associated with alterations to the local microclimate caused by an increase of activity in the nearby Merapi volcano. However, it is also important to note that 2006 was a weak El-Nino year as noted by the US National Oceanic and Atmospheric Administration (NOAA).[5]

## 5. Climate Change and Agricultural Loss Assessment

Climate change is unequivocally happening (Intergovernmental Panel on Climate Change (IPCC) (2007)) and experts have reached high agreement supported by robust

[5]See http://www.noaanews.noaa.gov/stories2006/s2699.htm [last accessed 30 Mar 2012].

evidence of climate change (IPCC 2012). The impact of climate change and climate extremes reported by IPCC (2012) shows that there will be increasing losses from climate extremes in some sea basins. Agricultural crops near coasts are likely to be more exposed to climate extremes and sea level rise. For the future, it is important to note that climate change is affecting the weather patterns and crop productivity in South and Southeast Asia. Basuno and Weinberger (2011) highlights that the impact is highly "place based" thus requiring location-specific responses.

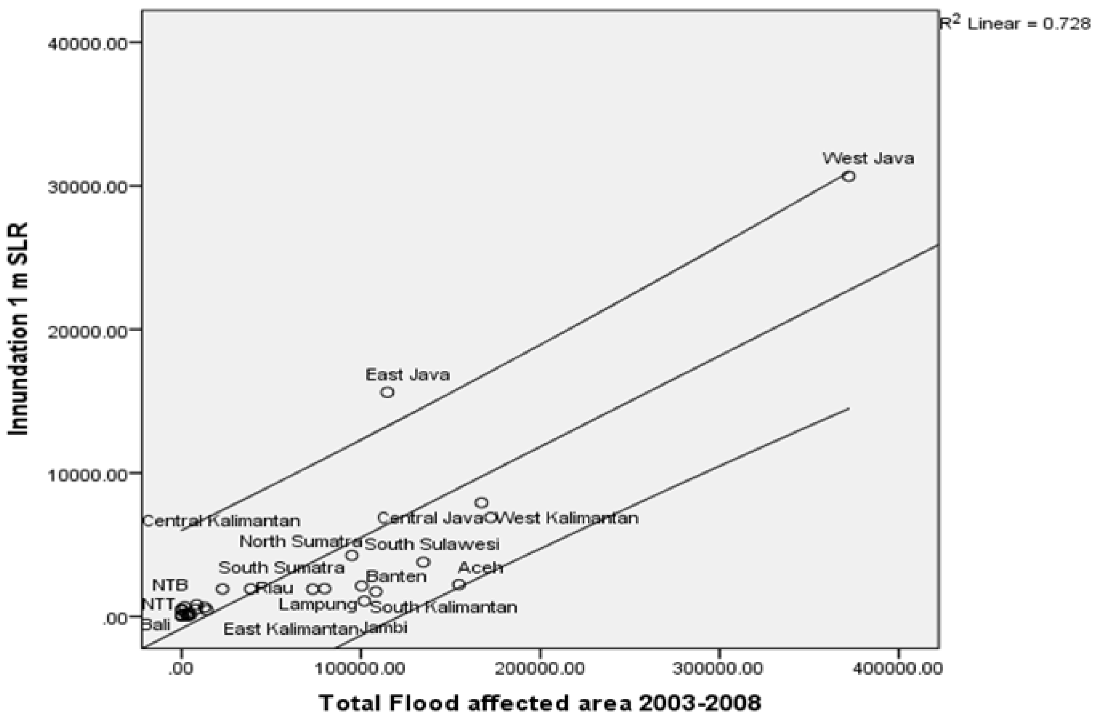
The Förster, *et al*. (2011) study on the impact of sea level rise on coastal agriculture suggests different impact scenarios: the 1 m and 2 m sea-level rise (SLR) scenarios in Indonesia. For the 1 m SLR scenario, the impact on 'absolute dietary impact' (ADI) is likely to concentrate in West Java, East Java and Central Java, followed by West Kalimantan and North Sulawesi. For 'relative dietary impact' (RDIP), West Kalimantan, West Java, Central Kalimantan, Aceh and South Sulawesi are predicted to be the most affected provinces. In the 2 m SLR scenario, the 'absolute dietary impact' (ADI) is predicted to be concentrated in West Java, East Java and Central Java, North Sumatra and West Kalimantan. The top 5 areas impacted by RDIP include West Kalimantan, West Java, North Sumatra, Aceh and Lampung (See Table 8). The author compares findings from rice field flood inundation data with the Förster, *et al*. (2011) projected data concerning coastal flood inundation due to a 1 m sea level rise (SLR).

Figure 5 shows that the projections of Förster, *et al*. (2011) are highly associated with the present trend of flood inundation (as shown in Section 4), especially based on provincial rice field inundation data during 2003-2008. Correlation testing shows a highly significant result (r=0.85) at .01. Table 8 presents a comparison of the top 5 flood affected areas with provinces to be impacted under the 1 m and 2 m scenarios. It is interesting to note that West Java is the most consistent province to experience flood inundation and loss, followed by Central Java and South Sulawesi. There is obviously a shift in regars to the different projection scenarios. For instance, North Sumatra and East Java are predicted to experience higher losses (in terms of absolute number of field inundations) for both scenarios of SLR 1 and 2 m.

Apart from loss assessment for SLR scenarios, the changing of seasonal patterns is likely to occur and may have a serious impact on agricultural outcomes. Previous studies such as Naylor, *et al*. 2007 found that, there are probability scenarios of a 30-

day delay in monsoon for West/Central Java and East Java/Bali (based on rice production data from Java and Bali during 1983–2004). They argued that "although the probability of a 30-day monsoon delay was lower in East Java/Bali than in West/Central Java, the impacts on rice production were higher". A 30-day delay caused rice production to fall by 11%, on average, in East Java/Bali during the main rice harvest season between January and April, as compared with 6.5% in West/Central Java. Their findings supports the findings in Section 4 and Förster, *et al*. (2011) as they predict that a 30-day monsoon delay in the January–April period is likely to cause a drop in rice output by as much as 580,000 metric tons in West/Central Java and 540,000 metric tons in East Java/Bali.

**Figure 5: Scatter Plots of Historical Flooding and Future Flood Inundation Scenarios**




*Source*: Author, data from Ministry of Agriculture 2009 and Förster, *et al*. 2011

**Table 8: Comparison of Past Events and Future Loss Scenario in Top 5 Provinces**

| No | Past flood events | | Future scenario ADI, 1 m SLR | | Future scenario ADI, 2 m SLR | |
|---|---|---|---|---|---|---|
| | **Inundation** | **Total loss harvest failure** | **ADI** | **RDIP** | **ADI** | **RDIP** |
| 1 | West Java | West Java | West Java | West Kalimantan | West Java | West Kalimantan |
| 2 | West Kalimantan | Aceh | East Java | West Java | East Java | West Java |
| 3 | Central Java | Sulawesi Selatan | Central Java | Central Kalimantan | Central Java | North Sumatra |
| 4 | Aceh | Central Java | West Kalimantan | Aceh | North Sumatra | Aceh |
| 5 | Sulawesi Selatan | Sumatera Selatan | North Sumatra | South Sulawesi | West Kalimantan | Lampung |

*Source*: Author. ADI 1m and 2m Scenario is taken from Förster, *et al*. 2011

## 6. Discussion

Losses in the agricultural production sub-system are by no means new phenomena. Conventional loss assessment in rice production often throws up surprises associated with the inefficiency of the harvest and post-harvest activities ranging from harvesting, threshing, transporting, drying, milling and storage. Simatupang and Timmer (2008) estimate that the total loss in Indonesian rice production (in ha cultivated areas) during 1976/1987 and 1994/1995 could have reached 21% and 20.8% respectively. Harvesting loss was the main source of loss of all processes (above 9% for both periods) in the production sub-system.

Loss and damage have also been associated with biophysical and geophysical events that have impacts upon the production sub-system. Quinn, *et al*. 1978 (p. 675-679) highlighted the impact of El-Nino on the fall of fisheries production. They suggest that 93% of Indonesian droughts during 1844-1976 (with exception of 1954-75 due to unavailability of drought data) occurred during El-Nino years. Using Indonesian rice production data, D’Arrigoa and Wilson (2008) highlights the impact of drought driven by El-Nino on Java’s rice production, where production loss was about 3 million tons of rice during 1997-1998 (in comparison to 1996 production data – See also Figures 1 and

4). The findings from other studies are quite consistent with the Section 4.1 based on year on year loss assessment.

**Table 9: Hierarchy of Rice Crop Loss and Mitigation Options**

| No | Type of agricultural loss | Causation of loss | Likelihood of occurrence | Mitigation option |
|---|---|---|---|---|
| 1 | Productivity loss | Lack of basic plot management measures incl. labor inputs | Every planting season, extensive | Training, basic management, incentives for crop specific farmers |
| 2 | Harvesting loss | Inefficiency in harvesting | Every planting season, extensive | Technological and logistical option |
| 3 | Post-harvesting loss | Inefficiency | Every planting season, extensive | Technological option; infrastructure development |
| 4 | Cyclones and floods | Exposure of agricultural ports to extreme rainfalls | La-Nina events, extensive | Flood management measures |
| 5 | Drought hazard | Exposure of agricultural ports | El-Nino events, extensive | Water management, drought resistance seeds |
| 6 | Geological hazard | Vulnerability of irrigation infrastructure | Area specific, intensive | Seismic Codes of dams and irrigation systems |
| 7 | Pest attacks/Plagues | Local environmental change, lack of bio-security measures | Area specific, intensive | Pest management and bio-security measures |
| 8 | Combination of losses | Lack of multi-loss mitigation measures | Worst scenario can happen | Multi-loss reduction scenarios |

*Source*: Author's.

Food self-sufficiency is not a popular policy in academic studies but politically seen as politically a legitimate food security policy in Indonesia during the last four decades. Unfortunately, food self-sufficiency is often short lived (Simatupang andTimmer 2008). Early government investment in irrigation system rehabilitation and expansion combined with a 'green revolution' policy at the national scale in the 1970s in Indonesia was considered a necessary decision. However, the government officials were seriously challenged by series of droughts and pest attacks that caused severe harvest loss during the 1970s and in 1982-1983 (Simatupang andTimmer 2008).

Simatupang and Timmer (2008) briefly note the condition of irrigation systems in 2006 based on reports from the Ministry of Public Works. The data shows serious damage in canals, dams and reservoirs. 1.5 out of the total 6.7 million ha irrigation canals were reportedly damaged. While 14,000 of the total 273,000 ha irrigation (associated with engineering dams as source of irrigation), experience severe damage. Some of the damage may be attributed to the biophysical condition surrounding both the canals and dams.

