Economic Research Institute for ASEAN and East Asia

Towards a Resilient ASEAN

Volume 1

Disasters, Climate Change, And Food Security: Supporting ASEAN Resilience

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CONTENTS

TABLES, FIGURES, AND BOXES

TABLES

PART I

PART II

PART III

PART IV

FIGURES

PART I

PART II

PART III

PART IV

BOXES

PART III

PART IV

PREFACE

One aspect of disasters that has been studied in less detail so far is that related to the distributional economic and social impacts. This is due, perhaps, to the intrinsic complexity that characterises long-term social and economic predictions, because they involve unprecedented productivity situations; or may be due to the variety of material, organisational, and cultural reactions of human society to food security.

The global interdependence of food supply chains is well known. When one part of the agricultural production network is affected by natural hazards or climate-induced disasters, the consequences reverberate globally: supply decreases and food prices increase. In agricultural production systems, food supply, supply chain infrastructure, and transport to and from local markets are vulnerable to natural hazards. These reduce the availability and affordability of food in the region.

In the developing countries of Asia, for example, 22% of the total economic impact of natural disasters was in the agriculture sector: crops, livestock, fisheries, and forestry. Data, however, are scarce, so little is known about the substantial impact of natural disasters and climate change on the agricultural value chains and the disproportionate burden placed on people who rely on agriculture for their livelihood. No consistent accounting for direct and indirect agriculture losses from natural hazards exist in any of the primary global hazard databases, although some national databases separately record losses in agriculture.

To further understand the distributional impacts of disasters on food security and to assess policy implications from this understanding, the Economic Research Institute for ASEAN and East Asia (ERIA) organised a study, that brought together leading academics from across the globe and policymakers from the ASEAN to describe several approaches for building resilience into food value chains, share knowledge, and better understand risk reduction from different disciplinary perspectives.

The two volumes of this book are the outcome of that study, and addresses the differential vulnerability of people, places, and sub-sectors, introducing concepts and methods for analysis, and illustrate the impacts on food security at the local, national, and regional level. The chapters in the first volume set the stage by focusing on the relationship between natural disasters and climate change and by broadly exploring their economic and social aftermaths. The chapters in the second volume discuss the resilience measures and adaptation road maps in terms of information sharing, preparedness, enhancing decision making capacity – particularly the relevance of improving the roles of markets through investments and insurance to face the financial challenges.

These two volumes complement each other in clarifying resilient pathways in the vital process of disaster risk management and adaptation to climate change. As the authors continue to research, debate, analyse, and propose an enabling environment to enhance resilience, new publications like this bring fresh insights into policy development.

Here we emphasise the need for holistic actions: for improved resilience of global food security rather than narrowly drawn sectoral approaches, for innovative disaster risk management measures rather than reliance on established patterns, and ensuring that governments and the private sector take a powerful lead in implementing robust institutional frameworks rather than entrusting the task to communities and international agencies. I am confident that this book will contribute to policy development and academic understanding in an area where new acumen is urgently needed.

Hidetoshi Nishimura
President
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CHAPTER 1

Introduction: Distributional Effects of Disasters and Climate Change – Economic and Food Security Implications

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Natural disasters and climate change have global impacts in terms of both causes and effects. These impacts are not distributed evenly across countries and sectors in the region, however, but can create dissimilar effects across different latitudes and altitudes – affecting food security. For example, some parts of Southeast Asia may be impacted by a large number of cyclones, while others suffer from frequent drought episodes. Depending on the location of populated areas, this makes many people vulnerable to food security risks with respect to access to water, disease, and hunger.

The Association of Southeast Asian Nations (ASEAN) Socio-Cultural Community (ASCC) Blueprint 2025 (ASEAN, 2016) and East Asia Summit (EAS) statement (ASEAN, 2015) clearly recognise the need for concerted efforts to address the issue of disasters and climate change and their impacts on socio-economic development, health, and food security. ASEAN Member States (AMS) have agreed on the implementation of eleven related actions, based on the principles of equity, flexibility, effectiveness, common but differentiated responsibilities, and enhanced institutional capabilities. Ensuring adequate access to food at all times for all ASEAN people is also identified as a priority agenda for the implementation of the ASCC blueprint. However, climate change and the increasing number of natural disasters are affecting regional and local food security. The Asian Development Bank (ADB, 2011) showed a yield reduction of 14%–20% for paddy rice, 32%–44% for wheat, 2%–5% for corn, and 9%–10% for soybean in Asia. Within ASEAN, differences may occur locally, and it is very difficult to make exact predictions since the available data are scarce at the subnational level and for major cash crops such as cashew nuts. However, given the biophysical impacts of disasters and climate change, when integrated with future food demand, food prices are projected to increase by 29%–37% for rice, 81%–103% for wheat, 58%–97% for corn, and 14%–49% for soybean in 2050, compared with no-climate change policy scenarios (ADB, 2009).

One aspect of disasters that has been studied in less detail in ASEAN is related to the agricultural production system and its socio-economic impacts. This may be due to the intrinsic complexity that characterises long-term economic predications as well as assumptions on food security or the wide variety of structural and non-structural measures for adapting to climate change induced disasters such as flooding and drought. The most likely scenario is that some AMS will suffer severe shocks because of the new risk conditions, whereas other countries will face moderate challenges. In any case, greater resilience to extreme weather events and disasters is achievable with better information on social and economic impacts, more economic resources, strengthened institutions, and government support.

1.1 Economic and Distributional Impacts of Disasters

Southeast and South Asian countries continue to be the world's most disaster-prone areas. Asia incurred more than $45 billion in economic damages and even higher indirect losses from 2000 to 2014 (United Nations Economic and Social Commission for Asia and the Pacific, 2016). These numbers are gross underestimations, however, as no systematic assessment has been made of the cost of all disasters – either climate-induced or manmade – that affect the region, especially slow-onset disasters such as droughts, heatwaves, and flash floods, which have direct impacts on the region's food security.

Why are AMS not investing more in disaster resilience, despite the prevalence and rising costs of disaster events? This may be because decision makers in governments, businesses, and households tend to focus on avoiding losses from disasters and perceive the return on investment as uncertain – only realised if a somewhat unlikely disaster event actually happens (Aldrich, Oum, and Sawada, 2015).

Effective policy actions require sector-specific damage and loss data for the agriculture and trade ministries of the AMS. Their national strategies on disaster risk reduction and climate change adaptation, which support resilience, must address the types of disasters with the greatest impact on the agricultural sector. Governments must design measures specific to the crop, livestock, and fisheries sub-sectors; and be enabled to adopt more systematic strategies that counteract the impacts of disasters on the sector's growth, and national as well as regional food security.

Nevertheless, business rationale should inform climate change adaptation and disaster risk management based on the multiple dividends of resilience. Actions should look beyond avoiding losses (the first dividend) to the wider benefits to be gained independently of whether or not a disaster event occurs. These include unleashing entrepreneurial activities and productive investments by lowering the threat of losses from climate change, and enabling farmers and supply chain actors to take positive risks (the second dividend); and co-benefits of resilience measures beyond disaster risk (the third dividend), such as flood embankments that double as roads or drought-tolerant crop varieties that maximise crop yields. The no-regret adaption strategies[1] should also reflect on recent efforts to build a stronger business case for resilience in the private sector, including the insurance sector.

Hence, the main objectives of this book are to (i) understand the distributional effects of disasters and climate change, and the related food security challenges in ASEAN; (ii) analyse the required actions taken by policymakers to address these risks; (iii) share experiences on the adjustment of key planning instruments relating to the crop, livestock, and fisheries sectors; (iv) exchange experiences on successful adaptation measures across key vulnerable areas; and (v) undertake cost–benefit analysis and identify necessary structural and non-structural measures that could contribute to a resilient ASEAN.

To meet these objectives, this book is organised into five interrelated parts and 13 chapters quantifying the distributional impacts of climate-induced natural disasters and – managing resilience and proposing a roadmap considering the key trends in the region and reviewing the local, national, and international levels of action. The book also seeks to highlight opportunities to build a resilient future through the implementation of both the 2030 Agenda for Sustainable Development and the Sendai Framework for Disaster Risk Reduction, 2015–2030.

[1] No-regret adaptation strategies aim at maximising positive and minimising negative outcomes of disasters for communities and societies in climate-sensitive areas such as agriculture, food security, water resources, and health.

1.2 Measuring the Vulnerability and Distributional Impacts of Disasters

In this section, we address many aspects of measuring the distributional issues resulting from disasters and climate change. The damage and losses calculated for sectors need to be analysed in relation to food security under free trade, moderate trade, and very restricted trade scenarios in the crop, livestock, fisheries, and forestry sub-sectors. Following this introduction, in Chapter 2, Yumi Shiomi et al. describe a vulnerability measurement model that uses several proxy indicators, grouped into eight elements, to assess the quantitative basis of the comparative potential vulnerability and resilience of countries, provinces, and counties vulnerable to disasters.

In Chapter 3, Srivatsan et al. employ climate modelling to assess the future of climate impacts in ASEAN countries. They argue that there is still considerable dependence on climate models produced outside the region which are not necessarily tailored to the needs of the region, and advocate for an increase in regional capacity to cope better with scenarios of climate change, food availability, and disaster forecasts from inside the region. For this, the scarce measurement network in ASEAN should become much denser. Current studies in Southeast Asia on the +2°C and +4°C warming available on the regional scale need to be interpreted on the local scale. This would lead to targeted assessments of climate impacts on local food production and disaster vulnerability, considering particular disaster events and agricultural commodities. In consequence, discussions on the policy perspectives of ASEAN could be widely altered if missing information becomes available and the full range of adaptation options becomes apparent.

John Kuwornu´s Chapter 4 studies the effects of disasters on intra-ASEAN agricultural trade. The author employs numerous public databases and modelling exercises to generate his results. First, he observes the increase in international trade of agricultural products during 1980–2013 between Thailand, Indonesia, and Viet Nam after investigating the trade policies of these countries. While Thailand and Viet Nam are export nations of agricultural products, particularly rice, Indonesia has followed a different pattern, importing rice and other agricultural products to feed its fast-growing population. In a second step, Kuwornu investigates the role of disasters in international trade and food security. On a national scale, disasters rank in the middle of trade barriers. He argues that disasters can be both a hindrance and a means of acceleration of international agricultural trade. Disasters become a hindrance to international trade if remote areas are affected, transportation becomes limited and expensive, and products cannot reach markets. Disasters can become an accelerator to international trade if central areas, key markets, and traffic nodes are affected; and otherwise existing trade barriers are lowered to recover quickly from adverse effects.

1.3 Technology Adaptation

Natural disasters and climate change tend to corrode or destroy physical and social infrastructure, change the environment, and cause economic stress. In Chapter 5, Budi Indra Setiawan and Eiji Yamaji identify types of disasters which have threatened food security and describe how each country has carried out technology-based adaptive measures. Special attention is given to Indonesia, as the largest food producer and consumer market, which has ambitious visions to achieve self-sovereignty; and the System of Rice Intensification, a promising rice cultivation method that can mitigate the effects of climate change. More frequent droughts and flooding as well as seasonal uncertainty are the main concerns, and adaptive measures for these issues range from improvements in infrastructure (structural) to management systems (non-structural). As food problems generate adverse relationships with other countries, mutual precaution and cooperation are very important while each country needs to develop individual agricultural policies that are compatible with those of their neighbours.

The effects of disasters and climate change on the livestock sector and the implications for ASEAN food security are analysed by Hyeon T. Kim in Chapter 6. This chapter reviews the current situation of the Korean climate, livestock production status, and adaptation measures to mitigate the effects of climate change. It covers (i) precision livestock smart farming, (ii) the application of information and communication technology, (iii) policies and strategies, and (iv) the role of institutions. AMS countries are facing long-term food security problems because of the increasing frequency of high impact natural disasters. Local short-term food insecurity in low-income households is often a result of extreme climate events in several ASEAN countries immediately after a disaster or extreme climate event occurs. With appropriate adaptation measures, ASEAN countries can reduce the losses that result from disasters and overcome food security problems.

The effects of disasters and climate change on the fisheries sector and implications on ASEAN food security are analysed in Chapter 7 by Thayalan Gopal and Venkatachalam Anbumozhi. The shortage of food security and fish production will become increasingly severe to the communities of ASEAN in 2030, which are in climate and disaster hotspots. This chapter identifies cost-effective adaptation options to reduce the impacts of climate change and disasters on marine and inland aquaculture. Based on the rule of risk management, the adaptation strategies are differentiated and analysed into autonomous adaptation and planned adaptation – with critical cost–benefit analysis. Public-supported proactive planned adaptation is emphasised to counter the risks posed by increasing climate variability and disasters in ASEAN. To improve food security and minimise the projected decrease in profitability, it is concluded that fisheries need to build overall adaptive capacity along the value chain and diversify income opportunities, ideally without small-scale fishers incurring additional social costs.

1.4 Institutional Adaptation

Unabated, increased vulnerability and malnutrition caused by disasters are likely to impact poor people more severely. But other important though less direct connections between climate change and institutional adaptation also remain. In Chapter 8, Meinhard Breiling addresses the question of how cost-effective adaptation regimes become feasible through institutional design. The focus of his analysis lies in policy and institutional design, the choice of policy instruments, and the timing of interventions. Strategies to avoid damage and losses caused by disasters differ according to the scale and size of the food value chain. The AMS are very diverse in their economic development and food supply. Today, all ASEAN countries depend on a mix of local, regional, and global food value chains. Different disaster risk institutional strategies apply according to the level of individuals and entities involved in the value chain formulation.

In Chapter 9, Tomonori Sudo argues that financial institutions and the insurance industry are decisive actors which influence disaster risk management and adaptation actions. Financial institutions can play a significant role in providing finance, managing risks, and producing information. A variety of financial instruments is available to cope with disasters. However, each financial instrument has unique characteristics and this chapter identifies their pros and cons. For efficient management of disaster risks, the author proposes a funding pool mechanism with three functions to support the government and financial institutions in fulfilling their roles; and six policy recommendations for financial institutions, governments, and the region.

Despite the increased interest in strengthening financial institutional capacity, it remains a challenge for many developing countries to bring resilience along the entire value chain. In Chapter 10, Suresh Babu et al. argues that institutional capacity for disaster management and risk reduction can be built through various mechanisms. One key approach is via the agriculture sector, where climate-resilient agriculture has become an effective tool for adapting to climate change and developing resilience in the long run – resulting in increased capacity for disaster management and risk reduction at the system, institutional, and individual levels. This chapter presents the experiences of four countries, which have been evaluated to develop an institutional strengthening framework.

Chapter 11, authored by Vangimalla Reddy et al., argues that understanding the effects of natural disasters and the changing climate on food security is crucial to ensure that the most appropriate policies and practices are implemented. Adaptation strategies and frameworks are required to manage food and nutritional security in the context of natural disasters and climate change. This chapter analyses the effects of natural disasters and climate change on food security and vulnerability. It also discusses the adaptation strategies and sustainable measures to strengthen the resilience of agriculture to curb economic losses and achieve food and nutritional security. This knowledge will assist policymakers in choosing appropriate actions for implementing policies to address natural disaster and climate change risks with the goal of ensuring food and nutritional security.

1.5 Policy Adaptation

People's livelihoods are impacted by the various types of disasters, which can lead to the damage or destruction of human lives, crops, animals, fishing boats and gear, infrastructure, etc. The extent of the impact depends on the intensity of the hazard, the level of people's vulnerability, and their capacity to cope with these shocks and stresses. In Chapter 12, Kumaresan and Rajapakse give an overview of the health-related aspects of disasters and food security, and bring together relevant information from recently published studies. They introduce the topic value chain resilience from health-related policy, pointing out that infants, small children, pregnant and lactating women, and elderly people are particularly vulnerable groups that are disproportionately affected by disasters and food scarcity. The authors describe the role of food security and the relevance of its three aspects – food availability, food access, and food utilisation – in meeting daily calorific intake and a balanced nutrient supply. Disasters alter general levels of malnutrition during food emergencies and increase mortality rates. The authors describe strategies to reduce the health impacts of disasters and underline the role of social safety nets, including consumer food price subsidies, food-for-work programmes, feeding programmes, and cash transfers. Finally, the authors recommend ASEAN to implement food security interventions, ensure access to appropriate healthcare, and prepare risk management systems and tools for disadvantaged groups.

In the final chapter, Venkatachalam Anbumozhi argues that effective mainstreaming of resilience considerations requires incorporating the Sustainable Development Goals (SDGs) in the planning process and arriving at a consensus on open agriculture trade pacts. Disaster and climate change risks, objectives, and policies should be based on a good understanding of SDG targets and free trade agreements that focus on agriculture. The shared roles and responsibilities of all players, including economic and planning ministries, are currently challenged in ASEAN countries. A general perception exists among the public, project proponents, and development authorities that climate change is the sole responsibility of environmental agencies, that disaster response is a humanitarian assistance issue, and that food security is better handled by the agriculture ministries – failing to implement the necessary measures effectively. As ASEAN economies continue to accelerate growth rates, the response to disaster will come under increased scrutiny and pressure. It is important to move quickly towards reaching broad agreement with all major stakeholders on SDG targets and agriculture trade, starting with the identified list, and to develop a medium- to long-term programme for implementing the agreed actions, supported by the necessary resources, monitorable targets, and clear accountability mechanisms.

1.6 Knowledge Gaps, Policy Equities, and Vulnerability Reduction

This book begins to fill a gap in the existing literature by covering the differentiated impacts of disasters and climate change on food security. It raises important issues that become relevant at the global, regional, national, and subnational levels in terms of the expected effects of disasters and climate change, and how adaptation roadmaps may help reduce vulnerability to food security in the ASEAN region. We conclude by synthesising the insights encapsulated in the chapters and discussing possible solutions to cope with the distributional effects of disasters and climate change and the implications for food security.

Authors discuss different ways for people and nations to deal with extreme weather events and climate variability. Many elements need to be combined to move towards a significant and sustainable reduction in the vulnerability of the poor to the impacts of disasters and climate change on their food security. Sustainable national food systems can be created through an effective interplay of governance, knowledge, and action from the household and community level to the national and international level. Such systems would adapt to and endure the current and projected risks associated with natural disasters and climate change, and would not exacerbate the drivers of climate change discussed in this book. Different chapters deliberate on the effort to be endorsed and actions to be taken, such as seasonal forecasts to anticipate extreme weather events and management practices to allow farmers to achieve the best yields under prevailing conditions, to avert the possibility of food insecurity as a result of natural disasters and climate change at every level. The authors also focus on identifying threats to agricultural production, and countermeasures and solutions in inland and coastal areas of the ASEAN region, by discussing at the local level and suggesting strengthening ASEAN cooperation with other stakeholders at the international level.

The chapters analyse the responses of agriculture to natural disasters and climate change, and introduce concepts and provide a framework for building adaptation roadmaps and policies for decision makers. Developing policies to support decision makers and relevant stakeholders in selecting farming practices and agricultural technologies that build resilience to meet future challenges requires data on the impact of disasters and climate change on agriculture as well as foresight to predict the situations that need to be met. The chapters highlight the impact assessment of agriculture and climate-resilient policies based on the regional and national scenarios in the ASEAN region. They deal with the issues relevant at the international, national, subnational, and regional levels in predicting the expected effects and identifying adaptation roadmaps to reduce vulnerability and achieve food security. The authors propose development plans including long-term national programmes integrating climate change adaptation strategies, and disaster risk reduction and trade pacts involving all relevant stakeholders, to create a shared understanding of the adaptation agenda for appropriate decision making. The book highlights the importance of re-evaluating research needs to provide decision makers with actionable data and/or information, and considering investment in climate and environmental monitoring.

Enhancing adaptive capacity depends on financial factors, including access to credit, financial assistance, and the insurance system. National governments and international organisations provide financial assistance to disaster risk reduction in the agriculture sector to prevent and mitigate the significant impact of disasters. Different types of disasters have significantly different effects on the agriculture sector and its sub-sectors, and across countries and regions, which requires tailored risk reduction interventions in terms of policy, and financial investments in prevention and sustainable post-disaster recovery responses. The adaptation roadmaps summarised in the chapters discuss potential solutions to cope with the distributional effects of disasters and climate change and the economic and food security implications. The strategies discussed would create plans to improve cooperation between sectoral, environmental, and financial authorities, as well as academia and private sector stakeholders. The policy coherence discussed in the chapters ensures that actors at all levels are included in the mainstreaming process for better information flow to fill the gaps in capacity building and financing. The discussions also support capacity building at the local level to help communities understand the climate risks and links to sector activities. The strategies discussed in the book would educate farmers on applying for financial assistance programmes to help with damage to farms, including disaster assistance programmes and schemes to help restore and rehabilitate farmlands. Table 1.1 synthesises the insights encapsulated in each chapter and discusses possible solutions to cope with the distributional effects of disasters and climate change and the economic and food security implications.

Table 1.1: Group and Sector-Specific Adaptation Strategies

Theme	Key messages	Policy Implications	Knowledge gaps
Economic losses and damage	• Loss of production resources affects final supply and demand in regions through the Cobb–Douglas function • Input–output tables allow calculation of 1st and 2nd ripple effects, respectively, through loss of production and consumption • Location of production and consumption compared to the disaster area determines the applicability of ripple effects	• Individual countries' Input–Output tables need to be available for this application • The Cobb–Douglas function is unique to the region and industry, and loss ratios depend on the type of disaster, therefore data collection is needed	• Application of this methodology to ASEAN countries • Communication with satellite companies for monitoring with sensor infrastructure, which is crucial for food security
Food security under 2°C global warming scenario	• Modelling climate change in the ASEAN area shows predicted variations in temperatures, rainfall, and crop yield • Case studies in Viet Nam and Indonesia predict crop losses	• We need to prepare for the worst-case scenario, in this case a 4°C increase • Major and minor factors that influence production need to be monitored in real time for policymakers to react appropriately • Vulnerable regions become more vulnerable, and payment schemes based on Standardised Precipitation Index (SPI) can help transfer risk away from farmers in these areas.	• This study can be extended to crops beyond rice and vegetables • New kinds of crops that can be brought in and the nutritional and health implications of such change • Uses of modelling to plan where to grow each type of crop (New crops and cultures that can withstand temperature change, as well as rediscovering 'forgotten foods' for culture diversification

Theme	Key messages	Policy Implications	Knowledge gaps
Effects of disasters on agricultural product trade	• An augmented gravity model shows the impact of disasters on trade in commodities of ASEAN countries • Trade restrictions are included to observe the effect of economic integration (or lack thereof)	• Countries need to strategically address disasters that have an impact on trade • Trade restrictions make the impact of floods more pronounced, showing the value of economic integration in disaster settings	• Applying this method to more countries and commodities. • Addressing the issue of access to reliable trade data
Effects on fisheries sector	• Natural disasters have positive, adverse, and indirect impacts on food security through both the agriculture sector and natural resources and the environment • Climate change has an impact on fisheries through natural disasters, amongst other factors • Malaysia is implementing a climate action plan to help fisheries mitigate and adapt	• ASEAN countries need more research and collaboration • ASEAN countries can use action plans to encourage data collection, research, capacity building, awareness programmes, and more	• The impact of climate change on fisheries is not yet fully understood. • The problem of coral bleaching merits further investigation. • Better ways of access to climate sensitive information by general public • Assessing the effect of disasters on water quality • Topic of the fishing industry in rivers
Effects on livestock sector	• Livestock production system is evolving to deal effectively with natural disasters and climate vulnerability as it grows to absorb new smart technologies • Livestock is one of the main providers of food security • The Republic of Korea has used different types of adaptation measures: Information and Communication Technology (ICT), policies, livestock smart farms, and public institutional involvement	• ASEAN needs to invest in research and development for innovative solutions to climate change • Smallholder and family farming can improve productivity • Governments should provide incentives to invest in the agriculture sector • A food security information system is needed in the region • Policy coordination and cooperation are required at the regional and global levels • ICT smart farm research centre system	• Variance of factors on each individual farm can make a difference, so local level data are needed • Reciprocally, livestock has an effect on climate change • Trend of de-correlation of livestock and its area of production
Successful adaptation measures	• Indonesia shows rising rice planting intensity and productivity in response to direct and indirect rice consumption • Extreme climate poses a challenge to this growth and requires mitigation and adaptation strategies • Experiments with SRI show possibilities to increase yield and decrease greenhouse gas emissions	• Countries need to develop water resources and secure irrigation systems • Extension efforts for agricultural methods such as System of Rice Intensification (SRI) can be improved	• The economic implications of climate change for Rice System Intensification are not yet clear • Need to look into which adaptation strategies (intensity, productivity, diversity, and dissemination improvements) should be maintained • Question of investment needs for spreading and implementing agricultural methods • Problem of needed labour intensity for SRI • Cost–benefit analysis and comparison of SRI in different contexts

Theme	Key messages	Policy Implications	Knowledge gaps
Health and food security	• Disasters hit vulnerable groups with malnutrition, communicable and non-communicable diseases, and psychosocial stress • Food security is about the availability, utilisation, and accessibility of food for adequate nutrition • Lack of food impedes investment in education, health, and more, creating a vicious cycle • The double burden of malnutrition concerns stunting and overweight issues	• Climate change needs to be adapted to in a location-specific way • Nutritional and dietary assistance, combined with nutritional education, are important tools to tackle malnutrition • Research, human capital investment, coordinated responses, and emergency food reserves are some medium- and long-term solutions • ASEAN needs to cooperate and coordinate policies between countries and with stakeholders • Health systems need safe infrastructure and trained personnel to cope with hazards	• Missing information reduces certainty and collaboration between global actors • Mechanism for data sharing with the public • Value of the local ecosystem and empowering local communities to make use of it • Relationship between acute and chronic food insecurity
Cost-effective regimes	• Food has been the centre of models and theories for a long time • Losses from disasters can happen at the agriculture, transport, storage, post -harvest processing, retail, or consumption stages • EU system relies on negative population growth, local food specialty prices, financial incentives for rural populations, and agriculture as a hobby	• ASEAN countries are more diverse and need to adapt to individual conditions • Looking at the EU experience, countries in ASEAN can expect deeper integration to cause important migration flows • EU system for disaster management relies on state intervention (e.g. in insurance premiums) and ASEAN needs to devise its own adapted system	• Change of behaviour in producers and consumers • Dramatic price fluctuations created by harvest schedules
Food and nutritional security	• Climate change is a global phenomenon with regional impacts, such as natural disasters, which are amongst factors influencing agricultural production • A threshold analysis on the Rice Bowl Index shows challenges to food security in many ASEAN countries	• Proactive solutions: early warning system, reliable data, hunger reduction, food storage, resistant infrastructure, preparedness at all levels • Reactive solutions: immediate impact mitigation, quick rebuilding, working with communities, resilience building, chronic hunger reduction, focus on food-insecure people • Adaptation strategies: monitoring and education, production optimisation, ecological restoration, food storage, capacity building, financial instruments, governance	• Empirical study on this topic through primary data • Considerations of short- versus long-term preparation

Theme	Key messages	Policy Implications	Knowledge gaps
Role of financial institutions	• Climate change affects the 'financial intermediation' and the role of financial institution by changes in costs for appraisal/due diligence • Different financial products are appropriate at the precautionary, emergency, and post-disaster stages • Catastrophe bonds and Catastrophe Deferred Drawdown Options allow different stakeholders to participate in risk sharing • Collaborative financial mechanisms are also possible (e.g. Disaster Risk Management funding pool)	• Financial policies and markets need to be as transparent as possible to reduce credit and market risks • Financial institutions need to develop their capacity for including disaster risk analysis in appraisal/due diligence and monitoring	• Stakeholders need to share disaster risk information amongst themselves • Role of domestic market and financial institutions • Problems of reappraisal in the face of climate change, e.g. of weather index insurance schemes • Role of regional cooperation versus actors external to the region • Effective ways and means of financial inclusion by nongovernment organisations or community based approaches.
Mainstreaming resilience into SDGs	• ASEAN food supply chains are vulnerable to disaster risk and therefore to climate change, but can gain resilience through participation in Free Trade Agreements (FTA) • SDGs need to be handled as a set because of interlinkages between different goals • Mainstreaming runs into obstacles – knowledge, capacity, and finance gaps • ASEAN's functioning and community blueprint show opportunities for synergies in reaching SDG goals	• Mainstreaming requires six steps: alignment with the national planning and policy framework; evidence-based actions; accelerating frameworks; benchmarking; mainstreaming of Climate Change Adaptation (CCA), Disasters Risk Reduction (DRR), and trade pacts; and horizontal and vertical policy coherence • Mainstreaming requires improving information, decision making, and finance • Cross-sectoral coordination is an important tool for mainstreaming	• Cost–benefit analysis of trade-offs between the SDGs and compensation of the 'losers'

ASEAN = Association of Southeast Asian Nations, EU = European Union, ICT = Information and Communication Technology, SDG = Sustainable Development Goal, SRI = System of Rice Intensification.

Source: Authors.

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PART 1

Assessment Methods

CHAPTER 2

Innovative Methodology for a Regional Assessment of Economic Losses and Damage Caused by Natural Disasters

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2.1 Introduction

Asia is exposed to natural hazards. It has the largest share of all regions in terms of disaster occurrence (39%), the number of people killed (61%) and affected (89%), and economic damage (48%) for 1986–2015 (Asian Disaster Reduction Center, 2016). In 2015 alone, Asia incurred more than $45 billion in economic damages and even higher indirect losses (United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), 2016). The Association of Southeast Asian Nations (ASEAN) region is the most prone to disasters in the world (Sawada and Oum, 2012). In recent years, it has suffered devastating disaster events such as the Indian Ocean tsunami in 2004, the Yogyakarta earthquake in 2006, the Myanmar cyclone in 2008, Typhoon Ketsana in 2009, the Thai floods in 2011, Typhoon Haiyan in 2013, and so on. These disasters – including earthquakes, tsunamis, storms, and floods – have direct and indirect cross-border impacts.

Natural hazards and their effects are transboundary by nature, which puts the ASEAN region in a unique position to confront the development challenges presented by these phenomena (ASEAN, 2016).

Focusing on disaster type, the ASEAN region has a variety of disaster risks: climatological, geographical, hydrological, and meteorological. Table 2.1 shows the disaster impacts of the ASEAN member countries by disaster type for 1986–2015.

Table 2.1: Disaster Types in ASEAN, 1986–2015

Disaster type	Occurrence	Dead and missing people	Affected people	Amount of damage ($'000)
Drought	18 (2.4%)	11 (0.0%)	28,889,289 (12.3%)	1,401,272 (1.4%)
Earthquake	59 (8.0%)	184,386 (51.4%)	11,377,256 (4.8%)	13,024,057 (13.4%)
Epidemic	34 (4.6%)	2,568 (0.7%)	325,826 (0.1%)	- (0.0%)
Extreme temperature	1 (0.1%)	63 (0.0%)	1,000,000 (0.4%)	- (0.0%)
Flood	337 (45.9%)	9,617 (2.7%)	85,480,497 (36.4%)	55,646,645 (57.3%)
Landslide	59 (8.0%)	3,013 (0.8%)	700,091 (0.3%)	69,685 (0.1%)
Storm	194 (26.4%)	158,968 (44.3%)	105,978,977 (45.1%)	25,768,266 (26.5%)
Volcanic activity	26 (3.5%)	367 (0.1%)	720,400 (0.3%)	188,580 (0.2%)
Wildfire	7 (1.0%)	19 (0.0%)	410,064 (0.2%)	1,014,000 (1.0%)
Total	**735 (100.0%)**	**359,012 (100.0%)**	**234,882,400 (100.0%)**	**97,112,505 (100.0%)**

ASEAN = Association of Southeast Asian Nations.

Source: Asian Disaster Reduction Center (2016).

While floods and storms occupy the largest shares in terms of occurrence, earthquakes (and subsequent tsunamis) and storms comprise more than 90% of fatalities. As for the number of people affected and the amount of damage, floods and storms again occupy the majority share amongst all disaster types. Overall, this tendency implies that the ASEAN region is vulnerable to meteorological and hydrological disasters, followed by geophysical ones.

With the increasing attention to and need for disaster risk reduction and management in recent decades, a significant amount of research has been carried out to examine disaster risks and economic impacts caused by natural disasters. This includes the statistical/econometric model, computable general equilibrium models, and input–output (I–O) analysis.

The World Bank et al. (2010) conducted a risk assessment of ASEAN countries by reviewing the existing hazard, vulnerability, and economic loss data at the country level. It estimated the economic vulnerability of each country in terms of the likely economic losses that an event with a 200-year return period would cause as a percentage of that country's gross domestic product (GDP at purchasing power parity). It ranked the economic vulnerability in descending order: Myanmar, the Lao People's Democratic Republic, Indonesia, Cambodia, Viet Nam, the Philippines, Thailand, and Malaysia.

The I–O model has been widely used in various disaster impact analyses. Kajitani, Yamano, and Tatano (2005) estimated the economic loss caused by the Chuetsu earthquake in 2005 with the multiregional I–O model, while van der Veen and Logtmeijer (2005) applied the model to simulate large-scale flooding in the Netherlands.

Fukushima, Hayashi, and Yashiro (2009) and Hayashi, Fukushima, and Yashiro (2009) focused on the linkage between business and the local economy, and suggested a methodology to estimate the indirect damage to business from the economic damage of an affected area in the case of a large-scale earthquake. They employed the loss of GDP as an index to measure the economic loss of the region by applying a model developed by the Central Disaster Prevention Council of Japan in 2008. That model has been used for various analyses, e.g. Japan's Ministry of Land, Infrastructure, Transport and Tourism (2013) applied its methodology to estimate damage from flooding.

Comparative analyses of such models identify both advantages and disadvantages in each model (Okuyama, 2009; Kelly, 2015). The I–O model has strength in its simple structure, detailed inter-industry linkage, wide range of analytical techniques available, and ability to be easily modified and integrated with other models, while its weaknesses are its linear structure, rigid coefficients, lack of supply capacity constraints, absence of response to price changes, and overestimation of impact (Okuyama, 2009).

In surveying the intrinsic complexity of disaster-prone ASEAN countries, this paper employs the I–O model to examine economic losses and damages in the region considering the applicability and adaptability of the model and data availability – it can show the ripple effects from a disaster-affected area to a country and then to other countries and the region.

The objective of this chapter is to introduce a model for an overall assessment of economic losses and damages caused by natural disasters at the local, national, and regional levels in the ASEAN region.

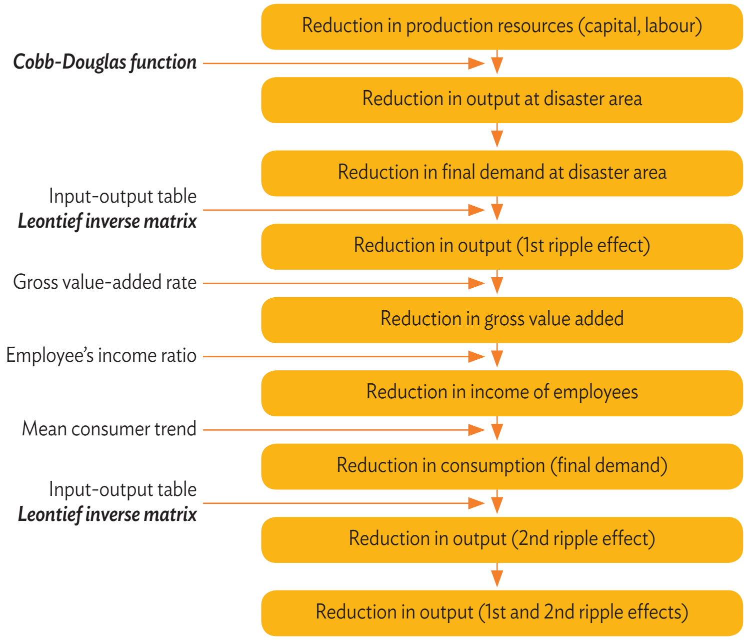
2.2 Establishment of Methodology to Evaluate Economic Loss at the Regional Level

This paper employs the loss of GDP as an index to measure the economic loss of the region concerned. Section 2.1 introduces the methodology based on that of the Central Disaster Prevention Council of Japan, while section 2.2 explains the economic loss of enterprises.

2.2.1 Methodology to Evaluate Economic Loss of Region

Figure 2.1 shows the flowchart of economic loss evaluation.

Figure 2.1: Flowchart to Obtain Economic Loss of Region



Source: Fukushima, Hayashi, and Yashiro (2009).

(1) Reduction in Final Demand at Disaster Area

It is assumed that the reduction in final demand at the disaster area is equal to that of the regional output. The reduction in regional output ΔGDP for each industry is estimated by the following equation:

$$\Delta GDP = GDP_0 - GDP_1 = \left(1 - \frac{GDP_1}{GDP_0}\right) GDP_0$$

where GDP_0 is the output during a normal period and GDP_1 is the output after a disaster. If the regional output is expressed by the Cobb-Douglas function, which is $Y = A \cdot K^{\alpha} \cdot L^{1-\alpha}$, the following equation is derived:

$$\Delta GDP = \left(1 - \frac{A \cdot {K_1}^{\alpha} \cdot {L_1}^{1-\alpha}}{A \cdot {K_0}^{\alpha} \cdot {L_0}^{1-\alpha}}\right) GDP_0 = \left[1 - \left(1 - \frac{k}{K_0}\right)^{\alpha} \cdot \left(1 - \frac{l}{L_0}\right)^{1-\alpha}\right] GDP_0$$

$$k = K_0 - K_1, \ l = L_0 - L_1$$

where K_0 and K_1 are the capital stock during a normal period and after a disaster; L_0 and L_1 are the labour input during a normal period and after a disaster; and A and α are the parameters defined for each industry. The above equation shows that the ratios k/K_0 and l/L_0 give ΔGDP using k and l, which are the lost capital stock and the lost labour input after disaster.

(2) Estimation of Loss Ratio of Capital Stock

The loss ratio of capital stock in a disaster area $R_K(= k/K_0)$ is given by the following equation:

$$R_K = \frac{1}{N} \sum_{i=1}^{N} r_{Ki}$$

where r_{Ki} is the loss ratio of capital stock of mesh i in the area and N is the number of the mesh. The loss ratio of capital stock r_{Ki} is given by the following equation:

$$r_{Ki} = z \cdot \frac{n_{RCi} + n_{RMi} + n_{SCi} + n_{SMi}}{n_{Ri} + n_{Si}} = z \cdot \left[\frac{n_{Ri}}{n_{Ri} + n_{Si}} f_{RM}(x_i) + \frac{n_{Si}}{n_{Ri} + n_{Si}} f_{SM}(x_i)\right]$$

where n_{RCi} and n_{RMi} are the number of collapsed and partially collapsed reinforced concrete non-residential buildings in mesh i, and n_{SCi} and n_{SMi} are those of steel non-residential buildings; n_{Ri} and n_{Si} are the numbers of reinforced concrete non-residential and steel buildings; $f_{RM}(x_i)$ and $f_{SM}(x_i)$ are the conditional failure probabilities of reinforced concrete and steel non-residential buildings in mesh i, given ground motion intensity of x_i; and z is the factor, which is 0.706 for manufacturers and 0.732 for other industries.

(3) Estimation of Loss Ratio of Labour Input

The loss ratio of the labour input in the disaster area $R_L\,(=l/L_0)$ is given by the following equation:

$$R_L = \frac{1}{N}\sum_{i=1}^{N} r_{Li}$$

where r_{Li} is the loss ratio of the labour input of mesh i in the area and N is the number of the mesh. The loss ratio of the labour input r_{Li} is given by the following equation:

$$r_{Li} = r_{Di} + r_F = \frac{n_{Di}}{n_{Pi}} + r_F$$

where r_{Di} is the casualty rate of mesh i; r_F is the unemployment ratio, which is constant (=0.036) for the area of ground motion intensity of 5.5 or greater on the scale of the Japan Meteorological Agency; and n_{Di} and n_{Pi} are the number of deaths and daytime population of mesh i. Using the number of collapsed wooden residential housings n_{WCi} as a parameter, n_{Di} is approximately given by the following equation:

$$n_{Di} = 0.06875 \cdot n_{WCi} = 0.06875 \cdot f_{WC}(x_i) \cdot n_{Wi}$$

where $f_{WC}(x_i)$ is the conditional failure probabilities of wooden residential housings in mesh i, given ground motion intensity of x_i; and n_{Wi} is the number of wooden residential housings in mesh i.

(4) Reduction in Output (1st Ripple Effect)

Let $\Delta\mathbf{F}_1$ be the vector consisting of $\Delta F (= \Delta GDP)$, which is the reduction in final demand for each industry. The first step of the ripple effect is given as $\Delta\mathbf{X}_1(1) = \Delta\mathbf{F}_1\,(= \Delta\mathbf{GDP})$. Next, the production of raw material $\Delta\mathbf{X}_1(2)$ necessary for the production of $\Delta\mathbf{X}_1(1)$ is stopped. $\Delta\mathbf{X}_1(2)$ is given by the following equation:

$$\Delta\mathbf{X}_1(2) = \mathbf{A} \cdot \Delta\mathbf{X}_1(1) = \mathbf{A} \cdot \Delta\mathbf{F}_1$$

where $\mathbf{A}$ is the input coefficient matrix derived from the I–O table, whose component a_{ij} is the amount of item i to produce item j of unity.

Further, $\Delta\mathbf{X}_1(3)$ necessary for the production of $\Delta\mathbf{X}_1(2)$ is referred as follows:

$$\Delta\mathbf{X}_1(3) = \mathbf{A} \cdot \Delta\mathbf{X}_1(2) = \mathbf{A}^2 \cdot \Delta\mathbf{F}_1$$

The same ripple effect is repeated, so that the final reduction in output $\Delta\mathbf{X}_1$ is given by the following equation:

$$\Delta\mathbf{X}_1 = \Delta\mathbf{F}_1 + \mathbf{A} \cdot \Delta\mathbf{F}_1 + \mathbf{A}^2 \cdot \Delta\mathbf{F}_1 + \cdots = (\mathbf{I} - \mathbf{A})^{-1} \cdot \Delta\mathbf{F}_1$$

The matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is called the Leontief inverse matrix, where $\mathbf{I}$ is the unit matrix.

(5) Reduction in Output (2nd Ripple Effect)

As illustrated in Figure 2.1-1, the reduction in output from the viewpoint of reduction in income is called the second ripple effect. The reduction in consumption $\Delta\mathbf{F}_2$ due to the second ripple effect is given by the following equation:

$$\Delta\mathbf{F}_2 = \mathbf{f}_1 \cdot \mathbf{f}_2 \cdot \mathbf{f}_3 \cdot \Delta\mathbf{X}_1$$

where $\mathbf{f}_1$ is the factor expressing the reduction in gross value added, $\mathbf{f}_2$ is the factor expressing the reduction in employees' income, and $\mathbf{f}_3$ is the factor expressing the trend of consumers.

By multiplying the Leontief inverse matrix to $\Delta\mathbf{F}_2$, the reduction in output $\Delta\mathbf{X}_2$ is given by the following equation:

$$\Delta\mathbf{X}_2 = (\mathbf{I} - \mathbf{A})^{-1} \cdot \Delta\mathbf{F}_2$$

2.2.2 Methodology to Evaluate Economic Loss of Enterprises

It is an important point whether the production area and/or consumption area is included in the disaster area. Table 2.2 shows the economic loss for each combination of production and consumption areas. Direct loss, of course, occurs only where the production area is in the disaster area.

Table 2.2: Categorisation of Economic Loss of Enterprises

		Consumption area	
		Within disaster area	**Outside disaster area**
Production area	Within disaster area	The maximum value of the following: • the reduction in sales caused by the reduction in production • the reduction in sales caused by the reduction in consumption	Economic loss is the reduction in sales caused by the reduction in production.
	Outside disaster area	Economic loss is the reduction in sales caused by the reduction in consumption.	No economic loss occurs.

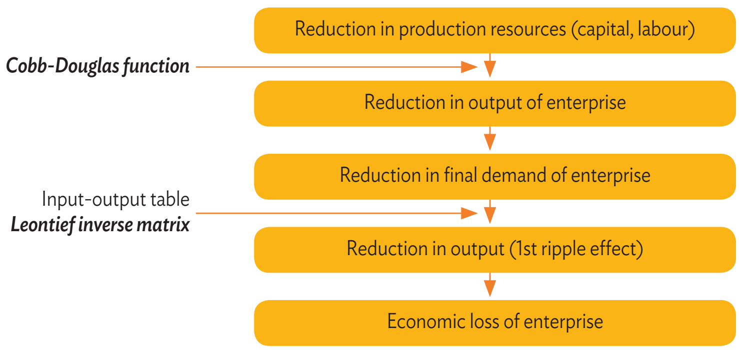
Source: Fukushima, Hayashi, and Yashiro (2009).

(1) Economic Loss Where the Production Area is in the Disaster Area

Where the production area is in the disaster area and the consumption area is not, the economic loss of enterprises is evaluated as the reduction in sales due to the reduction in production, as shown in Figure 2.2.

To realise the flowchart in Figure 2.2, it is necessary to evaluate the reductions in capital and labour. Capital is estimated by disaster simulation for the enterprise's capital, and labour is estimated by disaster simulation for labour, as illustrated before.

Figure2.2: Flowchart to Obtain the Economic Loss of Enterprises Where the Production Area is in the Disaster Area



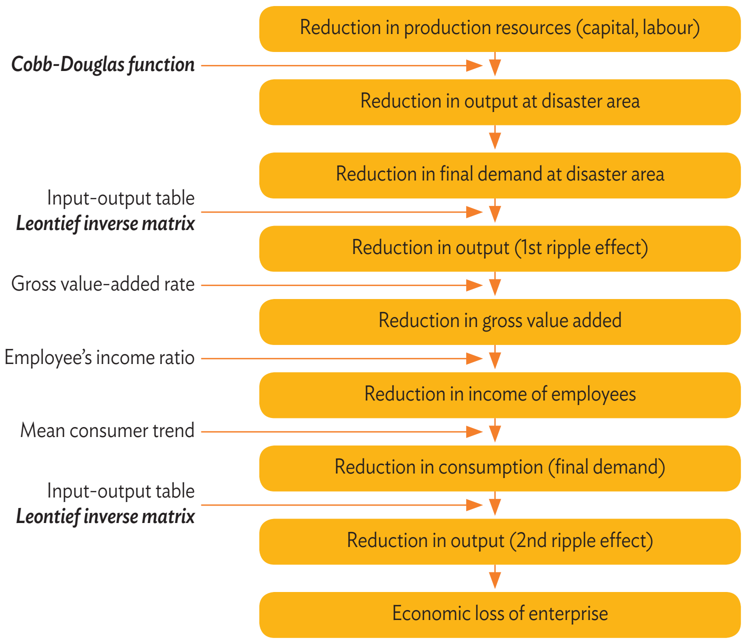
Source: Fukushima, Hayashi, and Yashiro (2009).

(2) Economic Loss Where the Consumption Area Is in the Disaster Area

Where the consumption area is in the disaster area and the production area is not, the economic loss of enterprises is evaluated as the reduction in sales due to the reduction in consumption, as shown in Figure 2.3.

Figure 2.3 is identical to Figure 2.2 for the evaluation of economic loss at the regional level. However, the reduction in output by the first ripple effect is not for the enterprises concerned, but those in the disaster area. Therefore, the reduction in output is given as the reduction in output by the second ripple effect. The first ripple effect is considered a condition to calculate the second ripple effect.

Figure 2.3: Flowchart to Obtain the Economic Loss of Enterprises Where the Consumption Area is in the Disaster Area



Source: Fukushima, Hayashi, and Yashiro (2009).

(3) Economic Loss Where Both the Production and Consumption Areas Are in the Disaster Area

Where both the production and consumption areas are in the disaster area, the economic loss is estimated as the maximum of the losses in the previous two cases.

2.3 Sample Application

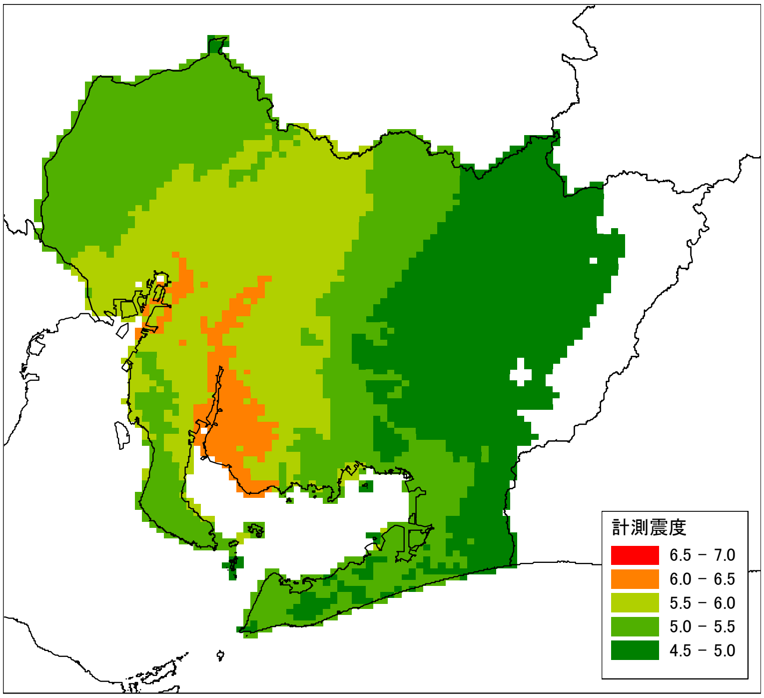
This section proposes methodology to evaluate economic loss at the regional level as well as for enterprises, based on the procedure by the Central Disaster Prevention Council in Japan. It applies the methodology to Aichi Prefecture, where Toyota and other major manufacturers are located, to illustrate how the evaluation is carried out.

2.3.1 Condition Setting

(1) Earthquake and Seismic Hazard Scenario

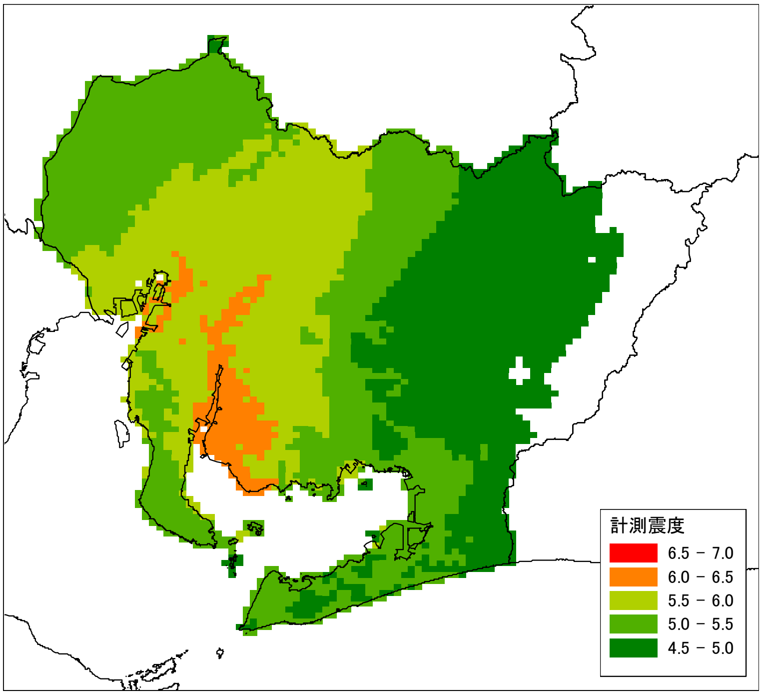
An earthquake occurring at Sanage fault is selected as the external event which yields economic loss to the region. The distribution of ground motion intensity and peak ground velocity are shown in Figures 2.4 and 2.5, respectively.

Figure 2.4: Distribution of Ground Motion Intensity



Source: Hayashi, Fukushima, and Yashiro (2009).

Figure 2.5: Distribution of Peak Ground Velocity



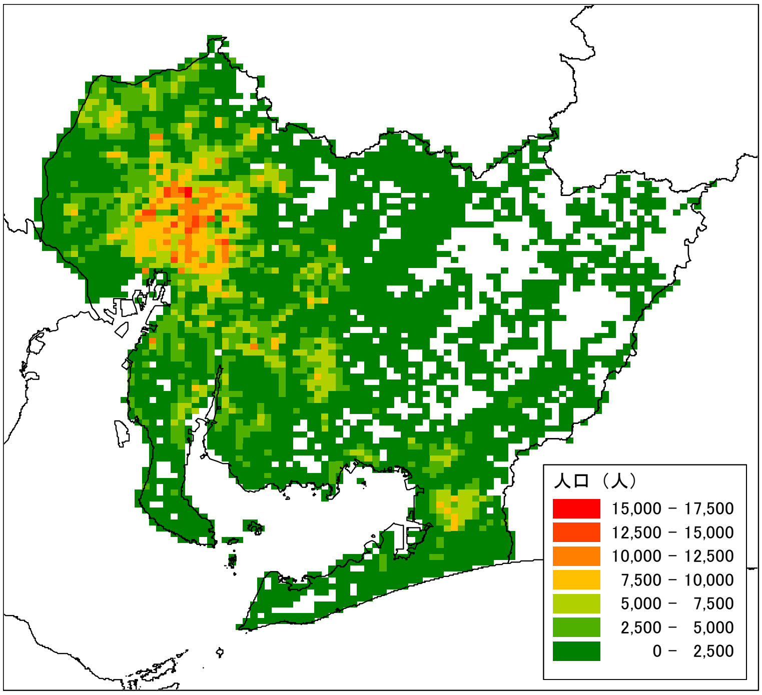
cm = centimetre, PGV = peak ground velocity, sec = second.

Source: Hayashi, Fukushima, and Yashiro (2009).

(2) Distribution of Population and Buildings

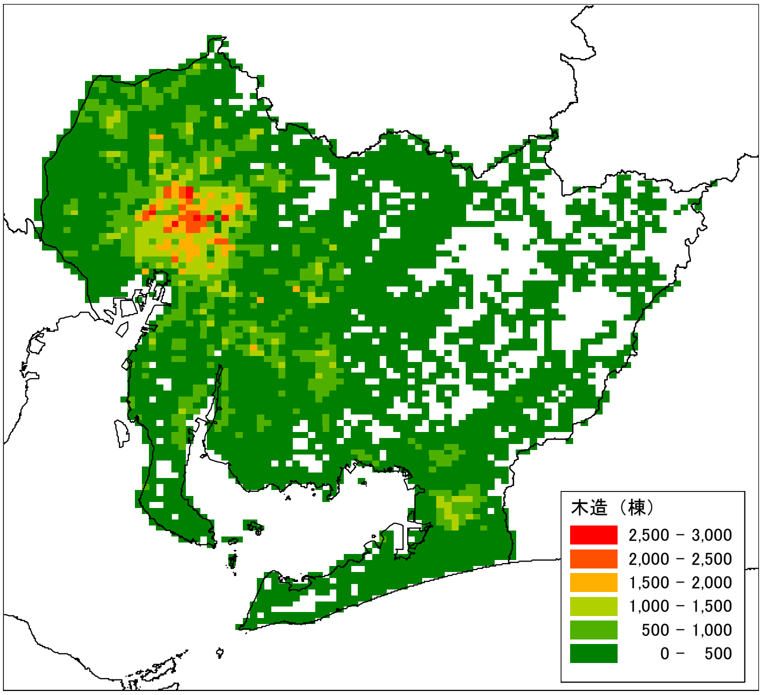
The distribution of population shown in Figure 2.6 is derived from Statistics Bureau (2005) prepared by Statistics Bureau in the Ministry of Internal Affairs and Communications. The distribution of buildings shown in Figure 2.7 is based on Statistics Bureau (2008). Table 2.3 shows the parameters for buildings' vulnerability based on past disasters.

Figure 2.6: Distribution of Population



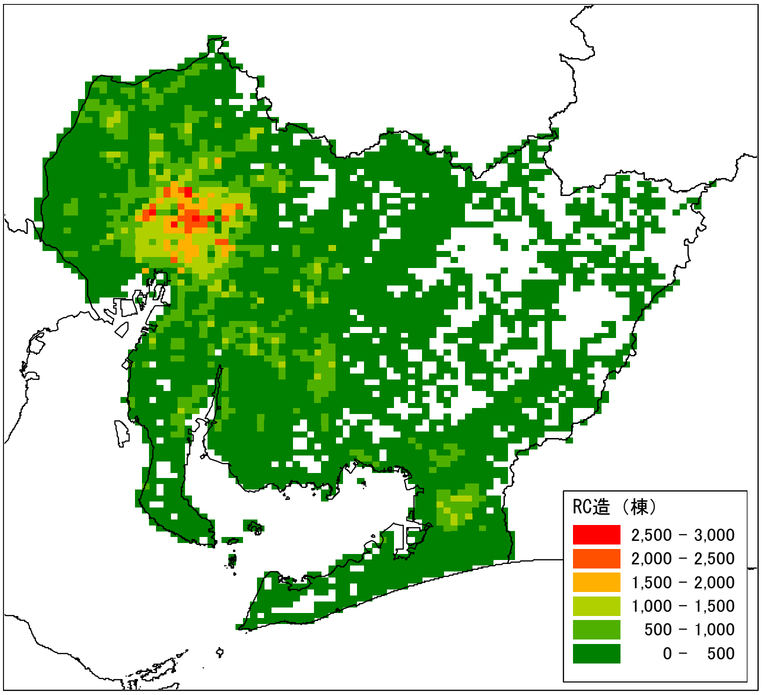
Source: Hayashi, Fukushima, and Yashiro (2009).

Figure 2.7 (a): Distribution of Wooden Buildings



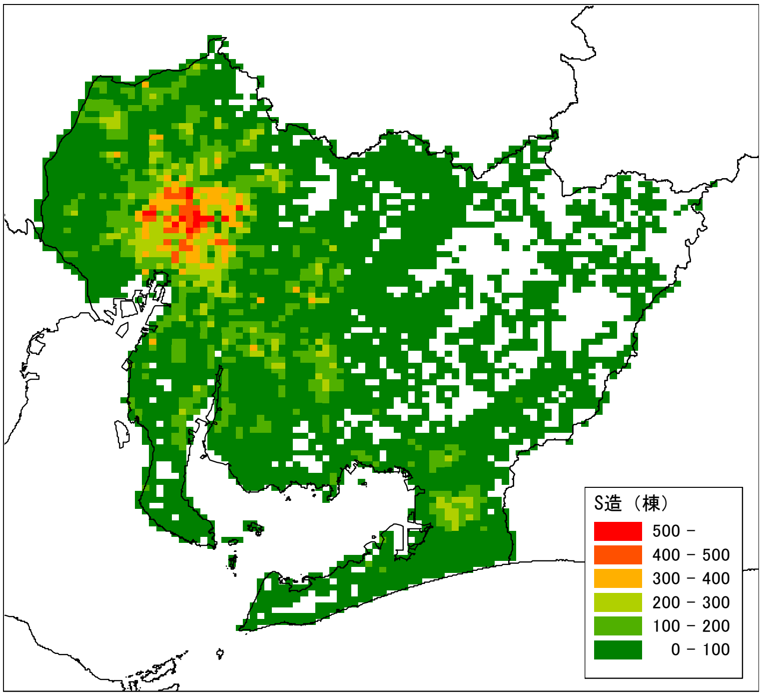
Source: Hayashi, Fukushima, and Yashiro (2009).

Figure 2.7 (b): Distribution of Reinforced Concrete Buildings



Source: Hayashi, Fukushima, and Yashiro (2009).

Figure 2.7 (c): Distribution of Steel Buildings



Source: Hayashi, Fukushima, and Yashiro (2009).

Table 2.3: Parameters of Buildings' Vulnerability

Type of building	Collapsed		Partially collapsed	
	Median (cm/s)	Log – normal standard deviation	Median (cm/s)	Log – normal standard deviation
Wooden/Residential (–1951)	78.3	0.411	38.9	0.674
Wooden/Residential (1952–1961)	84.8	0.353	53.0	0.490
Wooden/Residential (1962–1971)	85.6	0.342	55.7	0.456
Wooden/Residential (1972–1981)	113.3	0.378	70.1	0.395
Wooden/Residential (1981–)	167.3	0.496	100.5	0.474
RC/Non-residential (–1971)	167.3	0.646	112.2	0.691
RC/Non-residential (1972–1981)	206.4	0.575	127.7	0.612
RC/Non-residential (1982–)	403.4	0.789	206.4	0.789
Steel/Non-residential (–1971)	103.5	0.819	70.1	0.712
Steel/Non-residential (1972–1981)	144.0	0.490	89.1	0.549
Steel/Non-residential (1982–)	281.5	0.731	149.9	0.733

cm = centimetre, RC = reinforced concrete, s = second.

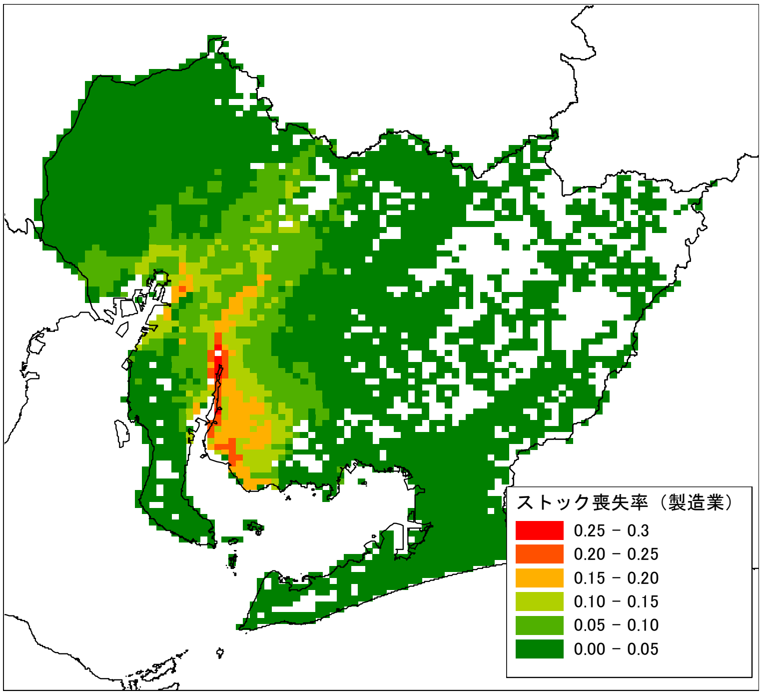
Source: Murao and Yamazaki (2000).

3.2 Result of Estimation

(1) Reduction in Regional Productive Stock

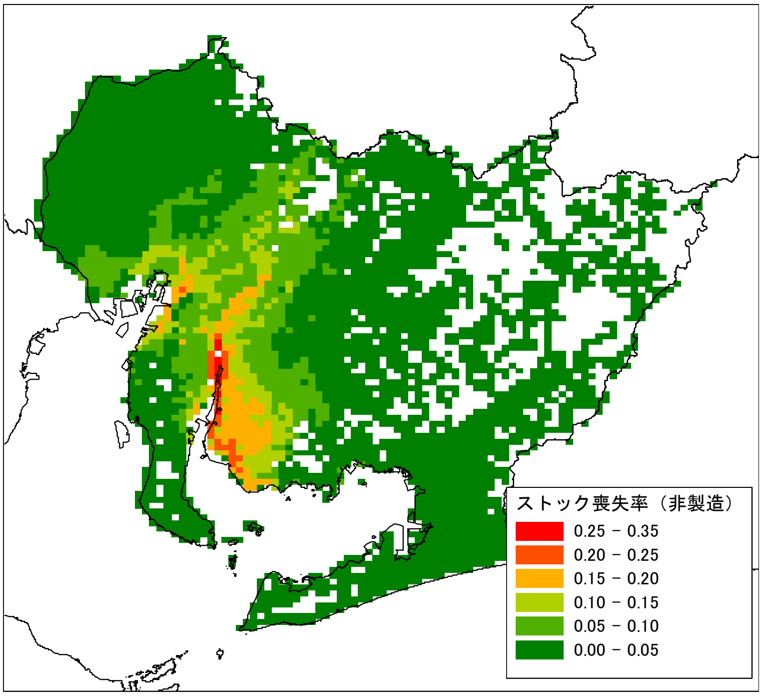
The distribution of the loss rate of capital stock and labour input is shown in Figures 2.8 and 2.9, respectively. The loss rate in each mesh is summed up and the total loss rates obtained are in Table 2.4.

Figure 2.8 (a): Distribution of Loss Rate of Capital Stock (Manufacturing Industry)



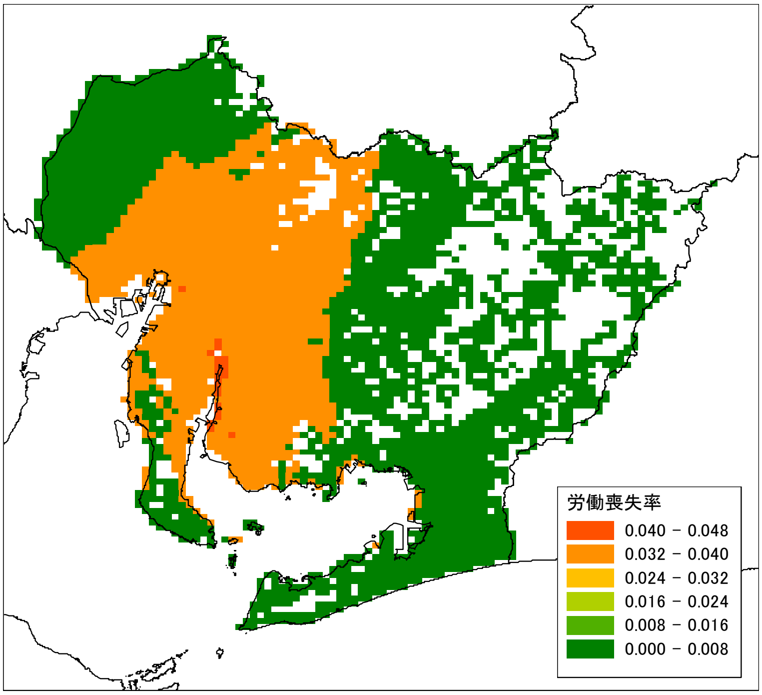
Source: Hayashi, Fukushima, and Yashiro (2009).

Figure 2.8 (b): Distribution of Loss Rate of Capital Stock (Non-manufacturing Sector)



Source: Hayashi, Fukushima, and Yashiro (2009).

Figure 2.9: Distribution of Loss Rate of Labour Input



Source: Hayashi, Fukushima, and Yashiro (2009).

Table 2.4: Total Loss Rates in Aichi Prefecture

Capital stock (Manufacturing industry)	Capital stock (Non-manufacturing sector)	Labour input
0.03443	0.03570	0.01533

Source: Hayashi, Fukushima, and Yashiro (2009).

(2) Reduction in Production Value of Each Industry

The reduction in production value is estimated for 13 industries categorised in the I–O table for Aichi Prefecture. Table 2.5 summarises factors for the Cobb–Douglas production function and the results of estimation. The reduction rate for production value in the table is equal to the ratio of the final reduction in demand to GDP.

Table 2.5: Total Loss Rates in Aichi Prefecture

Industry	Factors α for Cobb–Douglas production function	Reduction rate for production value (final reduction in demand)
Agriculture, forestry, and fisheries	0.378	0.337
Mining industry	0.369	0.343
Manufacturing industry	0.384	0.330
Construction industry	0.326	0.377
Electricity, gas, and water industry	0.364	0.347
Commerce	0.353	0.355
Finance and insurance	0.563	0.290
Real estate	0.695	0.351
Transportation	0.495	0.290
Communication and broadcasting	0.495	0.290
Official business	0.448	0.302
Service industry	0.448	0.302
Others	0.448	0.302

Source: Hayashi, Fukushima, and Yashiro (2009).

(3) Reduction in Output (1st and 2nd Ripple Effects)

Table 2.6 summarises the 1st and 2nd ripple effects for 13 industries. It shows a large difference in ripple effects amongst industries, though the difference in the reduction rate of industries is small, as shown in Table 2.5. For example, economic loss in the mining industry is several times of one by its own loss of production resources, and the ripple effect in real estate or official business is small.

Table 2.6: Ratio of Regional Economic Loss for GDP

Industry	1st Ripple effect	2nd Ripple effect
Agriculture, forestry, and fisheries	1.369	0.354
Mining industry	15.410	5.694
Manufacturing industry	0.816	0.202
Construction industry	0.440	0.106
Electricity, gas, and water industry	0.840	0.232
Commerce	0.625	0.240
Finance and insurance	0.880	0.325
Real estate	0.433	0.041

Table 2.6: Ratio of Regional Economic Loss for GDP (cont.)

Industry	1st Ripple effect	2nd Ripple effect
Transportation	0.823	0.310
Communication and broadcasting	0.678	0.221
Official business	0.302	0.082
Service industry	0.646	0.253
Others	2.709	1.329

GDP = gross domestic product.

Source: Hayashi, Fukushima, and Yashiro (2009).

2.4 Conclusion

In surveying the intrinsic complexity of disaster-prone ASEAN countries, this paper introduces various models, especially focusing on the I–O model, to examine economic losses and damages in the region considering the applicability and adaptability of the model and data availability. The I–O model can show the ripple effects from a disaster-affected area to a country and then to other countries and the region.

As a single disaster occurring in one country could directly and indirectly affect neighbouring countries and then a whole region, region-wide efforts for assessing the economic effects at the local, national, and regional level are required so that disaster risk reduction measures may be implemented accordingly.

This study has not yet applied the model to actual analyses because of the paucity and limited availability of both disaster and economic data for the ASEAN countries. The development of such data is indispensable for disaster loss analysis and highly required for the ASEAN region.

Nonetheless, the above-mentioned models can be applied not only to earthquakes but to other natural disasters by estimating the loss rates of capital stock and labour input, considering disaster- and country-specific characteristics.

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CHAPTER 3

ASEAN Food Security under the 2°C–4°C Global Warming Climate Change Scenarios

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3.1 Introduction

Southeast Asia, comprising the 10 member states of the Association of Southeast Asian Nations (ASEAN), is a highly climate-vulnerable region but under-studied when it comes to climate science. Unlike the scientific and technical expertise in countries such as the United States (US), the United Kingdom (UK), Australia, and New Zealand, climate research studies in Southeast Asia remain challenging. In addition to lack of sufficient scientific contributions, Southeast Asia has limitations in available climate data, dense and robust observational networks, and technology to support such an intricate science as that of climate. As a result, most data sets and models are derived from European or American models, and in more recent years, from China, Japan, and Australia. Much more work is required for Southeast Asia, given the economic and humanitarian impacts. The Asian Development Bank (ADB, 2009) has reiterated the need for more adaptive measures and strategies to mitigate climate change impacts. The reports of the Intergovernmental Panel on Climate Change (IPCC, 2014) and ADB have indicated that much more detailed research is needed for Southeast Asian countries. This includes not just refinements in data collection, analysis, and modelling, but also a new look at the archipelagic and insular land and seascapes unique to Southeast Asia.

The Met Office (2014) reported that the climate future for Southeast Asia may not be bright. The region is likely to face an increase in warm day temperatures of 4.3°C; a 5% increase in the number of days in drought; 77% of the region is projected to have an increase in flood frequency; and staple crops are expected to experience increases and decreases, but in different areas. With projected population increases and rising sea levels, this exposure is projected to increase considerably. The frequency of inland flooding events is also projected to increase. Warmer sea surface temperatures and ocean acidification could likely threaten fish stocks in this major fishing region. The region is important for rice exports and is also a major producer of corn. There could also be increased water demand for irrigation, decreased water run-off, increased drought days, and intensified effects of storms.

The general international view is that food prices are likely to increase in the coming years as global food production is unlikely to keep up with the demand, given adverse climatic conditions that affect harvests, degrade soils, and cause water scarcity for irrigation with increasing population and rapid urbanisation. If climate change projections are included, most of today's key agriculture regions are likely to experience more extreme rainfall distributions which can highly impact food production through more frequent and extreme events such as droughts and floods.

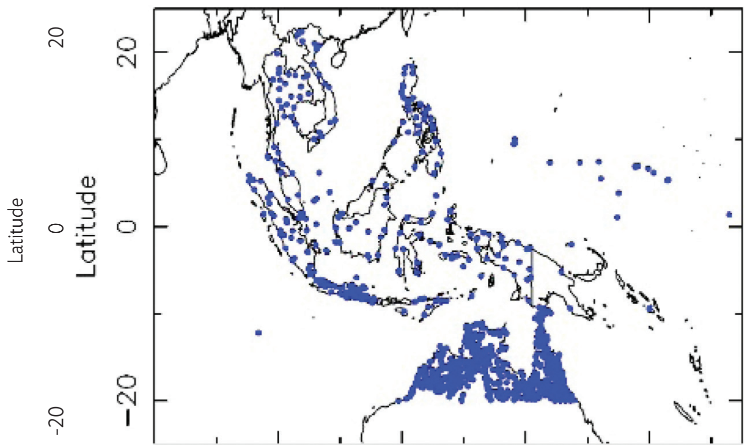
The reports of the IPCC suggest that the mean surface air temperature in this region has increased 0.1°C–0.3°C per decade from 1950 to 2000 (IPCC, 2007; 2014). The number of extreme weather events, or the number of heavy storm events and tropical cyclones, has also increased, as have the frequency of hot days and warm nights. These climate changes have impacts on other physical systems – increasing temperatures and extreme weather events also lead to a decline in crop yields in many Southeast Asian countries (Thailand, Viet Nam, and Indonesia); massive flooding in Hanoi and Hue (Viet Nam), Jakarta (Indonesia), and Vientiane (Lao People's Democratic Republic (Lao PDR)); landslides in the Philippines; and droughts in many other parts of the region (IPCC, 2007; 2014). Water shortages, agriculture constraints, risks to food security, infectious diseases, forest fires, and degradation of coastal and marine resources have also been increasing.

Future increases in precipitation extremes related to the monsoon are very likely in Southeast Asia. The region's temperatures may increase by 3°C–4°C and rainfall could rise by 40% by the end of the century. The strongest and most consistent increases are in northern Indonesia, Singapore, and Malaysia in June, July, and August; and southern Indonesia and Papua New Guinea in December, January, and February. Under scenarios of high levels of global warming, the IPCC report states that models based on current agricultural systems suggest large negative impacts, mainly related to water availability and a reduction in crop yields. The report also mentioned substantial risks to global food production and security, and high confidence regarding the adverse link between climate change on crop and food production in several regions of the world, including Southeast Asia (IPCC, 2014).

3.2 Climate Data, Models, and Scenarios

Information on the current climate and its change over the past decades is only available through observational data. Several gridded observational data sets, mainly on precipitation and temperature, have been developed by different research institutes. However, a close examination of these data sets (Raghavan et al., 2017) – especially rainfall – reveals substantial differences amongst them at sub-regional and local scales with respect to the rainfall amounts, and shows that extreme rainfall magnitudes are not being captured. These different data sets do not show large deviations on monthly time scales, but many uncertainties exist on daily scales. This suggests that, in general, data quality needs to be improved in the ASEAN region; and a dense, robust network of observing gauges needs to be installed and monitored, including in some of the developing countries in ASEAN which have a sparse network of observations. A co-ordinated effort in this data archival is important to ensure that climate data from now on are not lost forever. These data would help the climate community and policymakers to understand changes in the climate to better quantify climate projections provided by the climate models. A recent study (van den Besselaar et al., 2017), which developed a gridded data product, showed the distribution of stations in the region – highlighting the sparse network. In addition, although individual countries might hold the records of such station data, they are not made available to the community because of data sharing policies.

Figure 3.1: Rainfall Data Stations in Southeast Asia



Source: van den Besselaar et al., 2017.

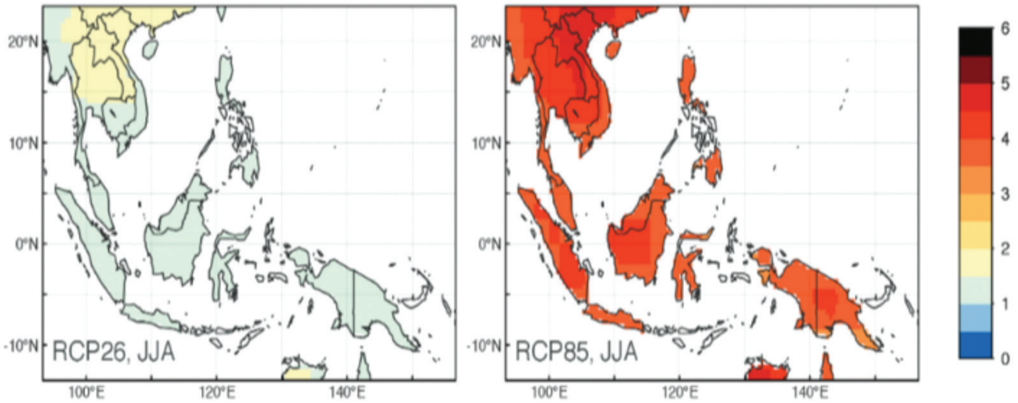
General circulation models (GCMs), also called global climate models, are the primary tools for the prediction of global climate. These models provide reasonable simulation accuracy of the current climate on a global, hemispheric, or continental scale, but their simulation accuracies are poor on a regional scale representation (Giorgi, 1990) because of coarse spatial resolutions (100–300 kilometres (km)). The representation of global climate models has advanced scientifically since 2001 to improve climate predictions. This is largely attributable to technological developments which facilitate simulations of the earth's climate at higher spatial resolutions. Regional climate is often affected by atmospheric phenomena, which occur at a sub-grid scale of the GCM. Some of the regional and local scale climate forcings – caused by land-use characteristics, complex topography, land–ocean contrasts, aerosols, radiatively active gases, snow, sea, ice, and ocean currents – are not resolved well by GCMs. They are computationally expensive because of their complexity; and the length of the simulations required for the present and future climates ranges from a few years to decades. Therefore, GCMs cannot capture the fine scale structure that characterises climate variables in many regions of the world, which is required to run impact models. This becomes particularly problematic for important climate variables like precipitation, which have high variability in space and time. As a result of their coarse spatial resolution and their inability to include mesoscale atmospheric features in their large-scale circulation, GCMs do not simulate the precipitation fields with adequate fine scale detail to be applied to impact models such as hydrological models. Hence, before the GCM output information of key variables can be used to drive the impact models at a regional or local scale, an intermediate step requires the downscaling of this large-scale GCM information to the regional scale. This is done by applying some downscaling techniques that are widely employed in the climate community – dynamical and statistical. The dynamical approach involves the climate simulation of a desired region at high spatial resolution (10–30 km) using a mathematical three-dimensional model, called a regional climate model. This approach, though climate-realistic, is expensive in terms of computational time and resources such as supercomputing, which few can afford. The statistical method is more empirically based on certain assumptions of climate statistics. A general review of downscaling methods by Trzaska and Schnaar (2014) suggests that there is no single best downscaling approach, and that these approaches depend on the desired spatial and temporal resolution of outputs and the climate characteristics of the region of interest.

GCMs use certain climate scenarios to assess future climate change based on the plausible trajectories of greenhouse gas emissions. The IPCC has made use of such climate scenarios since 1995 and, with the subsequent development of such scenarios, global models have been simulated under such prescribed scenarios to better quantify future climate changes. The IPCC (2014) report made use of the Representative Concentration Pathways (RCPs), which provide assessments of future changes by the end of the century related to a particular net radiative forcing. These are termed scenarios 2.6, 4.5, 6.0, and 8.5. Scenarios 4.5 and 8.5 have been widely used by the climate research community to study future climate changes, and provide a range of the low to high end of greenhouse gas trajectories, based on mitigation and no mitigation options, respectively. The 2.6 scenario is deemed almost unlikely, given the rate of global warming. This paper discusses some of the findings from studies that have used the 4.5 and 8.5 scenarios.

3.3 Studies of Southeast Asia for 2°C–4°C Warming

The Potsdam Institute for Climate Impact Research conducted a study for the World Bank on climate change impacts with respect to different warming scenarios (World Bank, 2013). The study projects the average summer warming around the 2040s in Southeast Asia to be about 1.5°C (1.0°C–2.0°C) for a 2°C rise; and the average summer temperatures over land are projected to increase by about 4.5°C (3.5°C–6.0°C) by 2100, for a 4°C rise. The region is also expected to experience a strong rise in monthly heat extremes, with the number of warm days projected to increase from 45 to 90 days (2°C) and 300 days (4°C). The strongest warming is expected in the regions of northern Viet Nam and the Lao PDR, with the multi-model mean projecting up to 5°C under 4°C global warming by 2071–2099 and up to 2°C under 2°C global warming. The changes in temperature and rainfall over Southeast Asia by the end of the century under two different climate scenarios (RCP 4.5 and 8.5) are shown in Figures 3.2 and 3.3, respectively.

Figure 3.2: **Multi-Model Mean Temperature Anomaly under RCP 2.6 and RCP 8.5 for June–August (2071–2099 vs 1951–1980) (°C)**

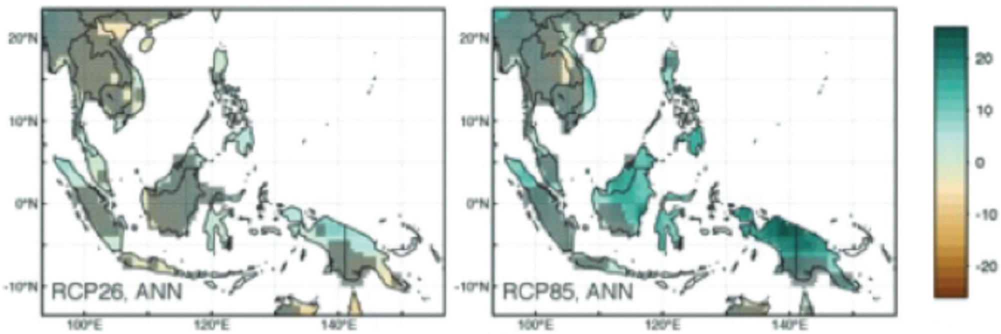


JJA = June, July, August; RCP = Representative Concentration Pathway.

Source: Adapted from World Bank (2013).

The report also predicts that population growth will largely exert pressure on water resources, which could be augmented because of climate change. Water reduction of up to 20% is projected for many regions under 2°C warming and up to 50% under 4°C warming. Vulnerabilities could increase because of greater variability in precipitation and disturbances in the monsoon systems (World Bank, 2013).

Figure 3.3: **Multi-Model Mean Annual Rainfall Anomaly under RCP 2.6 and RCP 8.5 (2071–2099 vs 1951–1980) (%)**



ANN = annual, RCP = Representative Concentration Pathway.

Source: Adapted from World Bank (2013).

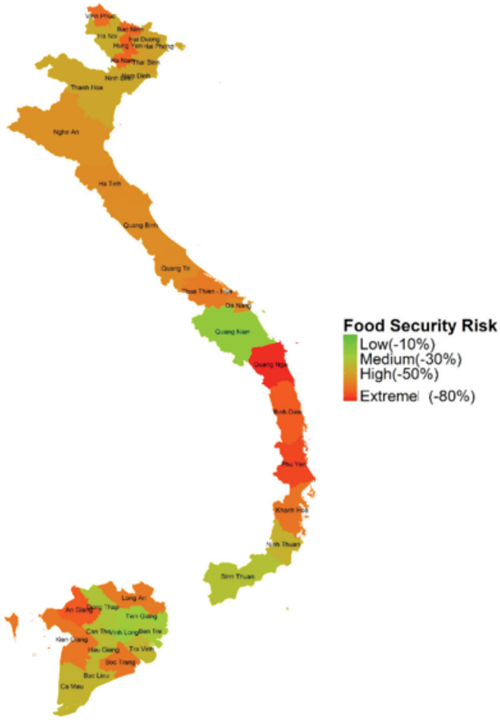
The World Bank also reported that crop yields will be under pressure to meet global demand for food supplies; and at 2°C warming, Southeast Asia will have reduced crop yields and production losses. Such impacts would strongly affect food security and could trigger reduced economic growth in the region. In addition to temperature increases, other factors such as saltwater intrusion, sea level rise, and tropical cyclones add to the uncertainties in agricultural production and losses, in addition to losses caused by pests and crop diseases. Deltaic regions such as the fertile Mekong River Delta (MRD), native to rice farming, could be particularly affected by saltwater intrusion; and temperature increases during critical growing periods could hamper productivity (Wassmann et al., 2009). Some cultivars could also be affected by prolonged flooding (Jackson and Ram, 2003). Although rice is resilient to salinity and water changes, sudden and total inundation could render the crops vulnerable to losses. The World Bank reported that a sea level rise could raise the MRD by 30 centimetres by 2040, resulting in an agricultural loss of about 12% because of a 193,000 hectare (ha) loss of crops (4.7% of the MRD); and saltwater intrusion could cause about 295,000 ha (8% of the MRD) to experience losses. A loss in export revenue of $1.22 billion in 2011 prices (World Bank, 2010) could incur when no adaptation measures are in place, and rice production could decline by about 2.6 million tons per year, assuming 2010 rice productivity.

A regional dynamical downscaling climate study for Southeast Asia was performed at the Tropical Marine Science Institute, National University of Singapore, using the Weather Research and Forecasting model, documented in detail by Skamarock et al. (2008). As mentioned earlier, this is a regional climate model that can be used to simulate climates for desired regions. Developed from a numerical weather prediction model, it is equipped with a large number of physical parameterisations which can be used to optimise the model for a specific region. The model is flexible, to be simulated at different resolutions, and is commonly used to downscale the GCMs dynamically over a specific region. Using this model, the study (Raghavan et al., 2017) involved simulating the climate in Southeast Asia at a 20 km spatial resolution over the baseline period (1986–2005), which was used as a reference period to compare against future climate periods (2020–2040 and 2070–2090). The study downscaled a few of the global models of the Coupled Model Intercomparison Project Phase 5 (CMIP5) under the RCP scenarios 4.5 and 8.5. The main findings from the assessments of climate change simulated by this model suggest that temperatures in the region could likely increase by 1.0°C–2.0°C by the 2020s and more than 3.5°C–4.5°C by the end of the century. Rainfall projections indicate both decreases and increases throughout the region, with significant decreases over Java Island in Indonesia and parts of northern/northeastern Thailand, parts of northern Viet Nam, and the Lao PDR.

Earlier studies on droughts in central Viet Nam (Vu et al., 2015) and some assessments of extreme rainfall in Viet Nam (Raghavan et al., 2017) suggest future climate impacts that have implications for crop production systems. A risk map (Figure 3.4) for rice production was developed as part of the same study, which applied the climate model outputs for crop (rice) growth simulation using the Decision Support System for Agrotechnology Transfer crop assessment tool. This risk map, developed for major regions of Viet Nam, shows areas of low to high risks in terms of rice production under future climate change and a temperature increase of about 4°C.

The findings of this study also indicated that rain-fed crops, in general, produce less yield than irrigated crops. Although irrigation could significantly improve crop yields, the main challenge is to find water sources given decreases in rainfall. The MRD falls in the category of high vulnerability to climate change, given other risks such as sea level rise and saltwater intrusion, droughts, and floods. Hence, prudent planning is necessary to counter negative impacts of climate change. This study provides some preliminary assessments of possible changes in the future though it is by no means exhaustive in its findings, as the science is growing and more research remains to be done both on the climate and crop modelling aspects.

Figure 3.4: Risk Map of Food Security over Viet Nam



Source: Liong et al. (2016).

3.4 Discussions on Policy Perspectives

In Southeast Asia, where agriculture is a major source of livelihood, about 115 million ha of land are devoted to the production of rice, maize, palm oil, natural rubber, and coconut (ADB, 2009). Rice has been feeding the region's population for well over 4,000 years and is the staple food of about 557 million people (Manzanilla et al., 2011). Climate change is likely to impact the agricultural sector in the ASEAN region. The World Bank (2013) stated that irrigation systems are likely to be affected by changes in rainfall and run-off, leading to problems in the availability of water and water quality. As the Southeast Asian region already faces water stress, future climate changes are likely to cause varied rainfall patterns that would further impact agriculture. Temperature increases, as mentioned earlier, are also likely to threaten agricultural productivity because of crop stress and yield reduction. These harsh impacts would affect low-income rural populations that depend on traditional agricultural systems, as in Khon Kaen Province, Thailand, which has seen reduced rice cultivation and production because of drought. Despite the government's efforts in training farmers to cultivate alternative crops, traditional rice farmers are unwilling to farm other crops. It is also notable that rice exports by Thailand have fallen since 2013 (Keck, 2013).

The reduction in crop yields in the MRD caused by climate change is important, as regional climate change is also likely to impact neighbouring regions in Thailand or even India. If the MRD has lower yields, parts of Thailand, Indonesia, and/or India are also likely to have lower yields. This should be borne in mind when it comes to the regional influence of climatic conditions. A reduced number of rainy days during the dry season, along with an increased number of rainy days during the wet season, are likely to cause considerable negative effects during growth seasons.

Evidence that climate change has affected food production implies challenges to food security (Porter et al., 2014), though quantifying this needs to incorporate many non-climate factors that interact with climate. The Fifth Assessment Report of the IPCC states that one important aspect of food security is the price of internationally traded food commodities (IPCC, 2014; Chapter 7, Section 7.1.3). These prices reflect the overall balance of supply and demand, and the accessibility of food for consumers linked to regional and global markets. The Food and Agriculture Organization of the United Nations (FAO) reported that food prices declined gradually for most of the 20th century (FAO, 2009), yet there have been several periods of rapid increases in international food prices. These spikes are attributable to increased crop demand, which may be further attributed to increased biofuel production and oil price fluctuations (Wright, 2011).

Climate-smart agriculture has become an active area of research and implementation towards adaptation to climate change. This new area of science and technology has led to addressing shortcomings in the agricultural practices and tools available for farmers – using modern agricultural practices, new devices, forecast warnings, and climate outlooks – which suggest that non-climatic factors that impact food security can be well managed. Using seasonal forecasts, in addition to climate-smart technological services, helps farmers in the short term to be better prepared to counter adverse impacts. However, climate change still poses uncertainties because of strong temperature increases (that hamper cultivar seeds) and uncertain rainfall (as in the case of irrigation). Although new cultivars have been developed and continue to be developed in light of climate change, they may be unable to withstand sudden fluctuations in temperature and rainfall.

Building on a multi-stakeholder partnership, with the support of the ASEAN governments and in collaboration with the ASEAN Secretariat, the World Economic Forum has launched a regional initiative called Grow Asia which is country-led and locally driven. This attempts to serve as a platform to help actions that contribute to food security; and paves the way for sustainable, inclusive agricultural development in support of national and regional priorities in the ASEAN region (Prakash-Mani and Tanvir, 2014).

The Global Agriculture and Food Security Program, a fund that supports country-led efforts to fight hunger and poverty, reported that seven countries – Burkina Faso, Ethiopia, Haiti, Myanmar, Nepal, Rwanda, and Tanzania – would receive grants of about $160 million to help each country increase food security, raise rural incomes, and reduce poverty. The program seeks to address multiple problems faced by farmers through a holistic approach that applies integrated, consolidated, and area-specific interventions responding to local constraints and opportunities. These include strengthening farmers' groups and building their technical and business capacities, increasing the productivity of food and high-value crops through efficient water usage, and improved agricultural inputs and technologies. This is expected to expand farmers' access to markets through post-harvest and market infrastructure support, and linkages to domestic and export markets. A similar scheme should be considered for the ASEAN countries to help developing countries in ASEAN. It is also important to develop a database based on the feedback and experience of farmers who have experienced diverse changes in weather and climate. Their experience and strategies will be useful to both the scientific community and the stakeholders. This would be a good source of 'ground data' to be recorded.

Climate change adaptation needs to be incorporated in strategies to achieve agricultural development goals by building resilience in the entire food system, not just production systems (FAO, 2012). This would lead to opportunities for additional funding for research and implementation by institutes of higher learning and policymakers. Since extreme weather and climate events are setbacks to farmers, price volatility is especially damaging to small-scale food producers when prices are too low because of good harvests or too high owing to crop damage. Any decreases in production in such circumstances affect both levels of income and food consumption (Haryadi, 2016).

A study by the Organisation for Economic Co-operation and Development (OECD, 2017) summarised some climate projections for Southeast Asia, which are in line with those mentioned earlier in this paper. Mixed rainfall patterns in the future are likely to reduce crop yields in some Southeast Asian countries, especially rice regions such as Thailand, Myanmar, the Lao PDR, and Cambodia, which mainly use rain-fed agriculture. Despite some challenges, the medium-term (next few years) outlook is likely to be in balance, giving a positive picture. By the 2050s, however, climate change could play a greater role in determining the outcomes for the agricultural sector. OECD (2017) also reports that following the production and price effects of climate change, agricultural trade between ASEAN and the rest of the world could reduce and climate change is expected to increase real prices for agricultural commodities. Price increases are predominately driven by changes in crop yields. Substantially lower yield growth, particularly for staples, combined with inelastic demand, leads to higher prices.
In Southeast Asia, prices for staple crops such as rice, maize, and cassava are expected to increase.

The IPCC stresses that food security studies are urgently required to estimate the actual range of adaptation open to farmers and other actors in the food system and their implementation paths, especially when possible changes in climate variability are included (IPCC, 2014). The negative effects of climate change on food security can be counteracted by broad-based economic growth – particularly improved agricultural productivity – and robust international trade in agricultural products to offset regional shortages (Nelson et al., 2010).
Adaptation does not necessarily imply acting only on the negative consequences of climate change but also harnesses positive changes where appropriate, as in the case of the warming climate zones/seasons where higher crop productivity could be obtained. Therefore, a

holistic approach and concerted effort to address these challenges in a broader perspective are needed. A joint effort on a regional scale and sharing of the science and adaptive measures with the regional community could benefit both the research community and policymakers, leading to effective planning that paves the way for mitigating harsh climate impacts.

However, while improvements in technology and advances in science are in progress, it is very important to have reliable seasonal forecasting and a real-time climate outlook to help farmers obtain early warning on the evolving weather/climate patterns. This gives them adequate time to develop adaptive strategies for their cropping patterns and harvests. It is also time to consider new breeds of different crops which require less water consumption and have high tolerance to soil salinity, soil moisture deficiency, droughts, and floods.

3.5 Summary and Conclusions

This paper is an overview of the possible changes to food security based on 2°C–4°C changes in future temperatures. It provides analyses based on the synthesis of available literature and climate modelling studies. Recent climate studies indicate that the average summer warming around the 2040s in this region is projected to be about 1.5°C (1.0°C–2.0°C) for a 2°C rise; and the average summer temperatures over land are projected to increase by around 4.5°C (3.5°C–6.0°C) by 2100, for a 4°C rise. Water reduction of up to 20% is projected for many regions under 2°C warming and up to 50% under 4°C warming. Climate vulnerabilities could increase because of greater variability in the precipitation and disturbances in the monsoon systems, which are the primary climate drivers of rainfall in the Southeast Asian region. Combined with responses to high temperature and variations in precipitation, it appears that yield reduction from severe climatic changes cannot be compensated, without adaptation measures, even accounting for the fertilising effects of carbon dioxide. The large reduction in crop yields, especially rice, is also likely to affect exports and the entire regional supply chain because of higher demand. This could influence the insurance markets and inflate prices – disrupting economic stability.

As the science of climate change is evolving and newer climate scenarios are being developed, the changes highlighted in this study serve as an early warning signal to the local agricultural sector to prepare for drastic changes and to be able to counter risks effectively.

Apart from increasing funding for both science and technology, coupled with policies, there is an imminent need for detailed food security studies. This could encompass several areas of study, including both climatic and non-climatic factors, to make in-depth assessments of the actual range of adaptations open to farmers and other actors in the food system. Yet, it is possible to counteract the negative effects of climate change on food security through broad-based economic growth, improved agricultural productivity, and robust international trade in agricultural products to offset regional shortages while concomitant measures to monitor climate change damages are in place.

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CHAPTER 4

Effects of Disasters on International Trade of Agricultural Products and Food Security in Southeast Asia: Empirical Evidence from Thailand, Indonesia, and Viet Nam

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4.1 The Theory of International Trade

The theory of international trade suggests that the more a country participates in international trade, the more likely it is to benefit from an open economy, thereby improving its prospects of rapid socio-economic expansion at home (Smith, 1776; Ricardo, 1817). Trade liberalisation opens export markets and eases access to the import of capital goods and intermediate products (United Nations Conference on Trade and Development, 2016). However, as developing countries turned their attention to achieving rapid economic growth after the Second World War, almost all nations in the early 1950s rejected the notion that they might grow through reliance on comparative advantage. Instead, they opted for policies of 'import substitution'[1] (Niroomand and Nissan, 1997: 167).

Tariffs are not the only intervention by which international trade might be restricted. Nontariff trade barriers include restrictive licenses, quotas, outright prohibitions, impediments to foreign exchange transactions (including required advance deposits for such transactions), customs valuation impediments, and many more. Quantifying the effects of such restrictions on a common scale is even more difficult. The welfare cost of tariff rates and other impediments to trade depends on general equilibrium effects and market structure (Dornbusch, 1992). Across regions, some of the fastest-growing countries in Asia and the oil-rich Gulf states have restrictive policies in services, whereas some of the poorest countries are remarkably open. Across sectors, professional and transportation services are amongst the most protected industries in both industrial and developing countries, whereas retail,

[1] Import substitution is a government strategy that emphasises the replacement of some agricultural or industrial imports to encourage local production for local consumption, rather than producing for export markets. Import substitutes are meant to generate employment; reduce foreign exchange demand; stimulate innovation; and make the country self-reliant in critical areas such as food, defence, and advanced technology.

telecommunications, and even finance tend to be more open (Borchert, Gootiiz, and Mattoo, 2014).

Multilateral trade arrangements for tariff reduction and fair trade must integrate enabling conditions with arrangements for earnings capacity to increase national income and reduce tariffs. The margins of import tariffs applied by high-income and least-developed members of the World Trade Organization (WTO) are vastly different and significant, and the marginal propensity to import is significantly dependent on output for the high-income members of the WTO (Warburton, 2010). Successful reduction of import tariffs in the least-developed countries is ultimately contingent on how trade policies are integrated with development capacity (including the minimisation of corruption) beyond multilateral agreements which are intended to foster longer transition periods and enabling conditions under international trade law (Warburton, 2010).

In the midst of trade restrictions through tariff and non-tariff barriers, natural disasters have adversely affected the domestic and international trade of agricultural products and food security in the world; and Southeast Asia is not an exception (De Haen and Hemrich, 2007; Skees, 2000; Gassebner, Keck, and Teh, 2006). The objective of this study is twofold: (i) to examine the effect of natural disasters on the international trade of agricultural products in selected countries of Southeast Asia (i.e. Thailand, Indonesia, and Viet Nam); and (ii) to assess the effect of natural disasters on food security indicators in these countries.

4.2 International Trade Policies in Thailand, Indonesia, and Viet Nam

4.2.1 Thailand

The general thrust of Thailand's trade and investment policy has remained liberal, and new efforts have been made to improve market access and facilitate trade. Such efforts have been particularly noticeable in customs valuation and foreign direct investment. The tariff is rather complex because of the multiplicity of rates applicable to each of the 5,505 tariff lines. It remains one of the main instruments of trade policy, however, and affords a relatively high level of protection with a simple average applied most favoured nation rate of 14.7% in 2003. Moreover, about a quarter of all tariff lines are unbound, and bound rates often considerably exceed applied most favoured nation rates. This affords authorities considerable scope to raise (or lower) tariffs at any time, by means of royal decrees or ministerial regulations and notifications, with cabinet approval. Import licensing on various items remains opaque and appears in some cases to correspond to quantitative restriction. Most of the import licensing requirements are for national security and health and environment reasons. A number of other non-tariff border measures remain for economic reasons, such as infant industry protection; the effectiveness of these measures is questionable. Thailand has not acceded to the Agreement on Government Procurement.[2] Government procurement continues to be used as an instrument of economic policy, with preference being accorded to domestic suppliers. The authorities recognise a need to remove impediments to investment rather than relying on tax-based incentives, which have been widely used. Thus, various subsidies tied to exports have been removed and investment incentives have been streamlined. On the other hand, the government appears to be taking a more proactive approach to industrial policy and the pursuit of competitiveness, with measures apparently targeted at industries such as agri-industry, automobiles, textiles, electronics, and high-value services. Most local-content and export-performance requirements, including those attached to incentives for new investments, were abolished during the period under review. While privatisation seems behind schedule, considerable progress has been made to corporatise state-owned enterprises (SOEs) in preparation for their eventual privatisation. Since 1999, the number of Thai industrial standards based on international standards has increased. Thailand has also made various amendments to its laws related to quarantine requirements. Various laws have been enacted to strengthen the protection of intellectual property rights, and the government has taken actions to enforce such protection. The implementation of competition policy appears to be weak; the Office of Trade Competition Commission has made decisions on only three cases since its inauguration in 1999. The apparently weak enforcement of the competition legislation may be attributable to institutional, procedural, legal, or resource limitations. However, effective enforcement of the Trade Competition Act, 1999 could be envisaged through continuous institutional and human resources development as well as experience gained from international cooperation (WTO, 2009).

4.2.2 Indonesia

The Uruguay Round improved Indonesia's bound rate to 92% of its tariff items, a development that Japan welcomes. However, the bound tariff rates for the vast majority of items remain extraordinarily high, at levels of 30%–40%. Effective tariff rates are also high, at an average

[2] The Agreement on Government Procurement (GPA) consists of 19 parties covering 47 WTO members (counting the European Union and its 28 member states, all of which are covered by the GPA, as one party). Another 33 WTO members/observers and four international organisations participate in the GPA Committee as observers. Ten of these members with observer status are in the process of acceding to the GPA.

of 27.8% for textiles and textile products, 30.6% for transportation equipment, and 26.1% for electric equipment. In its 'Individual Action Plan' for Asia-Pacific Economic Cooperation (APEC), Indonesia made an explicit commitment to begin in 1995 to reduce effective tariffs of less than 20% to less than 5% by 2000, and those in excess of 20% to 20% by 1998 and to less than 10% by 2003. Description of the import and export system Indonesian foreign trade, both export and import, is conducted openly and liberally with some exceptions for specific reasons. Payment can be made under any terms which are normally applied to international trade. The trade system works because it is supported by the free foreign exchange system, which means that there are limits to obtaining and using foreign exchange for export and import purposes. The export and import system has four categories of regulations for products: (i) products which are traded freely; (ii) products which are prohibited from being traded; (iii) products which may be traded only by licensed exporters or importers (approved traders); and (iv) products with controlled trade (WTO, 1994).

Trade remains limited as a share of economic output, with merchandise exports accounting for 21.0%–26.0% of gross domestic product (GDP) and imports for 15.0%–18.5% of GDP. Indonesia continues to trade more energy-related products (fuels) than any other product category on both the import and export sides. A number of measures – including export restrictions and taxes on raw resources, tighter import licensing requirements, point-of-entry restrictions on imports, ownership limitations on banks, and certain divestment requirements for foreign mining companies – have recently raised concerns about the direction of trade and investment policymaking. The tariff has remained Indonesia's main trade policy instrument, albeit a relatively small source of tax revenue. Indonesia's revenues from taxes on international trade constitute about 4% of total tax revenues, which is considerably lower than the average for developing countries. Nearly half of Indonesia's trade taxes are levied on exports, mainly commodities, the main policy objectives being price stabilisation, development of downstream processing facilities, and reducing the rate of depletion in non-renewable resources. SOEs continue to play a key role in Indonesia's economy, estimated to account for about 40% of Indonesia's GDP. No significant privatisation activity took place during the review period. However, the government has partially divested itself of some of its ownership shares in various industries, including cement, telecommunications, mining, energy, pharmaceuticals, construction, highways, steel, manufacturing, airlines, and banks. An SOE monopoly on the importation of alcoholic beverages was terminated in 2010 (WTO, 2013).

Input trade liberalisation has contributed partially to poverty reduction in Indonesia by increasing the incomes of the poorest segment of the population. The effects of tariff liberalisation and increased competition in the regional output markets tended to increase poverty, while tariff reductions for inputs led to poverty reductions. This shows that the effects propagated through input markets could also be relevant role for a short-term analysis of the poverty effects of trade liberalisation. The driving mechanism behind these effects seems to be increasing firm competitiveness as a direct result of reductions in import tariffs on intermediate goods, which induced increased work participation for low- and medium-skilled labour as well as wage increases for medium-skilled labour (Kis-Katos and Sparrow, 2015).

Concept of Food Estate in Indonesia

The Merauke Integrated Food and Energy Estate (MIFEE) programme in West Papua, Indonesia was initiated in 2007 based on the Merauke district proposal on Merauke Integrated Rice Estate. The proposal was made a national programme because of the vast land potential. At its launch on 10 August 2010, Merauke had reserved 1.2 million hectares (ha) of 2.4 million ha of development land. The commodities to be produced under the MIFEE programme are rice, corn, soybeans, sugarcane, and cattle. The programme yielded high levels of crop productivity: 7 tons/ha for rice, 2 tons/ha for soybeans, 40 tons/ha for sugarcane, and 5 tons/ha for dried beans. The national government set up a grand design for large-scale food and energy development, and total investment in the MIFEE programme reached Rp50–60 trillion during 2011–2014. After 2014, production was targeted to reach 2 million tons of rice and maize, 0.2 million tons of soybeans, 2.5 million tons of sugarcane, and 64,000 tons of beef per year. The programme is making a real contribution to improving national food security. Its basic concept is the integration of agribusiness sectors and sub-sectors by using resources optimally and sustainably, supported by institutional and human capacity and environmentally friendly technology. Food estate is directed at a strongly rooted agribusiness system in rural areas based on the empowerment of local communities. Government policies regarding the development of food estate include the licensing of food crop cultivation, livestock, and plantation; strategic environmental studies; maximum foreign capital participation of 49%, business actors' legal entities; and ease of doing business for foreign investors. The scale of the food estate business is limited to a maximum of 20,000 ha per investor (Syaukat, 2010; Indonesia Agency for Agricultural Research and Development (IAARD), 2010; Santosa, 2014). The total population of Merauke is 175,000 people. Food estate development sites are located in the districts of Merauke, Semangga, and Tanah Miring to produce upland rice and maize; Malind, Kurik, and Animha districts are selected to produce sugarcane, beef, corn, and soybeans; and Likable and Jagebob districts for corn, soy, and livestock (IAARD, 2010).

4.2.3 Viet Nam

Viet Nam is an economy in transition, so policymaking is largely ministry-specific and unfocused. An excessive number of policy objectives exist for each policy instrument, many policy instruments are changed frequently for fine-tuning purposes, the language of legal documents remains unclear, and not all legal documents are systematically collected and published (McCarty, 1999).

Viet Nam's trade and investment policies can be characterised as 'export-led protectionism', whereby import substitution is encouraged through trade promotion and export industries are promoted by providing subsidies to countervail the high relative costs of intermediary products. Administrative rigidities and delays in the customs administration have continued to remain important non-tariff barriers. Rigidities and delays in customs procedures have given rise to the widespread use of unofficial customs fees, which are widely held to hurt private firms disproportionately by raising opportunity costs and making customs transactions more time-consuming and cumbersome (Thang, 2004).

Highly strict sanitary concerns also act as a non-tariff barrier. For instance, the European Union (EU) has adopted a policy of 'zero tolerance' for fishery products containing residue of the chloramphenicol antibiotic. The standards have been so strict that they have led to a radical reduction in shrimp exports to the EU from Viet Nam, affecting the livelihoods of thousands of rural exporters. The absence of strict food safety guidelines in exporting countries means that the standards of the richest importing markets – such as the EU, the United States, and Japan – are applied to imports from these countries (Tuan, 2003).

Viet Nam's non-tariff barriers may be summarised as follows: (i) para-tariff measures – customs surcharges, additional taxes, and charges; special sales tax; value-added tax; and decreed customs valuations; (ii) price control measures – administrative pricing of import prices (minimum export prices); (iii) anti-dumping measures (currently being contemplated); (iv) countervailing measures (currently being contemplated); (v) finance measures – advance payment requirements and restrictive official foreign exchange allocation surrender requirements; (vi) quantity control measures – non-automatic licensing, quotas (global quotas, seasonal quotas as rice exports, and quotas linked to local production capacity as 'strategic products'), export prohibitions, and restraint arrangements (export restraint arrangements on textiles outside the multifibre arrangement (MFA), mostly from the EU); (vii) enterprise-specific restrictions; (viii) monopolistic measures – a single or limited number of channels for imports; (ix) technical measures – technical regulations, customs formalities, special formalities (stamping), and customs efficiency corruption; and (x) others such as export-related measures and distribution restrictions (McCarty, 1999; Vo, Nguyen, and Tran, 2016).

4.3 Natural Disasters and Trade

4.3.1 Introduction

A disaster can be defined as a serious disruption in the functioning of a community or society causing widespread material, economic, social, or environmental losses which surpass the ability of the affected society to cope with using its own resources (Dayton-Johnson, 2006). A disaster is the consequence of a combination of hazard, vulnerability, and insufficient measures to lessen the potential likelihood of risk.

Different types of natural disasters include geophysical, meteorological, hydrological, climatological, and biological disasters (Guha-Sapir et al., 2010). Geophysical natural disasters originate from solid earth (e.g. earthquakes, volcanos, and mass movements). Meteorological natural disasters are the result of events caused by short-lived/small to meso scale atmospheric processes (e.g. storms). Hydrological natural disasters are a result of deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up (floods, mass movements (wet)). Climatological natural disasters are caused by long-lived/meso to macro scale processes (in the spectrum from intra-seasonal to multi-decadal climate variability) (Guha-Sapir et al., 2010), e.g. extreme temperatures, droughts, and wildfires. Biological disasters are caused by the exposure of living organisms to germs and toxic substances (e.g. epidemics, insect infestations, and animal stampedes).

A rise in climatic disasters can reduce or increase trade. Beginning with channels reducing trade, disasters can destroy human and physical capital (e.g. kill people; destroy plants; and damage storage, transportation, energy, and communications infrastructure). As a result of the fall in production, income may decline, which reduces private spending and investments, and tax revenues may decline, which reduces public spending. The decline in aggregate demand and supply may reduce trade flows since domestic importers and exporters may not be able to absorb or produce the pre-disaster levels. Second, disasters may increase the cost of trade. For example, traders may need to use longer routes or other ports and airports to reach markets, increasing the costs of distribution and transportation. Insurance premiums may rise, as insurers seek to cover the increased risk. Disasters may also lead to new regulations, requiring goods to be less vulnerable to disasters through design changes or sturdier packaging. As a result, production and distribution technologies may require redesign, which increases costs. A rise in costs may raise the price of goods, causing a decrease in the total quantity demanded. Third, economic activity is partly driven by waves of optimism. Disasters can exhaust people and reduce their willingness to engage in normal economic activities such as consumption, production, and investment. Since disasters destroy sources of livelihood and homes, people may not be able to pay for goods. As a result, trade markets may collapse. In this vein, the Organisation for Economic Co-operation and Development (OECD, 2004) suggests that governments should focus on restoring confidence in the aftermath of disasters so that economic agents resume their normal routines. Consider next the possibility that disasters promote trade. First, a country hit by a disaster may lose production capacity. Other nations may enter the local market, motivated by humanitarian or other reasons (e.g. to increase market share or influence leaders). In doing so, they may grant aid or reduce their export prices, enabling their partners to buy more of their exports. Second, countries hit by disasters may choose policies aimed at increasing their bilateral trade flows. For example, the reconstruction efforts of damaged infrastructure in the affected countries may rely on imports of materials, technology, and skills. External aid may intensify this effect by providing foreign currency. Seeking to rebuild areas hit by a disaster, the government may increase exports to gain foreign currency. Seeking to intensify these effects, the government may also liberalise its export and import markets, which will likely further promote its trade flows. Third, the price of traded goods may rise as the result of a climatic disaster, as traders may seek to cover the higher costs and risks associated with doing business in this case. The quantity of traded goods may decrease because of a disaster. If the price increase is larger than the decrease in the quantity, the trade value will rise. Finally, whereas risk-averse traders are likely to exit markets hit by a disaster, risk-loving traders or speculators may view the situation as an opportunity to make super-normal profits. If the number of speculators and traders entering a market hit by a climatic disaster is larger than the number of traders exiting the market, the value of the bilateral trade may rise (Oh and Reuveny, 2010).

Trade concessions to disaster-hit countries may facilitate their recovery and be conducive to long-term growth, for several reasons. First, trade concessions may mitigate macroeconomic uncertainty in the aftermath of natural disasters, which have been shown to impede growth. The research finds that indirect effects from increased uncertainty after natural disasters hinder growth as much as the direct first effects of natural disasters. A promise or prospect of trade concessions in the near future could be helpful in mitigating post-disaster uncertainty (Baker and Bloom, 2013; Cheong, Won Kwak, and Yuan, 2017; Benali, Abdelkafi, and Feki, 2016; Marin and Modica, 2017). Natural disasters adversely affect foreign direct investment to countries (Anuchitworawong and Thampanishvong, 2015).

4.3.2 Disaster and Trade in Asia

Earthquakes and floods are the natural hazards with the highest potential of impacting small and medium-sized enterprises (SMEs) in Asia (Asian Disaster Reduction Center, 2011). The cases of the East Japan earthquake of 2011 and the Thai floods of 2011 are examples. SMEs in both economies are in a dominant positioning, comprising more than 99% of all enterprises. The impact was not restricted to the region but had a far-reaching impact globally. The two countries have taken up various good practices since the disasters. This learning is used to identify critical areas of action that support building the resilience of SMEs (Chatterjee, Ismail, and Shaw, 2016; Ye and Abe, 2012).