There is adequate evidence to conclude that Indonesian agricultural production is highly inefficient due to failure to mitigate losses associated with multiple risks (Table 9). The first of the major losses is loss associated with natural catastrophes (cyclones and floods, drought hazard, geological hazard). The second is loss associated with the internal human activities during the processes of production, harvesting and dealing with post harvesting problems. The third is loss due to the lack of a resilient irrigation infrastructure to cope with biophysical and geophysical problems. The rest of the losses relate to risk associated with pest attacks/plagues and to combinations of the risks.

Selection of new agricultural areas should be carefully made. Recent trends in losses may indicate that government's drive to create new rice field may have ignored the risks embedded in the newly expanded areas, such as flood proneness The question is whether the expansion of agriculture is taking place in hazard-prone areas. Or is there ecological change taking place that modifies losses? In order to answer these questions, one needs to assess at high data resolution to see the correlation between loss data and disaster risk assessment.

## 7. Policy and Institutional Scenarios

Indonesia adopts the United Nations' Hyogo Framework for Action (HFA) which aims to "Building the resilience of nations and communities to disasters - to make the world safer from natural hazards." It is a 10-year plan 2005-2015 adopted by 168 Member States of the United Nations in 2005 at the World Disaster Reduction Conference. HFA consist of five major priorities namely: Priority Action 1: Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation; Priority Action 2: Identify, assess and monitor disaster risks and enhance early warning; Priority Action 3: Use knowledge, innovation and education to build a culture of safety and resilience at all levels; Priority Action 4: Reduce the underlying risk factors; Priority Action 5: Strengthen disaster preparedness for effective response at all levels.

The highest-order disaster risk management (DRM) planning [time scale of mid-term planning] in Indonesia since the reform in 2007 is the national disaster risk management plan, a five-year policy document that guides national ministries to allocate resources for risk reduction annually. The DRM Plan 2010-2014 provides shopping lists of ministries/agencies with a clear budget line. The planning suggests that the Ministry of Agriculture should plan and control mitigation efforts in in respect of drought and other hazards related to agriculture.

In addition to the five-year DRM Plan (2010-2014), under the leadership of the National Development Planning Minister, a series of three-year national action plans (NAP 2006-2009 and NAP 2010-2012) have been added as complementary plans which include non-state actors' DRM planning. The NAPs are basically a national level implementation of HFA Priorities. The NAPs also listed basic commitments to DRM from other agencies.

The internal division of government labor in regard to agricultural risk reduction can be simplified by using the historical mandates of the central government ministries. The Ministry of Agriculture (MoA) deals with agricultural production in general. The Ministry of Public Works deals with investment in irrigation infrastructure. The Ministry of Environment directs climate change mitigation and adaptation. The National Disaster Management office (BNPB) deals with disaster risk reduction. BMKG (The Meteorology, Climatological and Geophysical Office) serve as the primary node of a multi-hazard early warning system framework for different sectors. The National Development Planning Ministry (Bappenas) is the planning coordinator. This is a gross explanation concerning the leading ministries/agencies that have been playing roles as in responding to risks in agricultural sectors.

BNPB is still new and inexperienced body to manage risk reduction according to the new disaster management law, as it was only established in 2008. Evidence suggests that BNPB has been struggling with the vision of promoting loss prevention not only in agricultural sectors but overall. BNPB's Strategic Planning 2010-2014 document made no mention of agricultural risks and how to deal with them.[6]

Gap analysis between the NAPs and their implementation suggests that actual gaps between planning and investment are enormous (Lassa 2011). Priority on post disaster intervention outweighed the rest of the Hyogo Framework for Action (HFA) priorities in 2007, which continues to be the case today. For the first three years after the enactment of the Disaster Management Law 2007, DRR investment was still being directed to emergency preparedness and post-disaster response. This is understandable and justifiable because the period 2007-2009 coincided with the time of responses to recent big disasters, such as post-tsunami activities in Aceh in 2004, Nias in 2005, and the devastating earthquake in Yogyakarta in 2006 (Lassa, 2011).

The recent National Action Plan 2010-2012 shows that national actors including the government have now tried to shift their focus from reactive responses to dealing with the root causes of disaster risks, such as investing in mitigation plans, integration of DRR into land use, natural resource management, and better social development policy. There is clearly a willingness on the part of all actors, including the government, to radically shift from emergency preparedness and post-disaster response towards mitigation and prevention-oriented intervention. However, such a radical turn from *ex-post* oriented interventions to *ex-ante* risk reduction seems to be unrealistic because, institutionally and culturally, change may only occur incrementally. Wignyo (2012) recently shows that that government spending on disaster prevention/mitigation remains low in 2012 (USD 11 million) in comparison to disaster recovery funds (USD 440 million). Gaps between planning and implementation remain future challenges.

[6]See http://www.bnpb.go.id/userfiles/Renstra%20BNPB%202010%20-2014.pdf [last accessed 30 Mar 2012].

**Table 10: BNPB's View on How to Reduce Risk in Agricultural Sectors**

| Selected terms | Quantity of the selected terms in Indonesia Progress Report | | BNPB's notes on the subject |
|---|---|---|---|
| | 2009 | 2011 | |
| Food security | 3 | 0 | establishment of Food Security Council toensureimplementation of food security policy (p. 19, p.20) |
| Agriculture | 2 | 1 | The report refers to Ministry of Agriculture |
| Food security assessment | 1 | | There is need to have comprehensive food security assessment P. 20 |
| Food security council | 1 | 0 | FSC is responsible for food security monitoring (P. 20) |

*Source*: Author. Data from Indonesia Progress Report 2009; 2012

At the discursive level, a quick audit of BNPB's reports to the United Nations International Strategy for Disaster Reduction (UNISDR 2009 and 2010) suggest that the terms 'food security' and 'agriculture' are untraceable. The reporting system requires member states to report theses sector(s). However, the reports have been silent about the multiple risks faced by agriculture and the necessary steps needed to begin mitigating agricultural risks.

The perception from Indonesia's disaster management bureaucrats concerning measures to reduce disaster risks in agricultural sectors can be traced from the recent Indonesia Progress Report for the Hyogo Framework for Actions (HFA) to the United Nations International Strategy for Disaster Reduction (UNISDR) 2009 and 2011. The HFA Priority 4 requires substantial reduction in the root causes of disaster risks. Its second "core indicator" is "*Social development policies and plans are being implemented to reduce the vulnerability of populations most at risk*". The2009 Report argued that "the awareness of food diversification is being promoted by the Ministry of Agriculture" (p. 19, Indonesia Progress Report on DRR to UNISDR 2009). In the 2011 Report, the government reported that "Ministry of Agriculture has started to develop programs to diversify food crops to reduce vulnerability to climate change and disaster" (p. 20).

Public Works Department (at different levels) often allocate annual budget for 'recovery and maintenance of irrigation infrastructure. So far, there is no mention of 'mitigation and loss prevention' in the Ministry of Agriculture annual budget.

However, there is some freedom of action in allocating the disaster recovery and maintenance budget. For instance, in 2010, the Ministry of Agriculture received IDR 4.2 trillion (or USD 460 million) to response to loss and damage due to flooding in the agricultural sector.

Recently, the government issued a new law (Law 41/2009) namely 'Protection of (Sustainable) Agriculture Land'. In the cases of natural hazards, the law regulates the change of land use due to disaster or to central government's interest. It further specifies the timelines and indemnity 'insurance' from the government concerning the change of land use after disasters. Chapter 37 regulates incentives to farmers including: building and land tax exemption, infrastructure development, support in terms of research and development of high yield seeds, and facilitating access to information and technology. Aside from this law, there is no clarity on what the ministry of agriculture and hundreds of local agriculture departments do towards risk reduction in the sector.

In regard to anticipatory planning for climate change, the central government, through the National Development Planning Ministry (hereinafter BAPPENAS) recently released the Indonesia Climate Change Sectoral Roadmap (ICCSR) which integrates climate change and development. This is the first step towards explicitly bringing climate change into national development planning. In addition, this is the first time, that climate adaptation has been mentioned in a BAPPENAS report as it claims to provide a: "national roadmap for mainstreaming climate change into development planning." In the ICCSR Chapter 5-7, there is detailed elaboration of climate adaptation in several sectors, including the water sector (water availability, floods, and droughts), the marine-fisheries sector (coastal inundation, sea temperature, extreme events) and the agriculture sector (food and plantation production).

The ICCSR for the agricultural sector is claimed to be a policy guide in the agriculture sub-sectors for 2010-2029. To address the impact of climate change in the agricultural sector, the government will focus on the following areas. First, adaptation in the agricultural crops sub-sector in sustaining and stabilizing national food resilience. Second, to promote carbon mitigation in the plantation sub-sector through environmentally friendly and low carbon technology.

At the local level, there is still no agricultural resilience. New dynamics arising from Indonesian decentralization is also delaying implementation of risk reduction measures at the local level, as prioritized by the central government. Missing links in disaster governance in Indonesia have been recently addressed by creating a stronger national disaster management agency (BNPB). The approach is to pool funds at the BNPB and enable regions (districts and provinces) to access the funds as long as they are willing to establish specialized institutions in disaster reduction at the local level. Even though this policy is well justified, recent close investigation shows that there remains a need for significant reform in balancing pre and post disaster oriented funds.

Questions remains on how these ministerial policies interact and streamline efforts towards agricultural risk reduction. In addition, it is unclear how local-national government can work in a clear risk governance framework that allows them to recognize and prioritize strategic sectors such as agricultural risk. Recent efforts to integrate disaster risk reduction and climate adaptation in Indonesia may keep hope alive that there will be sustained efforts in agricultural risk reduction.

## 8. Final Conclusion

This paper examines the impact of disasters and climate hazards on Indonesian agricultural and food crops. The findings firmly conclude that natural catastrophes have already caused a great deal of loss. This challenges the government's existing policy in expanding crop fields and agricultural areas. Loss accumulation over the last decade has caused significant leakage of central government funds, and reduced agricultural production.

Bourgeois and Kusumaningrum (2008) ask "what cereals will Indonesia still import in 2020". Should Indonesia change its rice import policy to be able to feed its people once widespread droughts and floods occur in the future, triggered by climate change? Climate change is likely to challenge agricultural crops in the Mekong Delta, the main source of rice imports for Indonesia (Thailand and Vietnam).

The emerging 'agricultural involution' - as an outcome of ignorance in dealing with multiple stressors in agricultural crops – suggests that Indonesia may hardly achieve stable food production. This challenges the long standing food 'self-sufficiency' policy.

In theory, one of the keys to achieving food ‘self-sufficiency’ in the broader sense could be loss prevention. The average rate of losses during 2003-2008 was 1%. Average area expansion was 2% per annum during the same period. This suggests that expansion is always held back by losses, by as much as 1%.

Agricultural crop losses will persist if the “business as usual” scenario (no mitigation or loss prevention) takes place. Global climatic change has certainly impacted local climate patterns and their impact on agriculture is clearly suggested by previous studies. It is very likely that Indonesia will continue to experience high levels of loss and damage in food crops. Therefore, hazard mitigation and adaptation strategies are needed for all agricultural crops.