Noy and Vu (2010) revealed that disasters tend to lower output for Viet Nam, but costlier disasters appear to boost the economy in the short run. This is because of the degree of access to reconstruction funds from both the private sector and the central government, where richer and less remote regions exhibit faster growth following a disaster.

Countries with higher literacy rates, better institutions, higher per capita incomes, larger governments, and a higher degree of openness to trade appear to be better able to withstand the initial disaster shock and prevent its effects spilling deeper into the macroeconomy. Financial conditions also seem to matter. Countries with less open capital accounts, more foreign exchange reserves, and higher levels of domestic credit appear more robust and able to endure natural disasters with less spillover to GDP growth rates (Noy, 2009).

The less democratic and the smaller a country, the more its trade flows reduced when struck by a disaster. We are also able to distinguish between the effect of a disaster on an importing country and an exporting country. The impact of a large disaster on international trade can be transmitted either directly or indirectly. Direct impacts on exports can occur because of human losses and injuries (affecting companies' human resources) and the destruction and damage of physical capital and equipment in the export sector. Damage to public infrastructure, such as roads, bridges, railways, and telecommunication systems, can cause disruption to the export supply chain (Gassebner, Keck, and Teh, 2006).

Using the simple gravity model, da Silva and Cernat (2012) revealed that natural disasters impact negatively on the exports of small developing countries. The negative effects of natural disasters on the export performance of small developing countries last for about 3 years. Small developing countries seem to be at higher risk of having their exports negatively affected by natural disasters. Such countries could be the focus of measures dedicated to reducing their export vulnerability to disasters in the first place or minimising the negative export impact of disasters when they occur.

If an economy has access to international markets, imports surge after a disaster. When capacity is restored, imports decline again, but exports have to rise so that the economy may meet the interim budget constraint. After a natural disaster, the economy should have a higher degree of openness (exports plus imports over GDP) than before. Further, considering the interaction between financial remoteness and natural calamities, we expect the positive effect of disasters on imports to be reduced if a country is less integrated financially (Felbermayr and Gröschl, 2013).

Floods have a negative impact on humans, crops, agricultural inputs, livestock, poultry, fish, and other assets such as land and infrastructure – impacting the socio-economic condition of a country. Most of the damages are irreplaceable, leaving humanity in distress. Floods are recurrent and cannot be avoided, hence preparedness would lessen the impact (Dewan, 2015).

Hayakawa, Matsuura, and Okubo (2015) examined the economic impact of natural disasters at the firm level. They explored the economic impact of the 2011 flooding in Thailand, focusing on the impact of flooding on procurement patterns at Japanese affiliates in Thailand, to examine how natural disasters affect production networks in multinational enterprises. The findings show that (i) small firms are more likely to lower their local procurement share, especially their share of procurement from other Japanese-owned firms in Thailand; (ii) young firms are more likely to increase their share of imports from Japan, whereas old firms are more likely to look to China; and (iii) there is no impact on imports from ASEAN and other countries. These findings are useful for uncovering how multinationals adjust their production networks before and after natural disasters.

4.4 The ASEAN Framework on Free Trade and its Integration into the Sendai Framework and ASEAN Socio-Cultural Community

4.4.1 ASEAN Framework on Free Trade

The ASEAN Free Trade Area (AFTA) is a trade bloc agreement initially signed by six members of ASEAN, encompassing Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore, and Thailand on 28 January 1992 in Singapore. The primary goal of the agreement is to increase the region's competitive advantage as a production base in the global market by eliminating tariffs and non-tariff barriers amongst members and attracting more foreign direct investment to the region (ASEAN, 2012).

The ASEAN Trade in Goods Agreement (ATIGA) was signed in February 2009 to replace the AFTA. The ATIGA aims at establishing an integrated single market to achieve the free flow of goods, deepen economic linkages amongst members, reduce business costs, and enhance economies of scale for businesses (ASEAN, 2009a). The ASEAN Economic Community was officially launched in late 2015.

4.4.2 ASEAN Cooperation on Disaster Risk Reduction

Southeast Asia is one of the most disaster-prone regions of the world. It has been exposed to all types of hazards, including typhoons, earthquakes, tsunamis, floods, volcanic eruptions, landslides, forest fires, and droughts. These disasters have caused severe sociocultural and economic impacts to the region (ASEAN, 2009b).

Anbumozhi (2017) developed an integrated approach and cooperative model for a sustainable and resilient ASEAN for scaling up activities to achieve resiliency and sustainability. The power of finance and public–private partnerships to drive change, where technological innovations and integrated policies and programmes are being adopted and scaled up as a result of policy innovations, are critical. Given the complexity of numerous challenges, three forms of cooperation between ASEAN and the international community could be valuable through an effective information system, capacity building, and innovative financing (Anbumozhi, 2017).

4.4.3 The Sendai Framework for Disaster Risk Reduction

The Sendai Framework relates to the risk of small- and large-scale, frequent and infrequent, sudden and slow-onset disasters, caused by natural or man-made hazards as well as related environmental, technological, and biological hazards and risks. It aims to guide the multi-hazard management of disaster risk in development at all levels as well as within and across all sectors. The expected outcome is the substantial reduction of disaster risk and losses in lives, livelihoods, and health and in the economic, physical, social, cultural, and environmental assets of persons, businesses, communities, and countries. The framework aims to prevent new and reduce existing disaster risks through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political, and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience. The framework specified seven targets: (i) reduce global disaster mortality, (ii) reduce the number of affected people, (iii) reduce direct disaster economic loss in relation to global GDP, (iv) reduce disaster damage to critical infrastructure and disruption of basic services (health and educational facilities), (v) increase the number of countries with national and local disaster risk reduction strategies, (vi) enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this framework and (vii) increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments. It also specified four priorities for action to prevent new and reduce existing disaster risk: (i) understanding disaster risk, (ii) strengthening disaster risk governance to manage disaster risk, (iii) investing in disaster reduction for resilience, and (iv) enhancing disaster preparedness for an effective response and to 'Build Back Better' in recovery, rehabilitation, and reconstruction (United Nations Office for Disaster Risk Reduction, 2015).

4.5 Methodology

4.5.1 Data

This study used annual data over 1980–2013 for the disaster and trade investigation and annual data over 1990–2013 for the disaster food security analysis. The data on disasters were obtained from the International Disaster Database (EM-DAT); and the following data set was obtained from the Food and Agriculture Organization of the United Nations Statistics Division (FAOSTAT): gross domestic, exchange rate, population, inflation rate, production, import quantities, export quantities, and food security indicators.

4.5.2 The Gravity Model of International Trade

The gravity model was used to explain the relationship of trade activities between countries. The key assumption of the gravity model in relation to trade is that the volume of trade between any two trading partners is an increasing function of their national incomes and a decreasing function of the distance between them (Head and Mayer, 2013). The gravity model has its genesis in Newton's law of universal gravitation (Anderson, 2016):

$$F_{ij} = \frac{G * MM_{ij}}{D_{ij}} \tag{1}$$

Where F_{ij} is the attractive force, M_i and M_j are the masses, D_{ij} is the distance between the two objects, and G is a gravitational constant (Kuratani, 2004; Head, 2003). Numerous studies have applied the gravity model (e.g. Antonucci and Manzocchi, 2006; Lewer and Van den Berg, 2008; Chakravarty and Chakrabarty, 2014; Hatab, Romstad, and Huo, 2010; Bruno and Improta, 2008; Filippini and Molini, 2003; Sartori et al., 2016; Avorgbedor, 2016). The gravity model is applied in this paper to examine the effect of disasters on the international trade of agricultural products. The augmented gravity equations employed in this study are expressed as follows:

$$EQ_t = \alpha_0 + \alpha_1 EXR_t + \alpha_2 DV_t + \alpha_3 GDP_t + \alpha_4 I_t + \alpha_5 P_t + \alpha_6 Q_t \tag{2}$$

$$IQ_t = \rho_0 + \rho_1 EXR_t + \rho_2 DV_t + \rho_3 GDP_t + \rho_4 I_t + \rho_5 P_t + \rho_6 Q_t \tag{3}$$

Where EQ_t and IQ_t denote export quantity and import quantity, respectively; EXR_t, DV_t, GDP_t, I_t, P_t, and Q_t denote exchange rate, disaster variable, GDP, inflation, population, and quantity produced, respectively; and α_i and ρ_i are parameters to be estimated. Numerous studies have revealed that these variables influence the international trade of products amongst nations (e.g. Avorgbedor, 2016). International trade (exports and imports) of four food security commodities (i.e. rice, cassava, potato, and banana) were examined in this study for each of the three countries (Thailand, Indonesia, and Viet Nam) where appropriate.

4.5.3 Disaster and Food Security Analysis

The disaster and food security analysis was also performed using regression models. Here, this study investigates the effects of floods, storms, and earthquake on food security indicators for each of the countries: Thailand, Indonesia, and Viet Nam. The regression model for the effect of disasters on food security is generally expressed as:

$$FS_{i,t} = \beta_0 + \beta_i\, DV_{i,t} + \delta_i Q_{i,t} \tag{4}$$

Where $FS_{i,t}$ denotes the food security indicator over time; $DV_{i,t}$ denotes the relevant disaster variables for a specific country over time; and $Q_{i,t}$ denotes the quantity of production of specific food security crops over time. This study assessed the effects of disasters on food security along the following four dimensions: *availability, access, stability, and utilisation*. The indicators of *availability* used are the average dietary energy supply adequacy; the average value of food production; the share of dietary energy supply derived from cereals, roots, and tubers; and the protein supply. The indicators of *access* are the number of people undernourished; the prevalence of undernourishment; the depth of the food deficit; and the prevalence of food inadequacy. The indicators of *stability* are the cereal import dependency ratio; the political stability and absence of violence/terrorism; per capita food production variability; and per capita food supply variability. The indicators of *utilisation* are the prevalence of anaemia amongst 5-year old children and pregnant women.

4.5.4 Econometric Considerations

The data sets were examined for stationarity. For each data set analysed in this study, the series were not stationary at the same order of integration. Thus, some series were stationary at levels while others were integrated at order one, [I(1)], and other time series were stationary at level two, [I(2)]. The time series observations of the disaster variables of particular interest in this study are dummy variables. Therefore, the application of cointegration analysis and the vector error correction model would not be appropriate in this case, as the vector error correction model presents the results in first differences, and using the first differences of dummy variables would generate zeros, hence the overall coefficients would not make much sense. The use of the autoregressive distributed lag model would not be appropriate either, as some of the time series in each set of analysis are integrated at the level two, [I(2)].[3] As a consequence, this study employed an augmented version of Box-Jenkins time series methodology for the analysis by differencing each of the series to be stationary for a specific estimation and applying the relevant autoregressive terms to the regression as appropriate, without differencing the disaster variables as they are dummy and would yield zeros after differencing.

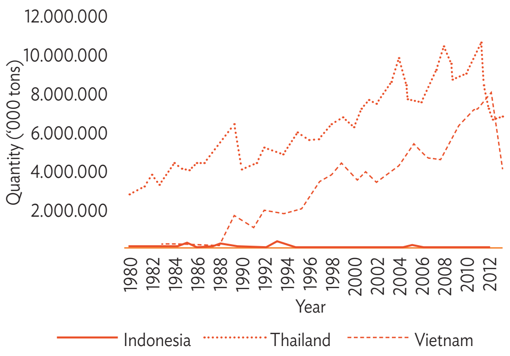
4.6 Overview of Trends in International Trade in Selected Agricultural Products and Food Security Indicators in Thailand, Indonesia, and Viet Nam

4.6.1 Trends in International Trade in Selected Agricultural Products

Thailand and Viet Nam's rice exports show increasing trends over the years, whereas those of Indonesia were minimal and stable over 1980–2013 (Figure 4.1). Indonesia's banana export quantity was stable over 1980–1992 before surging to a peak during 1993–2000, then decreasing in 2001 and remaining at that level until 2013. Thailand and Viet Nam's banana exports were stable over 1980–2001, exhibiting a positive trend thereafter, with some fluctuations in 2003, 2005, and 2012 (Figure 4.2).

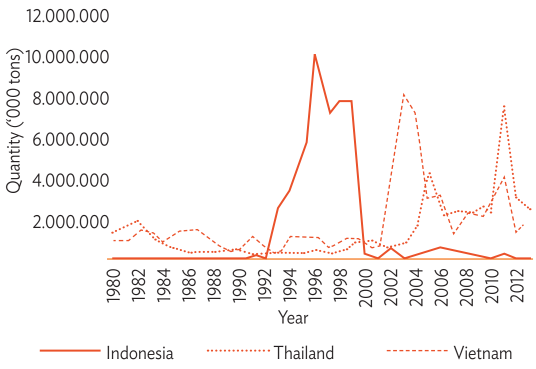
[3] For the autoregressive distributed lag modelling, the data sets have to be I(0) or I(1) or a mixture of these two.

Figure 4.1: Export Quantities of Rice from Indonesia, Thailand, and Viet Nam



Source: Author, 2017.

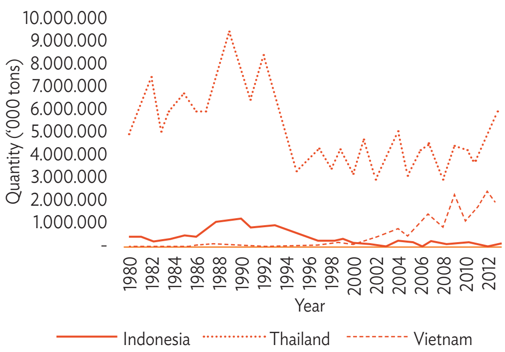
Figure 4.2: Export Quantities of Banana from Indonesia, Thailand, and Viet Nam



Source: Author, 2017.

Thailand shows a steady increase in the quantity of cassava exported, although exports fell over 1992–1995 before showing a positive trend thereafter. Indonesia and Viet Nam exported lesser than Thailand (Figure 4.3). In terms of exporting potato, Indonesia increased its export in the 1980s up to 1992 and reached the peak in the 1993. However, start from 1995, the export decreased drastically and continued to decline until the period of 2000. Thailand and Viet Nam exported less than Indonesia in the period 1980–2012. (Figure 4.4).

Figure 4.3: Export Quantities of Cassava from Indonesia, Thailand, and Viet Nam



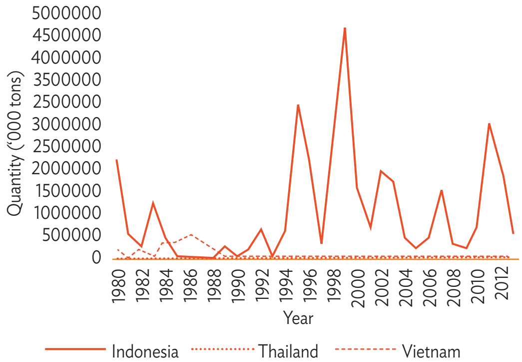
Source: Author, 2017.

Figure 4.4: Export Quantities of Potato from Indonesia, Thailand, and Viet Nam

Source: Author, 2017.

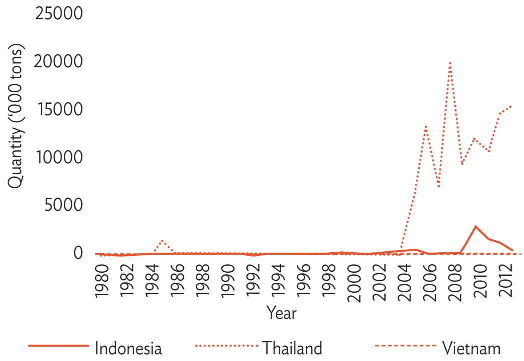
The quantity of rice imports fluctuated, peaking in Indonesia in 1999. Thailand had zero imports of rice from 1980 to 1994 and imported small quantities from 1995 onwards. Viet Nam also imported small quantities of rice, fluctuating from year to year (Figure 4.5). Thailand had zero banana imports over 1980–2002, increasing with some fluctuations after 2004. Indonesia had zero imports from 1980 to 1993 and some imports thereafter. Viet Nam did not import bananas over 1980–2013 (Figure 4.6).

Figure 4.5: Import Quantities of Rice by Indonesia, Thailand, and Viet Nam



Source: Author, 2017.

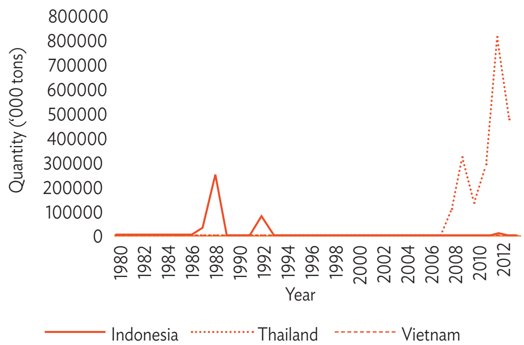
Figure 4.6: Import Quantities of Banana by Indonesia, Thailand, and Viet Nam



Source: Author, 2017.

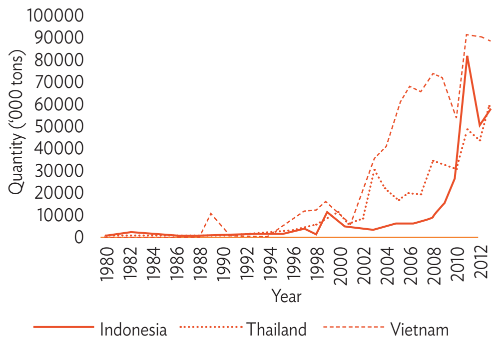
Thailand had no cassava imports from 1980 to 2001 and imported small quantities during 2003–2013. Indonesia imported some cassava, with peaks in 1988, 1992, and 2012. Viet Nam had zero cassava imports during 1980–2013 (Figure 4.7). Potato imports for the three countries showed an increasing trend over the period (Figure 4.8).

Figure 4.7: Import Quantities of Cassava by Indonesia, Thailand, and Viet Nam



Source: Author, 2017.

Figure 4.8: Import Quantities of Potato by Indonesia, Thailand, and Viet Nam

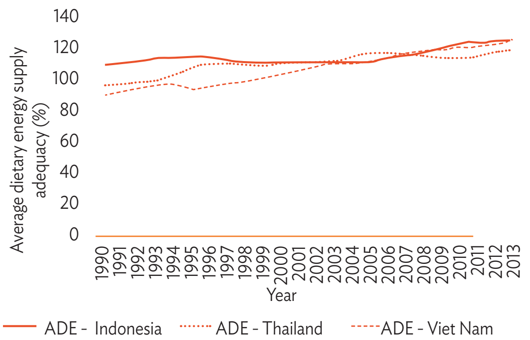


Source: Author, 2017.

4.6.2 Food Security Indicators

The average dietary energy supply adequacy (3-year average percentage) and the average value of food production in Indonesia, Thailand, and Viet Nam showed increasing trends (Figures 4.9 and 4.10). The share of dietary energy supply derived from cereals, roots, and tubers (3-year average percentage) in Indonesia, Thailand, and Viet Nam decreased over 1990–2013 (Figure 4.11). The average protein supply (3-year average grams/capita/day) in Indonesia, Thailand, and Viet Nam showed increasing trends (Figure 4.12) over the period of study.

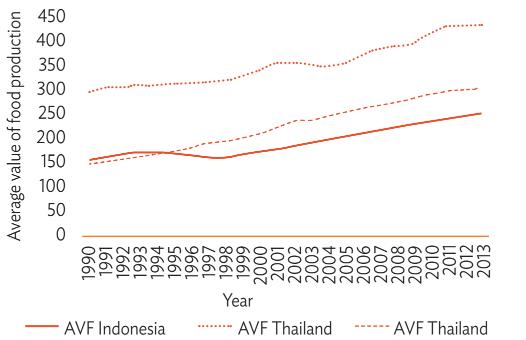
Figure 4.9: Average Dietary Energy Supply Adequacy (3-year average) in Indonesia, Thailand, and Viet Nam
(%)



ADE = average dietary energy.

Source: Author, 2017.

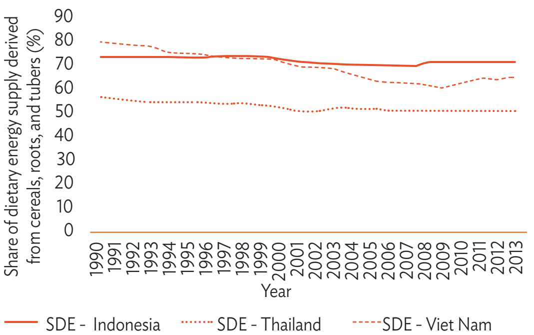
Figure 4.10: Average Value of Food Production (3-year average) in Indonesia, Thailand, and Viet Nam
(constant I$ per person)



AVF = average value of food.

Source: Author, 2017.

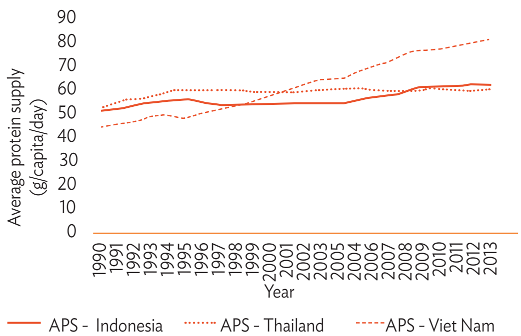
Figure 4.11: Share of Dietary Energy Supply Derived from Cereals, Roots, and Tubers (3-year average) in Indonesia, Thailand, and Viet Nam
(%)



SDE = share of dietary energy.

Source: Author, 2017.

Figure 4.12: Average Protein Supply (3-year average) in Indonesia, Thailand, and Viet Nam
(g/capita/day)

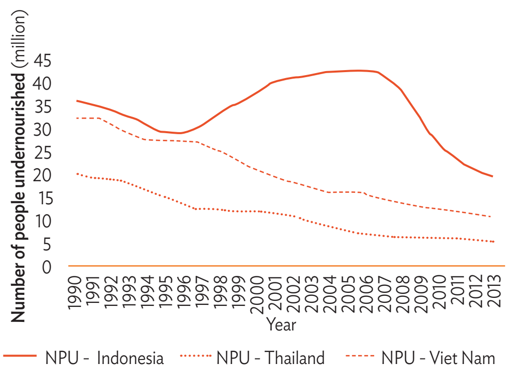


APS = average protein supply, g/capita/day = gram/capita/day.

Source: Author, 2017.

The following food security indicators – number of people undernourished; prevalence of undernourishment; depth of the food deficit; and prevalence of food inadequacy in Indonesia, Thailand, and Viet Nam – showed decreasing trends (Figures 4.13, 4.14, 4.15, and 4.16).

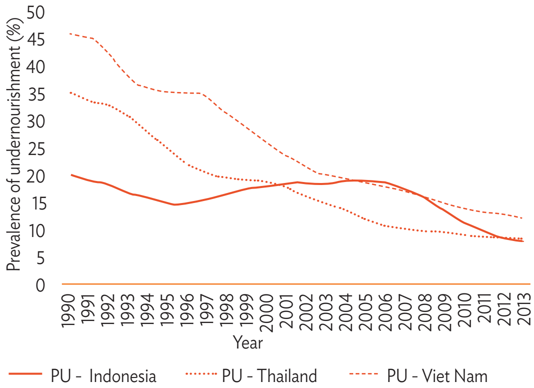
Figure 4.13: Number of People Undernourished (3-year average) in Indonesia, Thailand, and Viet Nam (million)



NPU = number of people undernourished.

Source: Author, 2017.

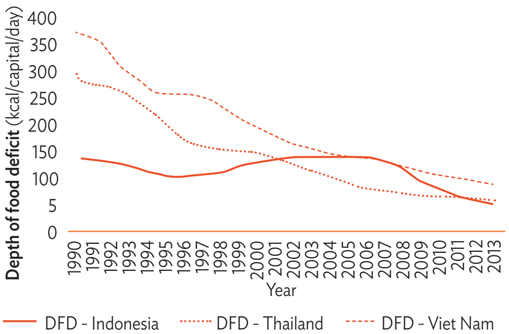
Figure 4.14: Prevalence of Undernourishment (3-year average) in Indonesia, Thailand, and Viet Nam (%)



PU = prevalence of undernourishment.

Source: Author, 2017.

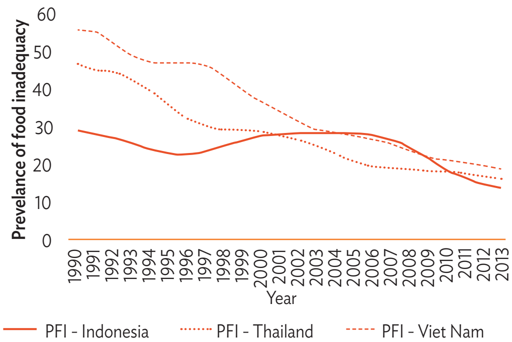
Figure 4.15: Depth of the Food Deficit (3-year average) in Indonesia, Thailand, and Viet Nam (kcal/capita/day)



DFD = depth of food deficit, kcal = kilocalorie.

Source: Author, 2017.

Figure 4.16: Prevalence of Food Inadequacy in Indonesia, Thailand, and Viet Nam (%)

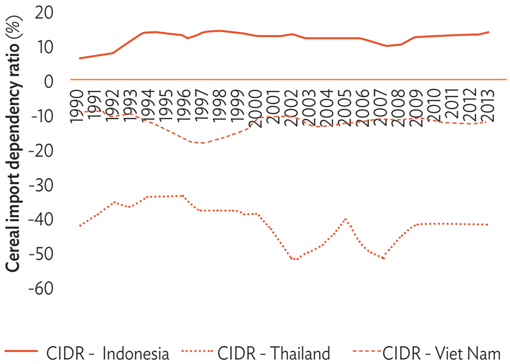


PFI = prevalence of food inadequacy.

Source: Author, 2017.

Figure 4.17 shows that Indonesia largely depended on cereal imports until 2013, whereas Thailand and Viet Nam did not. Amongst the three countries, per capita food production variability is highest in Thailand, followed by Indonesia and then Viet Nam (Figure 4.18). Nevertheless, the per capita food supply variability showed decreasing trends over the years for the three countries (Figure 4.19). In general, the prevalence of anaemia amongst 5-year old children and pregnant women decreased over 1990–2013. It is worth noting that the prevalence of anaemia amongst 5-year old children and pregnant women is highest in Indonesia, followed by Viet Nam and then Thailand. However, during 2011–2013, the prevalence of anaemia amongst pregnant women was at the same level for Indonesia and Thailand, with lower levels of prevalence in Viet Nam (Figures 4.20 and 4.21).

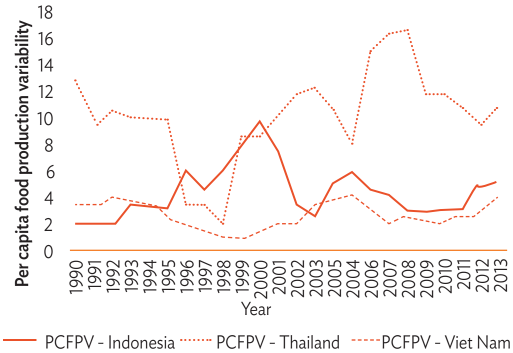
Figure 4.17: Cereal Import Dependency Ratio (3-year average) in Indonesia, Thailand, and Viet Nam (%)



CIDR = cereal import dependency ratio.

Source: Author, 2017.

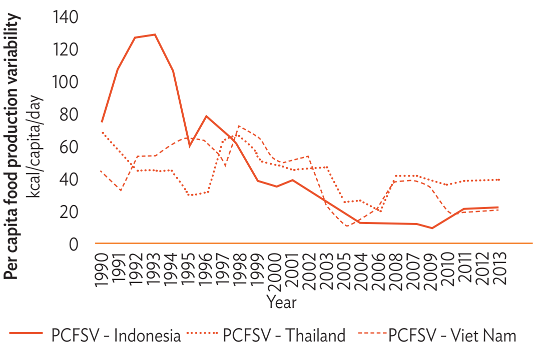
Figure 4.18: Per Capita Food Production Variability in Indonesia, Thailand, and Viet Nam (constant I$ per person, 2004-2006)



PCFPV = per capita food production variability.

Source: Author, 2017.

Figure 4.19: Per Capita Food Supply Variability in Indonesia, Thailand, and Viet Nam (kcal/capita/day)

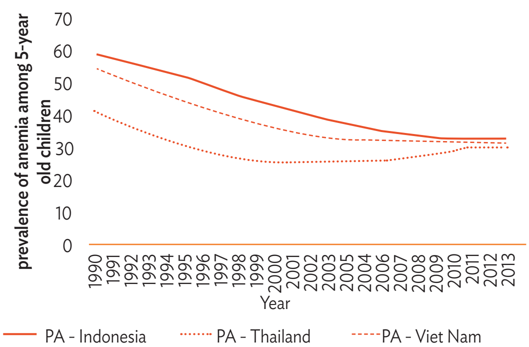


kcal = kilocalorie,

PCFSV = per capita food supply variability.

Source: Author, 2017.

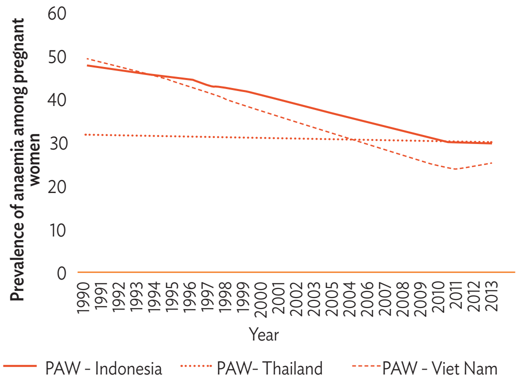
Figure 4.20: Prevalence of Anaemia amongst 5-years old Children in Indonesia, Thailand, and Viet Nam



PCFPV = per capita food production variability.

Source: Author, 2017.

Figure 4.21: Prevalence of Anaemia amongst Pregnant Women in Indonesia, Thailand, and Viet Nam



PAW = prevalence of anaemia amongst pregnant women.

Source: Author, 2017.

4.7 Conclusions and Recommendations

This study assessed the effect of disasters on the international trade of agricultural products and food security in Thailand, Indonesia, and Viet Nam. It employed the gravity model and the Box-Jenkins times methodology, using time series data that spanned 1980–2013 for the disaster-trade investigation and data from 1980 to 2013 for the analysis of the relationship between disasters and food security.

The empirical results regarding the disaster–international trade investigation revealed that floods negatively influenced Thailand's rice exports, with and without trade restrictions, and Indonesia's cassava exports. However, the disaster variables had no significant influence on Viet Nam's international trade in agricultural products.

The disaster–food security analysis revealed that floods positively influenced the average dietary energy supply adequacy in Thailand. Storms negatively affected the number of people undernourished, the prevalence of undernourishment, the depth of the food deficit, and the prevalence of food inadequacy in Thailand. These results are contrary to expectations, but can be explained by food supplies from national and international organisations to areas affected by floods and storms, which increased dietary energy supplies, decreasing the number of people undernourished, the prevalence of undernourishment, the depth of the food deficit, and the prevalence of food inadequacy, at least in the short run. Storms negatively influenced the value of food imports over total merchandise exports in Thailand. This could imply that individuals, especially the poor, benefit from food donations from national, international, and non-governmental organisations in the event of floods. This decreases the overall food import quantity, thereby reducing the value of imports compared with exports. Storms negatively influenced the prevalence of anaemia amongst pregnant women in Thailand. This may imply that pregnant women are given priority in food distribution after a storm. For Indonesia, earthquakes negatively influenced political stability and the absence of violence/terrorism (an indicator of food stability) in Indonesia. Thus, potential political instability and violence resulting from the occurrence of earthquakes threatens food stability. Floods positively influenced the average value of food production (i.e. an indicator of food availability) in Indonesia. This could imply that floods destroy crops such that the harvested crops reduce to lower than expected levels. The lower output, with a given level of demand, would trigger price increases to relatively high levels, thereby increasing the value of food production. Furthermore, it is possible that the value of food exports would increase after a disaster, even with lower quantities, because of higher market prices. For Viet Nam, floods positively influenced per capita food supply variability.

These results have policy implications for the governments of these economies. Floods adversely affect Thailand's rice exports and Indonesia's cassava exports. Governments and related organisations should adopt strategies to minimise the impact of floods on the production and international trade of agricultural products, especially rice in Thailand and cassava in Indonesia. The Government of Viet Nam should put in place strategies to minimise the effect of floods and improve the food security situation in the country, as floods increase the per capita food supply variability. Furthermore, adequate preparation by the governments of these countries is imperative for recovery after natural disasters such as floods and storms. The role of non-governmental and international organisations is critical for swift recovery from these natural disasters. Such recovery comes in the form of the provision of new settlements, food, and clothing for people affected by the disasters, but this assistance should be coordinated and delivered in a timely manner to achieve the desired objectives. Disaster risk awareness campaigns, training exercises, and propagating self-sustainability sustainability through insurance are also steps in the right direction. The proactive roles of the ASEAN Socio-Cultural Community, ASEAN Economic Community, and ASEAN Political-Security Community regarding disaster management – to reduce losses and facilitate recovery from natural disasters at the regional and international levels in Southeast Asia – are critical. Finally, the global disaster risk reduction commitments and the Sendai Framework should be strengthened and promoted amongst these countries.

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Appendix

1 Empirical Results and Discussions

A Trade and Disaster

i *Thailand*

Floods negatively influenced Thailand 's rice exports, with and without trade restrictions ($p<0.01$), as shown in Tables 4.1 and 4.2. This means that floods decreased Thailand's rice exports, with and without trade restrictions. Floods cause the destruction of rice farms, which negatively impacts production, leading to lower export quantities. Storms negatively influenced Thailand's cassava and potato exports, but not significantly (Tables 4.3 and 4.4). Storms lead to the destruction of cassava and potato farms, which negatively impacts production, leading to lower exports of these commodities. Storms also negatively influenced Thailand's potato imports, but not significantly (Table 4.5).

Table 4.1: Effect of Storms and Floods on Thailand's Rice Exports, without Trade Restrictions

Variable	Coefficient	Std. error	*P*-value
Constant	-107,628.4	181,235.4	0.5587
Exchange rate	-23,759.40	281,474.1	0.9335
Storm	405,161.8	475,402.0	0.4033
Flood	**-1,206,194**	**615,323.2**	**0.0628**
Gross dome stic product	21.55342	39.64721	0.5922
Inflation rate	5,650,155	15,136,103	0.7125
Population	-1.172721	2.795566	0.6789
Quantity of production	0.291442	0.173836	0.1078
AR(1)	-0.775642	0.156172	0.0001

Regression diagnostics			
R-squared	0.552568	Mean dependent var	-21620.26
Adjusted R-squared	0.389866	S.D. dependent var	2125291.
S.E. of regression	1660088.	Akaike info criterion	31.72034
Sum squared resid	6.06E+13	Schwarz criterion	32.13666
Log likelihood	-482.6653	Hannan-Quinn criter.	31.85605
F-statistic	3.396190	Durbin-Watson stat	2.519482
Prob (F-statistic)	0.010860		

Source: Author, 2017.

Table 4.2: Effect of Storms and Floods on Thailand's Rice Exports, with Trade Restrictions*

Variable	Coefficient	Std. error	*P*-value
Constant	-117,684.9	201,976.6	0.5663
Exchange rate	-5,219.401	323,157.3	0.9873
Storm	419,965.5	503,025.0	0.4132
Flood	**-1,198,986**	**632,243.3**	**0.0717**
Gross domestic product	23.93072	44.62322	0.5974
Inflation	4,252,730	19,344,339	0.8281
Population	-1.189077	2.862165	0.6820
Quantity of production	0.293660	0.179155	0.1161
Restriction	81,102.07	652,491.9	0.9023
AR(1)	-0.776320	0.162913	0.0001
Regression diagnostics			
R-squared	0.552906	Mean dependent var	-21620.26
Adjusted R-squared	0.361294	S.D. dependent var	2125291.
S.E. of regression	1698513.	Akaike info criterion	31.78410
Sum squared resid	6.06E+13	Schwarz criterion	32.24668
Log likelihood	-482.6536	Hannan-Quinn criter.	31.93489
F-statistic	2.885551	Durbin-Watson stat	2.515075
Prob(F-statistic)	0.021785		

* During 1980–1985, the following restrictions were placed on rice exports from Thailand: (i) export premium (i.e. private traders pay premium for obtaining export licenses); (ii) export duty (i.e. rice exporters were levied by a 5% ad valorem export duty; and (iii) rice reserve requirement (see Xie and Napasintuwong, 2014).

Source: Author, 2017.

Table 4.3: Effects of Floods and Storms on Thailand's Cassava Exports

Variable	Coefficient	Std. error	*P*-value
Constant	-65,7456.9	745,629.2	0.3874
Exchange rate	62,8012.1	221,215.4	0.0096
Storm	-23,5028.0	446,060.5	0.6035
Flood	99,8481.7	765,605.3	0.2057
Gross domestic product	85.70636	34.92394	0.0225
Inflation	-38,722,752	13,645,482	0.0096
Population	2.229179	3.113818	0.4816
Quantity of production	0.158176	0.073806	0.0434
AR(1)	-0.558738	0.185868	0.0065
Regression diagnostics			
R-squared	0.641231	Mean dependent var	-11016.81
Adjusted R-squared	0.510769	S.D. dependent var	2225414.
S.E. of regression	1556567.	Akaike info criterion	31.59156
Sum squared resid	5.33E+13	Schwarz criterion	32.00788
Log likelihood	-480.6692	Hannan-Quinn criter.	31.72727
F-statistic	4.915091	Durbin-Watson stat	2.283075
Prob(F-statistic)	0.001402		

Source: Author, 2017.

Table 4.4: Effects of Floods and Storms on Thailand's Potato Exports

Variable	Coefficient	Std. error	*P*-value
Constant	99.32380	337.0555	0.7710
Exchange rate	67.69273	106.9831	0.5334
Storm	-228.1667	211.8637	0.2932
Flood	15.05800	338.3998	0.9649
Gross domestic product	0.003861	0.016802	0.8204
Inflation	-5,112.568	6,575.148	0.4451
Population	-0.001203	0.001444	0.4135
Quantity of production	0.000606	0.013499	0.9646
AR(1)	-0.638225	0.179399	0.0018

Regression diagnostics			
R-squared	0.419782	Mean dependent var	5.387097
Adjusted R-squared	0.208794	S.D. dependent var	846.0694
S.E. of regression	752.5768	Akaike info criterion	16.32258
Sum squared resid	12460180	Schwarz criterion	16.73890
Log likelihood	-244.0000	Hannan-Quinn criter.	16.45829
F-statistic	1.989600	Durbin-Watson stat	2.426356
Prob(F-statistic)	0.096356		

Source: Author, 2017.

Table 4.5: Effects of Floods and Storms on Thailand's Potato Imports

Variable	Coefficient	Std. error	*P*-value
Constant	9,404.571	6,312.353	0.1498
Exchange rate	-1,475.168	998.2575	0.1530
Storm	2,218.694	1,973.398	0.2725
Flood	-526.5992	2,898.155	0.8574
Gross domestic product	-0.174084	0.156244	0.2767
Inflation	30,610.24	51,177.01	0.5556
Population	-0.007792	0.004269	0.0810
Quantity of production	-0.363931	0.099727	0.0013
AR(1)	-0.303665	0.208624	0.1590
Regression diagnostics			
R-squared	0.518924	Mean dependent var	1833.875
Adjusted R-squared	0.351594	S.D. dependent var	6763.821
S.E. of regression	5446.477	Akaike info criterion	20.27558
Sum squared resid	6.82E+08	Schwarz criterion	20.68782
Log likelihood	-315.4093	Hannan-Quinn criter.	20.41223
F-statistic	3.101191	Durbin-Watson stat	2.222842
Prob(F-statistic)	0.015844		

Source: Author, 2017.

ii *Indonesia*[4]

Floods and earthquakes negatively influenced Indonesia's cassava exports by 5% and 10% levels of significance, respectively (Table 4.6). These natural disasters destroy cassava farms, impacting negatively on production and hence exports. The quantity of cassava production positively influenced cassava exports ($p<0.01$). Floods, storms, and earthquakes negatively influenced Indonesia's potato imports, but not significantly (Table 4.7). This result is contrary to expectations, as these natural disasters are expected to destroy potato farms and lead to low production, thereby necessitating higher amounts of imports.

Table 4.6: Effect of Floods, Storms, and Earthquakes on Indonesia's Cassava Exports

Variable	Coefficient	Std. error	*P*-value
Constant	53,5012.7	219,080.2	0.0235
Exchange rate	-13.10864	46.86082	0.7824
Earthquake	**-191,610.1**	**108,069.4**	**0.0907**
Flood	**-386,595.6**	**168,730.1**	**0.0324**
Storm	197,379.1	94,870.95	0.0499
Gross domestic product	-0.247601	1.037085	0.8136
Inflation	192,151.7	265,727.7	0.4776
Population	0.814643	0.624071	0.2059
Quantity of production	**0.122263**	**0.025336**	**0.0001**
Regression diagnostics			
R-squared	0.609405	Mean dependent var	7992.613
Adjusted R-squared	0.442008	S.D. dependent var	210877.6
S.E. of regression	157523.2	Akaike info criterion	27.02823
Sum squared resid	5.21E+11	Schwarz criterion	27.49081
Log likelihood	-408.9376	Hannan-Quinn criter.	27.17902
F-statistic	3.640466	Durbin-Watson stat	3.209673
Prob(F-statistic)	0.007024		

Source: Author, 2017.

4 The analysis regarding rice imports has not been included for Indonesia, as in recent years the country has become self-sufficient in rice production due to pragmatic policies (including the food estate programme) being implemented by the government.

Table 4.7: Effect of Storms, Floods, and Earthquakes on Indonesia's Potato Imports

Variable	Coefficient	Std. error	*P*-value
Constant	-29,408.16	23,823.97	0.2301
Exchange rate	3.880784	2.395667	0.1195
Earthquake	-1,805.284	5,712.473	0.7550
Storm	-5,349.446	5,380.612	0.3309
Flood	-3,944.378	11,674.94	0.7387
Gross domestic product	0.152697	0.040914	0.0012
Inflation	-11699.40	16,586.33	0.4880
Population	0.010434	0.006905	0.1450
Quantity of production	-0.021173	0.018490	0.2645
Regression diagnostics			
R-squared	0.587061	Mean dependent var	1749.344
Adjusted R-squared	0.418131	S.D. dependent var	11755.95
S.E. of regression	8967.472	Akaike info criterion	21.29090
Sum squared resid	1.77E+09	Schwarz criterion	21.74894
Log likelihood	-330.6544	Hannan-Quinn criter.	21.44273
F-statistic	3.475182	Durbin-Watson stat	1.996104
Prob(F-statistic)	0.008220		

Source: Author, 2017.

iii *Viet Nam*

Storms negatively influenced Viet Nam's cassava exports, but not significantly. Nevertheless, the gross domestic product (GDP) and the quantity of cassava production positively influenced cassava exports ($p<0.05$), as shown in Table 4.8.

Table 4.8: Effects of Floods and Storms on Viet Nam's Cassava Exports

Variable	Coefficient	Std. error	*P*-value
Constant	-73,0422.8	797,627.8	0.3689
Exchange rate	-13.07205	22.12207	0.5601
Storm	-31,353.62	249,453.2	0.9010
Flood	15,515.58	82,807.46	0.8529

Variable	Coefficient	Std. error	*P*-value
Gross domestic product	**9.475686**	**1.714538**	**0.0000**
Inflation	-1,291,194.	1,004,672.	0.2110
Population	0.007687	0.015515	0.6248
Quantity of production	**0.097250**	**0.026457**	**0.0012**
AR(1)	-0.699856	0.178108	0.0006
Regression diagnostics			
R-squared	0.932208	Mean dependent var	468854.2
Adjusted R-squared	0.909611	S.D. dependent var	684958.6
S.E. of regression	205931.0	Akaike info criterion	27.53547
Sum squared resid	1.02E+12	Schwarz criterion	27.94361
Log likelihood	-445.3353	Hannan-Quinn criter.	27.67280
F-statistic	41.25325	Durbin-Watson stat	2.795232
Prob(F-statistic)	0.000000		

Source: Author, 2017.

Floods and storms negatively influenced Viet Nam's potato imports, but not significantly (Table 4.9). GDP positively influenced Viet Nam's potato imports (p<0.01). Thus, with an improved economy through higher GDP levels, the country can import more of the required potato for consumption. In addition, higher levels of cassava production increase exports.

Table 4.9: Effect of Floods, Storms, and Earthquakes on Indonesia's Cassava Exports

Variable	Coefficient	Std. error	*P*-value
Constant	-78,313.87	90,120.92	0.3935
Exchange rate	-1.114501	1.999246	0.5824
Storm	-785.4091	7,713.565	0.9197
Flood	-1,674.249	3,898.420	0.6714
Gross domestic product	**0.449080**	**0.118722**	**0.0009**
Inflation	76,759.15	3,6253.53	0.0448
Population	0.001244	0.001541	0.4275
Quantity of production	0.003002	0.029108	0.9187
AR(1)	0.550747	0.186230	0.0069

Regression diagnostics			
R-squared	0.948093	Mean dependent var	25073.82
Adjusted R-squared	0.930790	S.D. dependent var	31512.72
S.E. of regression	8290.273	Akaike info criterion	21.11055
Sum squared resid	1.65E+09	Schwarz criterion	21.51869
Log likelihood	-339.3241	Hannan-Quinn criter.	21.24788
F-statistic	54.79551	Durbin-Watson stat	2.122894
Prob(F-statistic)	0.000000		

Source: Author, 2017.

2 Disaster and Food Security

A Thailand

i *Food Availability*

Floods positively influenced average dietary energy supply adequacy (3-year average percentage) in Thailand ($p<0.05$). This result is not intuitive but can be explained by the food supplies from national and international organisations to areas affected by the floods, which increased people's dietary energy supplies. The quantity of cassava produced also positively influenced the average dietary energy supply adequacy ($p<0.05$) since cassava is a key food security crop in Thailand.

Table 4.10: Average Dietary Energy Supply Adequacy (3-year average) (%)

Variable	Coefficient	Std. error	*P*-value
Constant	-2.903369	1.547583	0.0852
Storm	-0.442857	0.784160	0.5826
Flood	**3.242449**	**1.252613**	**0.0237**
Quantity of banana	-1.94E-06	1.59E-06	0.2459
Quantity of potato	-5.15E-08	8.56E-08	0.5583
Quantity of cassava	**-1.56E-07**	**7.03E-08**	**0.0468**
Quantity of rice produce	-1.04E-07	2.35E-07	0.6647
Population	2.13E-06	1.82E-06	0.2658
AR(2)	0.470239	0.184489	0.0255

Regression diagnostics			
R-squared	0.529369	Mean dependent var	0.857143
Adjusted R-squared	0.215615	S.D. dependent var	1.236354
S.E. of regression	1.094983	Akaike info criterion	3.316882
Sum squared resid	14.38785	Schwarz criterion	3.764534
Log likelihood	-25.82726	Hannan-Quinn criter.	3.414034
F-statistic	1.687212	Durbin-Watson stat	1.611584
Prob(F-statistic)	0.199597		

Source: Author, 2017.

ii *Food Access*

Storms negatively influenced the number of people undernourished in Thailand ($p<0.1$). Floods also negatively influenced the number of people undernourished, but not significantly (Table 4.11). As explained previously, food supplies from national and international organisations to areas affected by these natural disasters decreased the number of people undernourished, at least in the short run.

Table 4.11: Number of People Undernourished (3-year average) in Thailand (million)

Variable	Coefficient	Std. error	*P*-value
Constant	0.022874	0.466916	0.9616
Storm	**-0.617263**	**0.290744**	**0.0508**
Flood	-0.525289	0.405306	0.2146
Quantity of banana produce	-4.81E-07	6.43E-07	0.4668
Quantity of cassava produce	-2.95E-09	3.33E-08	0.9306
Quantity of potato produce	6.70E-08	4.21E-08	0.1319
Quantity of rice produce	1.19E-07	9.82E-08	0.2459
Population	7.59E-08	6.17E-07	0.9038

Regression diagnostics			
R-squared	0.417431	Mean dependent var	-0.630435
Adjusted R-squared	0.145565	S.D. dependent var	0.524348
S.E. of regression	0.484684	Akaike info criterion	1.657571
Sum squared resid	3.523785	Schwarz criterion	2.052525
Log likelihood	-11.06206	Hannan-Quinn criter.	1.756901
F-statistic	1.535430	Durbin-Watson stat	1.154627
Prob(F-statistic)	0.229385		

Source: Author, 2017.

Storms negatively influenced the prevalence of undernourishment ($p<0.05$). Floods also negatively influenced the prevalence of undernourishment, but not significantly (Table 4.12). The explanation is the same as presented previously.

Table 4.12: Prevalence of Undernourishment (3-year average) in Thailand (%)

Variable	Coefficient	Std. error	*P*-value
Constant	0.033859	0.782596	0.9661
Storm	**-1.104271**	**0.487315**	**0.0387**
Flood	-0.866583	0.679333	0.2215
Quantity of banana produce	-1.09E-06	1.08E-06	0.3297
Quantity of cassava produce	6.38E-09	5.59E-08	0.9106
Quantity of potato produce	1.16E-07	7.05E-08	0.1214
Quantity of rice produce	2.22E-07	1.65E-07	0.1971
Population	-9.03E-08	1.03E-06	0.9316
Regression diagnostics			
R-squared	0.474967	Mean dependent var	-1.160870
Adjusted R-squared	0.229952	S.D. dependent var	0.925762
S.E. of regression	0.812378	Akaike info criterion	2.690507
Sum squared resid	9.899376	Schwarz criterion	3.085461
Log likelihood	-22.94083	Hannan-Quinn criter.	2.789837
F-statistic	1.938522	Durbin-Watson stat	0.998970
Prob(F-statistic)	0.133479		

Source: Author, 2017.

Storms negatively influenced the depth of the food deficit in Thailand ($p<0.05$), as shown in Table 4.13. Floods also negatively influenced the depth of the food deficit, but not significantly. As explained previously, this is as a result of food supplies from national and international organisations to areas affected by these natural disasters, which decreased the depth of the food deficit, at least in the short run.

Table 4.13: Depth of the Food Deficit in Thailand

Variable	Coefficient	Std. error	P-value
Constant	0.984546	6.734113	0.8857
Storm	**-9.848947**	**4.193267**	**0.0330**
Flood	-7.586811	5.845548	0.2139
Quantity of banana produce	-8.01E-06	9.28E-06	0.4019
Quantity of cassava produce	7.94E-08	4.81E-07	0.8711
Quantity of potato produce	1.01E-06	6.07E-07	0.1182
Quantity of rice produce	1.87E-06	1.42E-06	0.2073
Population	-7.85E-07	8.90E-06	0.9309
Regression diagnostics			
R-squared	0.486301	Mean dependent var	-9.695652
Adjusted R-squared	0.246574	S.D. dependent var	8.053428
S.E. of regression	6.990383	Akaike info criterion	6.995156
Sum squared resid	732.9818	Schwarz criterion	7.390110
Log likelihood	-72.44429	Hannan-Quinn criter.	7.094486
F-statistic	2.028567	Durbin-Watson stat	1.076175
Prob(F-statistic)	0.118497		

Source: Author, 2017.

Storms negatively influenced the prevalence of food inadequacy in Thailand ($p<0.1$). Floods also negatively influenced the prevalence of food inadequacy, but not significantly (Table 4.14).

Table 4.14: Prevalence of Food Inadequacy in Thailand

Variable	Coefficient	Std. error	*P*-value
Constant	0.082774	0.935685	0.9307
Storm	**-1.185284**	**0.582642**	**0.0600**
Flood	-1.067459	0.812221	0.2085
Quantity of banana produce	-9.66E-07	1.29E-06	0.4655
Quantity of cassava produce	1.81E-09	6.68E-08	0.9787
Quantity of potato produce	1.33E-07	8.43E-08	0.1363
Quantity of rice produce	2.82E-07	1.97E-07	0.1726
Population	-1.56E-07	1.24E-06	0.9012
Regression diagnostics			
R-squared	0.435897	Mean dependent var	-1.313043
Adjusted R-squared	0.172649	S.D. dependent var	1.067837
S.E. of regression	0.971293	Akaike info criterion	3.047830
Sum squared resid	14.15114	Schwarz criterion	3.442785
Log likelihood	-27.05005	Hannan-Quinn criter.	3.147160
F-statistic	1.655841	Durbin-Watson stat	0.946411
Prob(F-statistic)	0.194927		

Source: Author, 2017.

iii *Food Stability*

Storms negatively influenced the value of food imports over total merchandise exports (3-year average percentage) in Thailand ($p<0.1$), as shown in Table 4.15. This could imply that individuals, especially the poor, benefit from food donations by national, international, and non-governmental organisations in the event of floods. Therefore, the overall food import quantity decreases, thereby reducing the value of imports compared with exports.

Table 4.15: Value of Food Imports over Total Merchandise Exports (3-year average) in Thailand (%)

Variable	Coefficient	Std. error	*P*-value
Constant	0.186572	0.143337	0.2127
Storm	**-0.187294**	**0.089254**	**0.0532**
Flood	0.069486	0.124423	0.5848
Quantity of banana produce	-2.43E-07	1.98E-07	0.2372
Quantity of cassava produce	-4.25E-08	1.02E-08	0.0008
Quantity of potato produce	-1.38E-08	1.29E-08	0.3035
Quantity of rice produce	4.12E-08	3.01E-08	0.1917
Population	-1.93E-07	1.90E-07	0.3239
Regression diagnostics			
R-squared	0.652822	Mean dependent var	0.043478
Adjusted R-squared	0.490805	S.D. dependent var	0.208514
S.E. of regression	0.148791	Akaike info criterion	-0.704334
Sum squared resid	0.332083	Schwarz criterion	-0.309380
Log likelihood	16.09984	Hannan-Quinn criter.	-0.605004
F-statistic	4.029355	Durbin-Watson stat	2.342407
Prob(F-statistic)	0.011227		

Source: Author, 2017.

Storms negatively influenced per capita food production variability in Thailand, but not significantly (Table 4.16).

Table 4.16: Per Capita Food Production Variability (constant $ per person, 2004–2006)

Variable	Coefficient	Std. error	*P*-value
Constant	-1.124240	2.675070	0.6812
Storm	-1.768531	1.555532	0.2761
Flood	0.630646	2.468016	0.8023
Quantity of banana produce	7.28E-06	4.28E-06	0.1124
Quantity of cassava produce	2.25E-07	2.26E-07	0.3391
Quantity of potato produce	1.76E-07	3.03E-07	0.5711

Variable	Coefficient	Std. error	*P*-value
Quantity of rice produce	2.13E-08	7.37E-07	0.9773
Population	3.31E-06	2.91E-06	0.2759
AR(1)	-0.515249	0.246779	0.0571
Regression diagnostics			
R-squared	0.319280	Mean dependent var	0.059091
Adjusted R-squared	-0.099624	S.D. dependent var	2.950167
S.E. of regression	3.093632	Akaike info criterion	5.388658
Sum squared resid	124.4173	Schwarz criterion	5.834993
Log likelihood	-50.27523	Hannan-Quinn criter.	5.493801
F-statistic	0.762179	Durbin-Watson stat	1.780692
Prob(F-statistic)	0.640957		

Source: Author, 2017.

Floods and storms negatively influenced per capita food supply variability (kilocalories (kcal)/capita/day) in Thailand, but not significantly (Table 4.17).

Table 4.17: Per Capita Food Supply Variability in Thailand (kcal/capita/day)

Variable	Coefficient	Std. error	*P*-value
Constant	3.630886	10.54720	0.7366
Storm	-2.000275	7.165513	0.7849
Flood	-4.452650	10.65334	0.6834
Quantity of Banana Produce	2.47E-05	1.42E-05	0.1071
Quantity of Cassava Produce	2.03E-07	7.93E-07	0.8023
Quantity of Potato Produce	1.07E-06	8.84E-07	0.2514
Quantity of Rice Produce	2.42E-06	2.37E-06	0.3269
Population	-3.62E-06	1.14E-05	0.7573
AR(2)	-0.618246	0.243663	0.0261

Regression diagnostics			
R-squared	0.522482	Mean dependent var	-0.238095
Adjusted R-squared	0.204137	S.D. dependent var	11.81907
S.E. of regression	10.54393	Akaike info criterion	7.846505
Sum squared resid	1334.094	Schwarz criterion	8.294158
Log likelihood	-73.38831	Hannan-Quinn criter.	7.943657
F-statistic	1.641243	Durbin-Watson stat	1.574112
Prob(F-statistic)	0.211688		

Source: Author, 2017.

iv *Utilisation*

Floods and storms positively influenced the prevalence of anaemia amongst 5-year old children in Thailand, but not significantly (Table 4.18).

Table 4.18: Prevalence of Anaemia Amongst 5-year old Children in Thailand

Variable	Coefficient	Std. error	*P*-value
Constant	0.578986	1.128669	0.6166
Storm	0.033876	0.184304	0.8570
Flood	0.066962	0.172520	0.7042
Quantity of banana produce	1.21E-08	3.13E-07	0.9698
Quantity of cassava produce	-9.80E-10	1.35E-08	0.9434
Quantity of potato produce	3.50E-08	2.12E-08	0.1225
Quantity of rice produce	4.25E-08	4.71E-08	0.3832
Population	-2.69E-07	9.79E-07	0.7880
AR(1)	0.916454	0.066169	0.0000
Regression diagnostics			
R-squared	0.953484	Mean dependent var	-0.413636
Adjusted R-squared	0.924859	S.D. dependent var	1.070067
S.E. of regression	0.293326	Akaike info criterion	0.677024
Sum squared resid	1.118522	Schwarz criterion	1.123360
Log likelihood	1.552731	Hannan-Quinn criter.	0.782168
F-statistic	33.30914	Durbin-Watson stat	1.357398
Prob(F-statistic)	0.000000		

Source: Author, 2017.

Storms negatively influenced the prevalence of anaemia amongst pregnant women in Thailand (p<0.1), as shown in Table 19. This may imply that pregnant women are given priority in food distribution after a storm.

Table 4.19: Prevalence of Anaemia Amongst Pregnant Women in Thailand

Variable	Coefficient	Std. error	*P*-value
Constant	-0.158926	0.133141	0.2511
Storm	**-0.166391**	**0.082906**	**0.0631**
Flood	0.155135	0.115573	0.1995
Quantity of banana produce	-1.71E-07	1.83E-07	0.3650
Quantity of cassava produce	-3.42E-09	9.50E-09	0.7236
Quantity of potato produce	1.38E-08	1.20E-08	0.2668
Quantity of rice produce	-1.45E-08	2.80E-08	0.6132
Population	6.66E-08	1.76E-07	0.7105
Regression diagnostics			
R-squared	0.385259	Mean dependent var	-0.086957
Adjusted R-squared	0.098380	S.D. dependent var	0.145553
S.E. of regression	0.138208	Akaike info criterion	-0.851903
Sum squared resid	0.286523	Schwarz criterion	-0.456948
Log likelihood	17.79688	Hannan-Quinn criter.	-0.752573
F-statistic	1.342932	Durbin-Watson stat	1.060085
Prob(F-statistic)	0.297577		

Source: Author, 2017.

B Indonesia

i *Food Availability*

Storms and earthquakes negatively influenced average dietary energy supply adequacy in Indonesia, but not significantly (Table 4.20).

Table 4.20: **Average Dietary Energy Supply Adequacy (3-year average) in Indonesia (%)**

Variable	Coefficient	Std. error	*P*-value
Constant	-18.70440	6.497589	0.0121
Storm	-0.779275	0.881664	0.3917
Flood	1.615710	1.765595	0.3756
Earthquake	-0.799114	1.118996	0.4869
Quantity of banana produce	5.71E-07	7.11E-07	0.4350
Quantity of cassava produce	2.54E-07	3.16E-07	0.4347
Quantity of potato produce	-3.54E-07	2.48E-06	0.8888
Quantity of rice produce	-7.73E-11	4.95E-10	0.8782
Population	6.08E-06	2.16E-06	0.0136
Regression diagnostics			
R-squared	0.545286	Mean dependent var	0.652174
Adjusted R-squared	0.285449	S.D. dependent var	1.228772
S.E. of regression	1.038695	Akaike info criterion	3.199978
Sum squared resid	15.10441	Schwarz criterion	3.644302
Log likelihood	-27.79975	Hannan-Quinn criter.	3.311725
F-statistic	2.098573	Durbin-Watson stat	1.506933
Prob(F-statistic)	0.107568		

Source: Author, 2017.

Floods positively influenced the average value of food production (3-year average in constant International dollars (1$) per person) in Indonesia ($p<0.1$), as shown in Table 4.21. This could imply that floods destroy crops such that the harvested crops reduce to lower than expected levels. The lower output with a given level of demand would trigger price increases to relatively high levels, thereby increasing the value of food production. Storms also positively influenced average value of food production, but not significantly. However, earthquakes negatively influenced the average value of food production, but not significantly.

Table 4.21: Average Value of Food Production (3-year average) in Indonesia (constant $ per person)

Variable	Coefficient	Std. error	*P*-value
Constant	-20.37339	44.50642	0.6553
Storm	0.972053	1.199478	0.4335
Flood	**5.701917**	**2.672393**	**0.0542**
Earthquake	-2.522146	1.496360	0.1177
Quantity of banana produce	1.35E-06	9.80E-07	0.1920
Quantity of cassava produce	-2.62E-07	4.15E-07	0.5393
Quantity of potato produce	-2.54E-06	3.52E-06	0.4841
Quantity of rice produce	-4.68E-10	7.81E-10	0.5599
Population	7.11E-06	1.45E-05	0.6334
Regression diagnostics			
R-squared	0.831816	Mean dependent var	4.045455
Adjusted R-squared	0.705678	S.D. dependent var	3.387333
S.E. of regression	1.837678	Akaike info criterion	4.357838
Sum squared resid	40.52474	Schwarz criterion	4.853767
Log likelihood	-37.93622	Hannan-Quinn criter.	4.474664
F-statistic	6.594483	Durbin-Watson stat	1.565134
Prob(F-statistic)	0.001781		

Source: Author, 2017.

ii *Food Access*

Floods, storms, and earthquakes positively influenced the prevalence of undernourishment (3-year average percentage) in Indonesia, but not significantly (Table 4.22).

Table 4.22: Prevalence of Undernourishment (3-year average) in Indonesia (%)

Variable	Coefficient	Std. error	*P*-value
Constant	21.75911	4.398574	0.0002
Storm	0.639903	0.596847	0.3018
Flood	1.082259	1.195228	0.3805
Earthquake	0.056451	0.757510	0.9416
Quantity of Banana Produce	-4.65E-07	4.81E-07	0.3500
Quantity of Cassava Produce	-3.26E-07	2.14E-07	0.1503
Quantity of Potato Produce	-1.58E-06	1.68E-06	0.3627
Quantity of Rice Produce	-2.91E-10	3.35E-10	0.4004
Population	-7.64E-06	1.46E-06	0.0001
Regression diagnostics			
R-squared	0.700926	Mean dependent var	-0.526087
Adjusted R-squared	0.530027	S.D. dependent var	1.025678
S.E. of regression	0.703149	Akaike info criterion	2.419677
Sum squared resid	6.921865	Schwarz criterion	2.864001
Log likelihood	-18.82628	Hannan-Quinn criter.	2.531423
F-statistic	4.101401	Durbin-Watson stat	0.975281
Prob(F-statistic)	0.010399		

Source: Author, 2017.

Floods, storms, and earthquakes positively influenced the prevalence of food inadequacy in Indonesia, but not significantly (Table 4.23).

Table 4.23: Prevalence of Food Inadequacy in Indonesia

Variable	Coefficient	Std. error	*P*-value
Constant	27.54194	5.512515	0.0002
Storm	0.674373	0.747998	0.3825
Flood	1.215659	1.497920	0.4306
Earthquake	0.080893	0.949350	0.9333
Quantity of banana produce	-6.41E-07	6.03E-07	0.3056
Quantity of cassava produce	-4.18E-07	2.68E-07	0.1410
Quantity of potato produce	-1.58E-06	2.11E-06	0.4651

Variable	Coefficient	Std. error	*P*-value
Quantity of rice produce	-3.07E-10	4.20E-10	0.4776
Population	-9.62E-06	1.83E-06	0.0001
Regression diagnostics			
R-squared	0.700976	Mean dependent var	-0.652174
Adjusted R-squared	0.530105	S.D. dependent var	1.285538
S.E. of regression	0.881222	Akaike info criterion	2.871158
Sum squared resid	10.87174	Schwarz criterion	3.315482
Log likelihood	-24.01832	Hannan-Quinn criter.	2.982904
F-statistic	4.102371	Durbin-Watson stat	0.941758
Prob(F-statistic)	0.010389		

Source: Author, 2017.

iii *Food Stability*

Earthquakes negatively influenced political stability and the absence of violence/terrorism in Indonesia (p<0.1). Storms also negatively influenced political stability and the absence of violence/terrorism, but not significantly (Table 4.24).

Table 4.24: Political Stability and Absence of Violence/Terrorism in Indonesia (p<0.1)

Variable	Coefficient	Std. error	*P*-value
Constant	2.086879	6.094725	0.7371
Storm	-0.055660	0.826999	0.9473
Flood	0.056144	1.656125	0.9734
Earthquake	**-2.010102**	**1.049616**	**0.0761**
Quantity of banana produce	9.19E-07	6.66E-07	0.1895
Quantity of cassava produce	2.26E-07	2.96E-07	0.4585
Quantity of potato produce	-1.11E-06	2.33E-06	0.6419
Quantity of rice produce	2.32E-10	4.64E-10	0.6251
Population	-1.23E-07	2.02E-06	0.9522

Regression diagnostics			
R-squared	0.317938	Mean dependent var	0.051304
Adjusted R-squared	-0.071811	S.D. dependent var	0.941089
S.E. of regression	0.974293	Akaike info criterion	3.071963
Sum squared resid	13.28946	Schwarz criterion	3.516287
Log likelihood	-26.32758	Hannan-Quinn criter.	3.183709
F-statistic	0.815751	Durbin-Watson stat	2.975106
Prob(F-statistic)	0.601244		

Source: Author, 2017.

Floods, storms, and earthquakes positively influenced per capita food supply variability (kcal/capita/day) in Indonesia, but not significantly (Table 4.25).

Table 4.25: Per Capita Food Supply Variability in Indonesia (kcal/capita/day)

Variable	Coefficient	Std. error	*P*-value
Constant	-23.97088	24.61501	0.3479
Storm	1.188640	10.02268	0.9074
Flood	22.60340	21.95266	0.3220
Earthquake	1.022984	13.91128	0.9425
Quantity of banana produce	-1.59E-05	8.06E-06	0.0708
Quantity of cassava produce	8.40E-07	3.55E-06	0.8168
Quantity of potato produce	-2.99E-05	3.15E-05	0.3608
Quantity of rice produce	-7.73E-09	6.04E-09	0.2228
AR(1)	0.292704	0.253946	0.2698
Regression diagnostics			
R-squared	0.477081	Mean dependent var	-3.954545
Adjusted R-squared	0.155284	S.D. dependent var	13.72338
S.E. of regression	12.61294	Akaike info criterion	8.199413
Sum squared resid	2068.123	Schwarz criterion	8.645749
Log likelihood	-81.19354	Hannan-Quinn criter.	8.304556
F-statistic	1.482553	Durbin-Watson stat	2.190485
Prob(F-statistic)	0.253538		

Source: Author, 2017.

iv *Utilisation*

Floods, storms, and earthquakes positively influenced the prevalence of anaemia amongst 5-year old children in Indonesia, but not significantly (Table 4.26).

Table 4.26: Prevalence of Anaemia Amongst 5-year old Children in Indonesia

Variable	Coefficient	Std. error	*P*-value
Constant	-13.84480	2.577682	0.0001
Storm	0.256411	0.349768	0.4756
Flood	0.407245	0.700436	0.5702
Earthquake	0.610981	0.443921	0.1903
Quantity of banana produce	2.25E-07	2.82E-07	0.4373
Quantity of cassava produce	9.12E-08	1.25E-07	0.4790
Quantity of potato produce	-9.51E-07	9.85E-07	0.3510
Quantity of rice produce	-1.04E-10	1.96E-10	0.6054
Population	3.84E-06	8.55E-07	0.0005
Regression diagnostics			
R-squared	0.682714	Mean dependent var	-1.134783
Adjusted R-squared	0.501408	S.D. dependent var	0.583569
S.E. of regression	0.412064	Akaike info criterion	1.350897
Sum squared resid	2.377158	Schwarz criterion	1.795221
Log likelihood	-6.535319	Hannan-Quinn criter.	1.462644
F-statistic	3.765537	Durbin-Watson stat	0.787257
Prob(F-statistic)	0.014748		

Source: Author, 2017.

B Viet Nam[5]

i *Food Availability*

Floods negatively influenced the average dietary energy supply adequacy in Viet Nam, but not significantly (Table 4.27).

[5] Floods are the disaster variable used for Viet Nam with respect to food security indicators because earthquakes did not occur in Viet Nam during the 1990–2013 study period (for the disaster–food security linkage). In addition, floods and storms generally occurred in the same years, and using both variables in the regression equations resulted in a near singular matrix because of the high level of Tetrachoric correlation among them.

Table 4.27: Effect of Floods on Average Dietary Energy Supply Adequacy (3-year average) in Viet Nam (%)

Variable	Coefficient	Std. error	*P*-value
Constant	1.466681	0.891131	0.1206
Flood	-0.471471	0.852235	0.5883
Quantity of banana produce	3.91E-06	4.33E-06	0.3808
Quantity of rice produce	1.88E-07	2.44E-07	0.4532
Quantity of cassava produce	1.42E-07	4.29E-07	0.7446
Quantity of potato produce	4.36E-06	5.59E-06	0.4467
AR(1)	0.476170	0.229587	0.0557
Constant	1.466681	0.891131	0.1206
Flood	-0.471471	0.852235	0.5883
Regression diagnostics			
R-squared	0.258469	Mean dependent var	1.409091
Adjusted R-squared	-0.038143	S.D. dependent var	1.140555
S.E. of regression	1.162103	Akaike info criterion	3.391712
Sum squared resid	20.25727	Schwarz criterion	3.738862
Log likelihood	-30.30883	Hannan-Quinn criter.	3.473490
F-statistic	0.871405	Durbin-Watson stat	1.548080
Prob(F-statistic)	0.538025		

Source: Author, 2017.

ii *Food Access*

Floods positively influenced the number of people undernourished and the depth of the food deficit in Viet Nam, but not significantly (Tables 4.28 and 4.29).

Table 4.28: Number of People Undernourished (3-year average) in Viet Nam (million)

Variable	Coefficient	Std. error	*P*-value
Constant	-0.925997	0.578866	0.1305
Flood	0.073245	0.524082	0.8907
Quantity of banana produce	-1.03E-06	2.89E-06	0.7261

Variable	Coefficient	Std. error	*P*-value
Quantity of rice produce	-1.50E-07	1.46E-07	0.3222
Quantity of cassava produce	1.55E-07	2.67E-07	0.5703
Quantity of potato produce	-6.81E-07	3.22E-06	0.8354
AR(1)	0.579716	0.229142	0.0231
Regression diagnostics			
R-squared	0.357396	Mean dependent var	-0.968182
Adjusted R-squared	0.100354	S.D. dependent var	0.740904
S.E. of regression	0.702745	Akaike info criterion	2.385727
Sum squared resid	7.407765	Schwarz criterion	2.732877
Log likelihood	-19.24300	Hannan-Quinn criter.	2.467505
F-statistic	1.390420	Durbin-Watson stat	0.803515
Prob(F-statistic)	0.281181		

Source: Author, 2017.

Table 4.29: Depth of the Food Deficit (3-year average) in Viet Nam (kcal/capita/day)

Variable	Coefficient	Std. error	*P*-value
Constant	197.4523	63.16536	0.0062
Flood	1.307627	66.29186	0.9845
Quantity of cassava produce	-3.73E-05	2.77E-05	0.1962
Quantity of banana produce	-0.000311	0.000267	0.2595
Quantity of potato produce	-0.000354	0.000415	0.4051
Quantity of rice produce	5.96E-06	1.85E-05	0.7513
Regression diagnostics			
R-squared	0.199595	Mean dependent var	184.6522
Adjusted R-squared	-0.035818	S.D. dependent var	77.19610
S.E. of regression	78.56645	Akaike info criterion	11.78522
Sum squared resid	104935.7	Schwarz criterion	12.08144
Log likelihood	-129.5301	Hannan-Quinn criter.	11.85972
F-statistic	0.847849	Durbin-Watson stat	0.389314
Prob(F-statistic)	0.534818		

Source: Author, 2017.

iii *Food Stability*

Floods positively influenced per capita food supply variability in Viet Nam ($p<0.1$), as shown in Table 4.30.

Table 4.30: Per Capita Food Supply Variability in Viet Nam (kcal/capita/day)

Variable	Coefficient	Std. error	*P*-value
Constant	-21.87605	9.439270	0.0332
Flood	**25.08057**	**9.906486**	**0.0215**
Quantity of cassava produce	-2.05E-06	4.15E-06	0.6274
Quantity of banana produce	-7.93E-05	3.99E-05	0.0630
Quantity of potato produce	3.49E-05	6.20E-05	0.5805
Quantity of rice produce	9.20E-07	2.76E-06	0.7433
Regression diagnostics			
R-squared	0.343400	Mean dependent var	-1.043478
Adjusted R-squared	0.150283	S.D. dependent var	12.73677
S.E. of regression	11.74077	Akaike info criterion	7.983470
Sum squared resid	2343.376	Schwarz criterion	8.279686
Log likelihood	-85.80990	Hannan-Quinn criter.	8.057967
F-statistic	1.778192	Durbin-Watson stat	2.029695
Prob(F-statistic)	0.171122		

Source: Author, 2017.

iv *Utilisation*

Floods positively influenced the prevalence of anaemia amongst 5-year old children in Viet Nam, but not significantly (Table 4.31).

Table 4.31 : Prevalence of Anaemia Amongst 5-Year Old Children in Viet Nam

Variable	Coefficient	Std. error	*P*-value
Constant	-1.237873	0.630041	0.0660
Flood	0.117847	0.661226	0.8607
Quantity of Cassava Produce	3.74E-07	2.77E-07	0.1938
Quantity of Banana Produce	4.43E-06	2.66E-06	0.1142
Quantity of Potato Produce	1.19E-06	4.14E-06	0.7766
Quantity of Rice Produce	-8.93E-08	1.85E-07	0.6345
Regression diagnostics			
R-squared	0.287812	Mean dependent var	-0.978261
Adjusted R-squared	0.078345	S.D. dependent var	0.816287
S.E. of regression	0.783659	Akaike info criterion	2.569772
Sum squared resid	10.44005	Schwarz criterion	2.865988
Log likelihood	-23.55237	Hannan-Quinn criter.	2.644269
F-statistic	1.374022	Durbin-Watson stat	0.564860
Prob(F-statistic)	0.282765		

Source: Author, 2017.

PART II

Technology Adoption

CHAPTER 5

Successful Adaptation Measures for Inland and Coastal Food Security

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5.1 Introduction

Climate change has caused difficulty in local weather and widened the gap between the wet and dry seasons in tropical monsoon countries. Both extremely moist and dry weather conditions have become more frequent since El Niño hit in 1978, devastating vast agricultural production in the region. A more massive El Niño occurred in 2015, but its impact was not as severe because governments and society anticipated it and were well prepared to carry out adaptive measures.

Coastal land, which is relatively low altitude, flat, warm, and home to paddy fields, is generally prone to flooding during wet periods (La Niña). The main threats to agricultural production are heavy/less rainfall, less sunshine, high/low temperatures, strong winds, floods, and earthquakes. Lowland paddy fields mostly have enough water, even during dry periods, but the amount of soil water does not always last the whole cultivation period. Inland terrain is higher altitude, sloping, and relatively cold where horticulture is commonly cultivated; and might experience droughts during dry periods (El Niño). Extreme rainfall might not result in prolonged flooding but has the potential to cause landslides.

This chapter identifies types of disasters that have contributed to and threatened food production in some Asian countries, and analyses how the affected countries have carried out countermeasures and anticipated disaster risks caused by climate change. In most cases, extreme weather is the primary threat to agricultural production and related infrastructure. Natural disasters, which frequently happen in Japan, are good examples of how governments and people anticipate, respond, and adapt to catastrophes so that risks can be mitigated and the environmental conditions for production can be restored.

This chapter focuses on risks to food production resulting from extreme weather, which may be caused by climate change. It discusses the cases of Japan and the Republic of Korea (henceforth, Korea) to represent advanced countries, while Indonesia and Viet Nam represent developing countries. Case studies from developing countries are essential to analyse and learn from since their populations are highly dependent on farmland for survival while land productivity is relatively low. Indonesia is focused on since it is the fourth most populous country in the world but is still struggling to increase food production, achieve and maintain self-sufficiency from 2019, and become the world's largest rice producer in 2045.

The System of Rice Intensification (SRI) – a promising method of rice cultivation gaining popularity in Asian countries which can increase rice production and is hardy in extreme weather – is examined. Finally, a policy implication is raised on how to deal with the risks and provide a fast response to minimise damage, as learned from the country case studies in this chapter.

5.2 Threats of Natural Disasters

Since the 1900s, the global temperature has fluctuated around –2° C to +2° C (Intergovernmental Panel on Climate Change (IPCC), 2007). The warmer weather factually supports the increase of agricultural production, but the colder weather in many cases becomes the dominant cause of crop failures and the damage of infrastructure.

Japan experienced recurring bad weather, cold temperatures, and a severe famine in the 18th century, mainly because of frequent volcano eruptions where volcanic ash covered vast areas of agricultural land and caused crop failures. Smaller ash particles remained in the air and hindered solar radiation, triggering cold temperatures over a long period, which damaged crop production and caused famine. The hardest hit region was northern Japan. Low nutrition and starvation caused 920,000 deaths during 1780–1786.

Typhoons are another threat, frequently occurring in the autumn. Strong winds and heavy rains are the leading causes of crop and infrastructure damage.

Table 5.1 shows the types of disasters and the damage they have caused in the agriculture sector in recent years. The heavy rains that follow typhoons and their low-pressure systems are the main hazards. Earthquakes in Niigata (2004), Noto (2007), eastern Japan (2011), and Kumamoto (2016) were amongst the main disasters. As shown in Table 5.1 the damage to agricultural infrastructure in terms of value was significantly higher than that of agricultural production.

Table 5.1: Disasters and Agricultural Damage in Japan, 2006–2015

Year	Disaster	Agricultural production (A) (¥ million)	Agricultural infrastructure (B) (¥ million)	Total (¥ million)	(B)/(A)
2006	Heavy rain, typhoon	59,031	219,727	278,758	3.7
2007	Typhoon, earthquake	25,259	141,864	167,123	5.6
2008	Earthquake, heavy rain	13,621	197,336	210,957	14.5
2009	Heavy rain, typhoon	14,770	72,753	87,523	4.9
2010	Heavy rain in the rainy season	16,249	77,008	93,257	4.7
2011	Great East Japan earthquake	103,882	2,601,606	2,705,488	25.0
2012	Heavy rain in northern Kyushu	26,725	162,316	189,041	6.1
2013	Heavy rain and typhoon	36,395	164,419	200,814	4.5
2014	Heavy snowfall	55,412	257,208	312,620	4.6
2015	Heavy rain in Kanto area	27,266	83,390	110,656	3.1

Source: MAFF (2015).

The agriculture sector has experienced the impacts of climate change in many countries. These have caused crop and livestock losses because of severe droughts and flooding, as well as harvest failures resulting from pest and disease outbreaks, and difficulty in determining the appropriate time to start cultivation. Reports on agricultural failures caused by climate change globally have been compiled elsewhere (IPCC, 2007).

In some Asian countries, such as those listed in Table 5.2 , the impacts of extreme weather on agriculture have differed in magnitude (Amarnath et al., 2017). Drought, accompanied by extreme temperatures, caused harvest failures on about 1.8 million square kilometers

(km^2) of agricultural land in India, 359,000 km^2 in Pakistan, and 91,000 km^2 in Sri Lanka. Meanwhile, agricultural collapses in Bangladesh were mainly due to frequent floods caused by extreme rainfall and sea-level rise, while Nepal and Bhutan suffered more from excessive rain. Amarnath et al. (2017) also introduced four classes (low, medium, high, and extreme) to identify the risks faced by those countries – Bangladesh was categorised as extreme, Bhutan was low to medium, India was medium to extreme, Nepal was high to extreme, Pakistan was medium to extreme, and Sri Lanka was low to extreme.

Table 5.2: Impact of Individual Hazards on Agriculture, 1950–2014

Country	Flood (%)	Drought (%)	Extreme rainfall (%)	Extreme temperature (%)	Sea-level rise (%)	Agricultural area (%)
India	7.0	33.1	8.7	29.1	1.7	1,796,700
Pakistan	8.4	50.4	0.3	33.1	1.4	359,360
Bangladesh	53.1	2.9	42.6	1.8	18.4	91,280
Nepal	6.0	2.7	51.0	0.3	0.0	41,266
Sri Lanka	4.3	25.0	3.6	27.0	2.1	27,300
Bhutan	0.2	0.1	20.0	0.0	0.0	5,196

km^2 = square kilometre.

Source: Amarnath et al. (2017).

5.3 Threats of Climate Change

5.3.1 Japan

The agriculture sector has already experienced impacts of climate change, including crop and livestock loss from severe drought and flooding, large-scale losses from weather-related disasters, and shifts in planting and harvesting times. These impacts have profound effects, often significantly affecting the health and well-being of rural residents and communities (IPCC, 2007). Adaptation efforts require planning, but rural governance structures tend to de-emphasise planning capacity compared with urban areas. If rural communities are to respond adequately to future climate changes, they will need to assess their risks and vulnerability. The effects of global warming on agriculture have been spreading, e.g. high temperatures have caused unmatured grains of rice, grapes and apples are a bad color, bad ripening, tomatoes are of low quality, and the volume and quality of cow milk have decreased.

The Japanese Ministry of Agriculture, Forestry, and Fisheries (MAFF) have instigated countermeasures (MAFF, 2013a) to combat these effects. New varieties of rice were introduced to 55,800 hectares (ha) of paddy field in 2012. Late transplants, improved water management, and a change in fertilisation have also been implemented. New varieties of fruit have been introduced, the stem surface partial removal for ripening acceleration of grapes, and the shadowing method for reducing sunlight has been applied to apples. Shadowing and new varieties have also been introduced for strawberries to combat the late ripening and low quality and quantity. In the livestock sector, the cooling and shadowing techniques were also introduced for cow-milk industries.

The most significant countermeasure, however, is to reduce the emissions of greenhouse gases (GHGs). Emissions from industry and transport are high, at 42%, but emissions from agriculture are also significant. Therefore, the agriculture sector needs to reduce emissions as much as possible. For rice growing, intermittent irrigation is recommended to reduce GHGs and enhance plant strength.

MAFF issued the Overview of the Plan for Global Warming in 2017 (MAFF, 2017). The strategy is a combination of mitigation measures, adaptation measures, and international cooperation in agriculture, forestry, and fisheries. Through comprehensive promotion measures in those sectors, MAFF aims to promote agriculture, forestry, and fisheries that contribute to global environmental conservation.

Matsuo (2011) reported on the implementation of global warming adaptation measures. These include (i) monitoring the impacts of global warming, (ii) establishing a system to support producing areas, and (iii) supporting adaptation measures.

Disasters can be classified in the following categories:

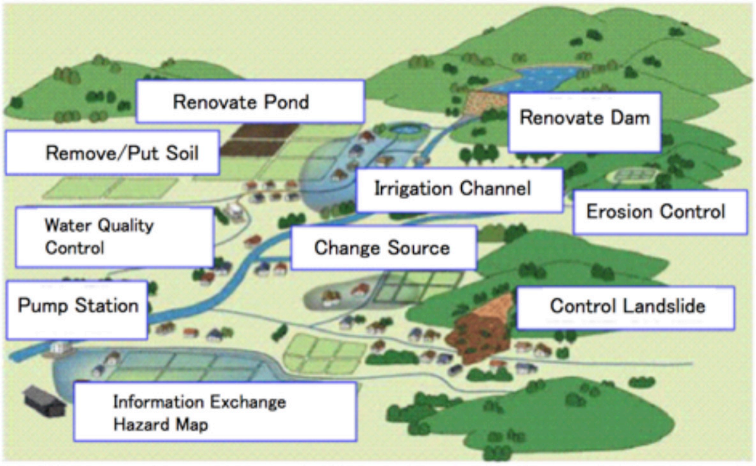
(i) Disasters which are difficult to predict: volcanoes, earthquakes, and tsunami. Preparation and evacuation training is adequate for these disasters. The affected areas are usually limited enough, so neighboring regions can assist. Municipalities, non-governmental organisations, and citizens are aware of the importance of rapid response; and some training has been provided.

(ii) Disasters which can be predicted sometime before: typhoons, heavy rains, strong winds, and extreme temperatures. This type of catastrophe leaves enough time to prepare for the consequences.

(iii) Disasters which can be reduced or stopped: global warming; water pollution; soil contamination; and land subsidence by pumping, floods, and landslides. Countermeasures for global warming have been noted above. Many of the other disasters can be reduced through technical innovation and legal restrictions on GHG emissions.

Villages need disaster prevention facilities for (i) landslides, (ii) wind and snow damage, (iii) fire, (iv) stormwater drainage, (v) waterway and pond safety, (vi) traffic safety, (vii) crime, and (viii) communications (radio). MAFF also executes disaster prevention projects for agricultural and rural infrastructure (Figure 5.1).

Figure 5.1: Disaster Prevention Projects of Agricultural Land

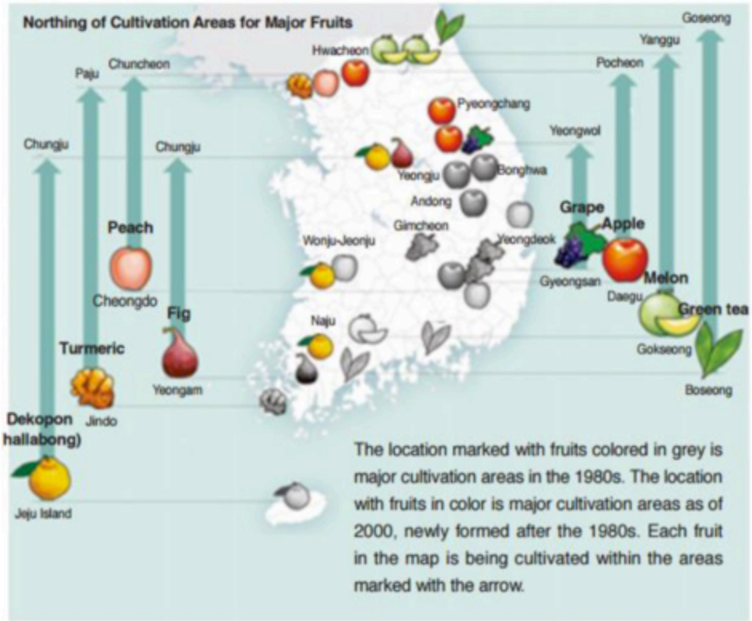


Source: MAFF (2013b).

5.3.2 Korea

Apples are the most cultivated and consumed fruit in Korea, with cultivation mostly occurring in North Gyeongsang Province in southern Korea (Kim, Heo, and Lee, 2010). In the past, most counties in North Gyeongsang Province had adequate annual mean temperatures for apple cultivation (8°C–11°C), but temperatures have increased in recent years for most counties and future temperature rises are expected – requiring careful adaptation measures for such impacts of climate change (Choi and Yamaji, 2016). In Korea, northing (moving to the northern regions) of cultivation areas of fruits had already occurred, as shown in Figure 5.2.

Figure 5.2: Climate Change Impact on Major Crop Cultivation Area



Notes:

1. Grey fruits denote the major cultivation areas in the 1980s. Colored fruits denote the main cultivation areas in 2000.
2. Each fruit is cultivated within the areas indicated by the arrows.

Source: Korea Rural Economic Institute (KREI, 2015).

5.3.3 Viet Nam

Rice is the staple product of Viet Nam, which produced 45 million tons (t) in 2014 and has a 6.1% share of the world's production. However, as a result of climate change, the Government of Viet Nam projects the country's rice production to decrease by 7.2 million t at the end of the 21st century.

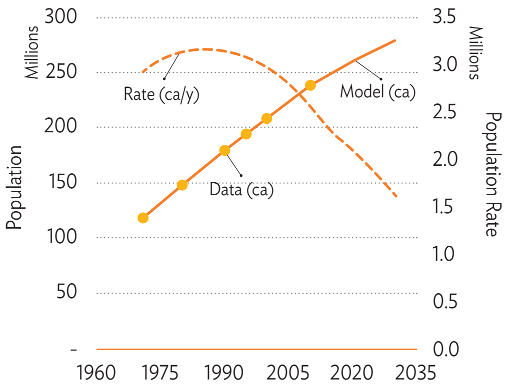
From 2002 to 2017, climate change-oriented natural disasters have increased – affecting the agriculture sector and socio-economic activities in Viet Nam. The Ministry of Agriculture and Rural Development reported that economic losses from natural hazards amount to $900 million or 1.5% of gross domestic product every year. Agricultural specialists have recommended the diversification of crops for adaptation to climate change. However, PanNature, a not-for-profit organisation, notes that diversification is difficult for small-scale farmers and points to farmers' lack of awareness of climate change as a more serious factor (SankeiBiz, 2017).

5.3.4 Indonesia

Overview

Indonesia is a rice-based country with a population of 240 million which is projected to reach 280 million in 2030, although its growth rate has been decreasing since 1990 (Figure 5.3). As rice is the staple food, rice production continues to increase through land intensification and expansion. As shown in Figure 5.4, the harvested area increases over time, mainly thanks to the increase in planting intensity, which is 170% on average and is projected to reach 190% by 2030. The rate of extensification and its contribution to national rice production is very small, but it helps to provide rice for people living in remote and isolated areas such as small islands and borders with neighboring countries.

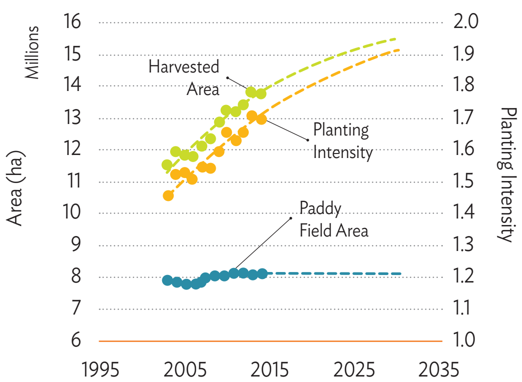
Figure 5.3: Population of Indonesia



ca/y = capita per year.

Source: Statistics Indonesia (2012).

Figure 5.4: Paddy Cultivation in Indonesia



ha = hectare.

Source: Statistics Indonesia (2017).

Seasonal shifting has been apparent since the first El Niño hit the Indonesian archipelago in 1997. Less rainfall from June to August has been detected in western parts of the country such as Java, Sumatera, Kalimantan, and Nusa Tenggara, causing longer dry seasons. Meanwhile, rainfall intensity from December to February in the eastern islands such as Sulawesi has tended to increase over time. Climate change has multidimensional effects on food resilience, agricultural resources, infrastructure, production systems, and farmer welfare. Land vulnerability to drought varies according to location. Paddy fields in Sumatera and Java amounted 74,000 and 1 million out of the total of 5.14 million ha are highly vulnerable to drought. Frequent flooding has intensified pest and disease outbreaks indirectly. Since crops are highly susceptible to extreme weather, efforts have been made to invent new varieties that are more tolerant of the drier and/or wetter conditions and improved cultivation methods and technologies.

National Policy

The Ministry of Agriculture planned to secure food and energy security over 2015–2019 to support national resilience. One of the agricultural development policies is to improve mitigation and adaptation capacities in dealing with climate change by strengthening agricultural infrastructure and applying adaptive methods and technologies. The agriculture sector contributes about 6% of the national GHG emissions in lieu of the target to decrease GHG emissions by 0.008%–0.011% by 2020.

The ministry has published guidelines that state the objectives, targets, and strategies to be followed by all parties (Agricultural Research and Development Agency (Balibangtan), 2011). The objectives are to (i) give direction to enhance understanding of how to identify climate change and its potential impacts, (ii) guide efforts and action programmes to obtain benefits from climate variability and reduce its effects, (iii) identify and register existing technologies that are adaptive to climate change, and (iv) develop a climate information system and disseminate innovative technologies in dealing with climate change.

The guidelines stress the importance of involving stakeholders not only in the agriculture sector but also other related sectors from the central government to the rural community, streamlining research and development programmes to come up with innovate technologies adaptive to climate change, and enhancing the awareness and understanding of farmers and rural society to climate information and how to implement adaptive technologies. There are structural and non-structural strategic approaches. The structural approaches include registering detailed information on the conditions of irrigation networks, rehabilitating irrigation infrastructure, expanding irrigated areas to increase planting intensity, and rehabilitating catchment areas to anticipate incoming extreme climate. The non-structural approaches include empowering the regulation of the prohibition on agricultural land conversion, prioritising the implementation of adaptive programmes in places highly vulnerable to climate change and natural disasters, introducing the integrated planting calendar or *Kalender Tanam* (KATAM) to a broader rural community, expanding the field climate school to empower local communities in reading and understanding and how to anticipate climatic phenomena, and smoothing the distribution of information through the existing related institutions to the end users.

Two factors need to be considered when assessing adaptability to climate change: (i) the capability to adapt and (ii) the significance of the impact caused. The capacity to adapt reflects how crops can survive and produce under climate stress. The significance of the impacts caused measures the physical losses which cause farmers not to reap benefits from their fields. The strength or weakness of the adaptation capability can be seen externally in the bearing capacity of the ecosystem and environment; and internally in the preparedness of regulations, institutions, funding, and human resources. The capability to adapt may reduce the tension generated from the socio-economic issues, climate risk, and climate change.

Successful adaption is determined by how to build a sound programme in applying appropriate technology that can enhance capacity building and the effective funding allocation. The need for technology should be assessed comprehensively, including whether it is available in the country or needs to be imported. Enhancing human and institutional capacities should focus on the adaptation that needs to be carried out. Decisions on funding should consider not only the amount but also how to manage it transparently with full accountability, and whether the source is national or international. There is a strong need to enhance cooperation amongst stakeholders and integrate work mechanisms and decision support systems to develop comprehensive programmes that can avoid failure and substantial losses in terms of energy and time, as well as funding (Ari, 2012). Early implementation of adaption programmes can save or reduce losses substantially.

Water availability is the main issue in dealing with climate change. Water harvesting from the excess of irrigation (run-off) and rainwater is critical to success in water conservation. Water is abundant during the wet season and may cause flooding, while water scarcity is threatening when crops are maturing in the second cultivation season. In general, the most critical period for water availability is 20 days before harvesting. Since 2017, the Indonesian government has constructed dams with the targets of 30,000 units – each with at least 500 cubic meters of water volume capable of flowing at 5 liters per second over 25 ha. The plan is to irrigate more than 4 million ha of paddy field and double the planting intensity, with the potential to add 16 million t of rice production.

Information systems for assessing real-time weather conditions – including the monitoring, analysis, interpretation, and prediction of future weather – are continuously improved. Additional automatic weather stations have been erected, and adaptive technologies have been inventoried and developed. Water resources, including the related infrastructure, have been managed and prepared to deal with unexpected extreme weather that threatens drought and flood events.

To anticipate climate change and its consequences, the ministries of agriculture, public works, and rural development are cooperating to accelerate relevant projects; and they have published a technical manual to fast-track the construction of water reservoirs (Directorate General for Agricultural Structure and Infrastructure (PSP), 2017). The government plans to intensify rice planting from 100% to 200% covering over 4 million ha, out of which 600,000 ha will be irrigated by small dams, 700,000 ha by on-farm reservoirs, 90,000 ha by the long water storage, 2.5 million ha by river water, and 24,000 ha by groundwater. To date, the government has built about 18,000 water reservoirs, which can make water available and enhance food production in places vulnerable to water scarcity during the dry season.

The main activities to sustain food production in the context of climate change are to improve water management, water harvesting, conservation farming, the planting calendar, adaptable crops, climate insurance, and cultivation methods. These countermeasures are described below.

Adaptive Measures

1) Water Management

Paddy cultivation is commonly supported by technical irrigation to ensure the availability of water during the growth period without water fees. In most cases, farmers feel uncomfortable if their fields are not continuously flooded every day. This has caused inefficient or excessive use of irrigation water and makes their fields less productive. Some farmers believe that continuous water ponding can reduce weeds and promote productivity, but instead productivity decreases because of bad soil aeration, nutrient loss, frequent pest and disease attacks, and more methane emissions.

Excessive irrigation is not sustainable in the era of climate change since it depletes the availability of irrigation water. Various modern irrigation methods can reduce the use of irrigation water without jeopardising productivity. The most common methods are covering the soil surface with a thin layer of water (shallow ponding); ponding the soil surface with water on certain days (alternate wetting and drying); rotating from one plot to another (rotating irrigation); and saturating the soil surface without water ponding (saturated irrigation). These techniques can improve land productivity. Saturated irrigation is commonly applied in SRI and has been proven capable of increasing water productivity and decreasing GHG emissions.

2) Water Harvesting

Dryland is another ecosystem with significant potential as farmland for food crops, horticulture, and annual crops as well as animal husbandry. About 25 million ha out of 76 million ha of dry land is arable, but the cultivated area is limited to one season because of water constraints. In some areas, dry land may have limited water resources, but in other areas, it may have excess water in the rainy season although the water is depleted in the following dry season. In these locations, rainwater harvesting is a potential solution through constructing on-farm water reservoirs and/or tapping groundwater if available beneath the land. This supplemental water may not be enough for the whole season of the main crop (paddy), but farmers will obtain additional income when they use the water for cash crop production such as shallots and peppers. Other forms of water harvesting are pumping water from nearby rivers and building dams in small streams, small artificial lakes, long-term water storage facilities, and groundwater wells.

Since 2017, Indonesia has constructed around 30,000 units of these forms of water harvesting, which will cover 4 million ha, and by this time more than 17,000 have been completed. Three ministries (agriculture, public works, and rural development) are working together to implement this project, which is planned to allocate more than Rp20 trillion. For small projects, farmer groups can perform the construction themselves (self-managed) following ministerial guidelines. This scheme will have the added benefit of giving farmers a sense of belonging and encourage them to take care of it and create appropriate management systems for operation and maintenance of the facilities.

From 2015 to 2016, the Ministry of Agriculture increased the planting intensity from 100% to 150% over 90,000 ha with the help of about 3,500 water harvesting units add more 230,000 t of dried paddy production. Since 2017, the ministry planned to build 6,000 more units to increase the planting intensity by 50% on more than 63,000 ha, producing an additional 350,000 t of dried paddy.

3) Conservation Farming

The primary objective of this programme is to conserve irrigation water by supplying water as and when required by plants, and by reducing water losses resulting from evaporation. In some areas, applying up to 60% less water than corn farmers typically use has not lowered productivity, so more farmland can obtain water for cultivation. Keeping the soil moist by enhancing its capacity to hold water can be done through the application of the appropriate amount and composition of manure and biochar. Furthermore, water loss caused by evaporation can be reduced by covering the soil surface with the disposed biomass left in the field after the previous harvest. Using this practice, farmers can increase of corn from 5.7 t/ha to 7.6 t/ha. It also allows farmers to cultivate watermelon, without any extra irrigation water, by reaping the benefits of the moist soil layers during the dry season.

4) Planting Calendar

KATAM is used to determine the appropriate time to start rice cultivation in a specific location (Balitbangtan, 2010). It is constructed based on historical climate information and geographical characteristics. KATAM also specifies varieties that could be adaptable under future climate conditions in the location, including how to manage plants during cultivation periods and how much water is available. Farmers can quickly determine the most appropriate varieties to grow and earn good yields. Online maps allow farmers to see the actual condition of the growth stages if they input the required data (Centre for Data and Information, Ministry of Agriculture (Pusdatin), 2017). Growth analysis is carried out based on the mean cultivated areas every 10 days in each district (kecamatan).

Under actual conditions, KATAM considers the first planting season in a district to begin when farmers have planted more than 8% of the existing paddy fields. The second and third planting seasons start after reaching 6% and 2%, respectively. KATAM also provides information on weather conditions, which informs its determination of the onset of the planting season and the availability of rain and irrigation water. The first planting season is determined when rainfall has exceeded 35 millimeters in 10 days during three consecutive 10-day periods. Under this criterion, Indonesia has eight distinctive planting season zones. In collaboration with the Meteorology, Climatology and Geophysical Agency (BMKG, 2017), KATAM distinguishes three annual rainfall patterns: (i) 'yearly wet', when the annual rainfall is 115% above the mean annual value (La Niña); (ii) 'yearly normal', when the annual rainfall is 85%–115% of the mean annual value; and (iii) 'yearly dry', when the annual rainfall is less than 85% of the yearly mean value (El Niño). This KATAM facilitates determining which actions to take in anticipating extreme conditions.

BMKG undertakes daily climate monitoring and updates this information to related institutions such as the Ministry of Agriculture. However, the results of the analysis are not accurate because of the limited number of reliable climate stations. Improvements are underway to tackle this, including (i) installing more or renewing climate stations in each district; and (ii) developing a method of climate analysis for determining the onset of the planting season more accurately and for providing reliable information on how much water is available during the planting season. Currently, a map is being developed to estimate the dynamic trend of weather conditions and water availability in the whole regions.

5) Adaptable Crops

Improving crop varieties to be more adaptable under extreme climate conditions is becoming a vital research topic. Many varieties now meet that condition. Balitbangtan (2017) released two varieties (INPARI 42 and INPARI 43) which can grow well under extremely wet and dry weather conditions. Their wide range of adaptability has earned these varieties the popular name 'amphibious paddy'. Their productivity may reach 9.2–10.6 t/ha even with limited input of pesticide and chemical fertilisers when they are planted in suboptimal soil with high acidity and waterlogging problems. Other characteristics include faster-growing varieties that can be harvested within 111–112 days after transplanting; stickier rice with an amylose content of about 18.8%–19.0%; a higher ratio of polished rice weight to grain, at 69.4%–70.1%; and increased resistance to pests and diseases common during extreme weather conditions. Seeds of these varieties are now distributed to locations prone to extremely wet and dry conditions.

6) Climate Insurance

Efforts to attain self-sufficiency need to consider the risk of weather-induced crop failure, which could affect farmers financially. To mitigate this risk, the government introduced a weather insurance scheme and accompanying guidelines in 2016 (PSP, 2016) to compensate for losses faced by paddy farmers as a result of flooding, droughts, and pest and disease attacks.

All farmers are eligible to apply for the government weather insurance scheme. The premium is Rp180,000/ha per planting season for insurance cover of Rp6 million. The government provides a subsidy of Rp144,000, so farmers only need to pay Rp36,000. Claims can be submitted if crop failures reach more than 75% of the planted area and the age of the plants is higher than 10 days for transplanted paddies and 30 days for direct seedlings.
Pest and disease attacks affected 76,000 ha of paddy field in 2014, 26,000 ha in 2015 (El Niño), and 35,000 ha in 2016 (La Niña). Most of the impacted areas could be recovered and harvested; however, thanks to a fast response and timely and appropriate treatment. Areas affected by drought totaled 180,000 ha in 2014, 800,000 ha in 2015, and 75,000 ha in 2016. Most of them could also be recovered and harvested thanks to early weather warning systems and the distribution of water pumps. In 2017, the government allocated a subsidy

for 1 million paddy fields; by this time, more than 450,000 ha had been registered, and more than 6,500 ha had claimed amounts totaling Rp40 billion (Irianto, 2017).

7) Cultivation Method

Farmers have implemented many cultivation methods considered adaptive to climate change. These include those related to (i) water management, e.g. intermittent irrigation, shallow ponding, and saturated irrigation, which have been proven to save up to 60% of water without any loss of yield, as well as reducing GHG emissions; (ii) nutrient management, e.g. by increasing fertilisation efficiency, e.g. substituting unavailable nutrients with locally produced nutrients; (iii) variety options, e.g. planting varieties with higher tolerance to extreme weather; and (iv) waste management, e.g. keeping waste biomass in the fields to add organic matter and retain more water in the soil (Balitbangtan, 2012).

SRI, introduced in early 1970 in Indonesia, is another cultivation method deemed adaptive to climate change. Under SRI, a seed is planted in a rice field with a broader planting space of 25–30 centimetres and saturated irrigation are applied to keep the surface soil moist. SRI can grow more shoots and achieve higher productivity (above 8 t of wet paddy per ha) and higher water productivity (2.5 kilogrammes per cubic meter of water) with lower GHG emissions (2.5 ton of carbon dioxide gas equivalent (CO_2e) per each ton of dried paddy). The area planted under SRI increased from 1,100 ha in early 2007 to more than 900,000 ha in 2016.

Another method, known as Salibu, was initially developed in West Sumatra. This method applies ratooning by cutting the harvested plants about 5 centimetres from the soil surface to allow new roots to emerge from the cuts (Puslitbangtan [Indonesian Center for Food Crops Research and Development], 2013; Abdurrahman et al., 2015). After 10 days, the roots touch the soil surface and extend to a deeper soil layer. Days to harvest become shorter (less than 90 days) with yields of more than 7 t/ha of wet paddy. In some locations, the ratooning intensity increased fourfold with yields that were not very different from those of the mother plants. With Salibu, seeds and seedlings are not necessary for the second or subsequent planting seasons, but the soil should be kept moist after harvesting.

The Hazton rice cultivation method is named after Hazairin and Anton Kamarudin, two scientists at the Agricultural Agency of West Kalimantan who invented this technique in early 2012. Hazton uses 20–30 seedlings at an older age (25–30 days) in one planted spot, and each plant generally has a similar age of maturity. Experienced farmers can have yields of 7–14 t/ha of dried paddy. Other advantages include not needing to weed, harvesting crops 2 weeks earlier than usual, higher adaptability to climate and location, and reduced or minimal pest and disease attacks. Hazton is being applied in 24 provinces on more than 50,000 ha (Directorate General for Food Plants (Dirjentanpangan), 2016b).

5.4 The system of Rice Intensification

5.4.1 Basic Features

SRI has spread significantly since the end of the 20th century. Its resource savings and high productivity contribute to food security in normal conditions and can reduce damages when the weather fluctuates. SRI is a rice cultivation method developed in Madagascar in the early 1980s by a French priest, Fr. Henri de Laulanié, S.J. It spread outside Madagascar after 1997 through the support of Norman Uphoff of Cornell University, the World Bank, and some non-governmental organisations. It is now practiced in more than 44 countries around the world (Uphoff and Kassam, 2009).

SRI has innovated rice production systems by raising the productivity of land, labor, water, and capital without increasing external inputs and materials. It is a set of modified practices for managing rice plants as well as the soil, water, and nutrients. SRI can produce more paddy yield with less external inputs and is environmentally friendly. It can be adopted for any type of rice variety (local, high-yielding, or hybrid).

It is based on the following principles: (i) transplant very young seedlings (baby seedlings); (ii) transplant single seedlings at a hill with the utmost care for seed roots; (iii) transplant using wider spacing; (iv) reduce the use of chemicals (fertilisers, pesticides, insecticides, and herbicides); and (v) decrease water use by applying a wet-dry cycle of soil moisture (Stoop, Uphoff, and Kassam, 2002).

Benefits and Impacts of SRI

SRI methods generally have the following benefits and impacts compared with conventional methods of paddy cultivation: (i) paddy yields increase by 20%–50% and sometimes 100% or more, especially with improved cultivation methods; (ii) the seeds required for transplanting decrease by 60%–80%; (iii) the use of chemical fertilisers and agrichemicals can be reduced; (iv) irrigation water can decrease by 25%–50%; (v) production costs usually decline by 10%–20%; and (vi) farmers' net incomes increase with higher outputs and reduced costs. Table 5.3 compares the SRI method with the green revolution (rice) approach.

Table 5.3: Comparison Between the Green Revolution and the System of Rice Intensification

Item	Green revolution (rice)	SRI
History	In the 1960s, a new high-yielding variety of rice (IR-8) developed by the International Rice Research Institute caused remarkable yield increases and was accepted internationally as a key to solving food shortages.	In the 1980s, an innovative paddy cultivation method was developed in Madagascar then disseminated worldwide.
Principle	The increased unit yield of paddy by using a high-yielding variety with increased use of chemical fertilisers and water.	The increased unit yield of paddy by any rice variety by reducing seeds, chemical fertilisers, and water.
Environment	Heavy burden on the environment because of the high use of chemical fertiliser and agricultural chemicals.	Environment-friendly because of the reduction in greenhouse gases through intermittent irrigation and chemical use.
Water use	High consumption of irrigation water	25%–50% less use of irrigation water
Evaluation	No rice yield increases in recent years. Shortage of water resources and overuse of chemicals have caused problems.	Rice yield can increase with less input of external resources and can lower production costs.

Source: Arranged from Uphoff, N. and A. Kassam (2009).

5.4.2 Mechanism of Soil Condition Improvement

The following two techniques contribute not only to plant growth but also to reducing GHGs.

1) Aerobic Soil Conditions

Using very young (baby) seedlings is the most important contributor to higher SRI yields. The second most important factor is keeping the paddy soil moist but not continuously saturated or flooded, as this can avoid the suffocation and degeneration of rice plant roots and supports more abundant and diverse populations of aerobic soil organisms that provide multiple benefits to the plants. This condition can be achieved through alternate wetting and drying cycles or keeping the surface soil moist but not flooded. The operative principle is to provide both roots and soil biota with optimising amounts of both water and oxygen. The result is larger and deeper root growth, which gives rice plants more resilience to adverse climatic conditions such as droughts, storms, or extreme temperatures.

2) Active Soil Aeration

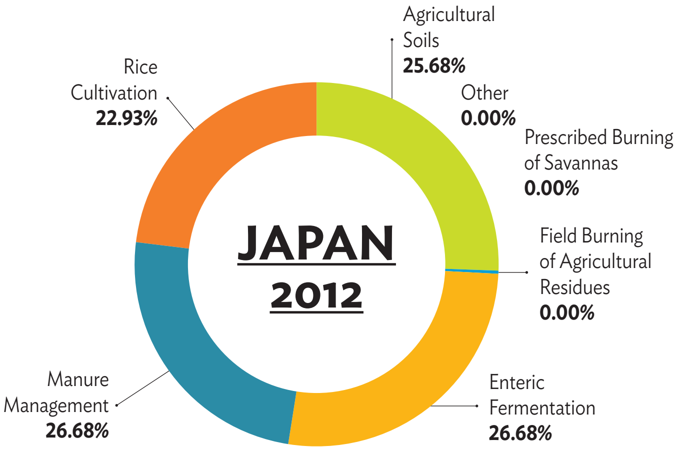
Not flooding fields is conducive to passive soil aeration, allowing biological processes to improve soil structure and functioning. Beyond this, SRI promotes mechanical measures to aerate the soil. When paddy fields are not kept flooded, weed growth becomes a more significant problem. SRI results depend substantially on maintaining mostly aerobic soil conditions. Good soil aeration can be obtained through biological means via the activity of the soil biota. Instead of weeding and throwing the weeds outside the plot, a rotary weeder can be used to turn the weeds into the soil. This technique creates the following benefits: (i) the soil becomes aerated and (ii) the weeds decompose in the soil and turn into organic matter. This causes the roots and plant to grow healthily, and higher yields can be achieved.

5.4.3 Advantages of SRI

1) GHG Emissions in Japan

In 2017, annual GHG emissions amounted to 1.3 billion t of CO_2 base, with Japan contributing around 3%. The share of agriculture is not very large within Japan's GHG emissions. However, every sector should decrease their emissions regardless of the size of their share. Figure 5.5 shows the breakdown of GHG emissions in the agriculture sector. The share of rice cultivation is about 23%. By introducing SRI, GHG emissions from rice cultivation will decrease.

Figure 5.5: Greenhouse Gas Emissions in the Agriculture Sector

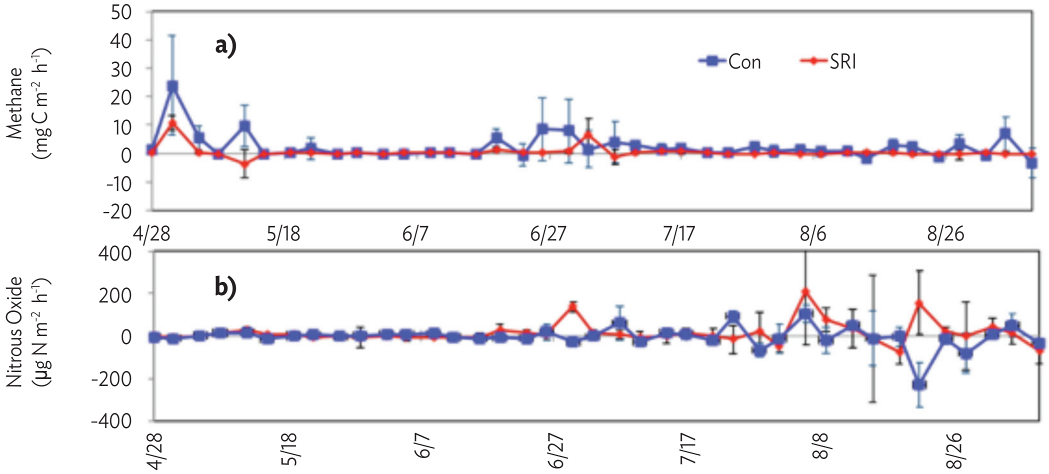


Source: MAFF (2017).