Flood management and water management in agricultural fields should be continuously integrated and sustained. In addition, it has become clear that earthquakes and tsunami mitigation in the agricultural infrastructure should also be considered. While these suggestions are technically feasible and necessary, they remain challenging at institutional levels.

Global discourse concerning risk management for future drought, within the context of agricultural adaptation to climatic change, suggests drought resistance seeds. Naylor, *et al*. (2007) added ‘water storage, crop diversification, and early warning systems’ to the list of investments needed for loss prevention in response to drought and El-Nino.

Agricultural catastrophe insurance has been barely recognized in the country. Most of the losses are therefore largely uninsured. This suggests the importance of risk transfer mechanisms such as agricultural insurance. The challenge is to find ways of making such a policy a reality in the future in both the local and the national context.

A question for future research concerns the kind of institutional scenarios required for Indonesia to be able to safeguard its agricultural infrastructure and agricultural crops from the impact of the natural hazards and climate change that are embedded in the nation’s biophysical and geophysical systems.

Indonesia is likely to experience agricultural involution in the 21st century, not because it fails to adopt the required technology but because there is a lack of loss mitigation and adaptation policy and planning relating to both natural catastrophes and to climate risks.

What is clear is that the definition of future sustainable agriculture must be revised to take account of natural hazards, climate risks and other relevant stressors.

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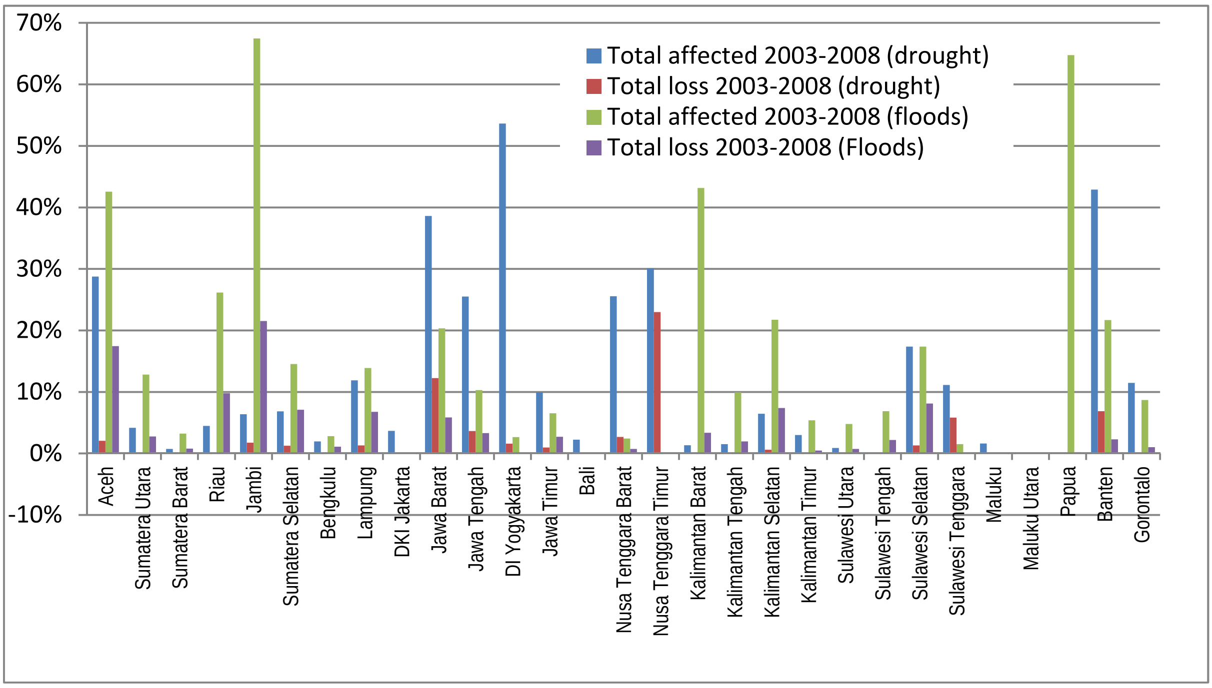
# Annex

## Annex 1. Rice Loss due to Flood and Drought



# CHAPTER 17

# Impacts of Natural Disasters and Disaster Risk Management in China: The Case of China's Experience in the Wenchuan Earthquake

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*Due to the complicated climatic and geographic conditions and distinct spatial-temporal variations, China is one of the countries which are severely hit by various kinds of natural disasters with high frequency and wide distribution. Investigating and scientifically researching the impacts of natural disasters on social and economic development of China in the past 30 years against a background of sustained and rapid economic and social development of China will help alleviate the disasters and respond to the threat of climate change. As a result, the explorations will lead to achieve the harmonious development of mankind and nature, and to promote the coordinated progress of economy, society, population, resources and environment. To this end, we analyzed the impacts of natural disasters on security of the persons, agriculture safety and economic security in the past 30 years. The results reveal the high vulnerability of China's economic system to natural disasters. Moreover, climate warming will further exacerbate the vulnerability of above mentioned social-economic development system to natural disasters and make the disasters' risks increased. Therefore, in order to effectively deal with the high-risk situation of natural disasters and build the low disasters risk society, there is an urgent need for implementing the comprehensive strategy of disaster reduction for sustainable development and adding the integrated disaster risk management throughout the whole process of natural disaster management. Accordingly, capacity-building of comprehensive disaster prevention and reduction will be strengthened and sustainable development mode coexisted with disaster risk will be realized, thus to reduce the vulnerability on socio-economic development system of natural disasters.*

***Keywords*:** China's social economy; Natural disasters; Impacts analysis; Vulnerability; Risk management; Sustainable development

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# 1. Introduction

Natural disasters are variations and extreme events which cause damage and destruction to human life safety, economic development, the living environment and resources. A natural hazard is a complex system with interactions between natural hazard-inducing factors (natural mutation factors) and the socio-economic system (the person-property-environment-resource composite system) under certain conditions. This complex system has intricate characters of structure, functionality, heterogeneity of spatial and temporal distribution, openness, high dimensionality, uncertainty and so on (Wei, *et al*. 2002). Natural disasters often affect large numbers of people worldwide. Every ten years the death tolls reaches 1 million and more millions of people are rendered homeless. Destruction to the global economy caused by natural disasters was to USD40 billion in the 1960s, USD70 billion in the 1970s and up to USD120 billion in the 1980s (Domeisen, 1995).

## 1.1. Overview

China, which stretches across a vast area with complicated natural conditions and a significant unstable monsoon climate, is a country severely affected by various natural disasters with high frequency and wide distribution. In the past 30 years, along with the sustained and rapid development of China's social economy, natural disasters in China present the character of multi-hazard concurrence, mass disaster occurrence and outbreaks. Rarely seen in history, there have been serious natural disasters, such as the Wenchuan earthquake, cryogenic freezing rain and snowy weather in southern areas, extended winter-spring drought, the Yushu earthquake, debris flows and flash floods in Zhouqu and so on, which have occurred frequently in recent years, and losses continue to increase. Since the beginning of the 21$^{st}$ century, there have been 13 earthquakes above 8 magnitude in the world, and two of them occurred in China. China's casualties inflicted by earthquake were the highest in the world. In the 20$^{th}$ century, there were about 1.2 million deaths caused by earthquakes in the world including, China's 600,000 deaths. Apparently, China, which occupies 70 % of the land, has 20 % of the population, and has 80 % of industrial and agricultural areas and cities in the world, is harshly affected by natural disasters. (Zhang, *et al*. 2006) There are numerous kinds of natural disasters in China. The most familiar disasters are those caused by meteorological factors, including droughts, floods, cryogenic freezing rain and snowy weather, hail and sandstorm. In addition, there are continuous geological disasters, such as earthquakes, debris flows, land subsidence, avalanches, landslides and ground fissures. In addition, some natural disasters arise from oceanic occurrences, such as tropical storms, storm surges, sea ice, coastal erosion and red tide[1]. Furthermore, there are environmental disasters like soil erosion, desertification, vegetation degradation, sharp decline of biodiversity, shortage of water and environmental pollution. Among all these natural disasters, meteorological disasters, which account for more than 70 % of all disasters, with great variety and high strength and frequency, pose serious threats to economic and social development and to people's lives and property, and therefore affect the implementation of a sustainable development strategy. According to Sun (2009), during 1978 to 2002, there have been 13 major floods and 12 major droughts. Disasters happened nearly every year, mostly floods in the south and drought in the north. Since the 1990s, in the context of climate change and global warming, global meteorological disasters have increased significantly, and have affected social and economic development on the slide. To mitigate the damage from natural disasters, respond to the threat of climate change, achieve the harmonious development of human and nature, and promote the coordinated development of economy, society, population, resource and environment, are important issues in dealing with disasters. Even national economic and social development is a factor here, as well as a vital part of national security strategy in the 21st century. In future,

[1] Red tide is a phenomenon caused by algal blooms during which algae become so numerous that they discolor coastal waters (hence the name "red tide").

exploration of the impacts of natural disasters on the social and economic development of China, recognizing the impacts of disasters from the perspectives of science and management, and then minimizing destruction are undoubtedly crucial research projects.

### 1.2. Literature Review

Research into the impacts of natural disasters on social and economic development has long been important. (Ma and Gao, 2010) There is an old saying in China, "Famine happens every three years, epidemic happens every six years, and natural hazard happens every twelve years." This is a perfect description of the pattern of natural disasters in China. Take flood and drought disasters as an example, from 1766 BC to 1937 AD, records show that there have been 1058 floods, 1074 droughts and the annual average of flood and drought is 0.86 times (Deng, 1937). Hirshleifer (1966) analyzed the short-term and long-term impacts of plague outbreaks on the economy of Western Europe in 1348-1350. Yu (1988) and Du (1988) are representative publications of the research into China's hazard economics. According to the records of natural disasters in China, Wang, *et al*. (1994) put forward a comment that China's disaster regions could be divided into western, northern and southern parts, using the Hu Huanyong population line[2] and the 34ºN line of latitude as the boundaries. Along the Hu population line, there may additionally be a transition region, and the time characteristics of the China's natural disasters show droughts from March to October, floods from June to September, and that the Huang-Huai-Hai area has always been a frequent location for disasters frequently. Zhang and Shen (1995) hold the opinion that natural disasters would cause negative impacts to economic growth, and based on the Harrod-Domar model, presented a method to calculate the economic losses from natural disasters indirectly,

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[2] Professor Hu Huanyong was a forefather of modern Chinese demography and the founder of China's population geography. He drew the "Aihui-Tengchong Line," which was known internationally as the "Hu Line," in 1934; the line marked a striking difference in the distribution of China's population.

which is an approach to quantitatively analyze the relationship between natural disasters and economic growth.