2) GHG Reduction by Adopting SRI

Not flooding rice cultivation can decrease methane emissions. This has been shown by researchers such as Setiawan et al. (2014) through measurements in SRI fields. shows the methane and nitrous oxides emitted from SRI paddy fields in Indonesia (Motomura and Yamaji, 2009). At the experimental fields in Puyung village, Sulawesi island in Indonesia, gases from SRI and conventional growing fields were collected and analysed every 3–4 days for a complete growing season. If converted to global warming potential, the conventional paddy field emitted 250 gCO_2 m^{-2} while the SRI paddy field emitted only 100 gCO_2 m^{-2} in one season. With SRI, methane emissions decreased significantly – about five times – while nitrous oxides increased 50 times, though their value was considerably small. The exciting part is that the proportion of methane and nitrous oxides to global warming potential is almost the same, at 50%.

Figure 5.6: Methane and Nitrous Oxide Gas from SRI Paddy Field



Con=Conventional, SRI=System of Rice Intensification.

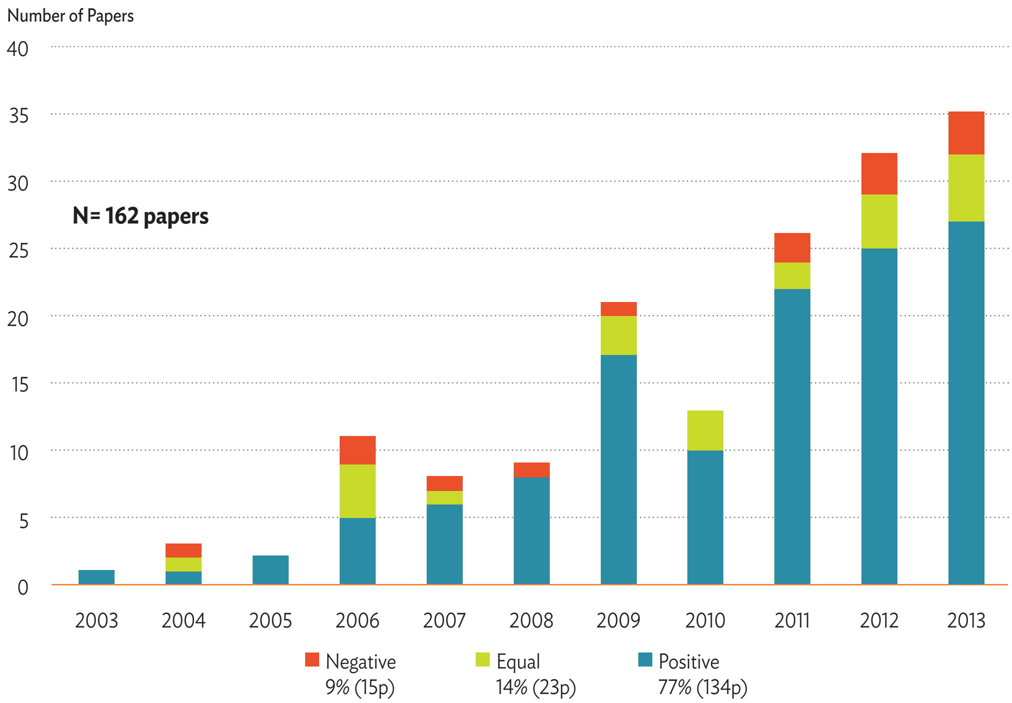
Source: Motomura and Yamaji (2009).

3) Other Effects of SRI

As SRI effect of yielding increase stated previously, however, there were some disputes found in scientific articles elsewhere during 2004–2005.

Figure 5.7 shows the number of articles that discuss the yield in the reviewed articles (Styger, 2015). Some 77% of the articles are positive regarding the yield increase, while only 9% report a decrease in yield. This suggests that SRI can provide farmers with higher yields in many cases. In Cambodia, SRI increased yields 30% more than the conventional method (Ches and Yamaji, 2015). SRI paddy also has more robust and stronger tillers, with thicker and denser roots, making it considerably more resistant to stronger winds and heavier rainfall (Chapagain, Riseman, and Yamaji, 2011). In Japan, where farmers prefer to grow a tasty variety that is vulnerable to strong winds and rainfall, the SRI method is a recommendable option for rice cultivation.

Figure 5.7: Yield Effect for SRI System in Comparison Trials



SRI = System of Rice Intensification.

Source: Styger (2015).

5.5 Concluding Remarks

This chapter has described the threat of natural disasters and the risks caused by climate change on food production in some Asian countries, paying attention to the different effects on inland and coastal areas. Successful adaptation measures carried out by each state to anticipate and minimise the risks were highlighted for lessons learned and further consideration in identifying adaptive measures. Table 5.4 summarises the common threats of climate change to food production, along with recommended structural and non-structural adaptive measures.

Table 5.4: Threats to Agriculture and Adaptation Measures

Areas	Threats and Adaption Measures		
	Drought	**Flooding**	**Seasonal Uncertainty**
Inland	Structural: • Groundwater extraction • Closed system irrigation • Efficient irrigation system Non-structural: • Weather monitoring • Insurance • Drought-tolerant cultivars • Integrated pest management	Structural: • Drainage system • Water harvesting • Groundwater recharge • River embankment • Checkdam • Efficient drainage system Non-structural: • Weather monitoring • Insurance • Delineation of high-risk areas • Amphibious cultivars	Structural: • Irrigation and drainage system • Distributed water reservoir • Pumping station Non-structural: • Weather monitoring • Insurance • Planting calendar • Tougher cultivars to weather fluctuation • Shorter age cultivars
Coastal	Structural: • Groundwater extraction • Closed system irrigation • Water storage system Non-structural: • Weather monitoring • Insurance • Drought-tolerant cultivars • Saline-tolerant cultivars • Integrated pest management	Structural: • Drainage canals • Groundwater recharge • River embankments • Sea embankments Non-structural: • Weather monitoring • Insurances • Amphibious cultivars • Integrated pest management	Structural: • Irrigation and drainage system • Groundwater extraction • Closed system irrigation • Water harvesting Non-structural: • Weather monitoring • Insurance • Amphibious cultivars • Integrated pest management • Planting calendar • Shorter age cultivars

Source: Anbumozhi, et al. (2018).

5.6 Policy Implications

All Asian states are facing the impacts of climate change on food production, which could cause food shortages and disturb the food supply chain within and amongst countries. Therefore, mutual precaution and cooperation need to be prioritised. In this era of connectivity, food problems in one country can generate adverse impacts on relations with others, trade imbalances, and regional security if not appropriately solved. Thus, it is essential to introduce an enhanced methodology for disaster risk and climate prediction at the regional level; and to strengthen early warning systems for international river basins and economic impact assessments of collective cross-border actions.

As the threats of climate change are more severe in developing countries, advanced countries should take the lead to ease the tensions caused by climate change in the region as they are more prepared in terms of human resources, technology, and management systems. Each developing country needs to develop an agricultural policy that is compatible with the real threats of climate change faced, which may differ from one place to another. Thus, it is essential to share and promote regional best practices in mainstreaming adaptation practices in the agricultural sector.

As farmers will bear the direct impacts of disasters in their fields, governments – from central to local authorities – should work closely with them and respond quickly when unexpected trends could be severe to plant growth. It is highly advisable for farmers to be protected with insurance to cover possible losses or lower quality products so that they can recover more easily. Thus, it is essential to provide training and capacity building to farmers and private sector operators for better no-regret adaptation management, focusing on internationally accepted best practices that are locally appropriate.

Finally, each country needs to share and integrate their adaptation roadmaps on appropriate guidelines, amongst others, on how to promote public awareness, improve scientific capacity, set feasible standards/benchmarks for structural measures, develop new programmes to strengthen non-structural measures, improve cross-sectoral coordination, augment financial resources, and strengthen capacity for regional cooperation (Anbumozhi et al., 2018).

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CHAPTER 6

Effects of Disasters and Climate Change on the Livestock Sector and Implications for ASEAN Food Security

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6.1 Introduction

With the effects of climate change already being felt, we are facing major challenges: food security and climate change adaptation. According to the Intergovernmental Panel on Climate Change (IPCC), the average global temperature has risen 0.74°C (0.56°C–0.92°C) over the past 100 years (Kim, 2011). The third report of the IPCC uses complex climate models which forecast global mean surface temperatures to rise by 1.4°C–5.8°C by the end of 2100. Global warming – the increase in average global temperatures – is the reason for climate change. Agriculture is vulnerable to disasters and climate change, in terms of economic resources as well as food security (Otte, 2014). Favourable weather and climate are the key to success in agriculture, but global warming and climate change affect the agriculture sector throughout the world. With increasing impacts of climate change and natural disasters, the yields and profits of agricultural systems have been declining. Soil scientists, agricultural engineers, and integrated crop and livestock farmers are making significant efforts to reduce the losses caused by disasters and climate change. The impacts of climate change on present day agriculture are essential in making a new vision for future agriculture policies (Kim, 2011). In the last 30 years, climate change has reduced global agricultural production by 1% to 5% per decade (Thornton, Boone, and Ramirez-Villegas, 2015).

6.1.1 Climate Change in the Republic of Korea

The Republic of Korea (henceforth, Korea), located in the northern hemisphere, belongs to a temperate climate zone with four distinct seasons. The average temperature of Korea has increased by 1.5°C over the last 100 years (Korea Rural Economic Institute (KREI), 2010). This is much greater than the global temperature rise of 0.7°C. Korea's average temperatures are expected to increase by a minimum of 2°C from 2000 to 2050 (when simulated under the IPCC's Climate Change Scenario A1B). Seawater surface temperature is estimated to increase by about 1.3°C by 2050 and 2.9°C by 2100.

Precipitation in Korea has risen by 19% over the last 100 years (Myeong, 2012). Increased instances of extreme rainfall in the summer and prolonged droughts in the winter are also expected. Scientists predict a further rise of 9.5 centimetres by 2050 and 20.9 centimetres by 2100.

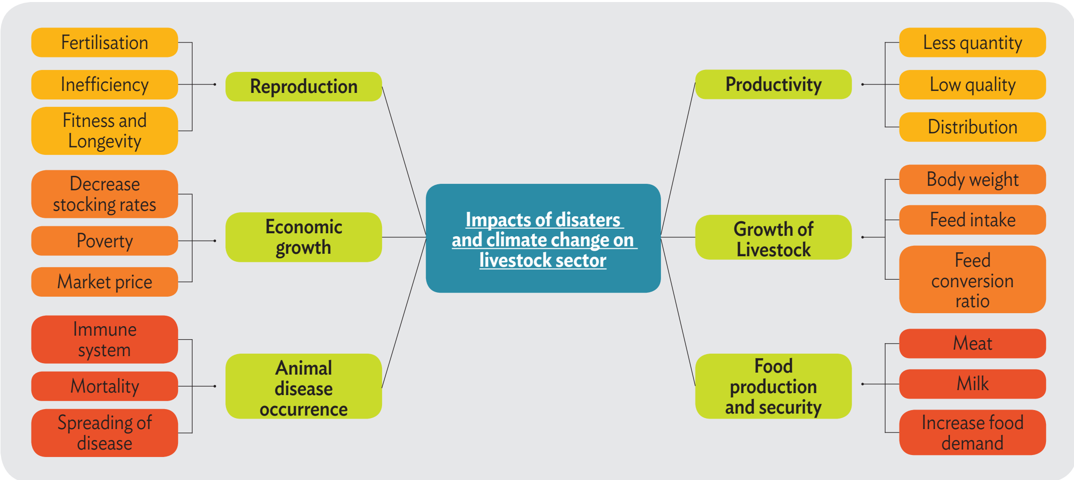
6.2 Climate Change Impacts on Livestock Production

Farming is a source of livelihood for one-third of the world's population, and about 60% own livestock. Nearly 800 million livestock owners live on less than $2 a day (Food and Agriculture Organization of the United Nations (FAO), 2011). Livestock is a rapidly growing subsector, with 40% of the global agricultural gross domestic product, and it is key to food security in all regions. Meat and milk consumption have increased significantly and are projected to rise in gross terms by 70%–80% over current levels by 2050 (Herrero et al., 2015). Demand for livestock production has increased because of the rise in the world's population. However, climate change affects livestock systems in several ways. It impacts livestock production and causes biological changes in livestock, such as fertilisation and breeding.

Extreme weather events (e.g. heatwaves, floods, and droughts) cause livestock productivity losses and deaths (Gaughan and Cawsell-Smith, 2015). Some animals can survive in hot conditions, but it will limit livestock production. It is generally accepted that an increase in temperature has negative effects on livestock feed intake, reproduction, and performance (Porter et al., 2014). More research is needed on the impacts of climate change on livestock since most of the work to date has focused on crops. The impacts on livestock systems will be measured through reduced feed quantity and quality, changes in pest and disease prevalence, and direct impairment of production caused by physiological stress. Growth and meat, egg, and milk yield and quality decrease as temperatures exceed 30°C because of reduced feed intake (Thornton and Gerber, 2010).

Directs impacts of climate change on livestock production include heat stress, humidity, wind, drought, frost, and floods – leading to a decrease in milk production, meat production, reproduction, animal health, and behavioural performance. Indirect impacts include nonavailability of food resources because climate change affects the livestock pasture pattern as well as rangeland vegetation patterns. Future impacts of climate change on livestock production are likely to be direct via productivity losses (physiological stress) owing to temperature increases; and indirect through changes in the availability, quality, and prices of inputs such as fodder, energy, disease management, housing, and water (Thornton, 2010). The impacts of disasters and climate change on the livestock sector are illustrated in Figure 6.1.

Figure 6.1: Impacts of Disasters and Climate Change on the Livestock Sector



Source: Author.

The major impacts of climate change on livestock and human diseases have been on vector-borne diseases. Increasing temperatures have supported the expansion of vector populations into cooler areas – higher altitude systems (e.g. malaria and livestock tick-borne diseases) or more temperate zones. Changes in rainfall patterns can also influence an expansion of vectors during wetter years. Variations in temperature and rainfall are the most significant climatic variables affecting livestock disease outbreaks. Many rapidly emerging diseases continue to spread over large areas. Warmer and wetter weather increases the risk of animal disease, which can damage the immune systems of livestock, cause mortality, and raise the risk of spreading disease (e.g. foot-and-mouth disease (FMD) and flu virus). Outbreaks of diseases such as FMD or avian influenza affect large numbers of animals and contribute to further degradation of the environment and surrounding communities' health and livelihoods. Outbreaks of FMD caused by the serotype O virus occur in cattle and pigs. Korea did not have an outbreak from 2000 until November 2010, when a widely extended outbreak last 5 months. The outbreak was extremely detrimental to the domestic food supply chain, resulting in economic losses of about $1.7 billion. Market prices were increased to help resolve the issue. The use of technology, improvements in breeds, more intensive production systems, and market opportunities at the local, national, and international levels were implemented to control and manage the situation. The government sector imposed quarantines, initiated a vaccination campaign targeting 9 million pigs and 3 million head of cattle, and culled 2.2 million livestock, with an overall cost estimated at around $1.6 billion. Nearly 74% of hogs and 99% of cattle were vaccinated and culled, and the number of daily FMD cases gradually decreased (Park et al., 2013). Currently in Korea, in 150,000 head of cattle, accounting for about 5% of the total head; and 34% of the total pig inventory affected by FMD, the Ministry of Agriculture, Food and Rural affairs confirmed FMD decreased because of appropriate vaccination.

Disasters and climate change can adversely affect productivity, resulting in less and lower quality production and affecting the distribution of livestock products. Decreased productivity causes food production to decline – including meat and milk – and demand for food to increase. The reproductive system of livestock is also affected by thermal stress, associated with climate change, through inefficiency in embryo development and fertilisation. To analyse how and to what extent the change in temperature and precipitation accompanying global warming affects the livestock sector, various experiments, simulations, and research have been carried out both in laboratories and in the field (Rojas-Downing et al., 2017).

Disasters and climate change also affect economic growth in the livestock sector. They cause poverty if the livestock of an area is damaged by disasters, the stocking rates of an area decrease, and the market price of certain types of livestock increases because of lower availability. Livestock systems have both positive and negative effects on the natural resource base, public health, social equity, and economic growth (World Bank, 2009). They make up 33% of the agricultural gross domestic product, and this share is increasing rapidly. This growth is driven by the rapidly increasing demand for livestock products, while the demand is driven by population growth, urbanisation, and increasing incomes in developing countries (Delgado, 2005).

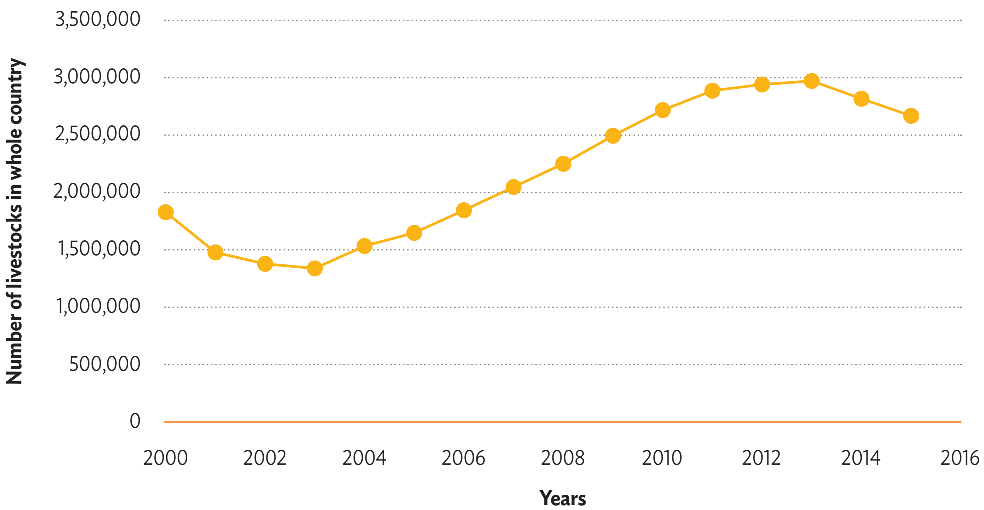
Climate change will have severely deleterious impacts in many tropical and subtropical zones, even with small increases in average temperatures. This is in contrast to many parts of the temperate zone where agricultural productivity is likely to increase slightly at mid- to high latitudes, with local mean temperature increases of 1°C–3°C (Parry et al., 2007).

Several options are available for livestock management, including grazing and manure management. Global agriculture could offset 5%–14% (with a potential maximum of 20%) of total annual carbon dioxide (CO_2) emissions at prices ranging from $20 to $100 per ton of CO_2 equivalent (tCO_2eq) (Smith et al., 2008). The increase in temperature also has negative impacts on forage quality, which is connected to livestock productivity (Thornton, Boone, and Ramirez-Villegas, 2015).

6.3 Status of Korean Livestock Production

Korea's livestock industry underwent rapid transformation as the production of poultry and pig farming expanded dramatically in the late 1970s and 1980s. In 1989, the domestic feed production for livestock was 10 million tons (Chung et al., 2014). Korean livestock demand increased with the growing population from 1995 to 2013. Per capita consumption grew 2.4% annually from 27.5 kilogrammes (kg) in 1995 to 42.8 kg in 2013, while meat production rose 2.2% per year from 1.057 million tons to 1.587 million tons over the same period. Meat imports also increased with rising consumption (KREI, 2015). Per capita pork consumption grew from 14.8 kg in 1995 to 20.9 kg in 2013. Imports increased because of the shortfall in pork production over demand, as self-sufficiency rates fell from 92.4% in 1995 to 81.1% in 2013 (KREI, 2015).

Figure 6.2: Annual Livestock Production in Rep. of Korea, 2000–2016

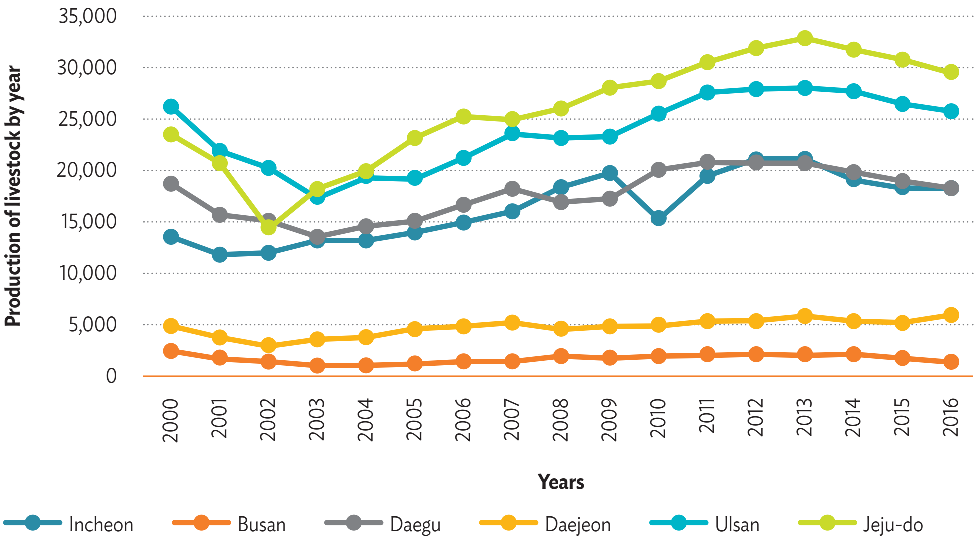


Source: Korean Statistical Information Service (KOSIS).

Korea's livestock industry is facing problems because of animal disease and the impacts of climate change. The planting of crops that are used to manufacture animal food is being delayed because of the temperature rise, which is causing a decrease in the productivity and quality of livestock products. Figure 6.2 shows the annual livestock production in Korea from 2000 to 2016. The lowest number of livestock was recorded during 2000–2004 because of heat stress, as the highest temperatures and lowest precipitation rates were recorded in 2001. High temperatures were also recorded in 2015, causing a decreasing trend. Therefore, heat stress directly affects the production of livestock.

FMD is another factor in the reduction of Korea's livestock sector. A serious outbreak of FMD occurred in Korea in 2010–2011, leading to the culling of hundreds of thousands of pigs (in January 2011) in an effort to contain it. The outbreak began in November 2010 in pig farms in Andong, Gyeongsangbuk-do and spread rapidly throughout the country. Figure 6.3 shows the livestock production in major cities of Korea from 2000 to 2016.

Figure 6.3: Livestock Production in Major Cities of Rep. of Korea, 2000–2016



Source: Korean Statistical Information Service (KOSIS).

6.4 Food Insecurity

Climate-related disasters cause food insecurity in their immediate aftermath and the long run. Drought is the main driver of food insecurity, which has negative impacts on nutrition. Floods and storms also cause food insecurity, destroying and changing livelihood assets. The factors to determine food security are food production, prices, demand, and supply. The effects of climate change on our ecosystems are already severe and widespread. Ensuring food security in the face of climate change is amongst the most daunting challenges facing humankind. While some of the problems associated with climate change are emerging gradually, action is urgently needed to allow enough time to build resilience into agricultural production systems to combat them (FAO, 2015). From 2011 to 2013, about 842 million people went hungry as they did not receive enough food to maintain an active and healthy life (FAO, International Fund for Agricultural Development, and World Food Programme, 2013). Livestock contributes greatly to food security because it (i) supplies calories, protein, and nutrients; (ii) mostly eats feed that is not appropriate for human consumption; and (iii) provides manure for crop production, which is rich in nutrients (FAO, 2011). Sustainable livestock production needs more research, extension, and demonstration.

It is also important to maintain efficient conversion of natural resources to human food to sustain a neutral food balance (FAO, 2011). Food balance can be accomplished through the efficient production of protein from livestock (FAO, International Fund for Agricultural Development, and World Food Programme, 2013). However, climate change will influence this conversion by affecting the nutritional content of livestock products (Harvell et al., 2002; Patz et al., 2000) and reducing livestock production (Hatfield et al., 2008). Animal source foods provide high-quality protein and a variety of micronutrients that are difficult to obtain in adequate quantities from foods of plant origin alone. Animal source foods provide 15% of total food energy and 25% of total dietary protein (Rojas-Downing et al., 2017). Currently, the livestock sector's best approach to food security is by addressing the primacy of food balance (FAO, International Fund for Agricultural Development, and World Food Programme, 2013; FAO, 2011).

6.4.1 ASEAN Livestock Production and Food Security

With limited arable land for growing crops and raising livestock, continuous human population growth, climate change, rising demand for fossil fuels, and so forth, we face unique challenges in ensuring food security for our people. Growing incomes in the region have caused demand for food to rise rapidly, and we face the challenge of meeting this demand with limited and sometimes declining natural resources. Since food security includes good nutrition, meeting true food security requires educating people on the nutritional value of foods and good eating habits, as imbalanced diets or malnutrition can cause a number of non-infectious diseases. These include obesity, micronutrient and/or trace element deficiencies, diabetes, cardiovascular disease, and cancer.

Table 6.1: Status of Livestock Production in ASEAN Countries, 2014

ASEAN countries	Buffalo	Goat	Cattle	Duck	Chicken	Pig
Brunei Darussalam	102	40	604	250	28,040	30
Cambodia	9,723	–	69,205	9,142	17,556	1,04,195
Indonesia	35,236	65,142	497,669	37,985	1,939,225	7,58,999
Lao PDR	19,750	1,923	30,131	4,550	25,234	68,443
Malaysia	3,477	1,670	27,462	157,279	14,15,515	2,17,558
Myanmar	46,914	66,356	232,804	129,005	1,389,207	834,000
Philippines	100,078	55,323	201,390	29,767	1,114,881	1,690,692
Singapore	0	12	46	5,000	90,000	18,542
Thailand	28,306	1,868	163,264	56,178	1,756,536	948,901
Viet Nam	94,420	8,085	292,501	102,646	633,334	3,330,590

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Note: All livestock values are in tonnes.

Source: Food and Agriculture Organization Statistics (2014).

The Association of Southeast Asian Nations (ASEAN) is one of the fastest growing regional economic communities, and its population of more than 600 million is larger than that of the European Union. Heterogeneity prevails, however, as ASEAN member countries are diverse in many aspects. Large disparities exist in population size, cultural background, economic structure and development, and level of disposable income. Likewise, there are large differences in the structure of the livestock sectors of ASEAN members and their respective levels of technology adoption. Large technology gaps in animal production practices exist between ASEAN countries and even within countries. It is thus necessary to clearly identify critical technology gaps and specify the rationale for attempting to bridge the gaps before embarking on major technology development/adaptation and dissemination programmes. This paper reviews these livestock sector developments with a 'sustainability lens' to produce recommendations on areas in which new technologies need to be deployed and/or developed. Table 6.1 shows the status of meat production of ASEAN countries.

ASEAN countries are facing food security problems as a result of natural disasters. The ASEAN region is home to 2.6 billion chickens, 225 million ducks, 15 million buffalo, 47 million cattle, 71 million pigs, 26 million sheep, and 12 million goats to feed more than 620 million inhabitants. Although livestock production is growing rapidly, the average meat consumption in ASEAN countries is still low when compared with industrialised countries; and food insecurity problems arise in many ASEAN countries, especially after disasters and extreme climate events.

6.4.2 Korea Begins Work to Improve Food Security in ASEAN

Korea will help improve food security in Southeast Asian countries, using its advanced technology to provide detailed information on regional and global food conditions. A collaboration project for 'Improving the Resilience of the Agriculture Sector to Climate Change Impacts' in the Lao People's Democratic Republic (Lao PDR) will help set up a real-time agricultural information system, according to the Ministry of Agriculture, Food and Rural Affairs in 2015 (International Food Policy Research Institute, 2016). Under the agreement, Korea will build a national system in the Lao PDR that shows food supply conditions in the Southeast Asian region and throughout the world. Such information will be shared by Korea with all 10 ASEAN Member States, helping them to prepare for possible food shortages or price hikes. The Lao PDR project is part of Korea's official development aid programme for ASEAN countries, which seeks to help establish the ASEAN Food Security Information System (International Food Policy Research Institute, 2016). Korea plans to spend up to $2 million to help set up the information system in six other countries: Cambodia, Indonesia, Myanmar, Philippines, Thailand, and Viet Nam.

6.5 Adaptation to Climate Change and Food Security

Adaptation contributes to reducing the negative risks associated with climate change and provides opportunities to use climate change for positive effects. It plays an important role in mitigating the impacts of climate change – including actions to mitigate damage from climate change and enhance future adaptive capacity both directly and indirectly. Evaluation of the impact of, as well as the vulnerability and adaptation to, climate change in Korea has ceased to remain in the theoretical and academic domain and is being used to formulate policies and action plans to address its problematic effects. Research-based observation can be the user guide in the formulation of action plans which will yield scientific and thus effective results. Decision-making stakeholders require a wide range of information to develop policies responsive to climate change. This includes (i) the locations where damage from climate change is expected, (ii) the predicted impact range caused by climate change, (iii) the climate change impact projections, (iv) the potential and inevitable impacts, (v) an analytical evaluation, (vi) the probability of the occurrence of various risk factors related to climate change, and (vii) an assessment of the reduction of vulnerability in response to future adaptation strategies.

6.5.1 Korean Adaptation Measures to Climate Change and Food Security

Korean adaptation measures for climate change and food security access current and future impacts of climate change, analyse the adaptive ability of each region to identify the key vulnerability, and thereby establish annual implementation strategies to reduce damage caused by climate change. Adaptation measures require extensive experience and many professionals, as they must predict the impact of climate change on health, agriculture, ecosystems, and various other areas; and prepare appropriate measures. The new adaptation measures include the following:

(i) precision livestock smart farming (PLSF);
(ii) the application of information and communication technology (ICT);
(iii) policies and strategies for adaptation; and
(iv) the role of institutions.

(i) Precision Livestock Smart Farming

Farmers are facing an unprecedented increase in animal and livestock disease outbreaks because of globalisation and climate change. This affects productivity, causes low production of meat and milk, and takes its toll on the economy. According to the FAO, International Fund for Agricultural Development, and World Food Programme (2013), technology solutions in agricultural and livestock production systems will play a key role in addressing this challenge and ensuring adequate food supply. While increasing production, it will be important to find ways to minimise the environmental footprint of livestock farming and ensure high levels of health and welfare for animals. Such solutions should enable farmers to manage a large number of animals in an adequate and profitable manner. PLSF systems offer solutions to all of the above challenges, as they help farmers to increase the quantity and quality of livestock production in a sustainable manner; offer tailored care for animals in terms of feeding, milking, and housing; and make many of the farmers' daily tasks much easier to handle. This system includes precision feeding systems, which allow farmers to feed their cows accurately, precisely, and with minimal human intervention. Precision milking robots or automatic milking machines are a good example of the large-scale adoption of PLSF systems. These robotic systems can handle up to 65 cows an average of 2.7 times per day. Stable and farm management systems also showcase the application of PLSF through support and monitoring systems which use cameras and microphones to act as the eyes and ears of the farmer at all times.

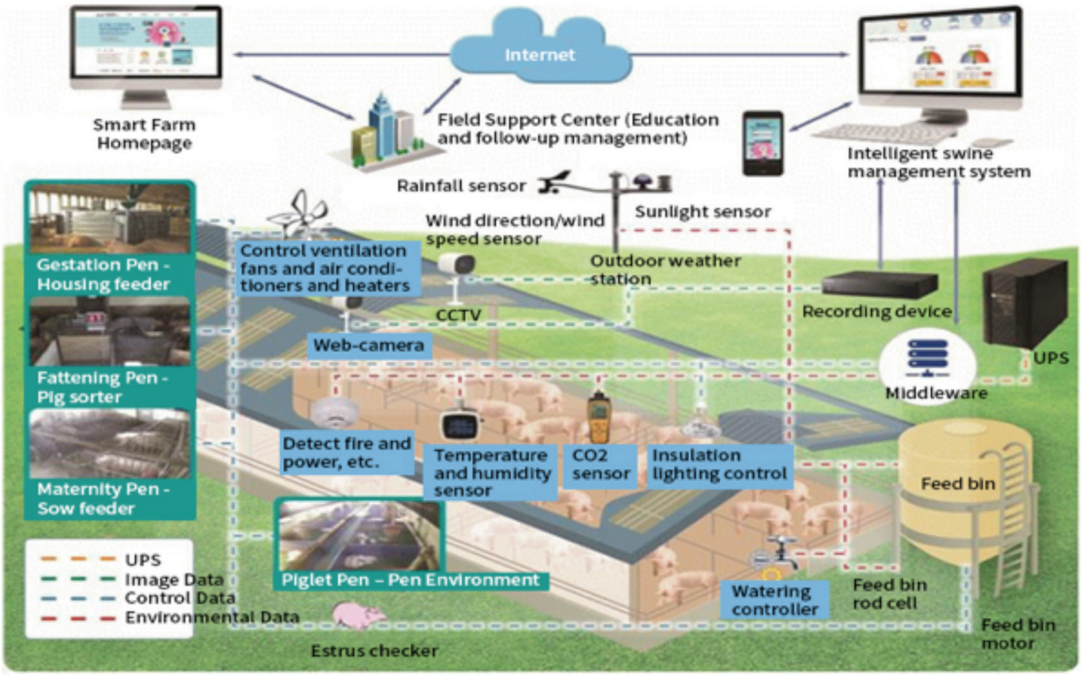
The Internet of Things (IoT) provides another platform for PLSF, as it can provide real-time data to the farm authorities. Data are collected through sensors installed at certain locations on a farm to create basic information for use in determining the optimal environment for livestock production. This information is easily transmitted on a wireless network and is automatically stored in the IoT server in real time. Farmers can receive the information on demand via a smartphone or personal computer. In addition, meteorological information pertaining to weather or predicted disasters can use an IoT system, with the aim of increasing the efficiency of livestock production.

(ii) Application of ICT

ICT plays a role in both supply chain and farm management. It uses information on climatic trends, enabling the use of environmentally friendly and sustainable practices to cope with threats to productivity. The application of ICT has been accepted as beneficial in relation to achieving sustainable agricultural production to increase livestock production and profits. However, small farm holdings require considerable investment to implement ICT systems.

To determine the environmental conditions and performance of each system, with the aim of controlling livestock farm temperatures, a number of factors are involved in implementing ICT. Such factors need to be estimated before applying or installing ICT to enable efficient management. Korea has been seriously affected by rising temperatures and altered rainfall patterns since 1981, which have had a strong indirect impact on increasing outbreaks of insects and FMD since 2000 (Park et al., 2013). Since 1995, the development trend of the ICT industry in Korea has been increasingly related to the agriculture, forestry, and fisheries sector (Lee and Kang, 1997). Figure 6.4 shows how ICT could be applied to optimize livestock farms.

Figure 6.4: Research on ICT Application in Livestock Farms

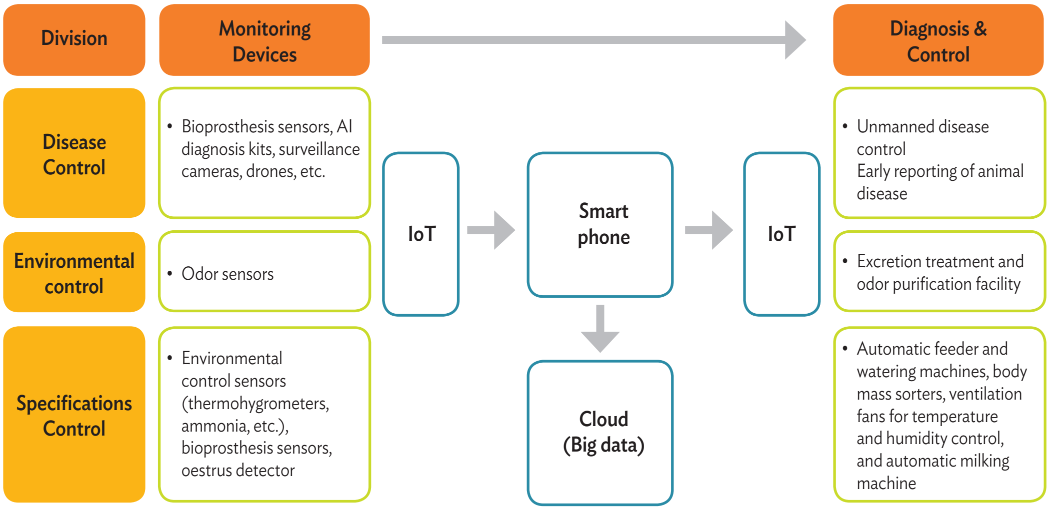


CO_2 = carbon dioxide, ICT = information and communication technology.

Source: Ministry of Agriculture, Food and Rural Affairs, Korea.

ICT is also used on livestock and aquaculture farms (Mana et al., 2015). In this decade, ICT has assumed increased importance in Korea. The policies of central and state governments are in favour of the use of ICT as a tool for agriculture extension activities. The spread of ICT-based information centres and the quality of rural connectivity is increasing. ICT shows considerable promise as a channel for the delivery of extension services. However, the success of ICT applications in livestock extension or allied sectors depends on various issues such as farmers' adoption of ICT, the political and policy environment, farmers' educational status, ICT penetration rates, ICT infrastructure (such as connectivity), and rural information models. Consequently, the use of IoT technology provides a platform for automatically controlling factors. To meet the growing appetite for meat and livestock derived products, livestock farms are increasing in size. Therefore, farmers must find greater integration of ICT into their production processes so that their farming knowledge can be exploited to better effect. In a new era where all things are digitally connected, ICT – including IoT – can raise productivity and bring innovation to traditional industries.

Figure 6.5: Structure of the Proposed ICT System in Farms



AI = artificial intelligence, ICT = information and communication technology, IoT = Internet of Things.

Source: Ministry of Agriculture, Food and Rural Affairs, Korea.

Korea's current livestock industry is competing with the livestock industry of advanced countries, but problems like climate change and disasters cause livestock diseases such as FMD and artificial intelligence, which lead to mortality and financial damages. To solve such problems, livestock farms need to create an optimal breeding environment using scientific technology and integration systems. ICT systems provide an optimal breeding environment to collect real-time environmental information. The installation of environmental sensors in livestock farms generally gives information on temperature, gas emissions, and humidity. This technology also provides information such as oestrus detection and delivery times. Therefore, it reduces labour requirements and operates livestock farms systematically. The use of these techniques is one way to increase the quantity and quality of livestock production and overcome food security in the country.

(iii) Policies and Strategies for Adaptation

As adaptation contributes to reducing the negative risks of climate change and provides opportunities to use the climate for positive effects, policies play an important role in mitigating the impacts of climate change. The effective implementation of adaptation measures should be encouraged, and the most suitable adaptation measures should be selected through the assessment of available adaptation measures. To determine the priorities for application of adaptation measures to climate change, efficiency, effectiveness, feasibility, and acceptance are set as assessment criteria. Adaptation and mitigation can make significant impacts if they become part of national and regional policies (FAO, 2009). The following regional policies are designed to provide adaptation and mitigation practices.

Flash Flood Forecasting System

The National Disaster Management Institute has established a plan to minimise damage from flash floods by operating an early warning system 20–40 minutes before floods.

Typhoon Committee Disaster Information System

During the 38th session of the United Nations Typhoon Committee in 2005, the members of the Working Group on Disaster Risk Reduction agreed to establish an efficient data sharing tool for various tropical cyclone-related disasters. Korea has actively engaged in collecting data and developing ways to strengthen its functions.

Storm and Flood Insurance

Storm and flood insurance is controlled by the National Emergency Management Agency and operated by a private insurance company. Central and local governments support part of the insurance premiums for customers so that they can cope with unexpected storms and floods.

Agriculture and Fishery Disaster Insurance

The Agriculture and Fishery Disaster Insurance Act was enacted in 2010 to compensate for crop, aqua-cultural product, livestock, and facility damages caused by agriculture and fishery disasters. Agriculture and fishery disaster insurance is controlled by the government to enhance the stability of agriculture and fisheries and to increase production. It aims to contribute to the balanced development of the national economy.

In the basic framework of climate change adaptation and food security related to livestock, the following additional support facilities should be included:

(a) Food sustainability
- Sustainability in livestock productivity
- Long-term food security responses

(b) Development of real-time application-oriented technology
- Livestock smart farm development
- Breed technology development
- Weather station development

(c) Supporting facilities
- Expansion of agriculture disaster insurance
- Expansion of disaster-resilient facilities
- Early warning systems
- Technology application in disaster risk reduction
- Promotion of savings and insurance schemes

(d) Sustainable management
- Animal waste management process
- Livestock disease management
- Land and water resource management
- Low-carbon agriculture technology
- Knowledge management and sharing across sectors
- Partnerships with other humanitarian, development, and environmental organisations; research institutions; governments; and the private sector to identify practical and effective responses to climate change and food insecurity.

(iv) Role of institutions in adaptation to climate change and disasters

For adaptation to climate change, it is important to understand how the private sector and government institutions can respond effectively to adaptation with appropriate institutional mechanisms and incentive structures – driving behavioural change. Institutions should (a) make disaster risk reduction a priority, (b) improve risk information and early warning systems, (c) build a culture of safety and resilience, (d) reduce the risks in key sectors, and (e) strengthen response preparedness.

6.6 Government Support for Disaster Prevention and Restoration

The Korean government decided to redirect investment from restoration to prevention to minimise damage and reduce the burden of restoration. Using the stability assessment for vulnerable areas and facilities, the government sets priorities according to the degree of danger and the urgency to increase the effectiveness of investments. The three main goals of the Korean government's disaster management and prevention are to

- establish a comprehensive response system against natural disasters, focusing on preventive countermeasures;
- establish a disaster prevention information system and science-based disaster prevention strategies and policies; and
- promote international cooperation and prepare for the unification of Korea.

6.7 Adaptation Programmes by Institutions in Korea

Following a comprehensive review of domestic and foreign adaptation measures, Table 6.2 shows the programmes applicable to the Korean agricultural sector. These 19 adaptation programmes include five for research and development, three for infrastructure management, one for economic adaptation, three for legal and institutional improvement, two for education and training, one for monitoring, and four for technology and management measures applicable to farm households.

Table 6.2: Adaptation Programmes by Institutions in Korea

Category	Detailed adaptation programmes
R&D	1. Breeding 2. Production technology development 3. Base technology development 4. Resource technology development 5. Climate information system
Infrastructure management	6. Farmland management 7. Agriculture water management 8. Agriculture facility management
Economic means	9. Provision of grants
Legal and institutional improvement	10. Expansion of insurance system 11. Resource management system 12. Formulation of an adaptation measure
Education and training	13. Worker training 14. Education and public relations

Category	Detailed adaptation programmes
Monitoring	15. Assessment of adaptation and vulnerability
Technology and management	16. Production technology management 17. Soil management 18. Water supply management 19. Financial management

R&D = research and development.

Source: Korean Rural Economic Institute (KREI) (2010).

6.8 Recommendations for ASEAN Countries to Overcome Food Security

Climate change and natural disasters are a threat to livestock production, which can lead to food insecurity. ASEAN countries are also facing food insecurity problems because of climate change and disasters. Proper adaptation measures need to be followed to overcome these problems.

Korean adaptation measures against climate change impacts in the livestock sector are (i) PLSF, (ii) ICT application, (iii) policies and strategies for adaptation, and (iv) the role of institutions. These are the key to reducing losses from disasters in the agricultural sector in Korea.

- The recommended policies are as follows:
  - **Enhance** food security information systems (e.g. statistical baselines, livelihood profiles, and vulnerability and risk analysis)
  - **Improve** early warning systems and communication related to agricultural livelihoods and food security (e.g. crop forecasting, food price monitoring, monitoring of plant pests, animal diseases, fish diseases, biosecurity risks, and wildfires) and natural hazards (e.g. droughts, floods, and storms). Strengthen links between early warning, preparedness, and response mechanisms, including decision-making processes.
  - **Strengthen** the institutional mechanisms and legal and policy environments that enable and facilitate strategies and financial investments in risk reduction for the agricultural sector.
  - **Strengthen** the capacity of line ministries to deliver national legislation, policies, and strategies on disaster risk reduction through technical advice, human resources, expertise, training, practical tools, and services.

- Integrate disaster risk reduction into rural and agricultural development policies and plans.
- Develop agricultural sector-specific national strategies on disaster risk reduction across agriculture, fisheries and aquaculture, forestry, and natural resources management.
- Support policies, laws, and management systems that can improve the resilience of the agricultural sector in the future.
- Improve national and local preparedness planning in the agriculture, fisheries and aquaculture, livestock, and forestry sectors.
- Promote agricultural practices to strengthen preparedness at the national and local levels.
- Strengthen the capacity and capabilities of relevant ministries and departments in preparedness and planning for emergencies.
- Enhance the utilisation of local feed resources and balance feed needs with feed availability.
- Balance manure production with the absorption capacity of the agricultural land.
- Reduce the risk of disease emergence and spread.
- Reverse the widespread prevalence of antimicrobial resistance.
- Enhance the safety of animal source food.
- Utilise the livestock sector to raise rural incomes and living standards.
- Provide optimal environment for appropriate technology development/adoption.
- Enhance the nutrient content and/or digestibility of local feed resources, mainly agricultural by-products but also food waste.
- Improve the formulation of balanced rations, drawing on local feedstuffs.
- Breed for the capacity to digest lesser quality feeds.
- Promote cost-effective practices of manure management.
- Develop vaccines and other alternatives to antimicrobials to control diseases of intensification.
- Capitalise on advances in ICT in support of family farms.

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CHAPTER 7

Effects of Disasters and Climate Change on the Fisheries Sector and Implications for ASEAN Food Security

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7.1 Introduction

The Association of Southeast Asian Nations (ASEAN) has made remarkable progress in improving food security. In the early 1970s, undernourishment rates of the member countries were the world's highest at around 31% of the population but fell below 10% by 2016. This region comprises a diverse range of countries and fishery resource endowments. It has 2 million kilometres of coastline and over 25,000 islands, where more than 50% of the population live. Fish are important primary sources of protein for the majority of this population. They account for at least 15% of animal protein for more than 100 million people and up to 50% for some communities.

Fisheries, including inland aquaculture, are not only important contributors to food supply but also to livelihoods at both the local and regional level. Aquatic products are also one of the most widely traded and exported food products for many ASEAN Member States (AMS). This sector employs an estimated 80 million people in the 10 ASEAN countries; and the processing, marketing, distribution, and supply industries associated with fishing and aquaculture employ up to another 10 million people (World Bank, 2017). Increasing the income of workers in fisheries will be an important national development policy. Sales proceeding from aquaculture products are of a higher value than those from agriculture products, so the promotion of fishery production and aquaculture for both international trade and domestic consumption is what the government and private sector ought to strive for, from the perspective of food security.

Aquaculture systems in ASEAN are diversified, consisting mainly of ponds and net enclosures under high and low tides. As aquaculture is a major component of the rural economy in Indonesia, Thailand, and Viet Nam, its development and resilience are regarded as top priorities for food security and sustainable rural development.

Marine capture fisheries in ASEAN are heavily reliant on modern fishing vessels and technology. While the trend of global marine capture fishery production has been in decline from 2000, some countries in ASEAN have also shown a decline in fishing activity in coastal areas. Past studies which examined the production and stocks share the view that coastal areas in this region – such as the Thai Bay, coasts in the Philippines, internal seas of Indonesia, coasts in the southern part of Myanmar, and the South China Sea – are either heavily depleted or overfished (Kato, 2008). Even the offshore areas in the region, such as the Indonesian internal waters, face significant overcapacity and overfishing (Pongsri, 2012) The capture fisheries of ASEAN have suffered a decline in production attributable to a lack of appropriate good management measures, monitoring, and enforcement. For example, Thailand showed a significant decrease in marine capture fishery production from 2.774 million metric tons in 2010 to 1.496 million metric tons in 2016 (Food and Agriculture Organization of the United Nations (FAO), 2016). The coastal areas are heavily depleted; and habitats are industrialised, reclaimed, polluted and/or overfished. Inevitably, a vicious spiral has evolved where domestic and export demand has increased fishing pressure on already degraded resources. While capture ocean fisheries are stagnating and decreasing, aquaculture has been increasing at a fast enough pace to offset any stagnation and depletion elsewhere. The lack of appropriate management measures, as well as conflicting short-term production goals, pose further challenges to fishery and food security in the region.

Meanwhile, the impact of disasters and climate change on food security has become a regional concern because of the magnitude and extent of their influence on fisheries production. Increasing disasters, such as floods and droughts, have caused dramatic fluctuations in production and a drastic rise in food prices. For example, the 2007–2008 global food crisis came into existence because of natural disasters, food shortages, and export restrictions imposed by the region's major food exporting countries. This food crisis also caused food shortages in the countries dependent on imports to meet domestic demand, such as Malaysia and Singapore. In the developing trends, ASEAN countries located in the equatorial and tropical zone with its seafood supply gradually becoming more dependent on imports to meet domestic demand is confronted with the same challenges, but of higher order by 2030 (Pongsri, 2012).

The objective of this chapter is thus to provide a comprehensive overview of the potential impacts of disasters and climate change on fisheries production as well as food security and to review the details of ongoing and completed adaptation initiatives. Sharing examples will aid in the planning and development of regional adaptation maps for food security in the fisheries and aquaculture sub-sectors. This compilation is intended to provide a critical analysis for policymakers and researchers involved in developing policy responses for resilience. The introductory section provides an overview of fisheries production and its role in food security, followed by a critical overview of selected adaptation options and economic choices at various levels in AMS to strengthen the resilience framework.

7.2 Fishery Production and Food Security Trends in ASEAN

Fisheries in ASEAN are generally characterised as small-scale, but have been playing a major role in accelerating economic development and generating livelihood opportunities. With projected annual growth of 1.3% from 2018 to 2030, the consumption of fish in the region is expected to grow from the current 24.86 to 64.50 kilogrammes (kg) per person per year in 2030 (Table 7.1). This means that the demand for fish in the region is about 15.5 million metric tons. Considering that the region's total fish production is about 26.82 million metric tons, only about 11.3 million metric tons would be bound for international fish trade. In the ideal fish supply and demand, the world's consumption of fish would be about 18.9 kg/person/year and the world's demand for fish would be about 126.7 million metric tons. This does not include the significant portion of the total fish catch that goes into the fish meal industry, which is no longer available for human consumption. In ASEAN, where inland aquaculture has developed so rapidly, the amount of fish catch transformed into aquafeed could be enormous. Considering the amount of fish catch being converted to fish meal and the fish food required for human consumption, fish supply may not be able to meet demand at a certain point, in which case food insecurity could occur.

Table 7.1: Fish Consumption, Production, and Number of Fisher Families in ASEAN

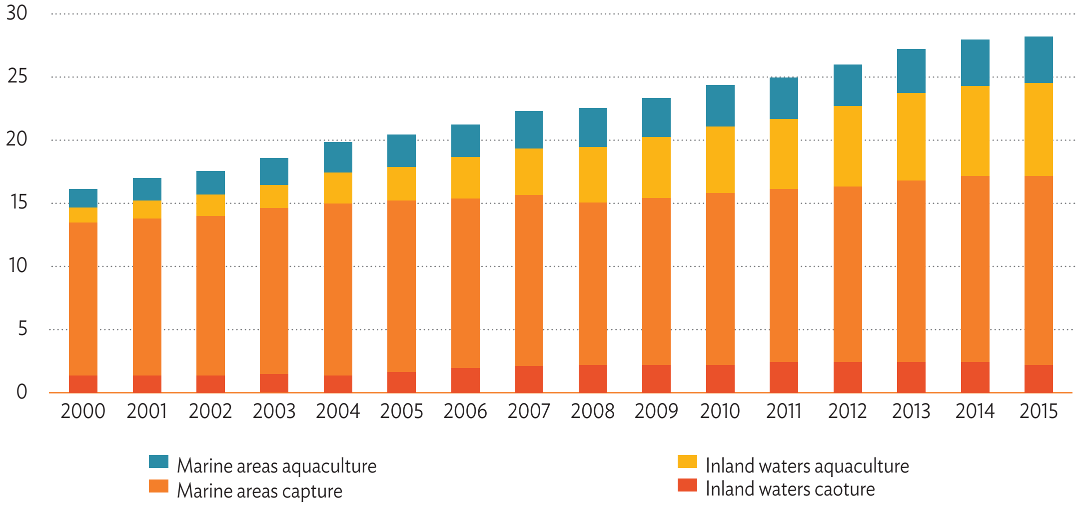
ASEAN Member State	Per capita fish consumption (kg)	Fish production (metric ton)	Estimated number of fishers
Brunei Darussalam	31.46	2,44	523
Cambodia	32.04	471,000	-
Indonesia	37.70	9,052,127	2,231,967
Lao PDR	24.86	145,687	99,617
Malaysia	63.30	1,753,310	140,358
Myanmar	64.40	3,168,630	3,201,923
Philippines	54.80	4,966,890	1,786,948
Singapore	-	5,141	122
Thailand	40.35	2,667,018	168,140
Viet Nam	53.40	4,584,900	
World		**159,089,695**	
ASEAN		**26,817,145**	

ASEAN = Association of Southeast Asian Nations, kg = kilogramme, Lao PDR = Lao People's Democratic Republic.

Source: Southeast Asian Fisheries Development Center (SEAFDEC). www.seafedc.org.

In terms of fishery production by quantity, the ASEAN region demonstrated a continuous increase from 2000 to 2015, both in volume as well as value (Figure 7.1). The average annual increase is 6% in terms of volume but 20% in terms of value. By weight of production, the total fishery activity of ASEAN yielded 24.5 million metric tons in 2000, increasing continuously to 31.4 million metric tons by 2015. At the global level, this rapid increase in production is second only to China. In terms of sector production for ASEAN fisheries, marine capture comprises 14.9 million metric tons, inland capture is 2.4 million metric tons, and aquaculture is 14.2 million metric tons, totalling 31.4 million million metric tons. By value, marine capture is worth $15.9 billion, inland capture is $2.5 billion, and aquaculture is $13.4 billion, totalling $31.8 billion (FAO, 2016). The value of ASEAN fishery products per kg is one-third that of the East Asian market.

Figure 7.1: Marine and Inland Fishery Production in ASEAN



ASEAN = Association of Southeast Asian Nations, Mt = Million metric tons.

Source: FAO (2017).

7.2.1 Marine Capture Fishery Production

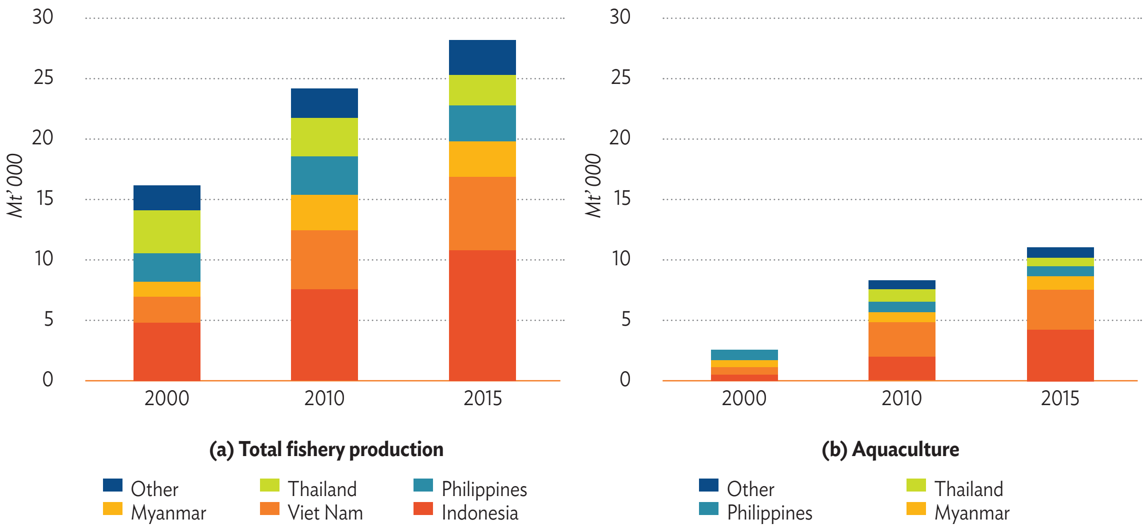
Marine capture fishery production in ASEAN increased slightly (1.6%) from 2000 to 2015, compared with the 11% average increase in value during the same period. In 2015, Indonesia remained the largest producer, accounting for 33.8% of the region's total production volume, followed by the Philippines (16.3%), Viet Nam (15.0%), Myanmar (13.8%), Thailand (10.9%), and Malaysia (9.4%) (Fig 2a). In terms of value, Indonesia was on top for production in 2015 at 41.2%, followed by Myanmar (21.4%), the Philippines (15.9%), and Malaysia (12.7%). In fifth place, Thailand accounted for 8.7%.

The marine capture fishery production outputs of Brunei Darussalam, Malaysia, the Philippines, Singapore, and Thailand have all shown a decrease. It is projected that the remaining countries – Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), and Viet Nam – will also decrease in the future unless the respective governments implement appropriate management measures, and specific hard target limits on catches are introduced with monitoring and enforcement (FAO, 2014). Thailand has already experienced a drastic reduction in production from a peak of 2.7 million metric tons in 2009 to 1.5 million metric tons in 2013. Its 200-kilometre zone of Thai Bay is no longer the main fishery and is now the site of depleted resources (Delgado et al., 2013). Thai vessels still operate in the waters of Myanmar where bottom fish stocks are depleted (Pongsri, 2012). If this too is phased out, Thailand's production will be further decreased. The Philippines' production in coastal waters has also fallen, but overall production may be sustained by operations at deep sea areas for tuna, although this resource faces overcapacity (Southeast Asian Fisheries Development Center (SEAFDEC, 2013). Marine fish including tuna, skipjack, and mackerel provided the highest production in 2010, accounting for about 76.4%, while crustacean groups such as tiger prawns and pink shrimps accounted for 4.1%. Mollusc groups such as octopus and squid accounted for 3.5%. Both fish and crustaceans decreased in 2015 over 2010, an indication of overexploitation in this region. This drop is mostly attributable to Indonesia. However, the Philippines' production also decreased significantly in 2015 over 2000.

7.2.2 Aquaculture Production

Total marine aquaculture contributed 52.2% to the region's aquaculture production in 2015. As illustrated in Figure 7.2 (b), brackish water aquaculture accounted for 21.0% while inland aquaculture accounted for the remaining 27.0%. However, brackish water aquaculture accounted for 49% in terms of value because the production species comprises prawn and shrimp species such as black tiger. Aquaculture in the region has increased drastically by 12% annually, contributing to the boosting of regional and national economies.

Figure 7.2: Contribution to Fishery Production by Country in ASEAN



ASEAN = Association of Southeast Asian Nations, Mt = million metric tons.

Source: FAO (2017), Global Production Fisheries.

Aquaculture production in Indonesia is the largest in the region, accounting for 44.3% in terms of volume and 52.0% in terms of value (FAO, 2016). This successful aquaculture production is attributed to Eucheuma seaweed. Indonesia has witnessed strong growth in aquaculture, especially shrimp species in terms of production and productivity; and land is still available for aquaculture in Lampung, Sumatra, and Tarakan, Kalimantan, amongst others (Kato, 2008). However, a holistic national development plan does not appear to be in place.

Viet Nam is the second largest aquaculture nation in the region, with catfish, Panangus species, and Tilapia. In the Philippines, production is dominated by Zanzibar weeds, milkfish, and black tiger shrimp, which enjoys popularity in the United States (US) market. In the case of Thailand, white leg shrimp, which accounts for 43% of production, is the major species, followed by Nile Tilapia at 13%. Thailand currently has the problem of early mortality syndrome (EMS), a disease whose cause has not been clearly identified and for which no treatment or eradication has been found. EMS first broke out in southern China and then spread to Viet Nam and Malaysia before coming to Thailand. In Thailand, EMS caused a reduction in production of almost 50% in 2010 (Organisation for Economic Co-operation and Development (OECD) and FAO, 2017). Prices increased by 40% from 2010 to 2015 in response to the scarcity of production. The fisheries industry and the Government of Thailand are seeking alternative lands suitable for white leg shrimp aquaculture in other countries such as Myanmar. The main products of aquaculture in Myanmar are freshwater species. The main species is Roho labeo, which accounts for 64% of the entire production (FAO, 2014). There is also some marine or brackish water aquaculture such as black tiger shrimps in Rakhine state, but this is still under development. Intensive aquaculture has not yet been developed as in Thailand and Viet Nam.

7.3 Economics of Fish Production, Planetary Limits, and Food Security

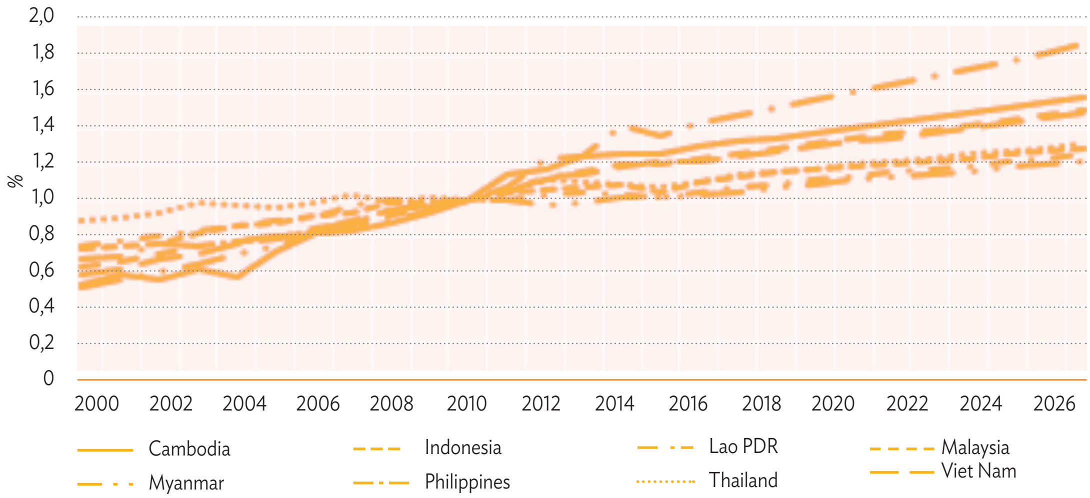
The main equipment for marine fishery harvest in ASEAN is trawling and purse seine nets. Although all ASEAN countries still use driftnets and bottom gillnets, pole and line, as well as jigging in coastal fisheries, most marine capture fishery production comes from trawling and purse seine nets. They are powerful and efficient, producing large amounts of catch in a single haul. Trawl-caught trash fish are directed to fishmeal and feeding for aquaculture. In Malaysia, trawling is prominent, with trash fish production accounting for 35% of the total. The continued production of trash fish, however, leads to a decrease in overall production and shrinkage in fish size.

In 2009, Indonesia reported the highest number of fishery workers at 5.9 million, with 36% involved in marine capture fisheries of which 50% were full-time. Its inland fisheries had 458,000 workers, 37% of whom were full-time. Myanmar had the second largest number of fishery workers at 3.2 million, with 44% marine capture workers of whom 16% were full-time, 18% part-time, and the rest occasional fishers. Its inland capture fisheries had 1.6 million workers, of whom 31% were full-time and 19% part-time. Aquaculture had 780,000 workers, with 25% full-time; the part-time and occasional workers were the main working force engaged in paddy-field rice production. These numbers demonstrate the great number of people reliant on fisheries, and the resulting poverty of fishery workers owing to very low per capita income (SEAFDEC, 2013). Amongst AMS, a decrease in the fisheries workforce is inevitable, and the shrinkage of rural fisheries communities and concomitant increase in urban populations will be a phenomenon of the future, as was the case in other East Asian economies such as Japan, the Republic of Korea, and Taiwan during the high economic growth economic era of the 1960s and 1970s.

On the other hand, ASEAN's exports to major fish-consuming areas such as Japan, the European Union (EU), and the US are expanding. AMS first exported to Japan and gradually diversified to the EU and US. Other markets such as China, the Middle East, the Russian Federation, and Brazil are expanding as income levels increase, economies develop, and dietary lifestyles become more borderless and international in a harmonising of cultures. Moreover, more attention is being given to health and aesthetics as the hygiene and sanitary treatment of fishery products are developed. Elements of Japanese dietary seafood culture, such as sushi and tempura, are now served in a locally adjusted style in each ASEAN country. This means that seafood, even in its raw form, is now accepted and adapted as international cuisine, bringing in new dimensions and definitions to regional food security perceptions. Fish is the most heavily traded of foods and is growing fast amongst agricultural commodities in the international markets. However, significant concerns have been raised by fisheries management experts and buyers of raw material for certain fisheries products, that fisheries management in ASEAN is less than adequate. None of the nations have an effective fisheries management regime with stock assessment, legislation, monitoring, and enforcement. As discussed before, a grave concern is the rapid depletion of marine fish production. This depletion has already been observed in the catch statistics of Indonesia, the Philippines, and Thailand. Although production statistics are not available for Myanmar, many professionals in the industry, marketplaces, and the processing and packing sector are concerned about recent decreases in total production and shrinkage in catch sizes (Brander, 2007).

Figure 7.3 shows the real and estimated fishery production changes in ASEAN, which is driven by demand originated from outside the region. In total, 78% of fishery exports are directed to developed nations. Owing to stagnant fishery production or the unsustainable management of domestic fisheries, developed countries are likely to depend on the import of fish and fishery products from ASEAN regardless of the quality of fisheries management and domestic aquaculture policy in those nations. However, continuous supply of fishery and aquaculture products to the market countries may not be possible because of the depletion of marine capture fisheries and the growing domestic demand for aquaculture products. At present, the international trade measures for fishery products require high-level quality and safety-related import standards and practices. The EU has the Generalized System of Preferences for the special treatment of ASEAN. It also has the EU certification on products for import to the EU market, as well as the Catch Certificate Scheme. Health and safety standards are imposed by the EU as good aquaculture practices. The Government of Thailand has adopted measures equivalent to the EU standard, known as the Good Aquaculture Practice.

Figure 7.3: Real and Estimated Net Fishery Production Changes in ASEAN



ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Source: FAO (2017), Global Production Fisheries.

Although the status of specific fisheries and populations varies, there is agreement that regionwide marine and freshwater species are at risk from human population pressure, including overexploitation, pollution, and habitat alteration (Chen, Watson, and Pandey, 2015). Destructive fishing practices, such as heavy bottom trawling gear and explosives, damage marine environments, while introduced species increase competition for native species. Overcapacity and overinvestment in many industrialised fisheries can lead to overfishing (Daw et al., 2009). Overfishing not only has impacts on the fish population, reducing stock resilience and potentially leading to stock collapse, but also cuts profitability and economic efficiency (Hsieh et al., 2006). On top of these pressures sit disasters and climate change impacts on fisheries and aquaculture sectors.

7.4 Effects of Disasters and Climate Change on Fishery Production in ASEAN

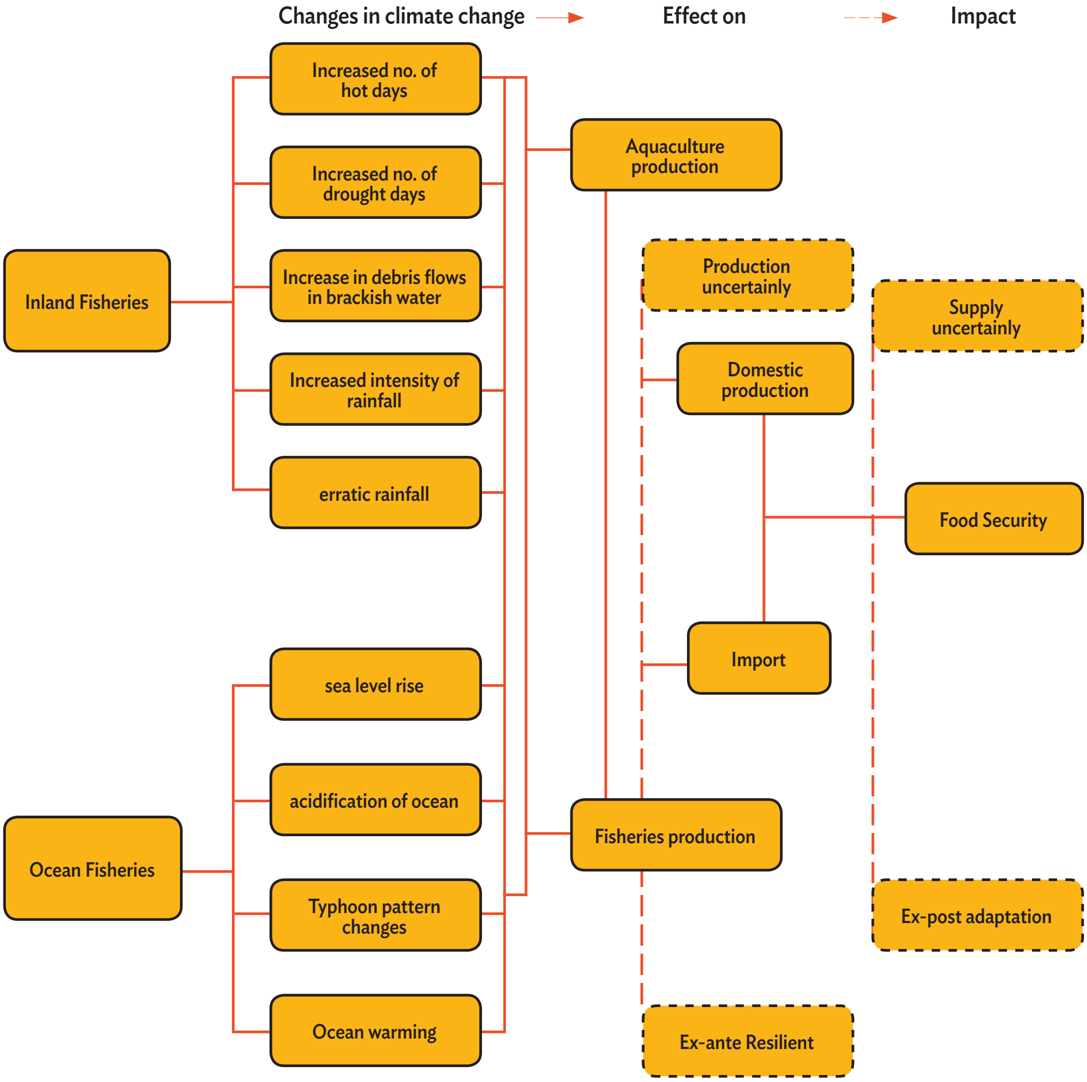
7.4.1 Cause and Implications of Disasters and Climate Change on Fish Production

Rising concern for climate change also means that the fisheries sector must respond by innovating and reconsidering the fishing gear used for the sake of fuel efficiency, instead of drawing trawl nets over long periods. Moreover, as the price of fuel oil increases, more effective use of fishing gear and reform of the operational pattern of fisheries is needed. The global effect of climate change has caused alarm in many areas of fish harvesting, marketing, and consumption. The fisheries sector is amongst the most vulnerable (Hatfield et al., 2011). Carbon dioxide emissions directly cause a decrease in ocean pH, leading to ocean acidification and a rise in water temperature (Ho et al., 2016). Both effects can change the ocean ecosystem, including the habitats and behaviour of fish and fisheries resources. Although efforts have been made to elucidate the effects of climate change in the ocean, much remains unknown.

The overall conclusion of previous studies (Hobday and Pecl, 2013; Hsieh, 2012), however, is that it will lead to a reduction in fisheries production. In tropical areas, the temperature rise will bring more fish to higher latitudes and the primary production of phytoplankton will decrease. Thereafter, production of the higher ecological niches, including fisheries resources, will be reduced. Models to analyse the future production of fish species, such as salmon and saury (Ho et al., 2016), concluded that they will become smaller in size and weight, lessening production. Moreover, acidification will damage coral reefs and demolish ecosystems, including nursery areas. It is necessary, however, to elucidate the effect of climate change in the oceans specific to ASEAN countries. Aquaculture is also vulnerable because rising temperatures affect ponds and intensive facilities, which are usually located in shallower waters. In addition, the recent problem of EMS is said to be induced by higher water temperatures (Kawasaki, 2013).

In domestic production, many studies have indicated the disaster and climate change impacts, the pathway of which could be illustrated as in Figure 7.4. In ASEAN, the climate impacts of agricultural production include rainfall regime change, an increase in the amount of heavy rainfall, diseases, and insect damage. The effects on fishery production include seawater warming, ocean acidification, increased frequency of debris flows, rainfall regime change, typhoon intensity, and sea level rise. The impacts on coastal and offshore fishery production include the disappearance of part of the sedentary and migratory species; a change or going away of seasonal swimming habits, which leads to decreased fishery production; a change in the composition of caught species; an imbalance in the ecosystem; and increased difficulty in fishing operations. In terms of aquaculture inland fishery, the impacts produced by climate and natural disasters include the occurrence of debris flows, changes in water quality, drought, alterations in the source of fish food, and deteriorated quality of fish oil. Finally, the impact of disasters and climate change will influence food security and the supply and demand market through domestic production and imports.

Figure 7.4: Disasters and Climate Change Impact Pathways in Fisheries and Aquaculture



Source: Authors.

ASEAN's food security vulnerability to natural disasters and climate change comes from an interplay of climate and geographic factors. Many types of disasters and climate impacts have been witnessed in the countries. Local people see floods and storm events as the greatest threats because they can trigger a sudden and strong change in sandbars and lagoon basement, otherwise known as the lagoon gate-opening effect (Trao, 2006). In addition, coastal hydrodynamic changes can lead to the destruction of important rural infrastructures such as dykes. Very deep erosion of hundreds of metres may be seen in many coastal zones of Indonesia, Malaysia, Thailand, and Viet Nam, and heavy sedimentation in inland ponds. Drought is another extreme condition that affects aquaculture and inland fisheries activities.

7.4.2 Farm-Level Impacts of Disasters and Climate Change

Several studies that assessed the climate change and disaster impacts of fisheries production in ASEAN have shown negative impacts. Binh et al. (2016) assessed the climate change and disaster impacts in Viet Nam. Their observations of the yield and aquaculture productivity of Phu Vang District from 2002 to 2012 are shown in Table 7.2.

Table 7.2: Changes in Aquaculture Productivity and Yield in Phu Vang District, Viet Nam, 2002–2012

Year	Yield (mt)			Productivity (mt/ha)		
	Brackish water	Freshwater	Total	Brackish water	Freshwater	Total
2002	2,009.50	298.10	2,307.60	1.47	2.85	4.32
2003	2,753.30	387.50	3,140.80	1.80	3.25	5.00
2004	4,098.90	638.10	4,737.00	2.23	3.81	6.04
2005	2,300.30	639.70	2,144.30	1.28	5.10	6.38
2006	2,059.60	632.50	2,576.60	1.09	3.84	4.93
2007	1,600.00	600.00	2,745.40	0.89	3.38	4.27
2008	2,502.90	424.80	2,927.70	1.26	2.20	3.46
2009	2,437.70	405.70	2,843.40	1.26	2.11	3.37
2010	1,742.10	457.90	2,200.00	0.89	2.21	3.10
2010	2,411.80	280.30	2,692.10	1.25	1.17	2.42
2012	2,796.50	143.50	2,940.00	1.41	0.58	1.99

ha = hectare, mt = metric ton.

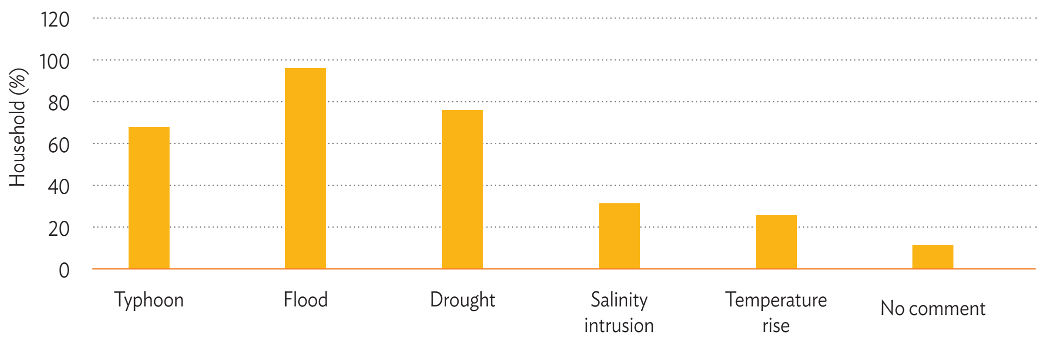
Source: Department of Agriculture and Rural Development (DARD, 2012).

The aquaculture production of the entire district had a downward trend from 2005 to 2012 compared with that in 2002–2004. Brackish water aquaculture yield was at its highest level in 2004 at 4,098 metric tons, while productivity was 2.23 metric tons per hectare (ha). However, the production and productivity of brackish water aquaculture decreased gradually since 2005, with the lowest yield of 1,600 metric tons seen in 2007 and productivity at

0.89 metric tons/ha. The figures in 2010 were 1,742 metric tons and 0.89 metric tons/ha, respectively. Yield was calculated on shrimp aquaculture in brackish water and fish aquaculture in freshwater. By 1995, the average yield of freshwater fish in the whole district had fallen to 143.5 metric tons, while productivity was 0.58 metric tons/ha. In 2005, freshwater fish in the whole district declined to 143.5 metric tons, with productivity of 0.58 metric tons/ha. In 2005, freshwater fish production was 639.7 metric tons and productivity was 5.1 metric tons/ha.

The impact of climate change on aquaculture productivity caused by rising temperatures, floods, droughts, and sea level rise has shown a direct impact on aquaculture. Household survey results in Phu Vang District of Viet Nam show 96% of households reporting that flooding has a great negative impact on aquaculture, reducing productivity and destroying infrastructure. Other factors that negatively affect aquaculture (Figure 7.5) are prolonged drought (74.87%), storms (66.00%), rising sea levels (31.18%), and an increase in temperature (28.57%).

Figure 7.5: Disaster and Climate Change Factors that Affect Aquaculture Activities in Phu Vang District, Viet Nam



Source: Binh et al. (2016).

In that area, storms usually occur in September, but in recent years tropical depressions occur during any month of the year. Furthermore, they occur more frequently and intensely. Up to 95% of the interviewed households said that flooding occurs frequently and unexpectedly, while the remaining 5% claimed that floods come earlier. The aquaculturists/farmers did not have a timely solution for these occurrences; as a result, many households suffer huge losses in their shrimp and fish business. Typhoons that occur with unusual intensity, such as Typhoon Chan-hom No. 9 in 2007, have destroyed irrigation facilities for aquaculture

(DARD, 2012). Heavy rains, combined with high tides, caused massive flooding in the area, bringing huge losses to fish farmers. The system of lakes and dams for brackish water aquaculture was also damaged, causing major setbacks in aquaculture in that district (Binh et al., 2016). Cases of prolonged rain lasting for 3–4 months were reported, causing low salinity and unsuitable temperatures which resulted in slow fish and shrimp growth. In the same way, in July and August, prolonged heat and increased salinity slowed down fish growth. Temperature plays an important role in the growth and development of organisms of aquaculture species. Heat raises water temperature to excessive levels and kills farmed aquatic species. Prolonged hot summers have greatly impacted on aquaculture activities, with water levels in ponds falling rapidly because of string evaporation. This often leads to additional investment in water pumps for shrimp culture in ponds. Historical analysis of sea level data in Hong Dau and Ving Tau cities, Viet Nam from 1957 to the present has revealed the reality of sea level rise. The water level rose by 2.3 millimetres a year along the major deltas of the Mekong from 1957 to 2010. (Ministry of Natural Resources and Environment, 2007). Calculations made by researchers point to the fact that sea level rise in 2010 was higher than in 1990 – increasing from 3 centimetres to 15 centimetres (Tu and Quang, 2010).

7.5 Adaptation Choices for Improved Resilience in ASEAN Fisheries Sector

According to the risk management principles, facing climate and disaster risks and adaptation strategy can be divided into prior preventive management and posterior compensatory management. Therefore, the resilience and adaptation strategies and measures could evolve in two divisions. The uncertainty of production places emphasis on prior preventive management and aims at the preventive measures of avoidance, transfer, and reduction to enhance the resilience of production behaviour and trade. Supply uncertainty uses posterior compensatory management, principles where production and marketing are corrected, and disaster and climate impacts are mitigated through adaptive management and risk retention. Such potential adaptation measures can be categorised as in Table 7.3.

Table 7.3: Potential Adaptation Measures in Ocean Fisheries and Inland Aquaculture

Impact	Adaption measures
Reduced yield	Shift aquaculture to non-carnivorous commodities Selective breeding for increased resilience in aquaculture Change aquaculture feed management Research and investment in predicting fish population movement Disaster-resilient and climate-smart aquaculture infrastructure investment (e.g. nylon netting and raised dykes in flood-prone pond systems)
Reduced yield variability	Ecosystem approach to fisheries and aquaculture and adaptive management Precautionary management Shift to culture-based fisheries Diversify livelihood portfolio
Increased risk	Adjustment in insurance markets Insurance underwriting Early weather warning system Improved communication networks Workshops to improve capacity in data gathering and interpretation Improved vessel safety
Increased vulnerability to fishing community in coastal zone	Hard infrastructure (e.g. construction of sea wall) Soft infrastructure (e.g. wetland rehabilitation) Rehabilitation and disaster response Post-disaster recovery Encourage native aquaculture species to reduce impacts

ASEAN = Association of Southeast Asian Nations.

Source: Authors.

Adaptation measures can be planned or autonomous, i.e. spontaneous reaction to climate change or planned action based on disaster-induced changes. Autonomous adaptation in fisheries may be changing the timing or location of fishing, as species arrive earlier/later or shift to new areas. Planned adaptation in fisheries may be research funding for finding species resistant to salinity and temperature fluctuations for aquaculture. A no regret approach relies on building general resilience to specific climate risks, which is useful in areas with high impact uncertainty, including equatorial areas in Indonesia, Malaysia, and Thailand – which have no long-term historical climate data and where disasters are becoming more frequent. Adaptation in fisheries can include a variety of policy and governance actions, specific technical support, or community-based capacity building activities that address multiple sectors, not just capture fisheries or aquaculture farmers. Although adaptation options are context-specific, a number of adaptation activities can be applied in most fisheries and aquaculture contexts of ASEAN countries. AMS have both different and diversified characteristics in capture fisheries and aquaculture, and thus adaptation options. Such an evolving practice is compiled in Table 7.4.

Table 7.4: Details of Selected Adaptation Options in Fisheries and Aquaculture as Practised in ASEAN Countries

Project	Goal	Adaptation activities	How these activities address food security	Other co-benefits	Reference
Strengthening adaptive capacities to the impacts of climate change in resource-poor small-scale aquaculture in Viet Nam	Increase adaptive capacity of small-scale aquaculture through assessment of adaptive capacity, perceptions, and an evaluation of potential adaptation options/ propose guidelines	Recommendations include deepening ponds, using soil to increase dyke heights, adding nursery areas to ponds, and adjusting crop calendars	Training workshops and publications Materials and resources have been shared between fishers on the implementation of assessments	Community learned about disaster and climate change impacts and was able incorporate other actions into community climate action plan	Muralidhar et al. (2010)
Community level climate change resilience building	Build local stakeholder capacity to increase resilience to climate change, with a focus on natural resources management	Integrated resource management plan, including resource maps, developed with stakeholder participation	Overall increased awareness of food security, local resources, and their distribution	Increased and more stable income from fish-rice farms, as well as increased resilience to incoming brackish water (from sea level rise or inundation from storms, etc.)	GEF (2012)
Development of leading centres for mud crab aquaculture in Hai Phong Province, Viet Nam	Improve local capacity for mud crab farming in rural Viet Nam	Strengthened extension capabilities and upgraded hatchery and facility and staff capabilities at selected centres Technology adapted and transferred to local conditions and species	Mud crabs are resistant to some common aquaculture diseases and more tolerant to changing salinity and oxygen levels than cultured shrimp. Mud crabs also work well with polyculture systems, allowing farmers to diversify and buffer against shocks/increase income	Landowners who invest in the fisheries sector will benefit more than the fishers	Linder (2005)

Table 7.4: Details of Selected Adaptation Options in Fisheries and Aquaculture as Practised in ASEAN Countries (cont.)

Project	Goal	Adaptation activities	How these activities address food security	Other co-benefits	Reference
Climate change adaptation initiative – Cambodia, Lao PDR, Thailand, and Viet Nam	Overall goals include poverty eradication and improved food security, guiding climate change adaptation planning and implementation through improved strategies and plans at a variety levels in the basin	Demonstration sites to pilot test adaptation activities based on local knowledge Awareness raising and capacity building via key climate change and disasters communicated simply in local language Support for adaptation plan development, learning experiences, and training manuals	Adaptation plans include focus on food security, including aquaculture and fisheries	Capacity building and good communication skills at local stakeholder, regional, and national level in the vulnerable region	Mekong River Commission (2011)
Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam	Share technologies and lessons learned amongst the countries on floodplain management and river basin development	Increasing communication and capacity via sharing lessons	Mekong River is an important source of food security.	Capacity building in new technologies, plans	United States Department of State
Indonesia, Philippines, Thailand, and Viet Nam	Building capacity in the region for fishers in marine protected areas to create awareness Conduct and implement monitoring programme in marine protected areas	Training participants in marine species identification, monitoring techniques, and protocols	Baseline information for marine areas to permit future decision makers to make more informed choices	Increased technical capacity for participants, as well as training handbook and ability for participants to create and implement programmes in own setting, which could result in further education for others and potentially employment	de Guzman and Suswandi

Project	Goal	Adaptation activities	How these activities address food security	Other co-benefits	Reference
Indonesia: adaptation to disasters and climate change through integrated coastal zone management	Incorporate sea level rise into coastal management	Climate risk assessment for integrated coastal management activities Living shoreline approach for coastal fisheries protection	Coastal ecosystem maintenance for increased fisheries productivity	Long-term planning is enhanced via disaster and climate risk assessment, and local participation builds capacity	GEF (2009)

ASEAN = Association of Southeast Asian Nations, GEF = Global Environment Facility, Lao PDR = Lao People's Democratic Republic.

Source: Compiled by the authors.

However, the overall similarity of the challenges in adapting to climate risks and disasters in the fisheries sector is recognised as follows. In terms of fisheries sector administration, scientific capacity building is urgently needed. There is a lack of human resources: specialists and experts in adaptation management, in laws and regulations for rule-making, in scientific assessment and enforcement in the areas of quality control, in international trade distribution and transportation, and in processing and storing. There is also a lack of economic analysts. To address these limitations, institutions should be established for professional training and education with fundamental and practical core courses. There should also be courses in leadership for adaptive change. Such institutions should have schools aimed at the workers' level, with practical training to educate skilled workers in adaptive technologies such as fishing vessels as captain or fishing masters, and workers at the processing facilities and industrial aquaculture ponds.

The principles of climate change adaptation and awareness of resilience for capture fisheries and aquaculture have been addressed at macro-levels in all the AMS. However, none of the countries have yet adopted effective climate-smart management measures with specific provisions for monitoring and reporting. Even surveillance and enforcement are weak. Moreover, science-based systematic resilience measures have not been introduced in any of the countries, although the importance of such approaches has been increasingly recognised. Several studies have stressed that effective management measures need to be introduced and implemented. The governments should address a holistic national policy to ensure the resiliency of both fisheries and aquaculture on scientific grounds, against the risk posed by climate change and disasters.

Financial assistance to small-scale aquaculture farmers and fishery processors for adapting sound practices is not available from official financial institutions, while private arrangements for loans come with disadvantageous conditions and are beyond the capacity of those who intend to modernise and innovate their supply chain business. Small-scale fishers, community-based fishers, aquaculture farmers, and processors should be given an opportunity to learn the transfer of appropriate technology and innovation for business by official development assistance, extended to them by governments or development banks. International trade is of prime importance for fisheries and aquaculture in ASEAN. Therefore, sanitary and phytosanitary measures – such as limiting ethoxyquin residues, eradication or mitigation and long-term treatment of diseases, and sustainable aquaculture – are heavy challenges for ASEAN countries. Hence, promoting resilience along global value chains also needs special attention.

Graduate schools need to be established to provide professional levels of education in advanced disaster management, science, and administration to qualify those who will become the high-level scientists, experts, economists, and government officials that serve in the future at senior levels. An institution also needs to be established to exercise the functions of research and scientific assessment of stocks together with providing education and training for scientists, engineers, and economists. Experts and advisors in advanced nations should cooperate to provide their expertise in the areas of adaptation assessment, data collection, monitoring, and management. Assistance is needed in collaborating with international organisations and advanced governments to support the AMS in formulating national resilience policies, with due attention to food security and climate change. International specialised organisations should cooperate in the eradication and remedy of diseases of fisheries products. AMS need to cooperate with the relevant international organisations and competent agencies to initiate global reviews of the causes and treatment of eliminated imported fisheries losses to enable the permanent and sustainable use of the aquaculture ponds.

Infrastructure is of vital importance for the climate-resilient development of the fisheries, aquaculture, and fishery processing industries. Such infrastructure may include, amongst others, landing facilities, storage, paved transportation roads, water supply, sledges, and electricity as well as the equipment and material for the construction of plants, freezers, refrigerators, and packing machinery. Introduction of the cold chain is of vital necessity. Such a cold chain should include fishing boats, transportation boats, and landing sites as well as distribution tracks, storing freezers, and packing facilities. The cold chain should connect the landing site and packing facilities/exporters via airports/fishing ports. The airports must have storage facilities to store produce during disaster emergencies. Since there is a lack of available and reliable funding to renovate vessels and expand the seafood business to meet the requirements of resilience, funding should be made available at a low interest rate and for longer terms. To facilitate the creation and establishment of such loans, funds should be provided by either governments or international development banks. Funding bodies should be encouraged to provide information seeking and sharing seminars regularly on sustainable fisheries, aquaculture, and trade. There should also be regular reviews and updates of information on market country policies and best practice trends in the EU, Japan, and the US. This may facilitate appropriate business decisions of export companies to increase resilience and permit them to absorb climate risks.

7.6 Costs of Adaptation Measures and Public Policies for Improved Resilience

7.6.1 Cost of Autonomous and Planned Adaptation in Lower Mekong Delta

The cost of adaptation measures will be variable and depend on the local context and type of adaptation action. There will also be variability in the benefits, although these may outweigh the costs, and there is high variability in the economic impact that disasters and climate change will have on different countries and sectors.

In an economic study of adaptation costs and benefits in catfish and shrimp farms of the Vietnamese Lower Mekong Delta, planned adaptation funded by the government was found to provide more benefits than if farmers were left to adapt for themselves by reducing or offsetting farmers' autonomous adaptation costs (Kam et al., 2012). However, the economic analysis also revealed that catfish farming was operating close to the edge of economic viability, and profits could be significantly affected by climate change without industry restructuring, e.g. reducing input costs or moving profit margins down the value chain to producers. The shrimp industry was able to tolerate adaptation costs longer than catfish, and improved extensive farming was found to be climate-resilient and economically sustainable, especially for small-scale farmers, despite lower profitability compared with semi-intensive and intensive shrimp farms.

Costs were estimated at the farm level and based on farmer interviews and expert advice, and scenarios with no climate change and with climate-induced disasters were compared. Growth in bot catfish and shrimp sales until 2050 was based on current and recent market trends. Income and yields were based on 2014 stakeholder interviews, and price changes were estimated based on expert advice considering price fluctuations from 2005 to 2014. Public investments in river and sea dyke construction to prevent flooding and sea level rise and tidal intrusion were used to consider the benefit to farmers of planned adaptation measures. The government funded adaptation measures to offset or reduce on-farm costs of dyke upgrading and increased electricity and fuel costs in response to increased salinity and flooding to the farm level.

Autonomous adaptation at the aqua farm level would result in reduced profits for shrimp farmers and probably drive out those small-scale fishers unable to cover these extra costs. Adaptation activities included in this study were dyke upgrading for flood protection and increased electricity and fuel costs for water pumping for increased aeration. Planned and government-funded adaptation activities included constructing sea dykes to prevent tidal flooding and reduce salinisation and river dykes for seasonal flooding, as well as support for increased electricity and/or fuel costs. The total cost for these planned adaptations over 10 years was projected at $191 million, while the catfish and shrimp exports bring in $2.7 billion. The cost for the government was only 0.7% of the total revenue from exports of these two aquaculture businesses (Kam et al., 2012). Although this study only looked at one kind of adaptation, it is an example of the kind of benefit that public-funded adaptation can have on small-scale producers, as well as highlighting the role governments can play in facilitating adaptation and linking adaptation to wider regional and local development.

7.6.2 Public Policy Choices for Capacity Building and Improved Resilience

In the face of aggravating climate and natural disasters and the uncertainty regarding inland and offshore fisheries production, supply, and demand, determining whether ASEAN has the capability and sufficient adaptive capacity to mitigate the impact of climate variation and enhance the resilience of the fisheries sector is a big question.

ASEAN had been exerting efforts to address the issues and enhance the role of fisheries towards attaining food security. Concerned ministries adopted the Resolution and Plan of

Action on Sustainable Fisheries for Food Security, which has served as a policy framework since its adaption in 2001.

Implementation frameworks and adaptation roadmaps are lacking at the subsector, provincial, and local levels, however. This may be attributed to fundamental flaws in the available statistics in fisheries and aquaculture. Fish species are poorly classified and sometimes unclassified. The ASEAN region has a significant lack of classification of species affected by climate change: 66.4% of the entire fish production in ASEAN is classified 'miscellaneous fish'. This is a serious obstacle for science and adaptation management. There is an urgent need to improve the level, magnitude, and accuracy of the collection and compilation of fishery data with various species. Therefore, urgent policies with specific measures to protect and restore the $16.0 billion tuna fisheries and ensure climate-smart production should be put in place as soon as possible. A fundamental obstacle is the lack of breakdown amongst various species for stock assessment and management. Myanmar simply labeled all marine capture fish as 'miscellaneous', by which no stock assessment can be conducted. Moreover, species-level reporting is not adequately conducted for administrative or scientific purposes in the inland fisheries of Cambodia, Myanmar, or Viet Nam.

This matter of concern should attract the attention of AMS. It is of prime importance to have the attention of high-level policymakers to adopt policies to take immediate action to protect species decreasing as a result of climate change – not only at the national level but also at the ASEAN ministerial level. The AMS have not undertaken management measures for species such as oceanic tuna, or even for the neritic tuna that migrate in the exclusive economic zones of each nation. Hence, none of the nations adopt comprehensive management measures to overcome the problems of a decreasing harvest. There is a need to strengthen the capacity of human resources for stock assessment. At present, human resources as well as physical capacities such as research vessels to collect data are far from adequate. Effective adaptation management should include the setting up of regional organisations for semi-enclosed areas surrounded by various international waters. Lack of cooperation is a fundamental obstacle to taking any action to prevent the depletion of key fishery stocks.

This issue is very much related to export-oriented Indonesia and Thailand, amongst others, regarding how to make future fishery production climate-smart and contribute to food security. AMS have insufficient fishery management, and most of the fisheries resources are overexploited or depleted. As aquaculture production at intensive inland sites expands, however, increasing problems are coming from overuse or overcapacity. The environment for aquaculture deteriorates after use for several years, and diseases can be triggered by factors that may be attributable to complex issues including climate change and disasters. However, many countries still seem to be expanding production. They must, therefore, introduce more science-based sustainable and resilience targets of production. Indonesia will soon experience a downward trend in marine capture fisheries because of overexploitation and lack of sustainable management. While Indonesia still has land available to expand marine, brackish, and inland aquaculture, long-term aquaculture production needs to be addressed for future changes in climate change and vulnerability to food security. In the case of Thailand, a scientifically grounded individual quota system must be introduced and implemented; otherwise, Thailand's fisheries will have a devastating outcome. Aquaculture in Thailand may require the long-term use of lands for aquaculture as well as the use of trash fish. A holistic scheme should be planned for sustainability and food security.

Bilateral aid agencies such as the Japan International Cooperation Agency have extended technical assistance and development and research cooperation grant aid to fisheries areas in ASEAN. The US also supports the management of fisheries resources, with a view to prioritising what ASEAN considers important. SEAFDEC is the only regional fisheries organisation for the assessment of fisheries stocks and that can enlighten AMS on adaptation measures. Its responsibilities should be extended to cover the rising needs of priority areas such as national policy formulation for climate-smart fisheries, for which SEAFDEC does not currently have a mandate. There are some impediments to potential assistance. Japanese, European, and US business corporations or enterprises may not extend assistance to small-scale farmers. Such small businesses should be supported for adaptation instead through official development assistance and public credit organisations. Finally, as the requirements for sanitation and health as well as the quality of inland aquaculture become increasingly high to obtain the certificate of standards of the EU, in the case of climate change, financial assistance for entire value chain resilience should be formulated.

7.7 Conclusion

ASEAN has experienced a significant improvement in the levels of food security along with strong growth in the fisheries and aquaculture sectors. Production growth in these sectors has been brought about by a significant increase in the use of both intermediate and natural inputs. However, both inland and marine fishery production will be unable to satisfy the change in demand resulting from climate change, leading to a food security crisis. The decline in food security and fish production will become increasingly severe to the communities of ASEAN, which are in climate and disaster hotspots. Numerous studies in the region have suggested that both inland and marine fishery production have started declining because of climate variation and climate-induced disasters, which may cause changes and instability in food supply and demand. Climate change and disasters also influence the profitability of ASEAN fisheries either directly by altering the availability of fish or indirectly by altering the costs of inputs to fishery, such as fuels and machinery maintenance, or the time spent on fishing or aquaculture practices. This chapter identified cost-effective adaptation options to reduce the impact of climate change and disasters on marine and inland aquaculture. Based on the rule of risk management, the adaptation strategies are differentiated and analysed into autonomous adaptation and planned adaptation – with critical cost–benefit analysis. Public-supported proactive planned adaptation is emphasised to counter the risks posed by increasing climate variability and disasters in ASEAN. It is concluded that to improve food security and minimise the projected decrease in profitability, fisheries need to build overall adaptive capacity along the value chain and diversify the income opportunities, ideally without incurring additional social costs to small-scale fishers.

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PART III

Institutional Adoption

CHAPTER 8

Distributional Effects of Disasters in Food Value Chains and Change of Risk Management Strategies: Experience from Europe and Implications for ASEAN

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8.1 Introduction

Today, we have a world population of almost 7.6 billion which is expected to grow to 9.8 billion by 2050 and 11.2 billion by 2100, taking a medium growth projection (United Nations Department of Economic and Social Affairs (UN DESA), 2017). Never before in history could more than 90% of the world's population fully satisfy their food demand, which is now the case. In 1974, the World Food Conference was held in Rome with the aim of eradicating hunger (United Nations, 1975). The goal to eliminate hunger was repeated twice by the Food and Agriculture Organization of the United Nations (FAO) at the Global Summit of Food Security in Rome (FAO, 1996; 2009) and reaffirmed as one of the new Sustainable Development Goals (International Food Policy Research Institute, 2016). While the goal to eradicate hunger came ever closer but was never reached, we can feed more people today than the populations of 1974 or 1996. This is related to the establishment of ever larger food value chains and people's increased budget to buy food originating from far away. However, the poorest people have no access to food value chains and depend entirely on local food production.

Changes are on the way: the current share of the urban and rural population – traditionally responsible for food production – is equal at the global level. However, this ratio will change in favour of the urban population, which is projected to grow to 80% by 2050 while the rural population will fall to 20%. We currently have a peak rural population of 3.8 billion in absolute numbers and expect this number to halve by 2050. Farming methods are changing. We currently have more than half a billion food production units, most of them traditional smallholders in the developing world. Their number will drastically decrease with the retreat of the rural population. Society will no longer need as many rural people involved in food production.

The rapidly increasing urban population will be fed primarily by fewer units of industrial agriculture with ever larger resource inputs, capital-intensive agriculture, the continued application of biological/genetic science to food production, greater ability to save crops from pests, and higher capacity to preserve perishable products during transport. Technology in agriculture and food production will play an important role in reducing excessive resource inputs or food waste and is a tool to re-establish global food production in a more sustainable way.

Sustainable development is a long-expressed goal and can be tracked in many publications. The Club of Rome ordered the first report on 'Limits to Growth' (Meadows et al. 1972). Other reports such as the 'Global 2000 Report' to former United States (US) President Jimmy Carter followed (Barney et al., 1980). The United Nations World Commission on Environment and Development issued a document entitled 'Our Common Future', which became known as the Brundtland Report (Brundtland et al., 1987). 'Agenda 21' of the Rio Conference 1992 was derived from these publications and sustainable development became included in the work of many governments. In addition to an expected lack of resources, we are troubled by the pollution of resource use such as the emission of greenhouse gases. Such exploitation of natural resources on a global scale has brought with it climate change and other climate-induced disasters. Further additions were introduced by the Millennium Development Goals, and the 2030 Sustainable Development Goals (United Nations, 2015). All these documents give testimony to efforts that date back almost half a century. The degree of involvement is, however, different today than what it was initially, when few stakeholders were sufficiently aware of the issues to take action. Today, the broad consensus of most stakeholders and nations is that the globe is our scale of operation.

Ambitious and targeted frameworks have been in place since the establishment of the Kyoto Protocol (1997), which aimed to regulate climate change and greenhouse gases (GHGs). The protocol failed, and was substituted by a less ambitious and more realistic framework – the Paris Agreement (2015) – to reduce GHG emissions to levels that do not surpass a warming threshold of 2°C. However, after achieving this milestone, the US government, the second largest emitter, withdrew from the accord (Shear, 2017). The regulation of the global climate, one of the most important parts of sustainable development, remains uncertain.

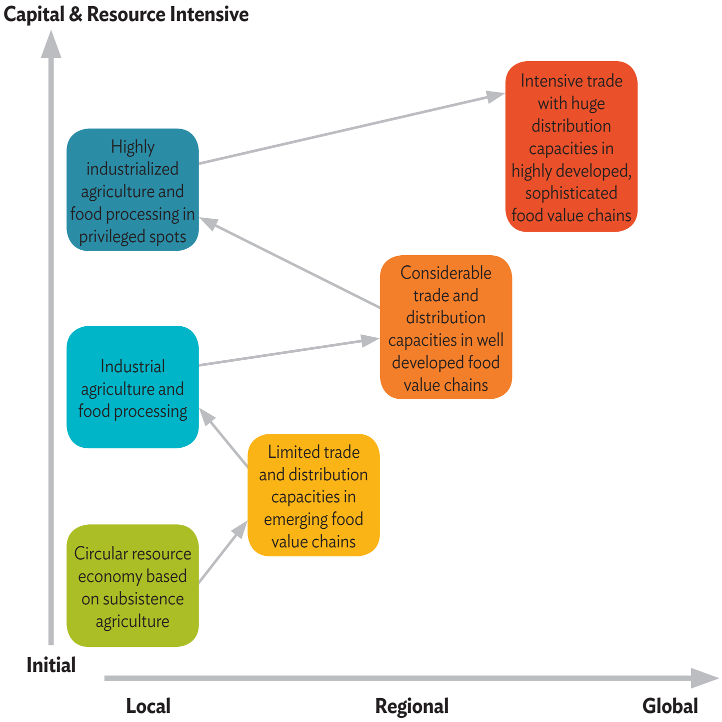
Agricultural production as the basis and food consumption as a final output have never been more distant to each other than today. While one family was traditionally the only stakeholder in a local subsistence farm unit, we now have ever more stakeholders in regional and global food chains. To appeal to new stakeholders, food chains need to create ever higher values and to develop into more efficient distribution systems covering large quantities and flows from various parts of the world. Food value chains cover every station from inputs to agricultural production, growing agricultural products, transporting them, processing food, retail in food stores, and consumption in homes or restaurants. The number of food items on the market, including variations and differentiations within food items, increases continuously. Globalisation, paired with higher average incomes and purchasing power for most people, accelerates changes in human lifestyles and modifies food consumption patterns.

Food availability and ever larger distribution channels play fundamental roles in food value chains. A long distance from the source (agricultural production) to the target (food consumption) means a high risk of food loss and damage and unwanted surprises along the way. The quantity and speed of distribution at and between the relevant stations of the food value chain are important for the smooth operation of sophisticated food value chains. This depends on the availability of infrastructure, technology, resources, and money, which are not equally spread throughout the world.

Figure 8.1 indicates that food value chains and their vulnerability are scale-dependent. In traditional resource-based subsistence agriculture, distribution is not yet very important, there is too little value involved, and farmers try to satisfy basic food needs for their families. Distribution becomes ever more important by widening the scale of action in regional and global value chains, where access to markets is decisive and the value of traded commodities increases. New industries and services find their way into food production and consumption, and ever higher values are generated in food chains.

Up to some 200 years ago, there were only local food production systems. This changed because of industrialisation, and food systems became regional, with increased trade and distribution necessities. In the current era, where food is traded all over the world, food systems are changing to achieve ever more variety and diversity. This process could prevail for a long period.

Figure 8.1: From Local Food Supply to Global Food Value Chains



Source: Author.

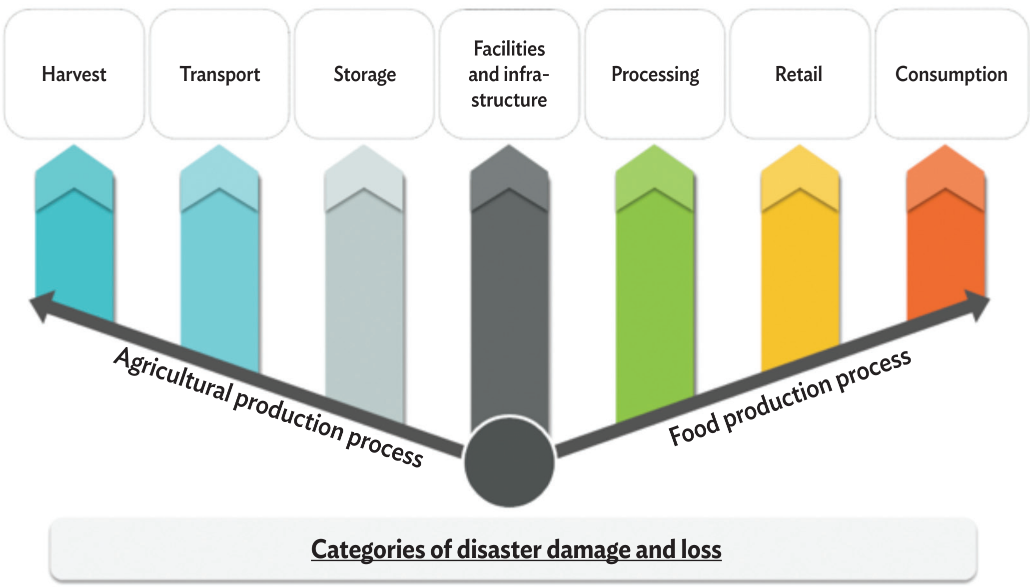
The following sections will inform on the role of disasters, resilience strategies for the food system, the food scarcity threat, the elements of the food value chain, changes in the context of food value chains, strategies against disaster damage, and recommendations for the Association of Southeast Asian Nations (ASEAN).

8.2 The Disaster Threat

Climate disasters are anticipated to increase over the next decades (Intergovernmental Panel on Climate Change (IPCC), 2014). Disasters can ruin parts or entire harvests of agricultural products, work as a hindrance to food distribution and storage, and impair serious hinders in the distributional flows of food value chains if infrastructure becomes damaged. However, there are important differences in relation to the scales of disasters and food value chains. Disasters hit particular areas that are specific for a disaster event. Droughts, cyclones, or floods have different impact and damage patterns. Losses are quantified in terms of agricultural production, damage to the food processing infrastructure, and blocking of the transportation network. Disasters disturb the flow of the supply of certain food products. This may lead to growing disparities within regions.

Disasters can become hindrances to development, as many peripheral areas of countries with emerging economies depend on income from cash crops. They may even exclude certain areas from further development prospects when affected regions are abandoned and the local population has to migrate. While some parts of the world, regions, or countries lose profits and development potential, other areas may profit from disasters because of better prices for their products and decreased competition. In summary, more disasters mean more fluctuations, price insecurity, and difficulties in business operations. Figure 8.2 depicts the categories of disaster damage and loss. These relate to the agricultural production process or the food production process. We can differentiate between harvest/pre-harvest; transport by road or sea; storage and conservation of agricultural products; inputs to agricultural production; facilities and infrastructure such as machinery halls, irrigation systems, livestock shelters, fishing boats and equipment, landing sites, and hatcheries; food processing technology; and retail and distribution to customers or final consumption in households, restaurants, and canteens.

Figure 8.2: Vulnerability to Disaster Damage in the Food Value Chain



Source: Author.

The first World Conference on Disaster Risk Reduction (WCDRR) took place in Yokohama in 1994. The 10 principles of the Yokohama strategy for a safer world (International Decade for Natural Disaster Reduction (IDNDR), 1994), do not refer to agriculture and food. At that stage, food security issues were not prioritised. The second WCDRR in 2005 in Kobe produced the Hyogo Framework for Action (United Nations Office for Disaster Risk Reduction (UNISDR), 2005). Key activity 2d of the Hyogo Framework highlights the importance of the promotion of food security in ensuring the resilience of communities to hazards, particularly in areas prone to drought, floods, cyclones, and other hazards that can weaken agriculture-based livelihoods. Ten years later, the United Nations General Assembly approved the Sendai Framework for Disaster Risk Reduction, 2015–2030 as an outcome of the third WCDRR in March 2015 in Sendai. Article 28b of the framework targets collaboration across global and regional mechanisms and institutions for the implementation and coherence of instruments and tools relevant to disaster risk reduction, such as climate change, biodiversity, sustainable development, poverty eradication, environment, agriculture, health, food, and nutrition (UNISDR, 2015).

The Sendai Framework for Disaster Risk Reduction, 2015–2030 did not offer new ideas on how to deal with an increase in disasters and disaster damage in particular. A joint international methodology on how to assess disaster damage and losses in agriculture and food security is still missing (Cutter, 2017; Breiling and Anbumozhi, 2017), but is likely to emerge during the next few years. In 2017, the FAO came up with a climate change strategy (FAO, 2017) after analysing disaster impacts in previous years in developing countries (FAO, 2015; 2016). Advice on how to quantify damage and losses in a standardized way has not yet been provided, but should be a topic in the future.

Natural disasters work within a larger system of food security issues, and other – sometimes hidden – factors can aggravate or mitigate disaster damages. Disasters can thereby impact agricultural production, food production, food storage, food distribution, the durability of food, and more. Floods and droughts, the most common form of natural disasters, are primarily climate-induced. According to the FAO, there were an average of 149 annual disaster events during 1980–1990 and 332 over 2004–2014. While the number of climate-related disasters more than doubled, the related damage was seven times higher. Therefore, the average damage tripled in connection with each disaster. One can expect a continuation of this trend, with even more damages, in the future. The total annual damage caused by these disasters was $14 billion in the first period during 1980–1990 and $100 billion in the second 2004–2014 period (FAO, 2016a). This is equivalent to an increase in the amount of disaster damage from less than 1% (1980–1990) to more than 3% (2004–2014) of the total global agricultural production value within a third of a century. The situation is particularly dramatic in developing countries, which are much more dependent on the agricultural sector and especially vulnerable to droughts, where the loss and damage from medium- to large-scale disasters already account for a 22% loss (FAO, 2015).

Disasters trigger and accelerate migration, primarily in developing countries (Lütz, 2013). How well countries cope with this situation depends on internal capacities. Natural disasters affect 218 million people or 3% of the global population each year – contributing to 65 million forcibly displaced persons and 22 million or 0.3% of the world's population as refugees (United Nations Development Programme (UNDP), 2016). Weather- and climate-related disasters are taking a heavy toll, which is difficult to calculate because of under-reporting in low- and middle-income countries, particularly on mortality caused by heatwaves. The period from 1996 to 2015 saw 7,056 disasters recorded worldwide by EM-DAT, the Emergency Events Database, taking the lives of 1.35 million people or 68,000 deaths per year. The number of weather- and climate-related disasters (floods, storms, and heatwaves) has more than doubled over the past 40 years, accounting for 6,392 events in the 20-year period from 1996 to 2015, up from 3,017 in 1976–1995. In comparison, the frequency of geophysical disasters (earthquakes, tsunamis, and volcanic eruptions) remained constant. In total, climate-related disasters claimed more lives than earthquakes (Centre for Research on the Epidemiology of Disasters (CRED) and UNISDR, 2016). The number of people under displacement risk because of natural disasters has quadrupled since the 1970s. This is twice the rate of population growth, meaning that people are twice as likely to be displaced now than they were in the 1970s. People in Asian countries have the highest risk of being displaced because a large number of vulnerable people in Asia are exposed to multiple natural hazards (Internal Displacement Monitoring Centre (IDMC), 2015).

8.3 Disasters and Resilience Strategies for the Food System

The increase in disasters coincided with a 70% increase in traded agricultural goods during 2006–2016 (World Trade Organization (WTO), 2017) and a general increase in exports of goods and services from 13% of global gross domestic product (GDP) in 1970 to 31% of GDP in 2008 (International Monetary Fund (IMF), 2009) before dropping slightly to 29% of GDP in 2015 (World Bank, 2017). A high proportion of domestically produced food in the total food supply is of key concern for almost all countries, although ever more food is imported.

Food security is not only related to continuous success in productivity but also safeguarding the current flow of resources, controlling the international trade in inputs, and providing an efficient global transportation network. Global energy prices fell by 45% during the decade from 2005 to 2015 (WTO, 2016). When the first General Agreement on Tariffs and Trade (GATT) agreement was negotiated during the 1990s (Saylor Foundation, 2017), special exceptions for agriculture were included, e.g. an allowance to use export subsidies. This enabled countries to keep prices for farm products high in domestic markets, but those prices generated a surplus of food which was dumped on international markets by using export subsidies. Agricultural producers in developing countries were thereby forced to compete with low-priced subsidised food from the developed world.