Hu (1996) calculated the statistics and pointed out that, a "hazard cycle" has clearly existed since 1949 with an average cycle length ranging from 3 to 3.5 years. On the impacts on food production, due to spread of the hazard-affected and damage-affected areas in China, while the per unit grain yield increased, grain losses rose, which directly led to fluctuation of food production. Zheng (1998) argued that the substance of disasters was the economic issue, and summed up four basic laws and five principles of the functions of disasters. In his analysis he showed the characteristics of the agricultural hazard economics, the cyclic fluctuations, the differentiation of regions and the orientation of macroeconomic policy. Lu, *et al*. (2002) discussed the direct losses from natural disasters and their indirect economic losses, using input-output tables, and built a quantitative analysis model for disaster loss assessment. Then he took agriculture as an example to analyze the impacts on the entire economic system of agricultural yield losses caused by natural disasters. He (2002) investigated the theoretical framework and research approach of hazard economic analysis, and made an empirical study of the hazard economy. Thereafter, He produced a rough evaluation of hazard risks in China's future economic development. In order to draw a definite conclusion regarding the impacts of disasters on economic development, Benson and Clay (1998) analyzed the impacts of disasters on long-term economic development using trans-departmental data of 115 countries' real GDP from 1960 to 1993. The results demonstrated that economic growth rates in a country with frequent disasters is lower than a country with relatively fewer disasters. Xie (2003) analyzed the economic losses caused by floods, including reduction of agricultural production, asset ineffectiveness or cessation of industry and mining enterprises, recession of the urban economy, impacts on finance, poverty and famine. Then from the viewpoint of economics, he elaborated the impact of floods both at macro-level and micro-level. Liu, *et al*. (2005) take the view that drought is one of the disasters which affect social economic development mainly in agriculture. Since 1949, China's annual average food loss caused by drought amounts to 5 % for several years and the loss trend is on the rise, especially in the northeast, northwest and north of China. Kunreutherd and Pauly (2006) came to the conclusion that the occurrence of natural disasters would constrain the economic growth, in the first place because of the losses caused by disasters, and then because of investment which has to be made in hazard prevention, rescue and recovery which could have been directed to promoting the development of the economy. Yuan and Zhang (2006) pointed out that the establishment of specified standards for disaster statistics, provision for catastrophic disaster statistics, assessment of disaster statistics and quality improvement for statisticians is a "master pathway" to promote China's disaster statistics.

Zhang, *et al*. (2006) hold the opinion that in the 20th century, along with the tremendous changes in China's social economy, the effect of natural hazards presented significant changes over age and differences among phases. Particularly, from 1900 to 1949, China experienced a semi-feudal and a semi-colonial period, and that resulted in no reduction in the frequency of disasters, and in more casualties and famines, which exacerbated the poverty of people and led to social unrest. Later, from 1950 to 1979, following the initial founding of the New China, there were low capacities for disaster reduction, and disasters happened regularly. Therefore, disasters not only caused serious damage, casualties and property losses, but also critically affected the development of the social economy. After 1980, with rapid and sustained economic development in China, the ability to reduce disasters improved. Even as the affected population increased, therefore, the death tolls and famines reduced notably. Moreover, the destructive effects and incidences of natural disasters spread widely. As well as damage to agriculture, industrial, transportation and other industries were widely affected. Though the direct and indirect losses caused by disasters increased, the relatively losses became smaller and the relationships among disasters, resources and the environment became intertwined, thus impacts on the sustained development of the social economy became profound. The analysis above indicates that the impacts of disasters are not only the result of natural conditions, but are also closely related to the socio-economic background. Economic development, therefore, with improvement in the country's hazard-reduction ability will help to alleviate the hardships arising from natural disasters.

On the basis of the above studies, this uses 30 years' recent data from the China Civil Affairs' Statistical Yearbook and the China Statistical Yearbook, and focuses on impacts of natural disasters on human life security, agriculture and economic security, in order to provide government policy-makers with an evidence base on disaster prevention and mitigation.

## 2. Impact Analysis of Natural Disasters on the Social and Economic Development of China

### 2.1. Impacts of Natural Disasters on the Security of Human Life

The impacts of natural disasters on human life security during the past 30 years were significant, and Figure 1 shows as following.

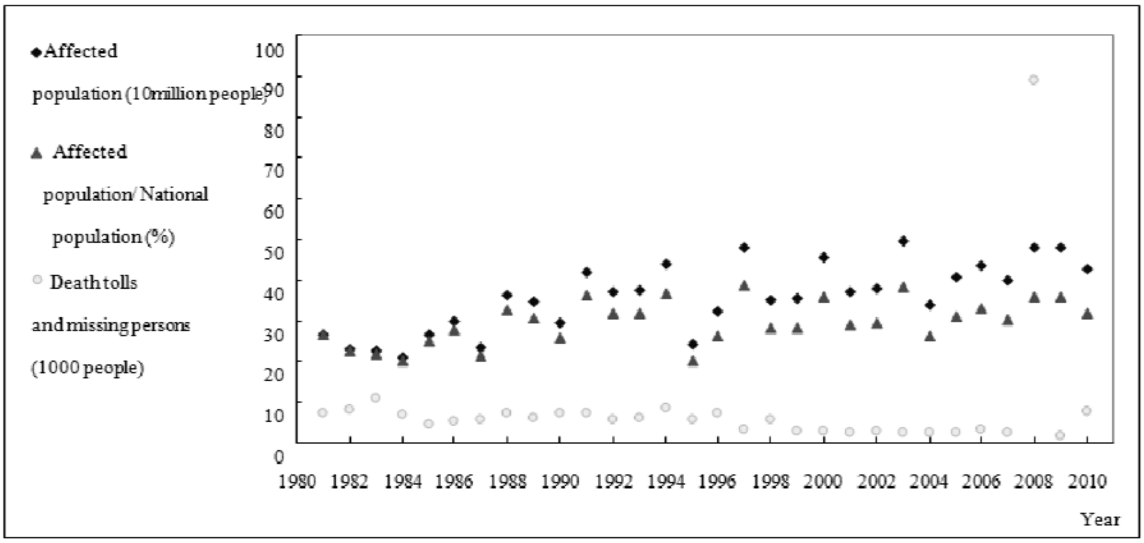
(1) Affected populations were between 209 and 498 million people, accounting for 20-39 % of national population. The annual average affected population reached 358 million people who made up 30 % of the national population. Death tolls and the number of people missing after disasters ranged from 1,528 to 88,928, and the annual average number of dead and missing people arising from disasters was 8,020.

(2) 1991, 1994, 1997, 2000, 2005-2010 were the worst of the 30 years, and the affected population was more than 400 million people in the past 10 years, the affected population increased radically.

(3) The numbers of dead and missing people following disasters showed a decreasing

trend. However, when struck by devastating earthquakes and other severe natural disasters, the numbers of dead and missing were very high.

**Figure 1: China's Disaster-affected Population from 1981 to 2010 (Excluding the population of the Hong Kong Special Administrative Region, the Macao Special Administrative Region and Taiwan Province, See also Figure 2, below)**




## 2.2. Impacts of Natural Disasters on Agricultural Security

From Figure 2, it can be seen that the impacts of natural disasters on agricultural security were extensive during the past 30 years.

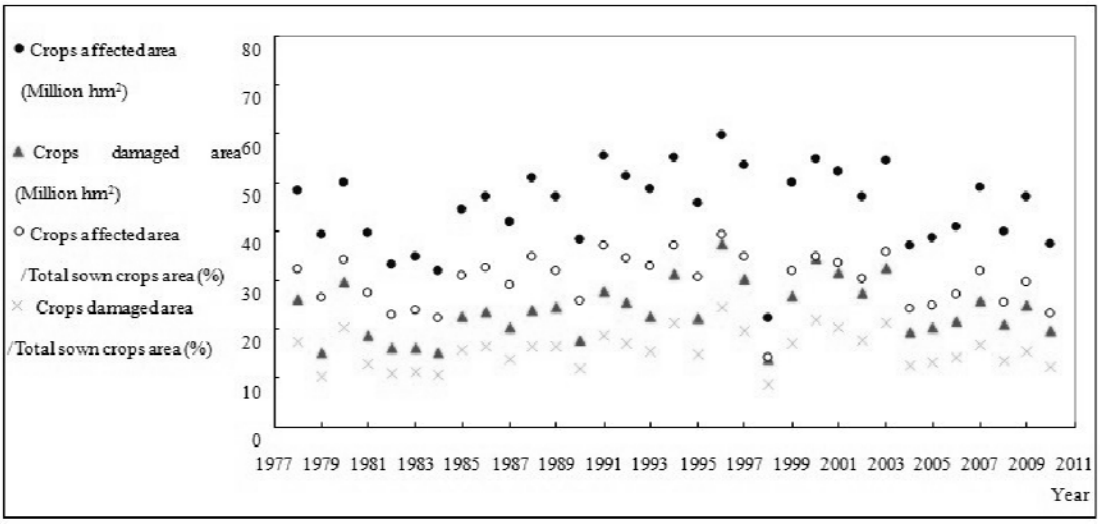
(1) The area of crops affected ranged from 22.3 to 59.8 million ha and the annual average area of affected crops reached 45.1 million ha which accounted for 14.32-39.21 % and 30 % of the total sown area of farm crops (hectare) respectively.

(2) The crop damage areas ranged from 13.8 to 37.5 million ha and the annual average damaged area extended to 23.8 million ha which accounted for the proportion of the total sown crops area to 8.86%-24.59% and 16% respectively.

In 1980, 1988, 1991, 1992, 1994, 1996, 1997, 2000, 2001 and 2003 the areas of crops affected extended to 50 million ha. The area of damaged crops covered more than 20% of the total sown crop areas in 1980, 1994, 1996, 1997, 2000, 2001 and 2003.

For nearly the whole of the 30 years period covered by the statistical record used, crops were brutally affected by disasters.

**Figure 2: Area of China's Crops Affected from 1978 to 2010**




### 2.3. Impacts of Natural Disasters on Economic Security

Figures 3 and 4, show that the impacts of natural disasters on economic security were widespread over the past 30 years.

(1) The number of collapsed houses in each year totaled between 0.922 million and 10.977 million rooms, and the annual average number was 3.3954 million rooms. The number of damaged rooms ranged between 3.121 and 26.287 million, and the annual average figure was 9.3225 million rooms.

(2) Direct economic losses extended from USD 8.23 billion to USD 212.30 billion, and the annual average direct economic losses caused by natural disasters amounted to USD 39.35 billion, which is ten times the losses suffered by the developed countries like the United States.

(3) The range of direct economic losses caused by natural disasters over 30 years, as a proportion of annual gross domestic product (GDP) was 0.7% to 5.6%. The

annual average direct economic loss was 2.5% of GDP. As a result, the impacts of natural disasters offset a portion of China's economic achievements.

(4) In the past two decades, direct economic losses caused by natural disasters showed an increasing trend. However, once in the event of catastrophic natural disasters, the direct economic losses will come to a huge amount.

(5) Over the past two decades, the percentage of direct economic losses to GDP has declined. However, once in the event of catastrophic natural disasters, the direct economic losses will highly account for the proportion of GDP.

(6) Direct economic losses and the growth rate of GDP are negatively correlated. One piece of evidence for this is that, while the growth rate of direct economic losses caused by natural disasters reduced from 9.7% in 2003 to -15% in 2004, the growth rate of GDP increased from 12.9% in 2003 to 17.7% in 2004. Moreover, although the growth rate of direct economic losses caused by natural disasters rose from -15% in 2004 to 27.4% in 2005, the growth rate of GDP fell from 17.7% in 2004 to 14.6% in 2005.

**Figure 3: Impacts of Natural Disasters on China's Economic Losses in 1989-2010**

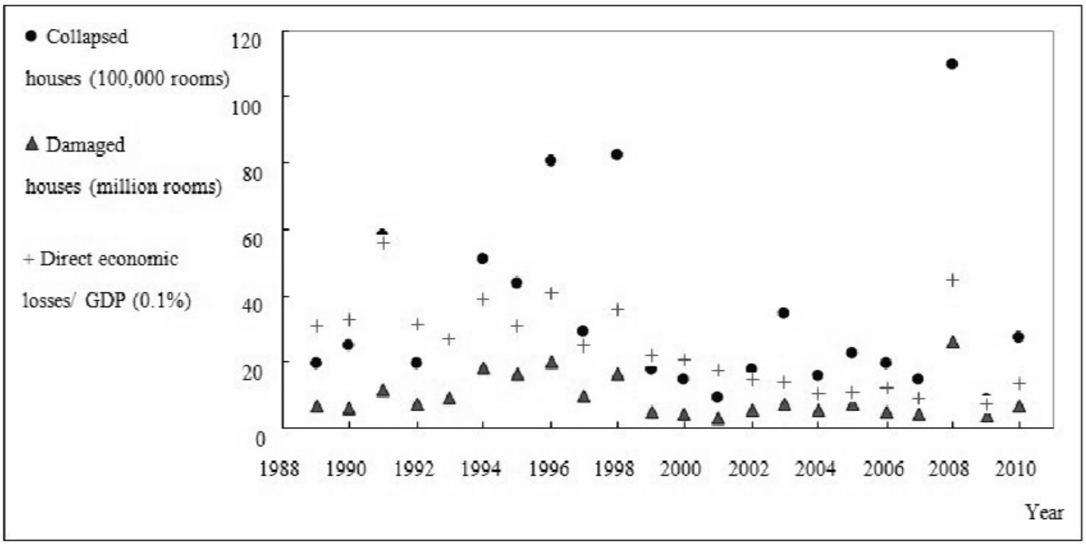
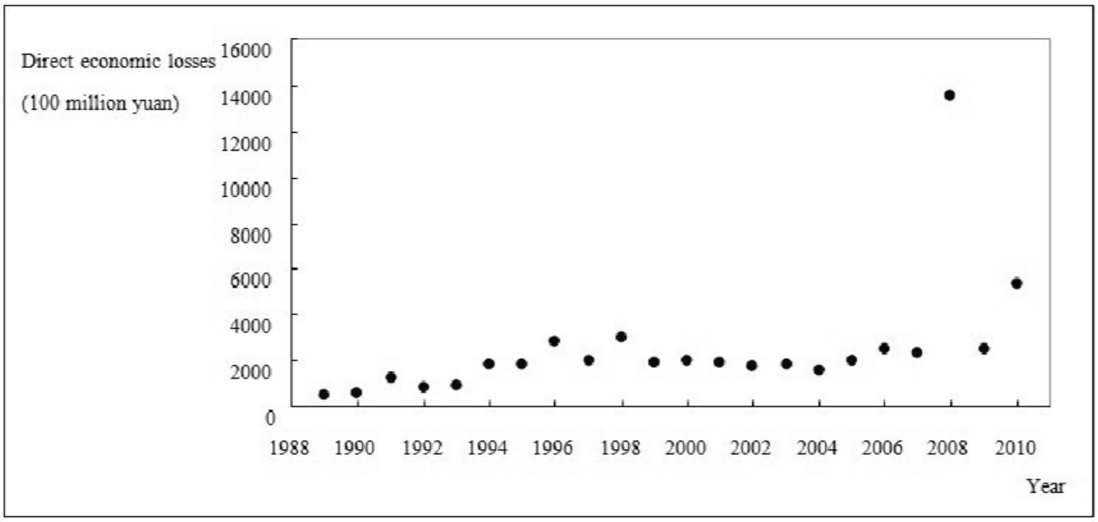


**Figure 4: China's Direct Economic Losses in 1989-2010**




### 2.4. Conclusions and Discussion

(1) The impacts of natural disasters on human life security have been significant over the past 30 years in China. The annual average affected population reached 358 million people who made up 57% of the world's annual average affected population and 30 % of the national population. The annual average rate of dead and missing people stemming from disasters was 8,020 which amounted for 9.9 % of the world's annual average rate of dead and missing people. While the affected population has risen significantly in the past 10 years, the numbers of dead and missing people have tended to fall. In the event of devastating earthquakes and other severe natural disasters, however, large numbers of people die or become missing. That indicates the high vulnerability of the human life security system to severe natural disasters.

(2) The impacts of natural disasters on China's agricultural security have been substantial. The annual average area of affected crops reached to 45.1 million ha which made up 30 % of the total sown area of farm crops. The annual average damaged area extended to 23.8 million ha, accounting for 16% of the total area of sown crops. For nearly every one of the 30 year period covered by our data crops were severely affected by disasters, indicating the high vulnerability of the crop

production system to natural disasters.

(3) The impacts of natural disasters on China's economic security were notable. The annual average number of collapsed houses reached 3.3954 million rooms, and the annual average figure of damaged rooms was 9.3225 million rooms. The annual average direct economic losses caused by natural disasters amounted to USD39.35 billion, or 2.5 % of GDP and 22 % of the global losses. In the past two decades, while direct economic losses caused by natural disasters showed an increasing trend, the percentage of direct economic losses to GDP has declined. However, once in the event of catastrophic natural disasters, the direct economic losses will come to a huge amount and highly account for the proportion of GDP. Consequently, direct economic losses and the growth rate of GDP are negatively correlated. Natural disasters offset part of China's economic achievements, pose a great threat to national wealth, and constrain economic development. All these factors reveal the high vulnerability of China's economic system to natural disasters.

(4) According to Qin, *et al*. (2005), climate warming in China has been almost synchronized with the global trend, but the range of warming may be greater. By 2020, the national average surface temperature could increase by 1.7°C, by 2030 2.2°C and by 2050 2.8°C. What's more, the extent of climate warming in China would increase from south to north, except for the increased rainfall in the western part of the northwest, while the north and southern part of northeast would be permanently dry. Climate warming would lead more droughts in China, the drought-prone area would continue to expand, and droughts would grow more intense. As a result, heavy rainfall, floods, soil erosion, landslides and other geological disasters would increase dramatically, and further aggravate the vulnerability to natural disasters of the socio-economic development system of China.

(5) In order to effectively deal with the high risk of natural disasters in China, and build a low disaster-risk society, there is an urgent need for transition from disaster

reduction to a comprehensive strategy of hazard reduction for sustainable development, and adding integrated hazard risk management throughout the whole process of natural hazard management. Accordingly, capacity-building for comprehensive hazard prevention and reduction must be strengthened and sustainable development alongside hazard risk needs to be achieved, thus reducing the vulnerability of the socio-economic development system to natural disasters.

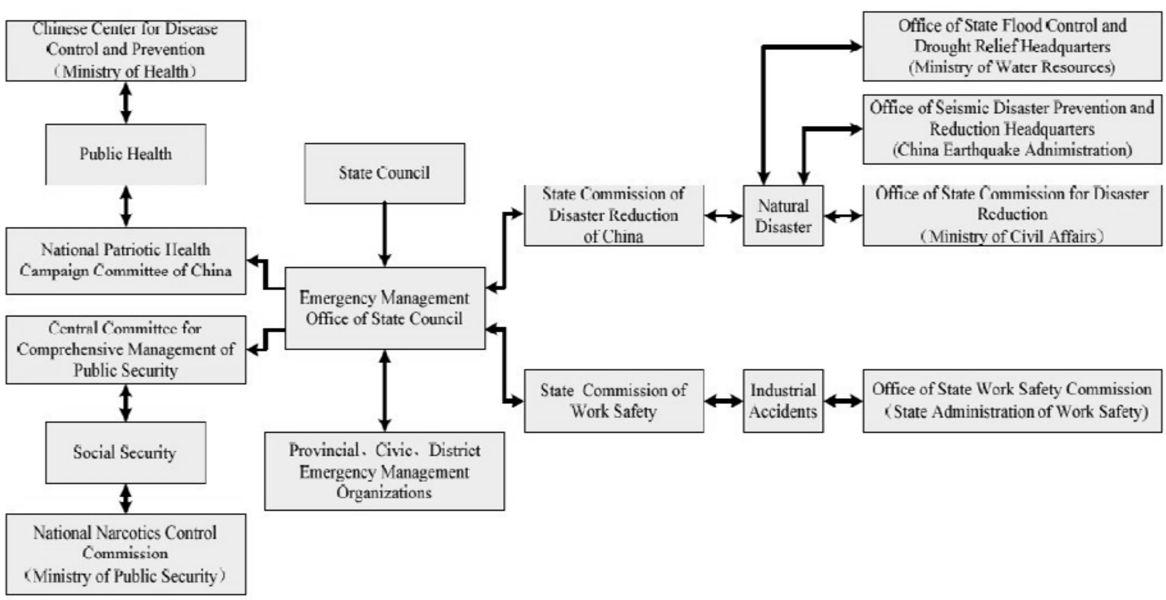
## 3. Disaster Risk Management in China

### 3.1. The Chinese Integrated Disaster Management System

In order to enhance emergency management and implement the governments' function entirely, the national Emergency Management Office of the State Council was established in April 2006. It works as an operation "hinge", taking charge of the daily work of national emergency management, responding to public security events, collecting real-time information and harmonizing the related departments. Since its establishment in 2006, the State Council Emergency Management Office has carried out some effective work to enhance disaster emergency management: it has helped implement the State Master Plan for Rapid Response to Public Emergencies in China; it has held an emergency management working meeting of the State Council and a management working meeting of enterprise emergency work, to deploy and unify emergency management. It coordinates governments of all levels to enhance emergency construction ability and to prepare for prevention of and dealing with public security emergencies. It has also started a Key Technologies R and D Program for emergency platform construction to provide science and technology support for emergency management, and to increase emergency treatment efficiency.

So far, the Chinese disaster risk (public security) management system has established, one office and four committees: the establishment of the State Council Emergency Management Office at the national level and corresponding organizations with regard to the four types of public security incidents—the National Committee for Disaster Reduction to manage natural disasters, the National Committee for Work Safety to manage industrial accidents, the National Committee for Patriotic Health to manage public health and the National Committee for integrated management to manage public security. The four committees are made up of a vice president or a committeeman of the State Council of China as committee director, a minister or vice minister from the main related ministries as administrative vice director or vice director, and the vice ministers from the corresponding ministries as committee members. At the local levels, there are corresponding disaster risk (public security) management organizations with accordance to the national level. Local emergency management centres and the committees of management for the four public security incidents have been gradually established. The disaster risk management organization system of China can be shown as follows (Figure 5).