The global food security system offers flexibility and trade-offs for most people around the globe. Some 90% of global citizens enjoy food security while 10% suffer from occasional or even permanent food insecurity or hunger (von Grebmer et al., 2016). Comprehensive food security became widely possible because of a combination of inexpensive external energy, fertilisers and material inputs, and sufficient internal land and water resources. It is a declared aim of the United Nations (2015) to eradicate hunger by 2030 – an expressed Sustainable Development Goal – and more than 97% of the global population should become food secure by 2030. Accordingly, appropriate food production and distribution policies should be put in place to guarantee food availability for all consumers.

Many ways to improve efficiency between agricultural production and food consumption will have to be considered to counter an increase in disasters and an even greater increase in disaster damage and losses. One option is to produce more food (FAO, 2013) than what can be eaten. We already produce food for more than 10 billion people (Holt-Giménez et al., 2012) or even 12 billion people (Tiwari, 2017). However, so far, the food security system has failed in distributing food to all the people in need. Challenges arise in deciding how the food will be distributed amongst the people, who has the power of distribution, and what methods should be used for distribution (Mission, 2014). Producing more food than necessary leads to more robustness after harvest failures in the case of additional climate-induced changes (Worldwatch Institute, 2013), unexpected animal diseases, or other sorts of crises. The food price plays an important role in the distribution system. If it is not high enough, local producers may be pushed out of business in favour of larger food producers. If it is too high, the number of poor and hungry people not able to buy sufficient food will increase. Food price fluctuations relate to petroleum prices, crop yields, food stock levels, and exchange rates (Ghanem, 2011).

A second option is to change the ratio within the agricultural production of non-food uses (in particular feed and fuels) and food consumption in favour of the latter. For example, grain can be feed for livestock or food for humans. In 2016, 1.03 billion tons – or 136 kilograms (kg) for every person on earth – was used as feed for animals, an increase of 8% over 2012 (Alltech, 2017). A high percentage of meat in a society's diet can also be considered a hidden food reserve if people were to substitute meat with cereals. In addition, a vegetarian diet is considered an efficient means to cut GHG emissions from agriculture (Hedenus et al., 2014). We should further question if cereals or palm oil are a good alternative for ethanol fuel production. In the case of India, it was considered a viable option for marginal lands while it should not compete with food production in densely populated areas (Srinivasan, 2009). In total, global cereal production amounted to 2.49 billion tons in 2016/17 (Statistica, 2017) or 328 kg per person. Considering 200 kg as the annual minimum requirement for one person, the amount produced implies that 12.45 billion people could theoretically obtain food from the current cereal production.

A third option is to minimise agricultural production losses and avoid food waste. Here, disaster-related damage and losses are relevant. On the demand side, reducing food waste can have a significant impact on the availability of food. The FAO (2011) suggested that about one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year. Huge amounts of the resources used in food production are used in vain. The related GHG emissions are also in vain. The average European wastes 179 kg of food in the value chain from the farm gate to the lunch or dinner table (Stenmarck et al., 2016). This is close to the annual consumption of a poor person mainly living on 200 kg of cereals. Reducing food waste can improve the efficiency of food value chains and help to improve food security.

A fourth option is to support the poorest nations with targeted food programmes. Assisting 80 million people in around 80 countries with 12 billion meals, the World Food Programme (WFP, 2017) is the leading humanitarian organisation fighting hunger worldwide, delivering food assistance in emergencies and working with communities to improve nutrition and build resilience. In the case of ASEAN countries, Myanmar and Cambodia have profited from such programmes and have seen the largest percentage reductions in hunger worldwide since 2000 (von Grebmer et al., 2016a). Particular directions of the WFP are the food for work, school meals, and first 1,000 days actions. The food for work action targets repairing irrigation facilities or other infrastructure after emergencies. Some countries such as India have established their own national work for food programmes for disfavoured regions within the nation. The school meals action and the first 1,000 days action are directed at children and infants and their mothers, usually the most vulnerable individuals after disasters (WFP, 2017).

Yet another strategy is to improve food safety further and detect emerging food security issues early. While the eating of insects is common in some Asian countries, it is entirely new in Europe. In recent years, entrepreneurial activities have been developed to introduce insects as food. Several start-ups established in the European Union, e.g. the Austrian Zirpinsekt (2017), produce high protein content food from grasshoppers. Appropriate standards and government ordinances have to be issued as the introduction of new food items is critical. This has led to a process within the European Union to regulate risk and safety aspects related to insect food. The European Food Safety Authority (EFSA) Scientific Committee (2015) considered introducing insects as food and feed, and common standards may be published in the near future.

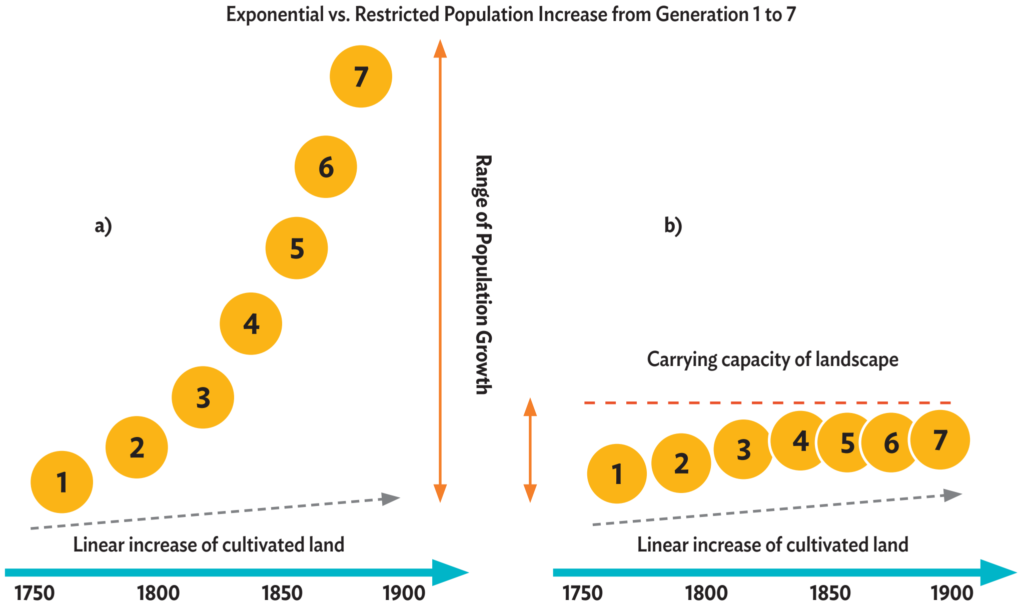
8.4 The Food Scarcity Threat

Climate change and increased frequencies of extreme weather events are a recent phenomenon, alongside many old ones in the history of food security, as the human population is dependent on food and available food quantities. For hundreds of years, there has been a persistent concern and theory that human population growth would not be met by sufficient increases in agricultural production. Malthus (1798) drew attention to the fact that the population doubles in a given period, so-called exponential growth, while agricultural production increases due to more agricultural land, with linear growth rates. At that time, this situation related primarily to gaining agricultural land through clearing forests. As land is limited and the possibility of converting forests to agricultural land gradually becomes impossible, famine and war are a logic consequence after a few generations because of the reduced food supplies.

Figure 8.3(a) depicts an example of the exponential population growth in a condition of limited arable land supply. This is typically for development in the centre of a region. We start in 1750 at generation 1. After six generations, on average 25 years, the arable land has grown modestly while the population has skyrocketed. Malthus intended to show his contemporaries the impossibility of such a development and that any society has to break down sooner or later because of famine and war. However, his doom model was – and still is – viable for urban areas. A precondition is that enough food can be imported from adjacent rural areas.

The Malthus model was contrasted by a resource constraint theory model (Verhulst, 1838) and stabilisation function to describe the relationship between population and food supply. The population cannot grow out of a certain range because of resource constraints, which define the carrying capacity of a given territory. If exceeded, the people have to migrate to other areas or suffer from scarcity, famine, and bad health, which also limit the reproduction rate. An equilibrium between agricultural land area and population will, therefore, be reached before extraordinary population growth. This situation is depicted in Figure 3b and is typical for rural areas. The surplus population of rural areas has to migrate to urban areas within the region or new less populated regions. In Malthus and Verhulst's time, many people emigrated from Europe to America and other continents. The global population increased from 679 million in 1700 to 957 million in 1800 and 1,650 million in 1900 (Demeny, 1990). For a very long time, the scale of operation was comparatively small – people were restricted to local food resources and limited interactions farther afield were limited. Optimisations in food production were achieved within territories.

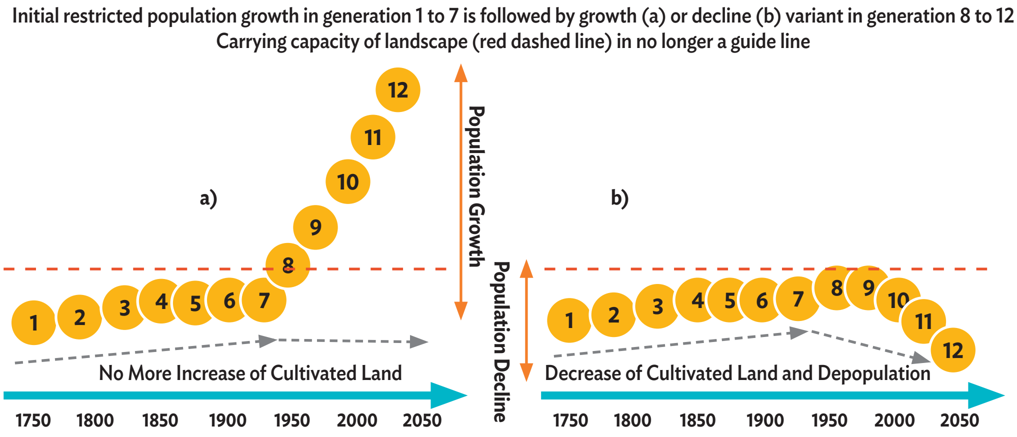
Figure 8.3: Land and Population in Dependence to (a) Malthus and (b) Verhulst



Source: Author.

In 1960, the world's population was 3 billion people. Gradually, the resource supply region extended and more resource imports became possible. Farmers produced surpluses and became richer. The scale of interaction was no longer restricted locally and could be optimised for larger areas. Non-local inputs such as machinery and chemical fertilisers increased productivity widely. The laws of economies of scale could be applied, and larger territories could be regarded as food markets because of higher productivity and larger quantities of food. Arable land was for a long time considered the single most important asset of grain and food production (Malenbaum, 1953). Local resources such as water and traded resources such as energy, fertiliser, pesticides, machinery, and more input materials become equally or even more important as access improves. This allows an unprecedented expansion of food supply which could not be anticipated under historical conditions. Rural regions (as shown in Figure 8.3(b)), up to the eighth generation restricted in growth, can now leave the state of equilibrium and overcome the limits provided by the carrying capacity of the landscape. They can start an intensification process (Figure 8.4 (a)) similar to the one projected by Malthus (Figure 8.3 (a)) or become urbanised. Alternatively, they can become marginalised, less populated, or even unpopulated areas because of better living conditions elsewhere and the strong incentive to migrate to places with more opportunities (Figure 8.4 (b)). We have both a decline in population and land in use because of marginal profitability. Fields that were used under hard conditions of external resource constraints are no longer managed in the new economic context. The disappearance of smaller local settlements – livelihoods, hamlets, villages, and sometimes even towns – happens in parallel to the prospering of new regional centres with access to more food items.

Figure 8.4: Land and Population in Verhulst Models Modified by Economies of Scale



Source: Author.

Access to foreign resources and trading changes land use dramatically. This section discusses cases from Austria in Europe.

<u>The Case of Austria</u>

Recently, Austria, in Europe – like other rich industrialised countries – has enjoyed a previously unknown variety of foods. Looking back to the times before Malthus and Verhulst, Austria's 84,000 square kilometres (km^2) of territory could hardly feed its 2 million people who were then living within its borders in the 18th century. Major famine periods were reported in 1709, 1770, and 1772 (Linsboth, 2008). Some 80% of the population was working in agriculture, struggling hard to cultivate food from their land. There were frequent famine periods, often leading to armed conflicts and migration to other parts of the empire in Southeast Europe. Today, 8.8 million people live on the same territory, perfectly served with a great and diverse supply of food: tropical fruits, out-of-season food items, and fresh seafood are now offered throughout the year not only in the capital Vienna but even in smaller towns in the countryside. The country could possibly provide food for 20 million people although the local resource base has not changed.

During less than 12 generations from 1750 to date, the capacity to feed the population has increased 10 times. In addition, the food is of higher quality and is continuously available. What has changed is the global resource availability facilitated by international trade, previously unavailable access to capital, a sharp decrease in transport costs, and the resulting possibility to import and export more kinds of foods in different qualities and larger quantities from various countries. In addition, less land is needed and marginal agricultural fields are again afforested.

From 1990 to 2010, more than 2,000 km^2 – 2.5% of the total land area or 6% of the agricultural land area – were afforested (Austrian Ministry of Agriculture, Forestry and Environment, 2015). About 1.5% of the Austrian land area was converted to land for construction, supporting the wish of many Austrians to move from the city centre to the rural fringe. Austrian society got used to full food stores where a diversity of inexpensive food is available. The former necessity of the non-farming population to produce food turned into a hobby to produce one's own food. Many people use their gardens for recreation rather than fruit and vegetable cultivation like two generations before. Sometimes fruits are not even harvested as the owners are busy with more profitable tasks than gardening. This indicates a radical change both within the society and the food support system.

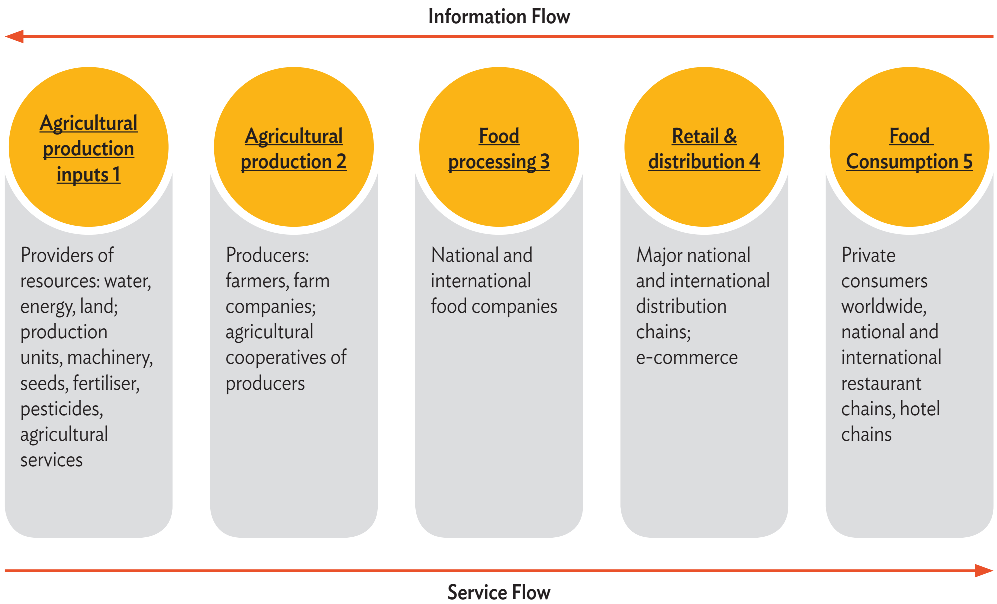
Endogenous population growth, as experienced in ASEAN countries with 639 million people (2016), does not happen in Austria or the European Union (EU) with 512 million people. It happened before during 1850–1970 when the fertility rate was well over two and far above the simple reproduction rate. In 2015, it was 1.47 and principally in a situation of decline. However, Austria is an attractive immigration or refuge country, and population growth has continued though many peripheral subregions experience depopulation. Primarily in these remote areas, people have fewer services and a less sophisticated food supply.

Austria's accession to the EU in 1995 offered a much larger and wider food market. National food value chains turned into regional EU food value chains. The protection of national agricultural markets became more difficult. Austrian farmers had to compete harder with their peers in other EU member countries with better production conditions. The former preference for agricultural productivity changed to a preference for tourists because of the importance of tourism – which is economically three times more important than agriculture (Breiling, 2006). Before, a beautiful landscape was a by-product of agricultural activity; now it is the main product. Landscape maintenance is a precondition for modern mass tourism. A healthy ecologically well-functioning landscape is not only the source of tourism revenue but also a means to cope better with disaster risks, which will be discussed later.

8.5 The Food Supply Chain

Food consumption is the end of a production chain. Figure 8.5 divides the food supply chain into the following groups of stakeholders: (i) providers of agricultural inputs, (ii) producers of agricultural outputs, (iii) the food processing industry, (iv) retail and distribution organisations, and (v) food consumers.

Figure 8.5: Actors in the Food Supply Chain



Source: Author.

The first group of stakeholders relates to agricultural inputs. Any agricultural production depends on inputs. We need the provision of basic resources such as farmland. With some 1.5 billion hectares globally, the right amount of water resources and energy in various forms (e.g. gasoline and electricity) are vital. Then, we need inputs such as seeds, fertiliser, pesticides, and machinery; and production units such as greenhouses, storage facilities, and other built environment. Finally, agricultural research and services can be named as an input class. During the last decade, following the financial crisis in 2008, farmland has become an important asset in trade and investment. Since then, every year at least 10 million hectares have been sold from family farms to institutional investors at a price of about $500 per hectare (based on Deloitte (2013)). Climate-induced water problems challenge agricultural production, and more frequent drought and flood disasters have increased prices for agricultural commodities. Unpredictable energy prices may further aggravate the situation. Progress in agricultural research – such as the introduction of drought-resistant wheat varieties – counters some of the new threats. Decreased levels of fertiliser and pesticides caused by precision farming allow important reductions in inputs. The development of smart farming may offer important new possibilities at even lower resource inputs.

The second group is producers, which is the group dealing with growing agricultural crops and breeding animals. Global producers comprise several hundreds of millions of mainly small family farm units, often organised in cooperatives, and a few large agricultural production units. They represent the core of agricultural production. The persistent trend is for smaller farms to be bought up by larger more profitable agricultural units, and the number of producers is constantly decreasing. Still, the current farm structure is considered too small to run profitably for many farms. Developed states usually support their farmers with product, production, or environment improvement subsidies to keep farmers alive economically. Many poor countries cannot support their farmers in a similar way. Here, the production base is challenged by lack of capital to compensate for the threats of land and soil degradation or more frequent water scarcity. Wu et al. (2014) reported on the implementation of genetically modified organisms in developing countries to make crops more durable, avoiding post-harvest food losses which can be as high as 50% by introducing small silos, appropriate transport, refrigeration, and storage facilities.

The third group of stakeholders includes food processing, which is organised in many national and international food companies. Food processing has been done on a regional scale but is now becoming global. Ever more food companies are merging or trying to buy each other to use synergies in producing more cheaply for a worldwide market. In February 2017, US food giant Kraft Heinz attempted to buy Unilever, its competitor from Britain/the Netherlands, for $143 billion (Hughes and Felsted, 2017). The takeover did not take place, but it would have been the largest in history. In 2015 (2 years earlier), the world's largest food processing company, Swiss-based Nestlé, tried to buy Heinz but the deal failed. Instead, Kraft and the Brazilian 3G investment companies bought Heinz and founded Kraft Heinz – the fifth largest food company in the world. We can expect even further moves in food companies which try to reduce costs by becoming ever larger multinational companies and overtaking each other. The number of players will be thereby reduced.

The fourth group of stakeholders is retail and distribution chains. Distribution is the key issue for global food chains, as the production capacity is high enough to produce food for some 12 billion people but we cannot distribute it to all the people who need it. While we produce up to twice the food needed (Deloitte, 2013), some 800 million people (FAO, International Fund for Agricultural Development (IFAD), and WFP, 2015) are still affected by hunger. Many states particularly target improving food distribution and access to healthy food for the global poor.

The global food retail industry has been experiencing steady growth in the last couple of years. During 2016, the highest growth in merchandise trade has been achieved in agricultural products, which have increased by 67% in value (WTO, 2017). The global food retail industry accounted for $7 trillion in annual sales or 8% of global GDP in 2016. The top 15 global supermarket companies account for more than 30% of world supermarket sales. With improved technologies and economies of scale, these retailers enjoy operating cost advantages over smaller local retailers. With a marked change in consumer preference, online shopping, rising populations, and an increase in purchasing power in emerging markets, the global food retail industry continues to grow. The entry of global food giants in emerging economies has led to a boom in the food retail sectors of these markets. China and India, in particular, are driving rapid growth in the global food retail industry as the Asia-Pacific region remains the largest market for food retail globally. Indonesia and Thailand are also witnessing excellent growth, as traditional outlets are being modernised. Meanwhile, the food retail market in Europe, particularly Western Europe, is thought to have reached a saturation point. Denmark, France, Italy, Greece, and Spain are in fact seeing a decline in their food retail industries.

The final group of stakeholders is consumers. The value of food consumption increases continually. People eat food in restaurants, canteens, food stalls, private households, and other places. Consumer preferences lead to changes in food consumption patterns, which depend on disposable income, education, availability, and more. In recent years, food delivery chains like Foodora, UberEat, and others have celebrated success and expansion by delivering restaurant foods directly to offices and homes (Nicola, 2016). Apart from the price, freshness, quality, customer service, and shopping experience are high on the agenda of food consumers. Very often, countries do not have only one single food market but several markets for different consumer types. In Europe, the US, and other countries, organic, green, or sustainable food is high on the agenda, while high quality might be sufficient for buying a food item in other countries. The complexity of food items has increased. For example, the EU has three classes of eggs, all of them fulfilling the hygiene quality criteria but with different ethical standards. The fourth kind of eggs, with the worst ethical standards but an appropriate hygiene standard, are eggs from cage breeding. This method has been banned by the EU but is still used outside the EU (Utopia, 2017).

Operational efficiency, food waste management, a high degree of control over nutrition norms, gaining technical expertise on data management, and innovative packaging solutions are additional focus areas (Frost and Sullivan, 2017). Yet the question arises as to whether this process of improvement can continue to meet the needs of all people in mature economies. So-called food deserts have come into existence (Cutter, 2017), where particular parts of the population have no access to adequate or high-quality food in otherwise wealthy countries. In the US, individuals spending less than $5 a day on food are considered at risk of being food-insecure. They lack access to healthy and affordable food. Other parts of the population living in scarcely populated areas do not have access to supermarkets where most food is traded. In total, some 7% of the US population is endangered. We can assume that considerably more people in ASEAN countries do not have adequate access to healthy food.

8.6 Adjusting for Global Food Distribution

The process of scaling up agricultural production and food consumption is visualised in Figure 8.6 with global, regional, and local food chains. Distribution is accorded an ever more important role with the extension of scale. At the beginning, in the circular economy of subsistence agriculture, the food produced is consumed locally. With more sophisticated agricultural production, food distribution and consumption emerge on a regional scale. Finally, we reach a global exchange food system. The distance between agricultural production, food processing, and food consumption can become very wide and food components may travel several times around the globe. Currently, local, regional, and global food systems exist in parallel. They compete with and complement each other. Food is overproduced on a larger scale, and the global or regional surplus can balance out shortcomings of the food supply at a local scale. A higher share of domestic food production makes countries less vulnerable to price fluctuations.

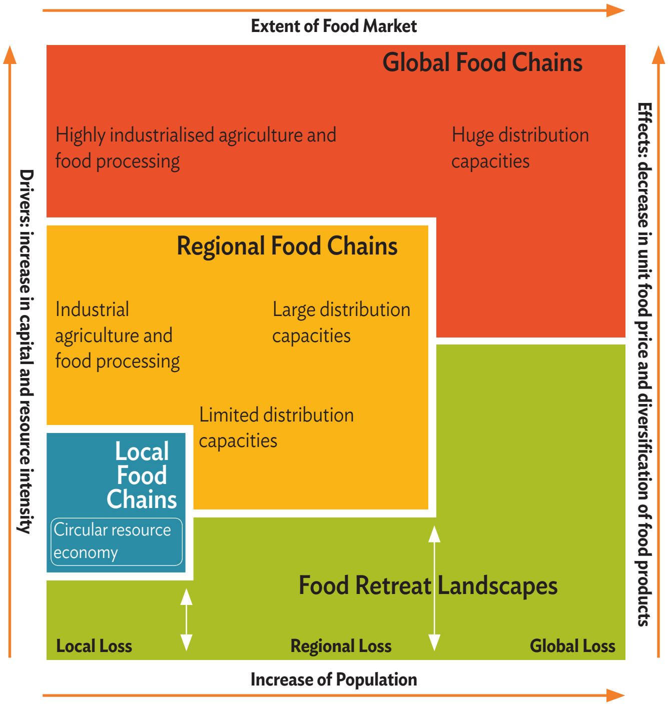
The local food system stretches into peripheral places inaccessible for the regional and global food systems. Here, poor people find a place for subsistence agriculture. They still follow local resource economy traditions and can cultivate food according to the given carrying capacity of the landscape without major inputs from outside. In local food systems, the number of foods is limited to the availability of local foods, which can vary from place to place. No or little money is needed to make a living in modest circumstances. These systems were often stable for centuries, but as the population increases they do not fulfil the needs of larger population groups.

The global food systems provide ever more food based on highly industrialised agriculture connecting major centres efficiently, and lead to population densities many times larger than what any dense network of local food systems could provide, but they can only prosper close to centres in favoured spots. They are dependent on huge capital investments and a secured supply of external resources. The intermediate regional food system connects centres within the region and is within local and global food systems. The most successful regional food chains develop into global chains while others become challenged by more efficient competitors.

A few regional networks have developed into huge international food production and trade networks, and are now major companies. Under the current conditions of globalising food trade, these players become ever more important by cooperating with, buying, or merging with their competitors. Large holdings enable global food availability over different climate and production zones to every state and region that is wealthy enough to import food. As with global distribution, the largest possible operational scale is reached. Additionally, other means to alter the food value chain are needed. This includes more differentiations of conventional food items and the invention of new food items, e.g. energy drinks.

More energy will be needed to fuel the growth of the global food chain. This will lead to additional GHGs in the atmosphere and more severe climate change. The IPCC (Fleurbaey et al., 2014: 327) cited research 'that food accounts for the largest share of consumption-based GHGs with nearly 20% of the global carbon footprint, followed by housing, mobility, services, manufactured products, and construction'. This, in turn, could cause more climate-related disasters and even higher damages than current disasters. The direct GHGs from global agriculture are 10%–12% of total emissions (Smith et al., 2014: 822), including non-food agricultural production. However, the indirect load of GHGs, including the inputs to agricultural production, is much higher. In the case of Japanese rice production, direct agricultural emissions were calculated for 1990 to be 40% of total emissions within the production process (Breiling et al., 2005). The remaining 60% comes from secondary emissions related to industrial inputs of rice production such as agricultural machinery, chemical fertiliser or pesticide inputs, and transportation. In line with this, we could hypothesise that global agriculture and its inputs contribute as much as 30% of the climate change carbon footprint.

Figure 8.6: Food Distribution – Scaling Up from Local to Global



Source: Author.

Figure 8.6 explains the transitions and trade-offs. It also depicts so-called 'food retreat landscapes'. The retreat of food production from landscapes can be forced by land degradation or done voluntarily through land conversion from agriculture to other purposes. This indicates that, with increasing spatial scales, technical progress, and resource inputs, less land is needed to produce sufficient food for an increasing global population in an industrial way.

The distance from agricultural land to markets and food streams (von Thünen, 1842) becomes ever more important. In the time of Malthus and Verhulst (Figure 8.3), the entire land was used for food production and a food retreat landscape did not exist. The world was covered by a web of independent small-scale food supply chains with limited interactions. Humans were fighting not to exceed the given carrying capacity of the landscape, which was the limiting factor. The world's population doubled during 1750–1900 from 0.8 billion to 1.7 billion (Durand, 1977). Up to a few decades ago, an increase in agricultural land was the sole means to increase food productivity (Malenbaum, 1953). With the increasing affluence brought about by the developing regional and global food chains, some, many, or most food items are now imported. Difficult-to-manage agricultural fields are given up first or afforested. Gradually, more land is taken out of food production because of limitations in increasing productivity. Finally, only the most suited, easy-to-cultivate landscapes targeted for regional and global markets are used for food production. In a local system, the share of food retreat landscapes is small. In a regional system, this share is considerably larger. In a global system, large parts of former food production areas can be used for other purposes such as bioenergy, afforestation, or ecosystem services.

The trend is for many family farms to be bought up by international investors in the food business and for small-scale production to turn into large-scale production or local into regional. Many regional food value chains compete against each other. In an attempt to avoid competition and overproduction, former regional food chains become more economically efficient and valuable in global food chains, which often connect several regional food chains under an umbrella structure. In other cases, regional food chains that formerly covered a broad range of food products concentrate on a few food products where they have a comparative advantage to compete in a much wider world market.

The idea of food retreat landscapes can be perceived as strange, knowing that until now huge areas were converted from rainforest to agricultural land. In ASEAN countries, this conversion favoured palm oil plantations. From 2000 to 2012, 50,000 km^2 of tropical rainforest were cleared each year globally (Mongabay, 2017). Initially, these were small-scale landholders, but larger companies became the actors in later years. In many cases, the land conversions were done in an unsustainable manner to generate quick income. This land contributes to one-third of the globally degraded agricultural land, totalling 5 million km^2, and needs to be restored ecologically. An estimated 24 billion tons of soil are lost annually according to a global land outlook (United Nations Convention to Combat Desertification (UNCCD), 2017a). Land degradation neutrality goals were articulated recently, and while this land is unattractive for industrial agriculture, it has an important role in providing ecosystem services (UNCCD, 2017b).

Another trend is that food production does not need to be on agricultural land. It can be on residential land, and many timely initiatives for urban agriculture to reoccupy urban people with food production and gardening prove that local food production is still popular (Foo and Teng, 2017). Yet another way, far from land and soil, is to use buildings for indoor food production (Specht et al., 2014). Information and communication technology and smart farming methods are technology-driven ways to boost food production in a limited land area. Many smart farming systems are under development, primarily in highly developed countries (Wolfert et al., 2017).

It is estimated that the current area devoted to food production is much higher than needed if perfect food distribution could be granted. Much of the land is kept for overproduction. The aims are to compete smaller food producers out of business at ever cheaper prices while fulfilling the food needs of a still growing world population inexpensively. This, despite the expectation of more environmental deterioration such as desertification, water scarcity, soil erosion, more frequent disasters, and more adverse impacts induced by climate change. In addition, a considerable part of the land classified 'agricultural' might be underused or even unused because of decreased fertility. According to UNCCD (2015), one-third of the agricultural land, estimated to total 15 million km^2 globally, has been lost since 1975. Out of the total global land area, estimated to cover 130 million km^2 including agricultural land, 25% is classified 'highly degraded' or is undergoing high grades of degradation.

8.7 Different Disaster Risk Strategies According to Scale of Food Production

Disasters have the worst impact on developing countries with traditional economies where ordinary people have no flexibility if hit by a disaster. Poor people rely on local food production and depend on the typical weather conditions for their climate region. Food availability and diversity are considerably lower than in countries with large food imports. With every disaster, these countries become more dependent on international aid and relief programmes. Decision making within the countries also becomes more limited after a disaster.

There is a firm connection between environmental and ecosystem management, climate change adaptation, and disaster risk reduction (Munang et al., 2013). This is particularly valid at the local scale. The attribution of a single hazard event or specific losses to climate change is still difficult because of the relevance of different spatial and temporal scales (Birkmann and von Teichman, 2010). Over time, there can be feedback reactions to the larger regional or even – assumingly very robust – global scale. The length of time this can take depends on the disaster frequency and preparedness to mitigate the effects of disasters.

On the local level, a disaster has much more disturbing consequences. Very often, a disaster entails the additional weakening of an already weak local society or in an extreme case a collapse of local villages. Local people primarily rely on the ties and support of family members. These ties are disturbed when children migrate. Sometimes local people do not trust that their fate can be positively influenced by local governments or public authorities. Many small villages are being abandoned, and old and weak people are the main remaining inhabitants. A drought or flood disaster event might be seen only as the last step in a series of decline processes. Therefore, many disasters in remote locations are not reported, and they are not dramatic enough to find their way into the news. Such events can be a further stimulus for younger inhabitants to migrate for a better future.

On the regional level, the observed increases in disaster events and the even higher increase in damage and losses have been widely balanced by the increase in GDP and the enlarged food trading possibilities. Local disasters might not be felt on the regional scale, and a regional disaster eventually has a limited effect on the global scale. We can postpone the adverse effects of disasters up to a point when larger regions or particular strategic nodes of the global food value chain are affected. Better access to more foods and a higher variety of food in regional centres can be an important pull factor for migration to well-supplied areas.

If a global food value chain is established – usually in richer countries and regions – it seems initially very robust. Disasters are not critical, as even food failures of entire world regions can be balanced on the global scale. If important parts of the harvest are destroyed by a disaster – e.g. coffee, tea, or spices – the price will increase. Following the price increase, fewer people are able to afford to consume a food product or have to reduce the frequency of consuming those food items. This often relates to luxury food products, not basic food commodities like rice, wheat, or corn. Here there is flexibility, as much of this product is consumed as animal fodder or even used to produce fuel. Many consecutive large disasters would need to occur before a major food crisis could happen in central areas of wealthy countries.

Wars and serious political crises could change the effects of disasters on food security. While drought or flood disasters may have limited consequences in peaceful conditions – e.g. when some damaged infrastructures can be replaced easily in a normal trade situation – the situation can become catastrophic when there are trade restrictions. South Sudan experienced serious droughts during 2011, 2015, and 2016 in a situation of civil war (Reliefweb, 2016). The agricultural production was disturbed, and coincided with repeated drought periods and extremely limited trading possibilities. Up to 5 million people, about half of the country's population, were severely food insecure – leading to the starvation of an estimated 30,000 people. Within ASEAN, Cambodia had a similar experience in 1979. Vietnamese troops invaded the country after 4 years of rule by the Khmer Rouge and a genocide in the country. Many people also died as landmines complicated local agricultural production and imports of agricultural commodities were not possible (Li and Rothstein, 2012).

Asian history shows dramatic examples of famines that were driven by disasters. The largest famine in human history took place in China during 1959–1961. Although drought was a contributory factor, this was largely a manmade catastrophe based on the policy of Mao Zedong and the Great Leap Forward. The precise number of casualties is unknown, but demographic reconstructions indicate 30 million dead (Smil, 1999). Long-term health effects were found in survivors of the great famine, in particular the children of that time (Chen and Zhou, 2007). Famine and long-term economic development have a crucial relationship, and disasters contribute adversely. The long-term economic consequences of famine in China prevail, even after more than 50 years (Gooch, 2017). Another example of a combination of policy and disaster-driven food scarcity is North Korea and the famine after flooding episodes, in combination with the breakdown in trade connections with former communist partner countries during the 1990s (Lee, 2006).

The dynamics of general development indicators and the frequency of disasters are important. As long as GDP and international trade growth rates are higher than the rate of increase of disasters, the challenge of food security in relation to disasters can be managed. Sudden changes in the availability of resources – like oil price shocks – can be more problematic than the increase in climate-induced disasters. Urban farms producing paprika or cucumber in indoor environments need long-term contracts with fixed energy prices granted by local governments. Water scarcity induced or aggravated by droughts, the infiltration of salt water, and a much higher price for water can become a serious hindrance to irrigation or the profitability of agricultural production. Current prices might not last in a time frame of 10 or more years and food producers should have emergency plans.

As we have local, regional, and global food supply, we have different types of disaster protection strategies:

- A recommended disaster protection action for local food chains is to (i) have a regular and continued food supply, with locally available agricultural and horticultural crops and traditional farm animals; and (ii) employ organic farming methods or agroforestry methods to manage local resources such as soil and water in the best possible way to achieve high and sustainable yields and improved local disaster resilience, even during the coming years.
- In the case of regional food chains, the following strategy against disasters is worthwhile: (i) produce more food at cheaper production costs with less resources per unit product; (ii) increase transportation and storage capacities for a fast exchange between regional markets; (iii) ensure appropriate food safety and control standards; (iv) minimise chemical fertiliser and pesticide use; and (v) make emergency food supply plans for all settlements, in particular remote ones.
- In the case of global food chains, the following recommendations are provided to minimise disaster damage: (i) ensure distribution capacities; (ii) limit resource inputs and become more efficient with the available resources by using smart farming methods and advanced technologies; (iii) avoid planning businesses in disaster-prone areas; (iv) diversify from established food products to a range of products with different levels of sophistication; (v) find a better mix of food diet for each target group in the market, considering that food tastes and food needs are different; and (vi) try to find new markets for food items all over the world and ensure a high-quality and sufficient quantity supply.

8.8 Change in Disaster Risk Strategies in ASEAN

ASEAN countries have large differences in economic performance and disaster risk reduction potential. An easy indicator can be GDP. Differences within the ASEAN region are huge. An inhabitant of Singapore has almost 50 times the income of a person from Myanmar. Countries with very high per capita GDP are Singapore and Brunei Darussalam, with about six and three times the average global per capita GDP at their disposal, respectively. These countries are primarily importers from the global food market. Thereafter follow Malaysia, Thailand, Viet Nam, Indonesia, and the Philippines, with average to half of the average global GDP. These countries contribute to both imports and exports of the global food market. In these countries, large groups of the population can participate in the global food chain, while the majority is still more bound to local and regional food chains. The Lao People's

Democratic Republic (Lao PDR), Cambodia, and Myanmar – with low GDP and less than a quarter of the global per capita GDP – have difficulties participating in the global food market as consumers, but consider a global market for their products. Even the EU has considerable differences in economic development between member countries. In 2007, new member countries – Bulgaria and Romania, formerly centrally planned economies – entered and required adjustments. This is similar to ASEAN, where countries such as Cambodia, the Lao PDR, or Myanmar are rooted in systems with centrally planned economies.

Table 8.1: Food Insecurity in ASEAN, 1992–2017 (% of population)

GHI Rank	Country	1992	2000	2008	2017
44	Malaysia	19.8	15.5	13.7	10.2
46	Thailand	25.8	18.1	12.0	10.2
64	Viet Nam	40.2	28.6	21.6	16.0
68	Philippines	30.5	25.9	20.2	20.0
72	Indonesia	35.0	25.5	28.3	22.0
75	Cambodia	45.8	43.6	27.1	22.2
77	Myanmar	55.6	43.6	30.1	22.6
91	Lao PDR	52.3	48.1	33.4	27.5

GHI = Global Hunger Index, Lao PDR = Lao People's Democratic Republic.

Note: GHI scores out of 119 observed countries.

Source: von Grebmer (2017).

ASEAN countries are more diverse than the 28 EU countries, the risk of hunger is higher, and they are more exposed to natural disasters. In principle, ASEAN countries follow a similar development pattern to developed countries in Europe. Models developed by Malthus or Verhulst in the 18th and 19th century are also valid in ASEAN countries, but the dynamics are different and change proceeds much faster than what was the case in Europe.
Reasons for this are the partly established transition to regional and global food value chains with sophisticated technological development, access to the global infrastructure, considerably more capital, and well-developed international trade.

A current indicator on food security is the Global Hunger Index (GHI), which regularly monitors 119 countries at risk. Economic progress in ASEAN, the development of regional food chains, and partial participation in global food chains were beneficial in terms of food security. For the East and Southeast Asian region, the GHI fell by 57% during 1992–2016 (von Grebmer, 2017). This is remarkable, considering that the region was most severely hit by disasters during this period.

Five ASEAN countries – Cambodia, Indonesia, the Lao PDR, Myanmar, and the Philippines – still had alarming GHI scores, with more than one-fifth of their population partly food-insecure in 2017. Viet Nam showed the best progress within one generation and reduced the percentage of food-insecure people from more than 40% in 1992 to 16% in 2017. Malaysia and Thailand are at the global average regarding the risk of becoming food-insecure. This risk does not exist in the richest countries of ASEAN. Singapore is an excellent performer and Brunei Darussalam is a good performer with regard to food security and the GHI. Fast integration into the global food market, combined with a gradual retreat of the most remote areas in ASEAN, seems a plausible way to become food-secure. In addition to differences between ASEAN countries, we find large differences in and between provinces or regions of ASEAN countries. Conditions differ widely and the ASEAN community is at an early stage of integration (ASEAN, 2016).

The economic differences and resulting ratios in the mix of local, regional, or global food chain participation enforce different disaster risk and food security strategies for ASEAN food producers. All ASEAN countries have producers in the local, regional, and global food chains, but the ratio is varied. Many consumers within ASEAN are mostly dependent on local production, but the shares of regional and global food products are continually increasing. Extreme disruptions in the food supply system of ASEAN countries are currently not in view. ASEAN countries are intensifying regional cooperation and trade volumes are increasing (ASEAN, 2016). This is good for both regional food security and disaster resilience. Severe conflicts, in combination with disaster events, could destabilise the region. Conflicts like the Moro conflict in the Southern Philippines could hinder food distribution efforts and lead to crisis. If such conflicts could be eliminated, food security could be achieved all over the ASEAN region, despite an increase in climate disasters.

8.9 Conclusions

Food security depends on food distribution. More food than necessary is already produced. However, poor people do not generate a market and producing more food at ever higher values does not help the poor and food-insecure people. Instead, food becomes feed for animals or fuel for machines. Deprived places and regions become less populated and more susceptible to disaster damage and losses. Food waste is another serious issue, amounting to one-third of the food produced. Elevated food health standards and differentiation of food products might challenge a lot of food producers in emerging economies if they intend to sell in the global food market.

Disaster damage and losses in agriculture and the food value chain are not yet systematically accounted for. It is possible to differentiate between harvest, transport, storage, infrastructure, processing, retail, and consumption damage and losses. In poor nations, production losses are much higher than in rich nations, and account for more than 20% of the annual harvest value. This damage could be even higher because of under-reporting.

The role of land or soil – historically the single most important resource of food production – becomes less pronounced. Access to external resources such as water, energy, minerals, and capital, allows farmers to exceed the former local carrying capacity at the expense of more pollution and climate change. Out of the global freight traffic, amounting to some 10 billion tons annually, almost 40% is related to agriculture and food. Some 20% of GHGs are attributed to food consumption. Much of the 1.5 billion hectares of agricultural lands become marginalised and are transferred to non-food uses. The best suited lands are used for ever more intense agriculture and food production.

Within the global food chain, production depends on several groups. Inputs became cheaper during the last decade as global energy prices decreased by 45%. New food industries were established, particularly in emerging economies. The number of players in the global food chains is reducing. Many family farms are bought up by industrial investors. Large multinational food companies buy up competitors, and record business transactions are happening in the food business. Food distribution is changing as new forms of retail are emerging offering online food orders to offices. Consumers are becoming more demanding, and both the hygiene and ethical standards of animal breeding are under scrutiny.

The food chains are scaling up as larger global food chains are coming into existence. This gradually changes the human interactions and settlement structures. People are living more densely in central parts of regions, and food retreat landscapes are emerging. Food retreat landscapes comprise more than 30 million km^2 of globally heavily disturbed land and include 5 million km^2 of agricultural land. Much of this land is in the ASEAN region, and there is a need to restore the land to natural areas for proper ecological performance and the provision of ecosystem services. Optimisation of food production for global markets and access to regional and global food are important drivers for this densification. Global food chains need sufficient distributional capacities in both directions. Specialisation in food niche products allows intensification for future growth areas. A side trend of this development is the local (re-) establishment of food cultivation in densely populated urban areas. This marks an important trend to bring back some parts of food production to the people. A revival of local food production could generate more healthy food and decrease dependence on the larger scale food value chains.

In emerging economies – the majority of ASEAN states – local areas develop intensified trade with agricultural commodities and food products on a regional basis. Companies of national and regional importance are established. The resource flow is multiplied by orders of magnitude and capital is generated to develop infrastructure with higher capacity. In addition, major regional disparities exist within these countries. Some parts of the countries, usually capitals or large cities, are considerably more developed than others; and several systems of agricultural production and food consumption exist in parallel. Rich segments of the population participate in global food value chain operations, while other parts cannot.

In mature economies, everyone participates in global food consumption in principle. Singapore and Brunei Darussalam have no hunger risk. Mature economies also have the highest per capita GDP. Food is generally available cheaply. However, there is considerable product differentiation between healthy food – generally expensive and particularly appealing to the better-earning groups of society – and mass production of cheap and unhealthy food. Food safety and consumer preferences are of dominant importance in the food and beverages industry and have a significant impact in dictating terms to food manufacturers and associated companies. There is increased concern regarding maintaining the nutritional benefits of food products because of rising health consciousness amongst consumers globally.

The efficiency of global food chains is connected to global environmental deterioration, forced migration, or gradually becoming poorer in remote rural areas. The costs of transportation and distribution of traded commodities are widely passed on to customers. These costs can be divided amongst many consumers in densely populated regions, while few people share the burden of distribution costs in remote areas. In some countries, governments try to balance inequalities between unequal parts by supporting remote areas at the expense of central areas. This generally works well during economic growth periods, but the support may be given up during stress periods. The inhabitants of remote areas are often aged, with far less income than the national average. Economic downturns also reduce food availability and quality. Foods might be less fresh than in cities, which are easier and more profitable to reach for distributors. Consequently, more rural areas are losing people, making it even more difficult to live in those areas for the remaining populations.

An increasing number of natural disasters does not seem to be a hindrance to the development of ASEAN region countries if GDP and food trade volume rates can be further augmented. This, however, means a concentration of population in more favourable areas of ASEAN countries and migration from disfavoured areas and regions to favourable ones. While some disasters will not be noted as they happen in depopulated remote areas, others will take an extraordinary toll on lives and values if they affect the core production areas of agriculture and food. The number of disaster damage or disaster events alone is not necessarily a decisive indicator. If several disasters happen in a short space of time or distance simultaneously, food prices will increase. Political instability and armed conflicts are a danger in particular areas of ASEAN. Here, like in all other war-affected regions, food security is not a given. The effect of natural disasters will increase and further aggravate the political situation.

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CHAPTER 9

Adaptive Solutions: What is the Role of Financial Institutions and the Insurance Industry?

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9.1 Introduction

Asia and the Pacific face a significant impact from natural disasters. Since 2000, a significant number of extreme disasters has hit this region – affecting the population and damaging assets. The region's growth is continuously threatened by disasters. A study by the Asian Development Bank (ADB) and the International Food Policy Research Institute (2009) forecasts, by 2050, a 15% decrease in irrigated rice yields in developing countries and a 12% increase in the price of rice as a result of climate change. To respond to this challenge, the Association of Southeast Asian Nations (ASEAN) has designed several policies to reduce the region's disaster losses, secure food production, and in turn protect the development gains attained.

The 2005 ASEAN Agreement on Disaster Management and Emergency Response aimed 'to provide effective mechanisms to achieve substantial reduction of disaster losses in lives and in the social, economic and environmental assets of the Parties, and to jointly respond to disaster emergencies through concerted national efforts and intensified regional and international co-operation' (ASEAN Secretariat, 2005). In 2011, ASEAN Member States adopted the ASEAN Roadmap on Disaster Risk Financing and Insurance (ASEAN Secretariat, 2011) and created a regional disaster risk financing and insurance programme (ASEAN Disaster Risk Financing and Insurance Programme, 2017) to implement the roadmap.

On food security in Asia, ADB (2011) reported a yield reduction of 14%–20% for paddy rice, 32%–44% for wheat, 2%–5% for corn, and 9%–10% for soybean. Responding to the predicted decline in food production in Asia as a result of climate change, ASEAN Member States have recognised the importance of addressing food security. The ASEAN Multi-Sectoral Framework on Climate Change: Agriculture and Forestry Towards Food Security (AFCC) was endorsed by the ASEAN Ministers on Agriculture and Forestry in November 2009 at Bandar Seri Begawan, Brunei Darussalam (ASEAN Secretariat, 2009). ASEAN Member States also recognised the importance of mobilising investment for food security in the ASEAN Economic Community Blueprint (ASEAN Secretariat, 2015).

At the international level, the global community adopted several important agreements in 2015 including the Sendai Framework for Disaster Risk Reduction, 2015–2030; the Addis Ababa Action Agenda; the 2030 Agenda for Sustainable Development; and the Paris Agreement. All these agreements recognise the importance of resource mobilisation for action.

The United Nations (UN) outcome document of the Third UN World Conference on Disaster Risk Reduction highlights 'investing in disaster risk reduction for resilience' as one of four priorities for action (UN, 2015a), and describes expected actions at the national and local levels (para. 30) and the global and regional levels (para. 31).

The 2030 Agenda for Sustainable Development (UN, 2015c) highlights food security (Box 9.1) as one of 17 development goals.

Box 9.1: Goal 2 – End Hunger, Achieve Food Security and Improve Nutrition, and Promote Sustainable Agriculture

2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.

2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.

2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilisation of genetic resources and associated traditional knowledge, as internationally agreed.

2.A Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries.

2.B Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round.

2.C Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility.

Source: UN (2015c).

UN (2015b), the agreement from the Third International Conference on Financing for Development, noted:

Shocks from financial and economic crises, conflict, natural disasters and disease outbreaks spread rapidly in our highly interconnected world. Environmental degradation, climate change and other environmental risks threaten to undermine past successes and future prospects. We need to ensure that our development efforts enhance resilience in the face of these threats (para. 4).

It also stated:

We encourage consideration of climate and disaster resilience in development financing to ensure the sustainability of development results. We recognise that well-designed actions can produce multiple local and global benefits, including those related to climate change. We commit to investing in efforts to strengthen the capacity of national and local actors to manage and finance disaster risk, as part of national sustainable development strategies, and to ensure that countries can draw on international assistance when needed (para. 62).

Investment and finance are recognised as key tools in achieving those agreements. However, the role of financial institutions may be recognised just as 'money supplier'. Financial institutions have important functions in managing, mitigating, and transferring risk.

This chapter discusses the role of financial institutions and their financial instruments in relation to food security based on the following questions:

- What is the theoretical role of financial institutions in managing disaster risks?
- What sort of financial schemes will work well for disaster risk management?
- What are the pros and cons of each financial instruments and scheme?
- Is there any possible collaborative financial mechanism to manage disaster risks amongst ASEAN countries?
- What sort of policies will be recommended to attract financial institutions to use their financial schemes more effectively?

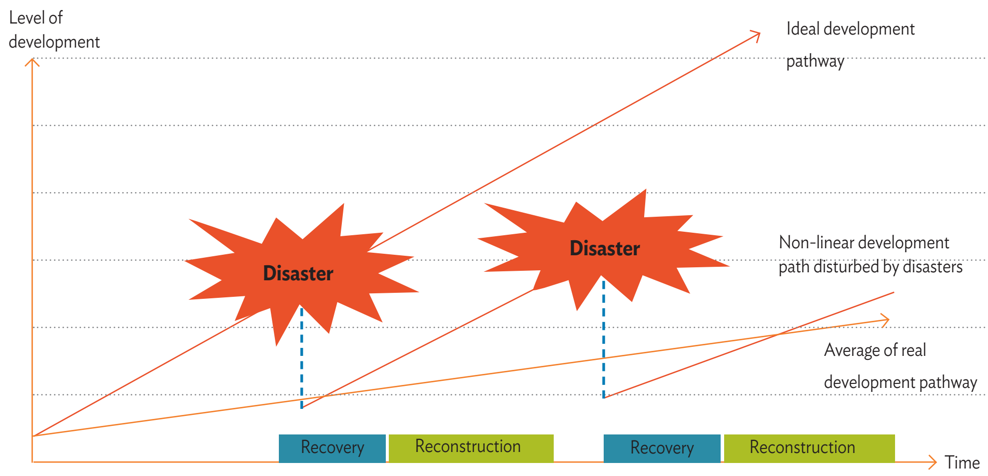
Section 2 reviews the current status and discussions on adaptation, disaster, and food security related finance. Section 3 analyses the relationship between the development pathway and disaster and food security, while section 4 discusses the theories of the role of financial institutions. These chapters provide the foundation for discussing the role of financial institutions in disaster risk management and food security. Section 5 reviews and analyses selected financial instruments and schemes. Section 6 proposes a possible collaborative financing mechanism amongst ASEAN countries. The conclusion and policy recommendations follow in Section 7.

9.2 Disasters, Food Security, and the Sustainable Development Pathway

Disaster is one of the typical barriers to development. The main purpose of development is to improve people's quality of life. To achieve this goal, policymakers try to design the best development pathway for each country. An ideal development pathway may be achieved if no external shocks occur. However, these efforts are easily disturbed by unexpected external shocks such as natural disasters.

Figure 9.1 compares the development pathway with and without external shocks such as disasters. Once a disaster occurs, many assets and capital will be lost, and many economic and social activities will be disturbed. In addition, because of the loss of assets and business and social opportunities, development may be derailed from the ideal pathway. If the impact of external shocks is limited and manageable, a derailed development pathway could be easily recovered. However, if the impact of the external shock is too large and unmanageable, it incurs a huge cost and long recovery time, making it hard to recover the ideal development path. Developing countries have particularly limited capacity to manage the risk of such large external shocks.

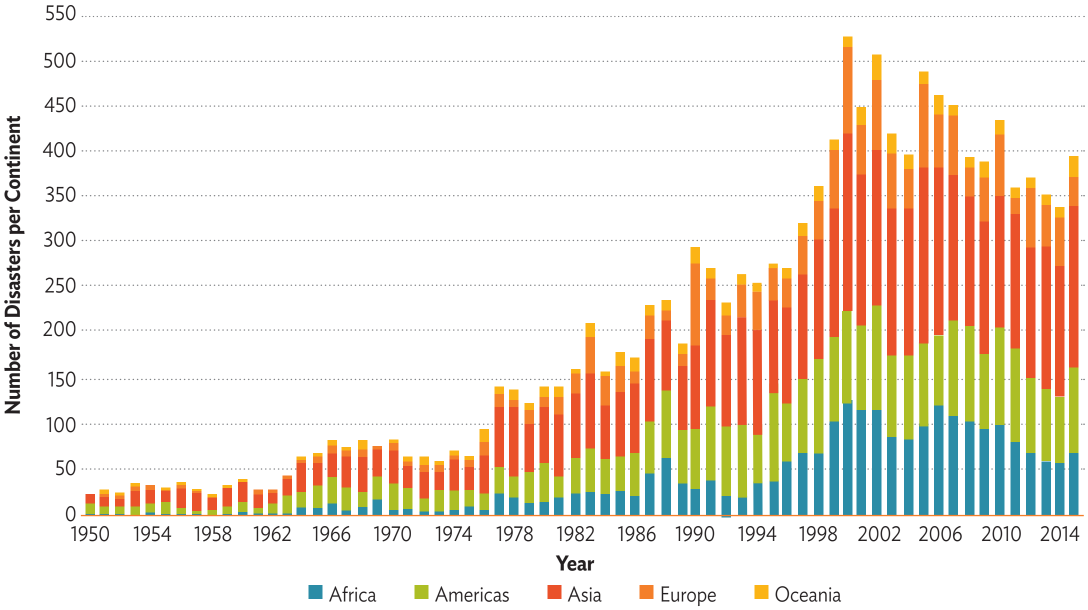
Figure 9.1: Disturbed Development Path



Source : Author.

The number of disasters is increasing. Figure 9.2 shows the rising trend in the number of disasters since 1950. According to data from the Emergency Events Database (EM-DAT), the number of disasters has increased exponentially – almost quadrupling since the early 1970s. Around 40% of the disasters occurred in the Asia and the Pacific region each year. The scale of the disasters has also strengthened, and the losses and damages caused by the natural disasters has increased.

Figure 9.2: Number of Disasters by Region, 1950–2015

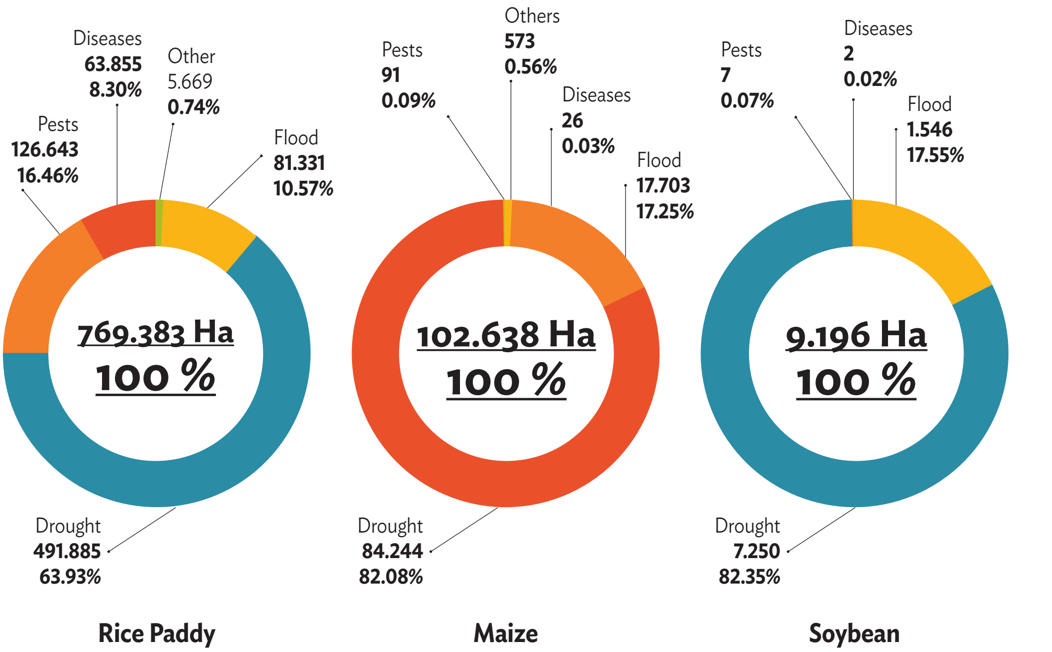


Source: Centre for Research on the Epidemiology of Disasters (2019), Emergency Events Database. www.emdat.be (accessed 10 February 2019).