**Figure 5: Disaster Risk Reduction Strategy of China ("One Office and Four Committees")**



Additionally, in order to enhance the disaster risk management work in these related ministries and commissions, corresponding management centers have been established, such as the Chinese center for disease control and prevention (Ministry of Health), the National Disaster Reduction Center of China (Ministry of Civil Affairs), the Chinese Supervision Center for Work Safety (State Administration of Work Safety), etc. Among these committees, the National Committee for Disaster Reduction (NCDR) is the national counseling and coordination body under the guidance of the State Council for emergency disaster response and relief. NCDR consists of 34 disaster related member agencies as shown below (Figure 6).

**Figure 6: Disaster Management Organization Structure**

In conclusion, China has started disaster risk (public security) management work on the basis of traditional disaster management and reduction, and has formed a primary disaster risk management framework involving related professional fields. In addition it is intended to pass emergency laws to enhance the legal basis of disaster risk emergency management. The China Association for Disaster Prevention has also established the first professional organization for risk research, which has been named as the Risk Analysis Specialty Committee. Many Chinese universities and research institutes have also been doing research on natural disasters, engineering hazards, economic risks, crisis management and disaster risk management, and so on. However, compared with the international situation, disaster risk management in China faces not only an austere and significant challenge but also a very good opportunity.

### 3.2. Regional Adaptation Strategies for Disaster Risk Reduction: The Disaster Management Cycle

The Chinese regional integrated disaster risk management philosophy adheres to the principle of "give priority to disaster prevention, and combine disaster prevention with disaster resistance and relief". Namely, before disaster occurrence, it's important to establish and test the monitoring and warning system, to carry out emergency planning, to strengthen the ability to procure emergency materials, to build an ecologically healthy environment, to accelerate regional economy and reduce disaster vulnerability. When a disaster takes place, it is important to improve emergency response ability to emphasize actions oriented toward human welfare, to reduce the casualty rate and the rate of property loss and to provide maximum protection to natural resources and the environment. After a disaster, government and society's relief ability at all levels must be strengthened, especially community self-rescue and self-relief ability. Finally, based on the results of a rapid disaster loss assessment, it's urgent to recover lifeline and product line systems and accelerate the effectiveness and efficiency of reconstruction.

At present, governance of natural disaster risk in China is the responsibility of different ministries or bureaus related to the different kinds of natural hazards, e.g. the China Earthquake Administration takes charge of governance in the case of earthquake disasters, the China Meteorological Administration takes charge of governance following meteorological disasters, the Ministry of Water Resources takes charge of governance in the case of floods and droughts, the Ministry of Land and Resources takes charge of governance following landslides and debris flows, the State Ocean Administration takes charge of governance in the case of ocean disasters, and so on. To enhance governance in the case of some large-scale disaster, the State Council has set up several leading groups for natural disaster governance, such as the State Flood Control and Drought Relief Headquarters and the State Earthquake Relief Headquarters. Correspondingly, each regional and local government has set up relevant departments. There are corresponding organizations in local governments at all levels in China. In a word, China has adopted a natural disaster governance system which combines vertical inter-government and inter-regional management modes, where vertical sector management comes before integrated regional management. The existing adaptation planning called the "disaster management cycle", and is presented as below (Figure 7).

**Figure 7: Disaster Management Cycle**

### *3.2.1. Monitoring and Warning*

During the disaster preparedness period, mitigation and prevention work are the responsibility of the professional technical departments, namely the bars.

In recent years, the Chinese government has increased investment in respect of natural disaster monitoring and warning system construction, and has established a natural disaster monitoring, warning and forecasting system, including meteorological disaster monitoring and forecasting, earthquake monitoring and forecasting, hydrological monitoring, forest fire prevention, forest and crop pest monitoring and forecasting, marine environment monitoring, and geological disaster monitoring and early warning. This natural disaster monitoring, warning and forecasting system can monitor a disaster's dynamic development, and provide information for disaster emergency decision-making.

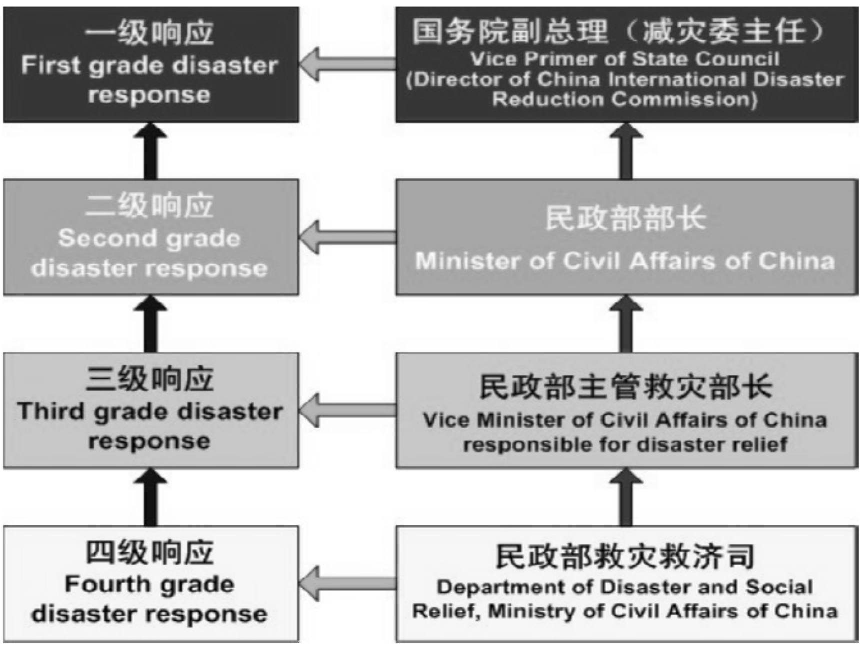
### *3.2.2. Emergency Response*

During a disaster period, the emergency management offices and the disaster reduction committees of all levels are in charge of emergency response, together with the Civil Affairs departments, the Public Security departments, the armed forces, etc. The bars and the blocks are combined together quickly and closely to deal with the emergency as soon as it begins. At present, a disaster emergency response system is up and running to guarantee that rescue taskforces, relief supplies, funds and information are on the ground and in place to address the immediate and real needs of the affected.

According to disaster emergency management, the Chinese government has strengthened the emergency planning system. In the Master State Plan for Rapid Response to Public Emergencies, public security events are divided into four kinds (natural disasters, industrial accidents, public health and social security) according to their causes, characteristics and mechanisms, and into four grades (huge, bigger, big and ordinary grade) according to their degree of severity, their controllability and the area affected. “Huge” and “bigger” grade emergencies must be reported to the State Council within 4 hours of the occurrence. Local governments or related departments have to start their related emergency plan promptly and effectively, in the responsibility and power range to control the further development. Additionally, several special plans and department plans for rapid response top emergencies have been drawn up.; and similar plans have also been compiled by national and local governments. This planning makes disaster risk management and disaster reduction more regular and systematic.

In the case of a natural disaster emergency, as prescribed in the “State Emergency Response Planning for Natural Disasters”, according to the degree of loss arising from the disaster, the Ministry of Civil Affairs of China adopts a four-grade response system (Figure 8). In other words, different levels of emergencies are to be dealt with by governments of different levels. The more severe the situation it is, the higher level of the government that will respond and make decisions.

**Figure 8: Emergency Responses Grading for Natural Disasters in China**



### *3.2.3. Restoration and Reconstruction*

During the post-disaster period, the disaster relief and recovery work is controlled by the local disaster reduction committee, which works as a coordinator for the main departments to organize people in disaster area and helps them to recover their normal lives These include the Civil Affairs departments, the Health departments, the Development and Reform Commission, the Finance departments, the Communications departments, the Construction departments, the Railway departments, etc. Namely, the blocks are the main responsibility body. Among these different departments, the Civil Affairs department takes the main responsibility for the disaster victims' life relief, and the insurance companies carry out the compensation for the disaster victims to help them to recover as soon as possible.

In addition, the Chinese government encourages the public social donations and voluntary activities from the whole society, and NGOs are to be an important force in the post-disaster period. This social mobilization mechanism provides a solid material support for disaster management, and helps the people in less-developed areas to recover rapidly after disasters.

### *3.2.4. Legislation*

China has instituted, promulgated and enforced laws and regulations as it moves forward to phase in a legal framework for disaster reduction. The laws and regulations are, however, all about single aspects of disaster risk management, such as the "Law of the People's Republic of China on Protecting Against and Mitigating Earthquake Disasters", the "Flood Control Law of the People's Republic of China", the "Law of the People's Republic of China on Safety in Mines" and so on. There is no systematic and comprehensive series of laws and regulations about disaster reduction, especially in respect of disaster relief, disaster insurance, post-disaster subsidies for reconstruction, tax reduction for the victims, and so on. Moreover, existing laws and regulations are generally aimed at singe disaster types. It is therefore urgent to construct a law in respect of integrated disaster risk management, so as to carry out integrated disaster prevention and reduction. There is currently no explicit legal status for any integration and coordination of sectors.

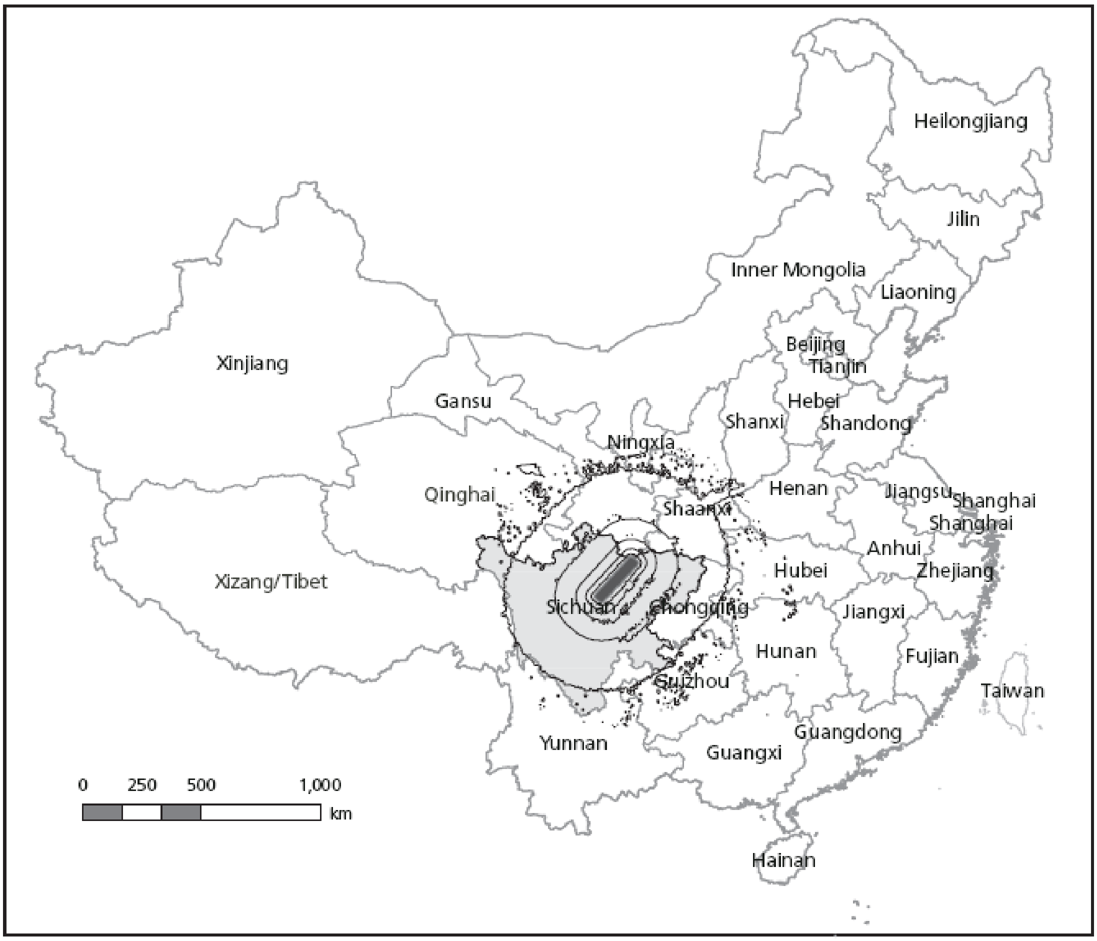
Since the 1990s, moreover, in the context of climate change with global warming, global meteorological hazards have increased significantly, and are negatively affecting social economic development. Accordingly, capacity-building relating to comprehensive hazard prevention and reduction will be strengthened and sustainable development alongside hazard risk will be achieved, thus reducing the vulnerability of the socio-economic development system of to natural hazards.

## 4. China's Experience in the Wenchuan Earthquake

### 4.1. Overview of Earthquake Impact in Affected Areas

The Wenchuan earthquake struck China on May 12, 2008 with a strength of 8.0 on the Richter scale. Its strength and deadly impact made it one of the most disastrous earthquakes in the world (U.S. Geological Survey 2008). The earthquake epicenter was located in Yingxiu in Wenchuan County, Sichuan province. Figure 9 shows the location of Sichuan province and the impact zone of the Wenchuan earthquake. The area shaded dark grey is the most intense impact zone, while the semicircular lines surrounding it indicate boundaries between areas of progressively lower intensity.

**Figure 9: Sichuan and the Impact Zone of the Wenchuan Earthquake**




*Source*: Earthquake Geospatial Research Portal (2008A)

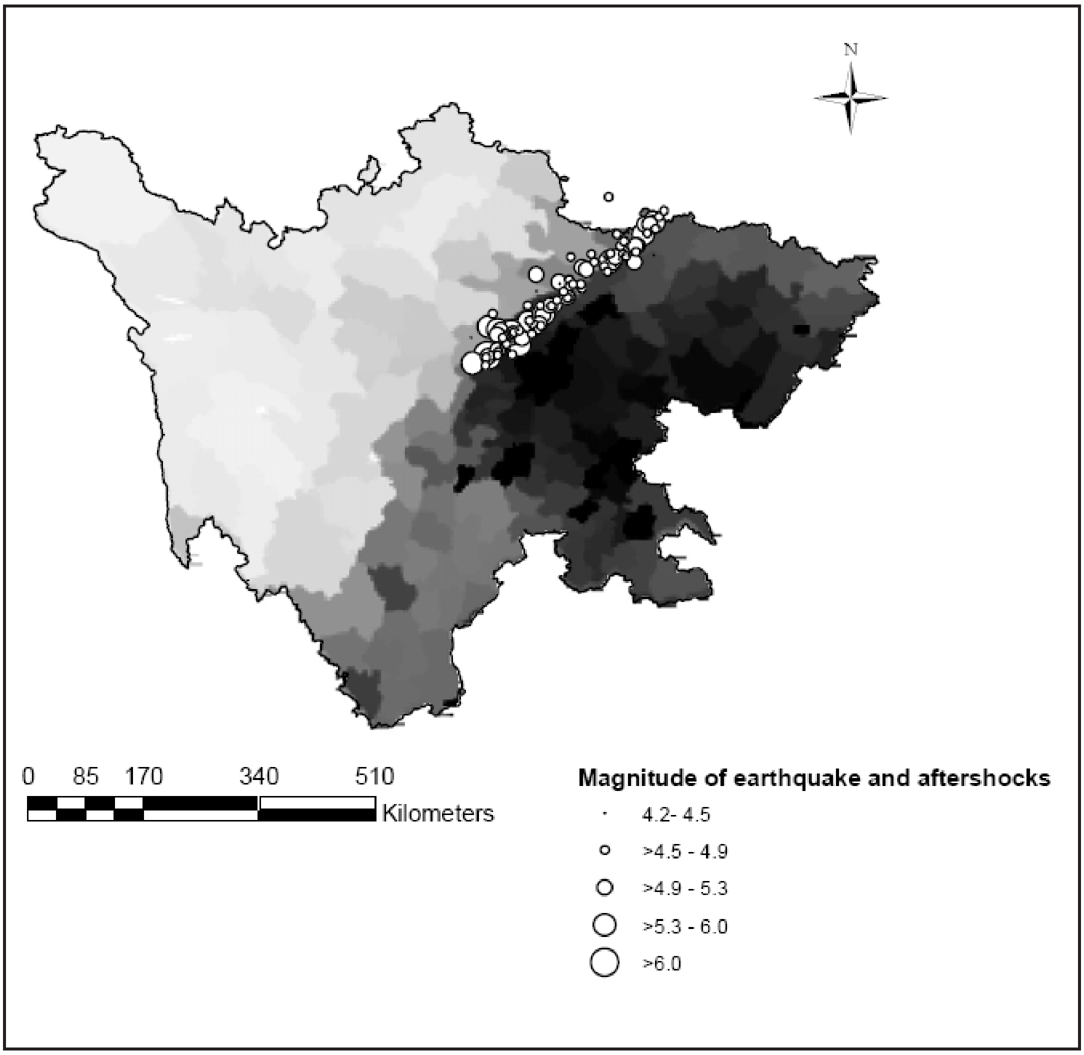
The Wenchuan earthquake caused destruction across 10 provinces in China, and its tremors were felt as far away as Thailand. Strong aftershocks, landslides, mud-rock flows, barrier lakes and other secondary disasters continued to threaten people's lives and property for many weeks, and made the rescue work difficult. Altogether, more than 45.5 million people were affected by the earthquake. By August 25, 2008, 69,226 people were confirmed to have been killed in the disaster, while 17,923 were missing and 374,643 had been injured (U.S. Geological Survey 2008, p.4). At least 15 million people were evacuated from their homes following the earthquake. In total, an estimated 5.36 million buildings collapsed and 21 million buildings were damaged (US Geological Survey 2008). The direct economic loss from the earthquake was more than USD125.7 billion, most of it due to loss of infrastructure and buildings (China State Council Information Office, 2008). It is estimated that around 1.2 million people had lost their jobs by the end of July 2008 (China Ministry of Human Resources and Social Security, 2008).

While large parts of the country can be said to have been affected by the Wenchuan earthquake, efforts were made to delimit the areas that had received the heaviest direct impact and were thus in most need of help. In what has been the Government's official classification since August 2008, 51 counties were eventually officially defined as "seriously" or "very seriously" affected by the Wenchuan earthquake. Decisions about which counties should be considered "seriously" or "very seriously" affected were political ones based on a review of what was known about the situation in the various counties at the time, rather than on strict scientific criteria. Most of the counties that were "very seriously" affected faced near-complete devastation.

At the time of the earthquake disaster, the total population of the 51 seriously and very seriously affected counties was 19,867 million people[3], of which approximately four million were living in very seriously affected areas (The State Planning Group of Post-Wenchuan Earthquake Restoration and Reconstruction, 2008, p.2). Covering an area of more than 130,000 square kilometers, these counties are spread across Sichuan, Gansu and Shaanxi provinces. Most are located in Sichuan, including all the counties classified as the most seriously affected.

[3] This was the official population count at the end of 2007.

**Figure 10: Population Density in Sichuan and Location of the Wenchuan Earthquake (Population Density)**




*Source*: Earthquake Geospatial Research Portal (2008B))

The large majority of people in the earthquake-affected areas were rural residents who were relatively underprivileged compared to those in other parts of China. The Wenchuan earthquake and its aftershocks were centered just north of the most densely populated areas in Sichuan (Figure 10). The North-west part of the impact area is sparsely populated, while the south-east area is densely populated. There are large differences between the North-west and the south-East with regard to resources, ecology and economic development. The plain area in the east, with Sichuan's capital

Chengdu at its centre, is a fertile, well-irrigated agricultural region. The area was developed as an industrial base during the Mao era, and its level of industrialization remains comparatively high, including industries in the fields of mechanical equipment, electronics, energy, chemicals, steel and biopharmaceuticals. Many of these local industries were seriously damaged in the earthquake.

By contrast, the mountainous western region is geographically isolated, scarce in resources and population, and home to many of China's ethnic minorities. It is relatively isolated and economically underdeveloped, with a vulnerable ecology and limited industrial development. Most of the heavily-hit zones are located in these western mountains and valleys, which are difficult to access under normal circumstances and were extremely difficult to reach for rescuers facing destroyed or blocked roads as well as secondary disasters (The State Planning Group of Post-Wenchuan Earthquake Restoration and Reconstruction, 2008, pp. 2-3).

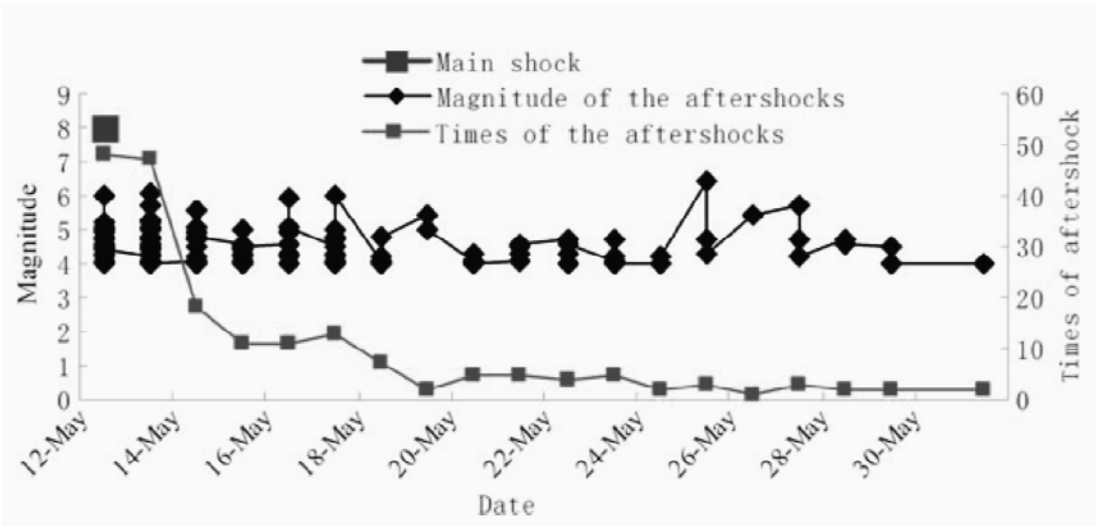
### 4.2. Aftershocks

As is often the case for earthquakes on reverse faults, aftershocks are of high intensity and long duration due to a lag in tectonic strain release.

Figure 11 is a graph of the aftershocks. As of 10 a.m. June 5, a sum of 10,254 aftershocks had been detected by the China Earthquake Monitoring Web. Among these aftershocks, the number with a magnitude 4.0 and above was 197, 166 had magnitudes among 4-4.9, 26 had magnitudes among 5.0-5.9, and five aftershocks occurred with magnitudes of 6.0 or greater. The strongest aftershock was of magnitude 6.4.

Within 10 hours after the major shock of May 12, there occurred one aftershock of magnitude 6.0, and 12 of > 5.0. As time passed, the number decreased, but the magnitude remained high. Two weeks after the major quake, an aftershock of magnitude 6.4 Mw occurred. The aftershocks occurred mainly in the middle and northern portion of the Longmenshan Fault zone. Aftershocks showed a tendency of moving to the northeast along the Longmenshan Fault zone, moving toward Wenxian County in Gansu Province and Ningqiang County in Shaanxi Province.

**Figure 11: After Shocks Series of the Longmenshan Earthquake as of 10 AM June 5, 2008**




### 4.3. Partner Support regarding Wenchuan Earthquake

The "Partner support" program is a system where provinces or cities provide support to a related affected area on a one-to-one basis, under the principle of "one province helps one significantly affected county". With resources reasonably placed based on the economic development level of each area, 19 provinces (cities) support 18 heavily affected counties (cities) as well as seriously damaged areas (seriously affected district) in Gansu and Shaanxi provinces (Table 1). Provinces (cities) assigned under the program provide assistance for three years. Each supporting province (city) is required to allocate 1% of local financial revenue in the preceding year for goods and work operations every year.

**Table 1: Partner Support regarding the Wenchuan Earthquake in China**

| Supported areas | | Supporting areas |
|---|---|---|
| **(Sichuan)** | | |
| Wenchuan | ← | Guangdong |
| Beichuan | ← | Shandong |
| Qingchuan | ← | Zhejiang |
| Mianzhu | ← | Jiangsu |
| Dujiangyan | ← | Shanghai |
| Shifang | ← | Beijing |
| Jinagyou | ← | Henan |
| Pingwu | ← | Hebei |
| Anxian | ← | Liaoning |
| Pengzhou | ← | Fujian |
| Maoxian | ← | Shaanxi |
| Lixian | ← | Hunan |
| Heishui | ← | Jilin |
| Songpan | ← | Anhui |
| Xiaojin | ← | Jiangxi |
| Hanyuan | ← | Hubei |
| Chongzhou | ← | Chongqing |
| Jiange | ← | Heilongjiang |
| **(Gansu)** | | |
| Seriously affected district in Gansu province | ← | Shenzhen |
| **(Shaanxi)** | | |
| Seriously affected district in Shaanxi province | ← | Tianjin |

*Source*: Report on the 2008 Great Sichuan Earthquake, UNCRD

## 4.4. The Government's Recovery Plan

As soon as the immediate post-earthquake emergency had passed, the Government started planning longer-term post-disaster reconstruction. From the beginning, the Government did not merely aim for full recovery. Instead, it aimed for reconstruction to contribute to political processes initiated with the 1999 "Development of the West" policy, and to the Hu Jintao administration's heavily promoted "scientific development" approach, which seeks to pursue a "harmonious society" by addressing inequities that have arisen with China's economic growth.

The General Office of the State Council announced "The State Overall Planning for Post-Wenchuan Earthquake Restoration and Reconstruction" on September 23, 2008 (The State Planning Group of Post-Wenchuan Earthquake Restoration and Reconstruction, 2008). The Plan served as a long list of guiding principles for the process of reconstruction. Although the Plan stated that the main priority was to reconstruct residential houses and public facilities within a period of three years, it also encouraged local authorities to consider the reconstruction process as a development opportunity, and it explicitly stated that one of the objectives for recovery and future development in Sichuan was to contribute to existing strategies of economic and rural development.

There is a strong focus on rural development, continued economic growth and market reform throughout the policy document. It states that "We shall promptly restore the public facilities and infrastructures, earnestly expand employment, and increase the residents' income (…)". Urban and rural spatial layout, population distribution, industrial structure and productivity layout were to be readjusted "so as to promote the harmony between man and nature". The Plan calls for using reconstruction to spur development and self-sufficiency, particularly in poverty-stricken and ethnic minority areas. Future development was to be ensured by furthering industrialization and urbanization, as well as by constructing new rural areas. The Plan underlined that such processes should be conducted in an environmentally friendly manner, with strict protection of farmland.

USD 157 billion was allocated in the Plan for restoration work in the 51 counties classified in the Plan as seriously and very seriously affected in the provinces of Sichuan, Gansu and Shanxi. Local governments at all levels were given a predominant role, and the Plan introduces diverse and collaborative funding arrangements including "counterpart assistance" from provinces in other parts of China to designated earthquake counties.

In order to reach the overriding goals, the Plan stipulates six specific objectives which were to be attained by the end of the three-year reconstruction period:

(1) To complete the restoration and reconstruction of urban and rural residences, making it possible for the disaster-affected population to live in safe, economical, practical and land-saving houses.

(2) To ensure that at least one member in each family has a stable job, and that urban household per capita disposable income and rural household per capita net income surpass the pre-disaster levels.

(3) To ensure that everyone in the disaster-affected population enjoys basic social security and has access to fundamental public services such as compulsory education, public sanitation and basic medical treatment in addition to public culture and sports, social welfare etc.

(4) To completely restore infrastructure functions such as transportation, communications, energy, water conservancy etc. to meet or surpass pre-disaster levels.

(5) To develop the economy, improving and expanding industries with special advantages, optimizing industry structure, and enhancing capacity for scientific development.

(6) To gradually restore ecological functions, improve environmental quality and ensure visible improvement in disaster prevention and mitigation ability.

## 4.5. Recovering from the Wenchuan Earthquake

The results from the three post-Wenchuan earthquake surveys (Fafo-report, 2012) give grounds for describing the recovery process as successful. Communities in disaster areas were severely disturbed, but in the long term society remained stable. Their report shows that most damage caused by the earthquake was quickly repaired, that households were able to resume economic activities relatively quickly, and that education and healthcare systems continued to function under extraordinarily difficult circumstances, and resumed normal operations well before the end of the recovery period. In material terms, the recovery process did succeed in “building back better” by providing new and improved public facilities, houses and infrastructure.

A fundamental observation is that China’s Government efficiently managed and coordinated the disaster response and recovery processes, striking a balance between the commitment of considerable financial, human and organizational resources on the one hand and devolution to local and external agencies on the other.

However, the fact that societies in earthquake-affected areas remained stable also meant that social inequalities and other structural problems that were to some extent mitigated in the period immediately following the disaster were reproduced by the end of the recovery process. Few of these challenges were directly caused by the earthquake disaster; instead, they are related to socio-economic inequities and other problems prevailing in Chinese society in general.

## 5. Policy Implications

Integrated Disaster Risk Management Strategies of China are shown as below:

*To establish the "National Disaster Reduction Planning"*

Disaster reduction has been high on the agenda for the central government, which views it as vital to sustainable economic and social development, coordinated development and harmony between economy, natural resources and ecology. The central government has created the State Disaster Reduction Commission (SDRC) to harness the synergy of relevant efforts and initiatives. In 1998, the Disaster Reduction Plan of the People's Republic of China (1998-2010) was designed to identify guidelines, targets, commitments and measures for disaster reduction efforts. With the guidance of the Disaster Reduction Plan, all the local governments, departments, and industries have enhanced their disaster reduction work effectively, and their integrated disaster reduction ability has been improved. During the $12^{th}$ Five-Year Plan, there is an urgent need to establish a further "National Disaster Reduction Plan".

*To Accelerate the Creation of a Disaster Reduction Ability*

The Chinese government has paid much attention to creating disaster reduction ability. This can be seen from the disaster risk management research programs. The National Natural Science Foundation of China has sponsored and carried out a large number of risk management research projects, such as "regional disciplines of Chinese natural disaster" and so on. The Ministry of Science and Technology also supports risk management research in the fields of major natural disasters, engineering accidents, public health, and public security, through the Key Technologies R&D Program in every five-year planning period.

During the period of the 12th Five-Year Plan (2011-2015), China will make consistent efforts to improve its ability to prevent and mitigate disasters. The country's disaster reduction ability will be accelerated, by learning from developed and other developing countries, and through all the possible means, to utilize its disaster reduction resources efficiently and effectively.

*To Improve the Emergency Response Program*

The Master State Program for Emergency Response is the general program for national emergency responses and is the criterion file for the prevention and treatment of public security events, clarifying the classification and framework of incidents, prescribing the organization system and operation mechanism for dealing with a severe emergency. Although the Master State Program is of great importance and guidance, it only pays major attention to the in-disaster integrated response, and overlooks the need for integrated optimization among the in-disaster emergency management, pre-disaster mitigation, and post-disaster recovery and reconstruction. It is therefore necessary to improve the rapid emergency response plans, harmonize all the aspects of integrated disaster reduction, and ensure the emergency response program is political, scientific and feasible.

## 6. Conclusion

(1) China faces increasingly complex natural situations for disaster management, but has insufficient experience both for creating appropriate institutions and for capacity building. These are therefore a subject of focus in China.

(2) China is using a stronger government role to take the leadership in dealing with disasters, together with a multiple approach and more participation from all fields. The chain of governance can lead to improved efficiency, or to the opposite.

(3) China is confident that it can create effective cooperation, for disaster management both at home and abroad, while keeping developments in line with the interests of both China and the bordering states. This latter is in the initial stages, and some sensitive issues need to be resolved. In addition, more sub-regional or local cooperation within China should be stressed.

(4) China is improving its abilities in disaster management together with its domestic comprehensive and sustainable growth, including political, social, cultural, economic and conceptual changes. Moreover, China is now focusing on the impact assessment of climate change in relation to disasters, and not simply on the issue of disaster management only.

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