In 2011, Thailand was affected by a large-scale flood. According to the World Bank and the Government of Thailand (2012), the total damage and loss amounted to THB1.43 trillion ($46.5 billion), which was more than 13% of that year's gross domestic product. The floods were estimated to reduce real gross domestic product growth in 2011 by 1.1% from pre-flood projections, cut Thailand's current account to $11.9 billion from a projected $20.6 billion, and cause a 3.7% loss in tax revenue from estimated pre-flood revenues (World Bank and Government of Thailand, 2012).

Figure 9.3 shows the damage area of major agricultural products in the ASEAN region by the cause of damage. According to these data, drought is the major event affecting the production areas of major foods, followed by floods. In the case of rice paddy, 492,000 hectares were damaged by drought while 81,000 hectares were damaged by floods. This comprises 75% of the damaged area in crop year 2014/15 and 1.2% of the total rice paddy in the ASEAN region. In the case of maize and soybean, almost all the damage is caused by drought or floods.

Figure 9.3: Damage Area of Major Agricultural Products in ASEAN by Cause, 2015 (Crop Year 2014/15)



ASEAN = Association of Southeast Asian Nations, ha = hectare.
Source: ASEAN Food Security Information-System Office (2016).

Thus, risk management is an essential tool for development because people in developing countries are exposed to many risks, and an inability to manage those risks can jeopardise development goals, including economic growth and poverty reduction. The prevalence of risk in everyday life in the developing world is apparent in Table 9.1, which presents data from household surveys conducted by the World Bank that count the number of respondents who have been affected by various shocks. According to the World Development Report 2014 (World Bank, 2013), a majority of households across a sample of developing countries report having been exposed to a shock in the preceding year, and a substantial proportion were exposed to more than one. It also shows that the shocks most frequently reported are natural hazards (such as droughts and floods) and health risks. Rural areas tend to be more severely affected by shocks, especially by droughts and floods.

Table 9.1: Shocks Faced by Households in Developing Countries (% of respondents reporting type of shock)

Shocks	Afghanistan[a]		India[b]	Lao PDR		Malawi		Peru		Uganda	
	Urban	Rural	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
One or More	16.4	48.9	61.6	34.4	72.1	40	66.8	20.7	34.4	29.7	56.2
Two or More	8.7	39.2	23.4	11.9	36.1	12.7	40.4	1.4	1.9	5.6	15.6
Natural Disasters (drought, flood)	10.6	42.2	57.3	5.6	36	10.4	47.2	2.6	21.5	19.9	52.1
Price Shocks[c]	0.2	3	-	4.4	4.9	21.1	42	-	-	1.7	3.2
Employment Shocks	6.4	43.3	-	9.3	3.1	7.7	3.4	6.4	1.5	1.9	0.7
Health Shocks (death, illness)	6.9	14	30.2	23.2	33.8	10.1	18	9.1	8.9	11.8	14.9
Personal and property crime	1.8	6.6	0.9	5.8	1.9	8.5	8.4	3.2	3.1	6.6	8.7
Family and legal disputes	-	-	1.9	0	0.9	1.7	4.3	0.7	0.3	-	-

- = not available, Lao PDR = Lao People's Democratic Republic.

[a] The 2005 Afghanistan National Risk and Vulnerability Survey aims to be statistically representative at the national level. However, to the extent that it is difficult to access the households most acutely affected by insecurity, the data may underestimate shocks for those households. Conversely, it shows that the risks faced by the households that were surveyed are not unlike those in other developing countries.

[b] Data for India are based on representative surveys from rural Karnataka, Madhya Pradesh, and Orissa.

[c] Price shocks refer to strong or unexpected changes in the price of agricultural outputs or inputs, or the price of staple food items.

Source: World Bank (2013), based on data from household surveys in various years from 2005 to 2011.

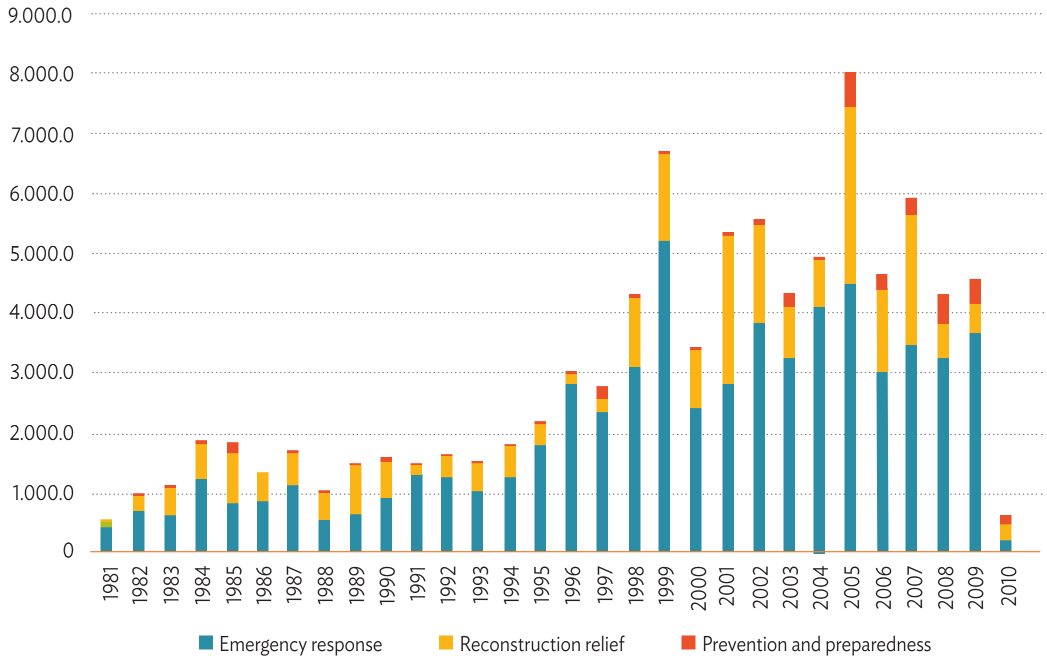
Donors provide financial assistance for disaster management. The World Bank (2013) compiled disaster-related aid commitment data over 30 years from 1981 to 2010 (Figure 9.4). This shows that most disaster-related aid is provided to emergency response (69.2%) and reconstruction relief (27.1%), while only a limited amount is provided for prevention and preparedness activities (3.7%).

Although such disaster-related aid is essential for the affected people, it can be considered an opportunity cost. If the disaster were not to happen, such aid money could be used for another development purpose, which could contribute to economic and social development.

Disaster-related aid can only cover a limited part of the direct losses and damages caused by disasters, while governments and affected people cover the remainder. Indirect losses caused by the delay in recovering from disasters and the decline in economic activities may be covered by the people affected by the disasters, which may affect the clients of businesses run by these people.

The business of financial institutions, such as domestic commercial banks, may also be affected by disasters. The most direct impact on financial institutions is damage to their premises (headquarters and branches) and employees. Nevertheless, they should continue to provide financial services to their clients, who need cash for emergency and recovery purposes.

Figure 9.4: Disaster-Related Aid Commitments



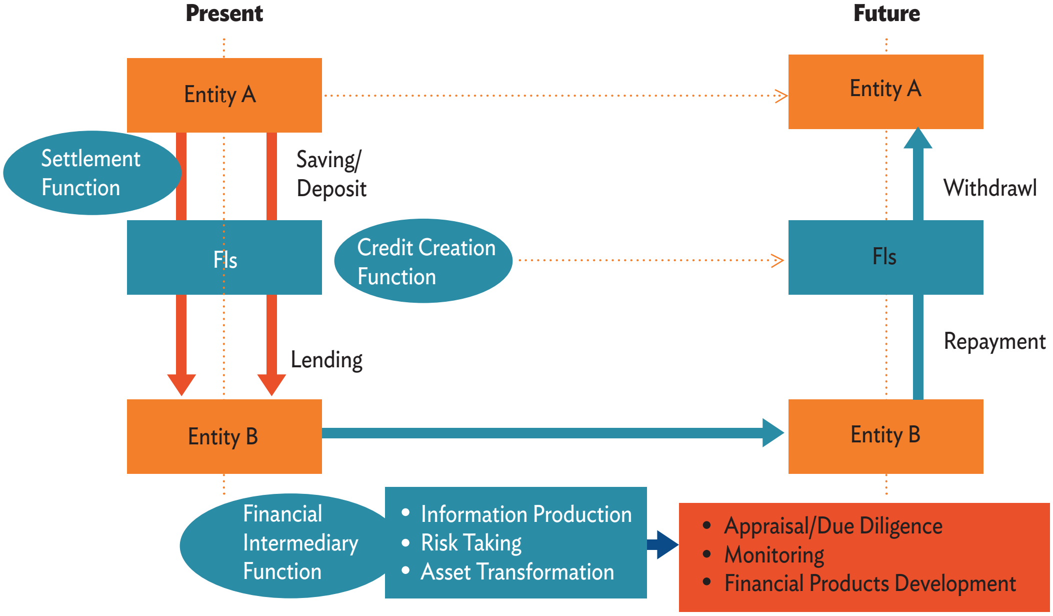
Source: World Bank (2013).

9.3 Roles of Financial Institutions

9.3.1 Functions of Financial Institutions in Theory

We start our discussion on the role of financial institutions in disaster risk management by reviewing the functions of financial institutions. Some finance and banking textbooks[1] identify several key functions of financial institutions, such as (i) the settlement function, (ii) the credit creation function, and (iii) the financial intermediary function. Figure 9.5 shows the relationship between stakeholders and financial institutions, and the functions which support transactions between stakeholders.

Figure 9.5: Key Functions of Financial Institutions



FI = Financial Institutions.

Source: Author.

[1] For example, see Bodie, Merton, and Cleeton (2012); Cecchetti and Schoenholtz (2016); Miller and VanHoose (2000); and Mishkin (2016).

Settlement Function

The settlement function is the simplest but most fundamental function of financial institutions. Settlement is the business process of payment of money for the delivery of goods and services between two parties. Although buyers can pay sellers for goods and/or services in cash, this involves a risk (delivery risk) and a cost for payment. For cross-border trade, in particular, buyers may not be able to deliver cash because of government cash control policies. Thus, settlement is considered a key function of financial institutions.

Credit Creation Function

As various studies have noted, another important function of a financial institution is the creation of credit.[2] Financial institutions create credit by advancing loans, purchasing securities, and/or investing in projects. They lend money to or invest in individuals and businesses from customers' deposits. However, commercial banks cannot use the entire amount of public deposits for lending purposes. They are required to keep a certain amount as a reserve with the central bank to serve the cash requirements of depositors, but can lend the remaining portion of public deposits to customers. Borrowers deposit their borrowed cash in the banks, and the banks can lend the deposits once the reserve portion has been covered. By continuing these transactions, the commercial banks can generate 'credit money'.

Financial Intermediary Function

The financial intermediary function is the most important function of financial institutions. It allows us to reallocate the uninvested or inactive capital to productive actors to generate additional value. Where a commercial bank serves as a financial intermediary, the commercial bank receives deposits from households (entity A in Figure 9.5) and lends money to companies (entity B). If there is no financial intermediary function, households may store the money at home or find a company that will accept a small amount of borrowing from households. Companies need to borrow a small amount of money from a lot of households to invest in the construction of new factories and other physical assets. This could be a costly transaction for both entities. Further, since households may face difficulty in collecting information on the company that will borrow their money, they should take a default risk of borrower. This is one of the risks for households as lenders because of the information asymmetry. Unlike the other functions, the financial intermediary function covers uncertainty over time, since the borrower may go bankrupt and not be able to continue their repayments

[2] For example, see McLeay, Radia, and Thomas (2014); and Federal Reserve Bank of Chicago (2015).

and interest payments during the repayment period. So, the financial institutions should assess the borrowers on their credibility and monitor them during the repayment period. Thus, the financial institution as a financial intermediary plays an important role in connecting these entities, and reducing the risks and costs associated with financial transactions for both sides. From the financial intermediation function, we can identify three key roles for financial institutions as financial intermediaries: (i) asset transformation, (ii) information production, and (iii) risk taking and/or transfer.

(i) Asset Transformation

As noted above, financial institutions such as commercial banks receive deposits from one entity (surplus units) and lend money to another entity (deficit units). In financial terms, receiving deposits is considered an issue of indirect securities and lending is considered an acceptance of prime (or direct) securities – i.e. the financial institutions transform the different types of assets. Through this asset transformation, financial institutions can collect money from many clients who hold a surplus of money and distribute it to other clients who need money for investment. This means the financial institutions will reallocate money by transforming assets.

(ii) Information Production

When financial institutions lend to borrowers, they appraise them to reduce the risk of default. They try to collect and analyse information on the borrowers to decide whether they can lend to them. To minimise the information asymmetry, financial institutions try to collect as much information as possible and carefully analyse it to decide the terms and conditions of the loan. If necessary, the financial institutions ask the borrower to provide collateral to cover the remaining risk. The financial institutions also monitor the borrowers since the business of the borrowers varies over time because of changes in the economic and social environment. Thus, the financial institutions produce information on the borrower through this appraisal/due diligence and monitoring process.

(iii) Risk Taking and/or Transfer

Financial institutions identify and analyse the risks associated with loan operations through the appraisal and due diligence process, and decide whether they can manage such risks by absorbing them within their portfolio and/or transferring the risks to others. Such risk management is another function of financial institutions, which develop financial products to help clients manage risks by using financial engineering techniques. Some of the financial products are already used as financial mechanisms for adaptation and disaster risk management. Further details of such financial mechanisms are discussed in section 4.

9.3.2 Using Functions of Financial Institutions for Adaptation, Disaster Risk Management, and Food Security

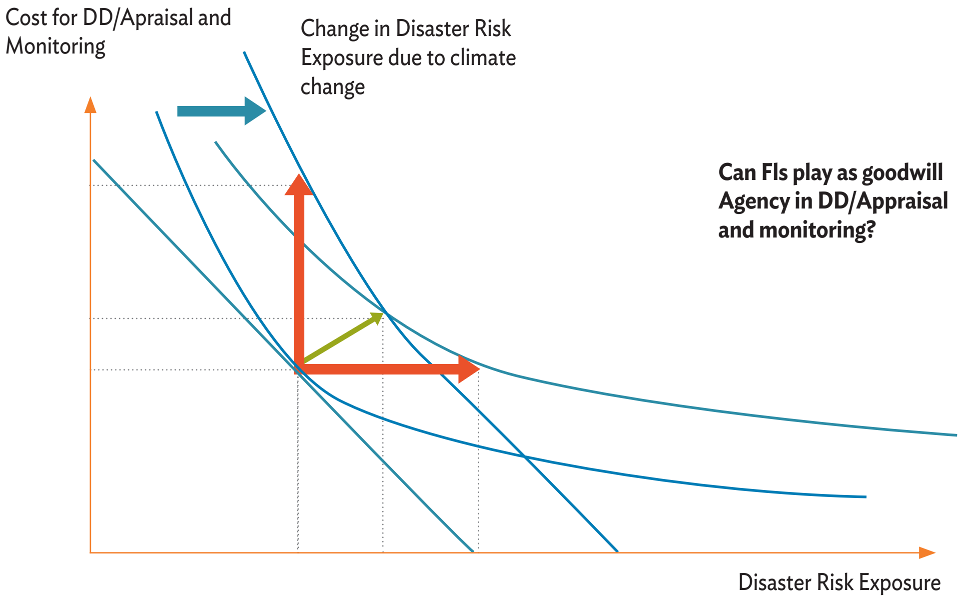
Financial institutions may be able to use the above-mentioned functions for adaptation and disaster risk management. However, a crucial issue is whether the financial institutions recognise climate change related natural disasters as risk, and whether they can identify the level of vulnerability against natural disasters.

Financial institutions assume a variety of risks, including natural disasters. However, nobody – including financial institutions – knows when, where, or how many extreme natural disasters will occur. Therefore, financial institutions also need to prepare for severe natural disasters.

Financial institutions generally prepare for their own damages, such as the loss of physical and human assets, system errors, and loss of profits caused by market confusion. If they try to reflect the disaster risks their clients will face, they need to consider the balance between the appraisal and/or due diligence cost and the expected natural disaster risk exposure.

Figure 9.6 shows the relationship between the appraisal/due diligence cost and the disaster risk exposure of financial institutions. We are facing a general risk of disasters. Most weather events will not cause serious damage, however, and the extreme weather events which cause severe damage rarely occur. The scale of such damage depends on the social and economic conditions as well as the severity of the disasters. If financial institutions reflect the disaster risk exposure in their appraisal and/or due diligence, the appraisal and due diligence cost will increase. If financial institutions make a more precise analysis, the disaster risk exposure will decrease but the cost for the appraisal/due diligence will increase. Thus, the relationship between the cost for the appraisal/due diligence and the disaster risk exposure will be inversely proportional.

Figure 9.6: **Change of Cost and Risks, and Behaviour of Financial Institutions**



DD = Detailed Design.

Source: Author.

Financial institutions may try to find an optimal balance between the expected disaster risk exposure and the appraisal cost, based on their unique sensitivity. In Figure 9.6, a straight line shows a financial institution's sensitivity against the cost. The slope of the line will vary, depending on each financial institution's sensitivity to disaster risk exposure. A point of contact will be an optimal balance between the cost for the appraisal or due diligence and the disaster risk exposure of a financial institution.

However, the risk of disaster will vary because of climate change. Severe disasters will occur more frequently and the probability of extreme disasters will rise – increasing the expected disaster risk exposure. In this case, the curve in Figure 9.6 will shift to the right. If the curve shifts, financial institutions should seek a new optimal point of contact to balance the cost of the appraisal/due diligence and the disaster risk exposure. If financial institutions ignore the change in the frequency and severity of natural disasters, the loss they incur through exposure to disasters will increase.

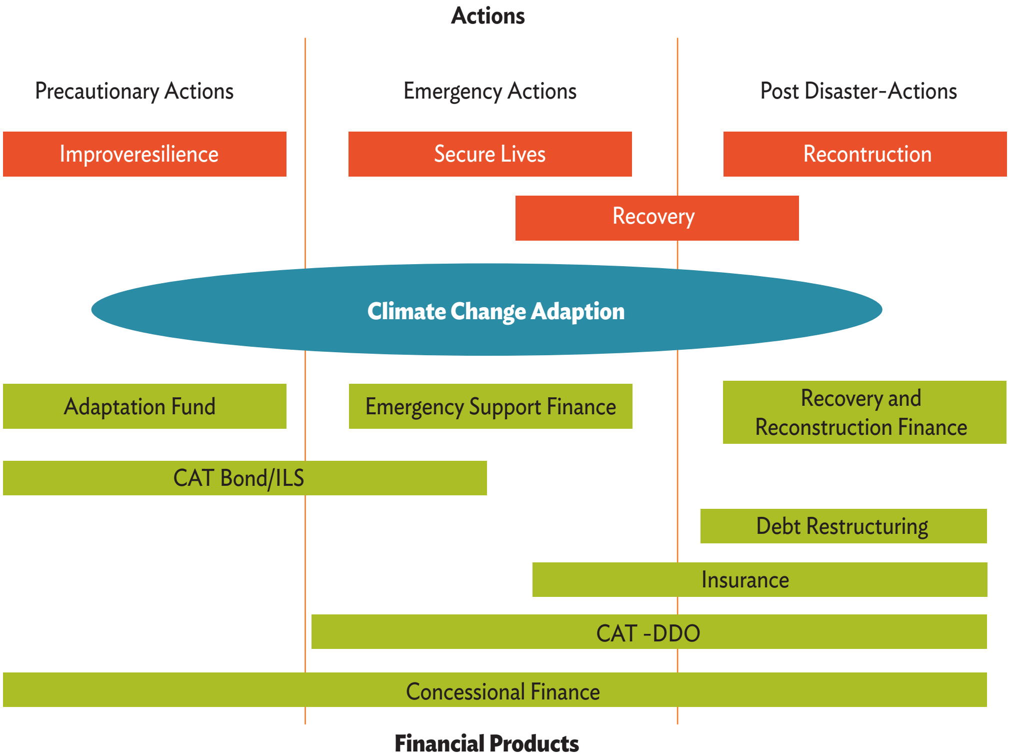
Thus, financial institutions should be sensitive to the change in disaster risks caused by climate change. They should reflect this change in their appraisal and due diligence by using their information production and risk management functions, and allocate funds for precautionary and post-disaster activities.

9.4 Financial Instruments for Disaster Risk Management and Food Security

9.4.1 What Sort of Financial Instruments are Available?

Some financial institutions have developed financial products to cope with disasters and food security. In this section, we identify financial instruments for coping with disasters and food production volatility, and categorise them by the stage of the events. Figure 9.7 categorises selected financial instruments for coping with disasters into three stages: precautionary, emergency, and post-disaster. The respective stages differ in terms of uncertainty and the terms and conditions of finance.

Figure 9.7: Financial Instruments for Disaster Risk Management and Food Security by Stage of Action



CAT = catastrophe, CAT-DDO = Catastrophe Deferred Drawdown Option, ILS = insurance-linked securities.

Source: Author.

Financial Instruments for Precautinary Actions

Precautionary actions are defined as actions to prepare for and strengthen resilience to extreme weather events. At this stage, nobody knows when the disasters will occur or how large the extreme weather events will be, i.e. the scale of the disaster is uncertain.

Given this uncertainty, project and programme managers raise finance based on the design and financial requirements of their own projects and programmes. At the design stage of the project and programme, the manager may incorporate disaster risks into their consideration through sensitivity analysis. In this sense, the financial instruments to be used for those projects and programmes may be general project finance.

If the project or programme is sensitive to disaster risk, their managers may select the catastrophe (CAT) bond to minimise (or transfer) the risk of default caused by disaster-induced damage. CAT bonds are discussed further in section 9.4.2.

The public sector provides services to help citizens cope with disasters – precautionary actions such as preparing evacuation centres, food stocks, and early warning systems – using its own budget. Other external funds such as the Adaptation Fund (2017) and concessional finance from donor countries and international development finance institutions is also available to support precautionary actions.

Financial Instruments for Emergency Response

Emergency response is defined as actions to secure the lives of people affected by disasters; quick repair of lifeline utilities; and the provision of evacuation centres, temporary housing, and related works for affected people. Most of these activities are temporary, but the costs and resources needed are huge. Therefore, quick disbursement and/or payment are crucial to cover the costs.

The public sector generally has contingency funds for emergencies. However, since the scale of disasters is uncertain, the contingency budget is not necessarily able to cover the whole cost of emergency actions. In such cases, local governments at the site of disasters request financial and human resources support from the central government since the local government officials may be affected by the disaster. Thus, mutual support is essential during emergencies. In the case of huge-scale disasters, where even the central government cannot cover emergency costs, the governments of other countries may provide emergency services including financial and human resources support.

Other financial instruments are helpful for emergency purposes. Insurance is a traditional and well-known instrument for emergencies. Once disaster occurs, an insurance payout is made based on the terms and conditions of the policy. However, in most cases, the payout is based on the damage assessment, which often takes time, and recipients may receive the insurance payout at the recovery stage rather than during the emergency. In some cases, insurance companies pay a lump sum as part of the payout to meet the needs of policyholders.

Another financial instrument that is helpful for emergency actions is the Catastrophe Deferred Drawdown Option (CAT-DDO), which is a type of credit line scheme used only for emergencies when affected people and governments need cash urgently. Disbursement from the CAT-DDO is made quickly when the triggering requirement is satisfied. Details of the CAT-DDO are discussed in section 9.4.2.

As noted in the previous section, CAT bonds ease the pressure of redemption and coupon payments for issuers, since the CAT bond is issued with a condition, e.g. the bond will be invalid if the assumed scale of disaster (trigger) happens. This eases the bond issuers' cash flow in an emergency, allowing them to use the cash prepared for redemption and/or coupon payments for emergency purposes.

Financial Instruments for Post-Disaster Actions

Post-disaster actions are defined as actions to recover from damage and reconstruct affected peoples' lives. Recovery and reconstruction efforts can take years to complete, where disasters cause severe damage, and the cost is huge. Large-scale disasters inflict damage not only on physical infrastructure but also soft infrastructure such as social systems and institutions. The level of economic activity declines during the emergency and post-disaster stage because of damage to assets, systems, and institutions. Disasters may also reduce the fiscal budget for governments because of the decline in tax revenue and the need to provide additional funds to financial institutions as a result of increased withdrawals from their customers. Even if disasters damage the social system and institutions, governments need to retain stable fiscal and financial management. To fulfil the financial liquidity gap for governments, concessional finance from donors is helpful.

On the other hand, affected people whose assets are lost or damaged face further problems since the value of any assets that they have used as collateral may be lost or reduced along with the assets. So, although these people need additional funds from financial institutions, they have limited financial capacity to borrow new money from them. In addition, some may be existing borrowers, liable to repay the outstanding amount of loans and interest payments. Thus, people affected by disasters face complex financial difficulties.

During the recovery period of the Great East Japan Earthquake, the Ministry of Finance of Japan took special measures for local governments in disaster areas (Box 9.2).

Box 9.2: Special Measures for Local Governments in Disaster Areas

The following special measures were taken for local governments affected by the Great East Japan Earthquake.

1. **Substantial exemption of interest which is overdue because of disaster**
   To deduct the amount of overdue interest from future interest payment amounts, the loan terms were changed (interest rate reduction).

2. **Special measures for loan procedures**
   To reduce the administrative burden on affected organisations and enable smooth borrowing, measures were taken such as simplifying procedures and extending deadlines.

3. **Extension of redemption deadlines**
   To reduce the burden of the single fiscal year expenses of local government bonds on affected organisations, the redemption deadlines of disaster recovery project bonds, amongst others, were extended.

4. **Exemption from forcible pre-maturity redemption for facilities destroyed by disaster**
   If a local government does not restore burned or destroyed facilities, a pre-maturity redemption can be demanded from the local government. However, to support the recovery of disaster areas, considering the fiscal situation of affected governments, pre-maturity redemption shall not be demanded in principle.

Source: Ministry of Finance, Japan (2011).

Fukuda (2014) reviewed the function of local finance in the recovery process after the Great East Japan Earthquake, and highlighted the importance of the role of local financial institutions in supporting local companies damaged by the disaster – to ensure business continuity and recovery of profit levels, and to assess and provide financial support to new industries and businesses emerging during the recovery.

Thus, at the post-disaster stage, the provision of additional financial liquidity and financial restructuring are effective ways to relax the pressure of financial obligations on the affected people and to cover the cost of restarting their businesses and/or lives as soon as possible to minimise economic losses. Concessional finance, whether general budget support or project-based finance from donors, is helpful for countries that need additional liquidity. Insurance is the traditional financial instrument to cover the damage cost resulting from disasters. Once insurance claims are settled, policyholders receive payouts to help reconstruct their lives. The CAT-DDO has a similar effect to the insurance scheme in terms of liquidity support. Including the CAT bond can work effectively to restructure the debt portfolio, as the CAT bond is cancelled if the scale of the disaster exceeds the trigger of the cancellation condition.

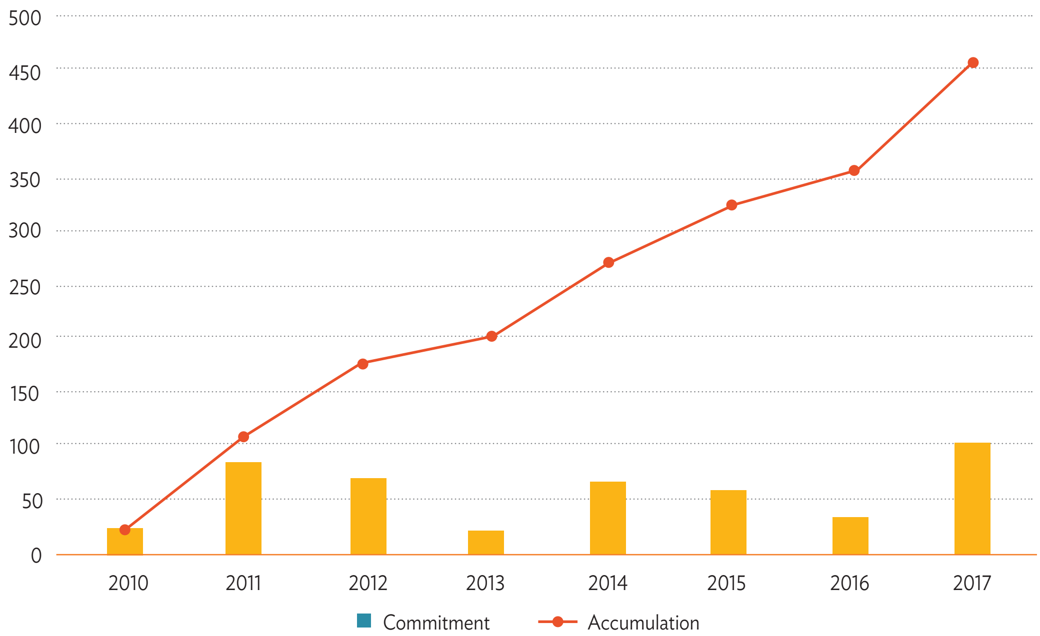
9.4.2 How the Financial Instruments Work

In this section, we review some of the financial instruments for coping with disaster-related actions. As discussed in the previous section, several financial instruments support disaster-related actions. Amongst others, we highlight the Adaptation Fund, the CAT bond, and the CAT-DDO.

Adaptation Fund

The Adaptation Fund is one of the financial mechanisms established under the Kyoto Protocol of the UN Framework Convention on Climate Change. The objective of the Adaptation Fund is to finance concrete adaptation projects and programmes in developing countries, particularly in countries vulnerable to the adverse impacts of climate change. As of September 2017, the Adaptation Fund had committed about $461 million to 95 projects. Annual commitments and the accumulated commitment amounts are shown in Figure 9.8. The average size of the 95 projects was $4.9 million, and that of projects, except readiness grants, is $6.6 million. About $171 million of the total commitments (37.2%) had been disbursed by September 2017.

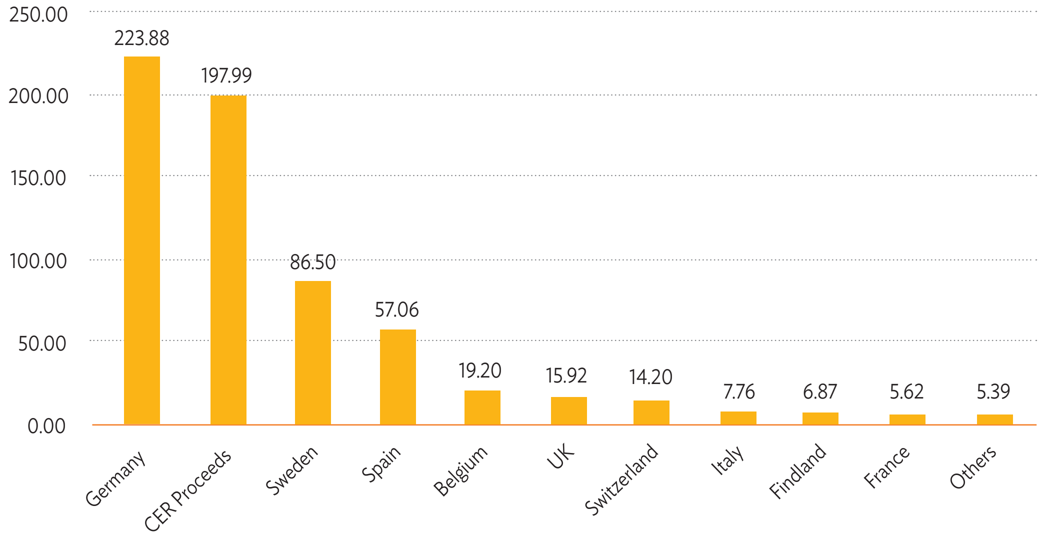
Figure 9.8: Annual and Accumulated Commitment by Adaptation Fund ($ million)



Source: Adaptation Fund (2017a).

The Adaptation Fund was originally designed to be financed from a 2% share of the proceeds of certified emission reductions (CERs) issued for Clean Development Mechanism projects. The fund now receives contributions from public and private donors. The World Bank, as a trustee of the fund, reports its financial status (Adaptation Fund (2017b)). Figure 9.9 shows the receipt of funds by resources. As of 30 September 2017, the Adaptation Fund had received $197.99 million from CER proceeds and $442.40 million as donors' contributions. The contributions from donors were more than double the share of the CER proceeds. Germany was the top donor, followed by Sweden, Spain, Belgium, and the United Kingdom.

Figure 9.9: Receipt of Funds by Resources ($ million)



CER = Certified Emission Reduction, UK = United Kingdom.
Source: World Bank (2017).

Considering the financial need and compared with other sources of funding for adaptation, the Adaptation Fund contributes quite a limited share, even though it is one of the key financial mechanisms under the UN Framework Convention on Climate Change (UNFCCC). Trujillo and Nakhooda (2013) reviewed the Adaptation Fund and pointed out that 'the operationalisation of the Adaptation Fund has played an important role in scaling up available finance for adaptation in developing countries, albeit from a very low baseline' (Trujillo and Nakhooda (2013: 28). They evaluated the role of the Adaptation Fund: 'it has developed a functional system for delivering adaptation finance that meets high levels of transparency, and has important provisions for accountability and learning' (Trujillo and Nakhooda, 2013: 28).

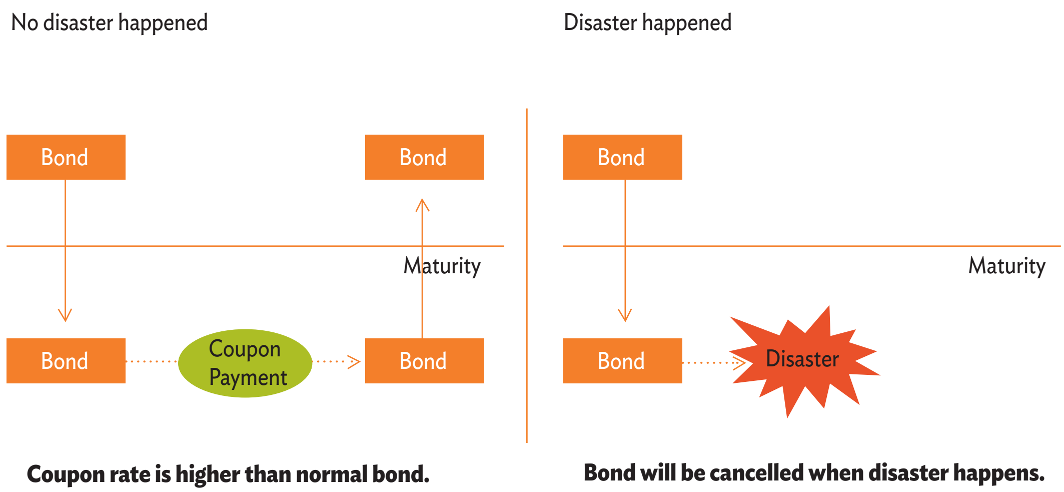
Although the Adaptation Fund plays an important role, it only covers the cost of precautionary actions against climate change – mainly supporting capacity development for adaptation planning – because of its limited scale.

CAT Bond

The CAT bond is a disaster risk-linked security that transfers the risk of damage caused by disasters from a bond issuer to investors. If no disaster occurs, the bond issuer pays a coupon to the investors. Once trigger conditions (such as the occurrence of a large-scale disaster) are met, the principal is forgiven. Figure 9.10 illustrates how the CAT bond works.

CAT bonds are typically used by insurers as an alternative to traditional catastrophe reinsurance. Therefore, the CAT bond is considered one of the insurance-linked securities (ILS).

Figure 9.10: Catastrophe Bond Scheme



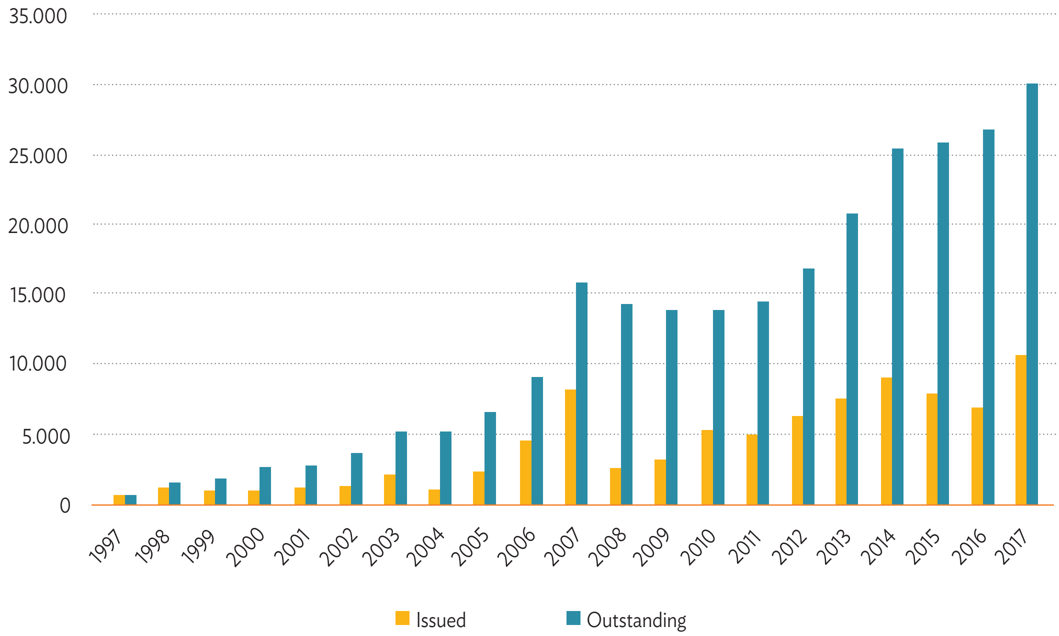
Source: Author.

Since the CAT bond is considered a high-risk security, its coupon rate is higher than normal bonds issued by the same issuer with identical maturity – reflecting the default risk of the bond being triggered by catastrophic disaster.

Although the issuer of the bond should pay a higher coupon rate, they are released from repayment of the principal and the bond when triggered. This helps bond issuers to secure finance for recovery and reconstruction, while investors receive higher returns if no disaster occurs. Sudo (2008) analysed the effectiveness of the CAT bond as a tool to share the disaster risk in the market; and found the potential of CAT bonds to apply to fund-raising not only by insurance companies but also commercial companies as part of their debt portfolio.

Figure 9.11 shows the CAT bond and ILS risk capital issuance and the outstanding amount of capital from 1997 to 2017 based on Artemis (2017). According to these figures, the issuance of the CAT bond and ILS increased gradually from 1997, with the largest issuance in 2007, before declining drastically in 2008. Issuance gradually recovered and reached a historic peak by the third quarter of 2017. Reflecting this trend, the outstanding total amount of capital of the CAT bond and ILS also increased, reaching around $30 billion by the third quarter of 2017.

Figure 9.11: CAT Bond and ILS Risk Capital Issued and Outstanding, 1997-2017 ($ million)



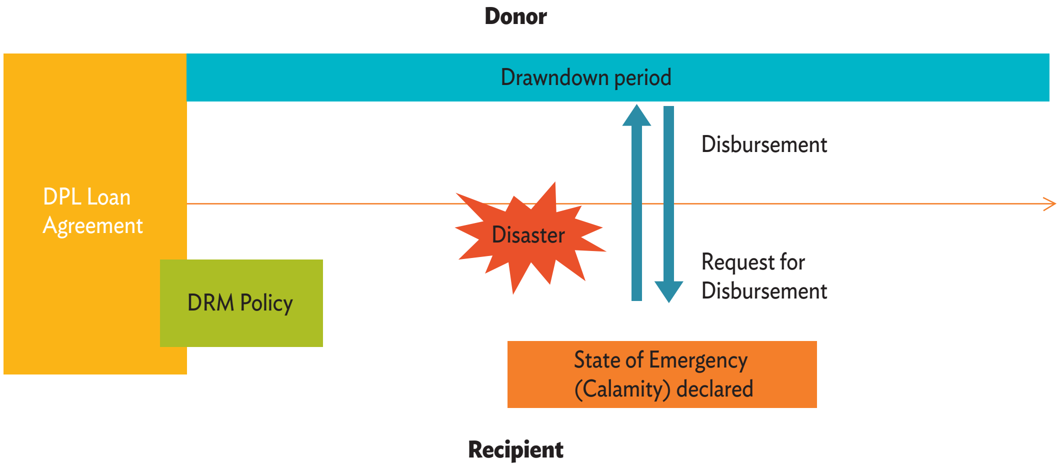
CAT = catastrophe, ILS = insurance-linked securities.

Source: Artemis (2019), Catastrophe Bonds and ILS Issued and Outstanding by Year. http://www.artemis.bm/deal_directory/cat_bonds_ils_issued_outstanding.html (accessed 1 March 2019).

Development Policy Loan with a CAT-DDO

The CAT-DDO is an application of the Development Policy Loan (DPL) with a drawdown option, which was developed by the World Bank (2011a). The DPL is one of the lending schemes to support the fiscal budget of developing country governments. Under the DPL, donors and recipient countries agree to a list of actions for specific policy purposes when the loan agreement is concluded. Both donors and recipient countries monitor the progress of the actions on the list, and disbursements are made when the targeted actions are implemented. Figure 9.12 shows how the CAT-DDO works. The scheme of the CAT-DDO is almost the same as the DPL. The difference between the DPL and the CAT-DDO is whether the trigger for disbursement is placed or not. In the CAT-DDO, the policy matrix is formulated as a list of policy actions related to disaster risk management. Once the policy actions are completed, the drawdown option is enacted, i.e. once the trigger event occurs, disbursement is made.

Figure 9.12: CAT-DDO Transaction



CAT-DDO = Catastrophe Deferred Drawdown Option, DPL = Development Policy Loan, DRM = disaster risk management.

Source: Author.

The World Bank provided a CAT-DDO to the Philippines in 2011. The objective of the project was to enhance the capacity of the Government of the Philippines to manage the impacts of natural disasters. This objective was achieved by supporting the following aspects of the government's disaster risk reduction and management framework: strengthen the institutional capacity for disaster risk management efforts, mainstream disaster risk reduction measures into development, and better manage the government's fiscal exposure to natural disaster impacts. The World Bank explained that 'The Cat DDO allows governments to respond quickly to emergency needs without diverting resources from important long-term development projects. The product is typically used to finance liquidity gaps in the government budget for countries exposed to natural disasters. It is triggered by a Presidential Declaration of a State of Calamity' (World Bank, 2011b). The triggering disaster, Tropical cyclone Sendon (Washi), occurred in December 2011. The Government of the Philippines declared a state of calamity and the World Bank quickly disbursed $500 million from the DPL. Thus, the CAT-DDO works as a contingency line of credit, which provides emergency liquidity to cope with extreme disasters.

Traditional Insurance Scheme

Insurance is a traditional means of protection from financial loss. In 2016, Asia suffered higher economic losses because of natural and man-made catastrophes than any other region of the world. Swiss Re (2017) reported that economic losses from disaster events in Asia totalled an estimated $83 billion in 2016, of which about $9 billion were covered by insurance. This included the damage caused by the magnitude 7.0 earthquake in Kyushu, Japan, in April. Economic losses from this earthquake were estimated to be $25 billion–$30 billion, of which $4.9 billion were insured. Of the remaining $53 billion–$58 billion of economic losses in the region, $4.1 billion were covered by insurance – i.e. less than 10% of the economic losses caused by disaster were insured in the rest of the Asian region.

The traditional insurance scheme presents a number of problems, including adverse selection, moral hazard, information asymmetry, and high transaction costs such as monitoring and administrative costs in developing countries. Further, Nakata (2015) noted that insurance for natural disasters is not common practice since the occurrence of a catastrophe typically incurs a macro risk, invalidating the application of the strong law of large numbers on which a typical insurance mechanism is based. Nakata et al. (2010) showed that the diverse probability belief would be inevitable, which in turn results in weak demand for catastrophe insurance. Chantarat et al. (2015) pointed out that, without an effective insurance market, public disaster assistance and highly subsidised public insurance programmes have been the main supports for the affected population.

For agriculture, crop insurance protects against crop loss resulting from natural disasters. In the United States, a subsidised multi-peril federal insurance programme, administered by the Risk Management Agency, is available to most farmers. Some 551 types of crops are covered under this scheme. The United States Department of Agriculture (USDA, 2017) reported that more than $3.4 billion in indemnities were paid in 2017 (as of 21 December 2017). Pierro and Desai (2009: 2) noted that 'traditional crop insurance has been seen as a poor model for export, particularly in developing countries, most of which are under serious fiscal constraints and have smallholder economies suffering from high exposure to covariate risk, the risk of simultaneous losses from a single event'.

The traditional insurance scheme is a mature and reliable risk management scheme which covers economic losses caused by disasters. However, the settlement of insurance claims may be delayed since damage assessment by insurance companies takes a long time. This slows down the recovery of affected people, causing additional economic losses. Therefore, some insurance companies allow partial payments to the insured as part of insurance claims so that the insured may use it for emergency recovery.

Index-Based Insurance

Index-based insurance is an alternative to traditional insurance. It provides financial protection based on the performance of a specific index in relation to a specific trigger. Unlike traditional insurance, contracts for index-based insurance are written on an objective index (e.g. precipitation, temperature) which works as a proxy for crop losses. Therefore, under index-based insurance, insured farmers' actual losses are not needed to determine an insurance claim. This can drastically reduce transaction costs and time for damage assessments.

Pierro and Desai (2009) described case studies of index-based insurance in selected countries. Some international organisations (e.g. World Bank, 2011c; International Fund for Agricultural Development and World Food Programme, 2011) compiled information on the creation of a weather index insurance scheme based on their experience in several countries. Chantarat et al. (2015) discussed the index-based insurance scheme as an attractive means to address traditional insurance imperfections, with a case study on index-based insurance for rice farmers in Thailand.

The Bank for Agriculture and Agricultural Co-operatives of Thailand, in collaboration with the World Bank and Japan Bank for International Cooperation, introduced a weather index-based insurance pilot scheme for maize and rice. According to Yimlamai (2010), the pilot weather index-based insurance for maize with the World Bank started in 2006 in Nakorn Ratchasima Province with 110 farmers (1,970 acres). This pilot project was expanded to seven provinces (Nakhon Ratchasima, Saraburi, Lopburi, Nakhon Sawan, Phetchabun, Pitsanulok, and Nan) with the participation of 2,535 farmers. The index was developed based on the growing pattern and water requirements of maize.

Since these were pilot schemes, the coverage of the number of insured farmers was limited. In addition, index-based insurance faces a basis risk – the difference between the payout as measured by the index and the actual loss incurred by the farmer. This may cause losses for farmers and, in turn, loss of trust in this scheme.

9.4.3 Pros and Cons of Disaster-Related Financial Instruments

Several different financial instruments may be used to cope with large-scale natural disasters and climate change adaptation. However, their applicability depends on the purpose, stage, scale of finance, and beneficiaries. Policymakers do not necessarily fully understand financial instruments, leading to misunderstandings and/or misuse. To facilitate understanding of the differences between financial instruments for disaster management and climate change adaptation, Tables 9.2 and 9.3 show the pros and cons of the respective financial instruments.

Table 9.2: Pros and Cons of Financial Instruments (for Precautionary Actions)

Financial instrument	Pros	Cons
Adaptation Fund	• Clear objective of the fund • Useful for capacity development in adaptation	Limited amount of fund
Climate-Proof Financing	• Supporting disaster-resilient infrastructure	Difficulties in finding appropriate level of resilience and cost
CAT Bond	• Debt service will be cancelled or reduced when disaster happens	Higher financial costs

CAT Bond = catastrophe bond.

Source: Author.

Table 9.3: Pros and Cons of Financial Instruments (for Post-Disaster Actions)

Financial instrument	Pros	Cons
Emergency grant assistance	• Cost-free and additional finance	• Uncertainty regarding amount to be received (depends on donor's efforts
CAT-DDO	• Quick disbursement • Supporting emergency liquidity	• Limited cases • Uncertainty for finance provider in disbursement (monetary cost for preparing to disburse)
Insurance	• Traditional and established scheme • Partial payment will be given as a part of insurance claims	• Insurance does not necessarily suit large-scale disaster • Adverse selection, moral hazard, information asymmetry, and high transaction cost • Long time for damage assessment and delay in settlement of the claims
Index-based insurance	• Reduce inefficiency of traditional insurance such as adverse selection, moral hazard, information asymmetry, and high transaction cost • Quickly settled once triggers are hit	• Data availability – difficulty in setting appropriate triggers • Basis risk – difference between the payout as measured by the index and the actual loss incurred by the farmer

CAT-DDO = Catastrophe Deferred Drawdown Option.

Source: Author.

These tables show that no single instrument can cover all purposes for disaster management and climate change adaptation at any stage. This means that knowledge of the appropriate choice or combination of financial instruments and their usage is indispensable for policymakers.

9.5 Possible Collaborative Financial Mechanism amongst ASEAN Countries

As discussed in the previous sections, financial institutions are expected to play an important role and several financial instruments are expected to be available in managing the risks associated with natural disasters and climate change adaptation. However, financial institutions do not necessarily play such a role properly, and the financial instruments do not work as expected, particularly in developing countries.

The World Bank (2012) studied the state of disaster risk financing and insurance in ASEAN countries and pointed out that inadequate disaster financing arrangements had exacerbated the adverse socio-economic consequences of disasters. It made five key recommendations to support and encourage further development of disaster risk financing and insurance in ASEAN countries (Box 9.3).

Box 9.3: Steps in Developing Disaster Risk Financing Schemes

1. Develop risk information and modelling systems to assess the economic and fiscal impacts of natural disasters
2. Develop national disaster risk financing and insurance strategies at the national and subnational levels
3. Establish national disaster funds
4. Promote private catastrophe risk insurance markets
5. Strengthen regional cooperation on disaster risk financing and insurance

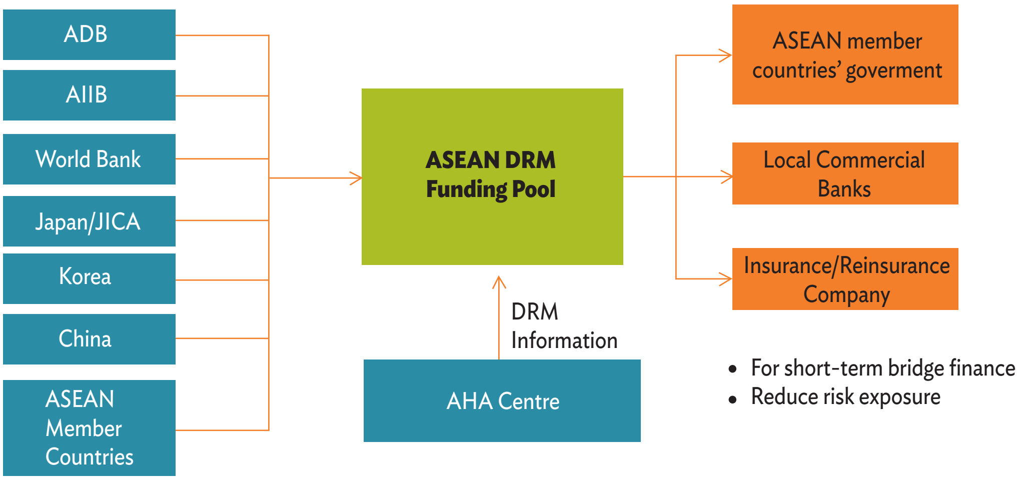
Source: World Bank (2012).

In managing the risks associated with natural disasters and climate change adaptation, information on disasters and climate change is critical for financial institutions. Such information is also indispensable for the selection of appropriate existing financial instruments as well as developing new ones. However, financial institutions do not necessarily have enough capacity to collect and handle such disaster-related information properly. Further, the volume and quality of information on disasters may vary amongst financial institutions. As a result of such asymmetry of information amongst stakeholders, financial institutions and their clients will not take collective actions on disaster risk management. Supporting financial institutions' disaster and climate change risk management would benefit not only financial institutions but also their clients, including the government and the population. In addition, since the scale of disasters and their damages are increasing, some will affect multiple areas and countries without regard to borders. In these cases, a single financial institution and/or country will not be able to manage the damage. Therefore, a regional financial mechanism should address such problems to cope with disasters.

One of the mechanisms for supporting natural disaster risk sharing and management and finance is to establish a common pool of finance and information for coping with disasters and climate change. At the 2nd Meeting of the ASEAN Cross-Sectoral Coordination Committee on Disaster Risk Financing and Insurance (DRFI) held on 8 February 2017 in Davao, the Philippines, participants exchanged views on the next phase of the ASEAN DRFI Roadmap and Programme, which will focus on the considerations and preconditions for establishing a regional risk insurance pool in the region (ASEAN Secretariat, 2017).

Figure 9.13 shows an example of a funding pool mechanism, developed based on the proposal made by Sudo (2015; 2016). Although both proposals highlight the role of the financial pool as leverage to finance climate change mitigation actions, those could be applicable in this field since the leveraging effect through pool funding will be effective in mobilising finance from a variety of sources for specific purposes.

Figure 9.13: Regional Financial Mechanism



ADB = Asian Development Bank, AHA Centre = ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management, AIIB = Asian Infrastructure Investment Bank, ASEAN = Association of Southeast Asian Nations, JICA = Japan International Cooperation Agency, DRM = disaster risk management.

Source: Author.

This facility is expected to serve several functions:

1) Coordination and delivery of disaster finance

The fund for disaster finance in the emergency and recovery stage, unlike general funds (including funds for climate change mitigation actions), does not necessarily need to hold a large amount of cash in normal circumstances. However, a huge amount of finance is needed once an extreme disaster occurs. Thus, the uncertainty of disasters in terms of scale and timing makes the fund inefficient. To overcome such inefficiency, the fund will conclude a contingent line of credit via CAT-DDO agreements with bilateral and multilateral donors such as Japan, the Republic of Korea, China, the World Bank, ADB, the Asian Infrastructure Investment Bank, and ASEAN Member Countries. The fund will receive and coordinate the contributions from these donors, then disburse them to beneficiaries such as governments, commercial banks, and insurance companies. This fund will be used for emergency liquidity support for governments and as short-term bridge finance for commercial banks for securing liquidity during emergencies.

2) Special purpose vehicle for issuance of CAT bonds

The fund can serve as a special purpose vehicle for the issuance of CAT bonds. According to Artemis (2017), most of the outstanding CAT bonds and ILS are issued by insurance companies and financial institutions in advanced countries. Because of the high-risk nature of the CAT bond and ILS, it may be challenging for insurance companies and financial institutions to issue CAT bonds and ILS with competitive conditions. Therefore, the fund, backed by the donors, should serve as a special purpose vehicle for the issuance of CAT bonds and ILS in favour of local insurance companies and financial institutions to mitigate the risks associated with disasters.

3) Disaster information sharing mechanism

Sharing accurate and timely information amongst stakeholders is indispensable to manage the risks associated with disasters. Even if financial institutions have a function to manage and transfer risk, they are not able to use such a function properly without accurate and timely information. Further, asymmetry of information prevents the ability to take collective actions against disasters. Thus, the fund – in collaboration with the ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management (AHA Centre) and the Asian Disaster Reduction Center – should serve as an information hub for financial institutions. This would allow governments, donors, and local financial institutions to share information in a timely manner; and permit financial institutions to take appropriate collective actions to cope with disasters.

9.6 Conclusions and Policy Recommendations

9.6.1 Conclusion

In this paper, we discussed the role of financial institutions and their financial instruments in relation to natural disasters. Financial institutions can play a significant role by providing finance, managing risks, and producing information, in theory. Based on those functions, financial institutions develop a variety of financial instruments which is useful in supporting disaster risk management, emergency actions, and the recovery and reconstruction process.

However, each financial instrument has unique characteristics, and the pros and cons of the respective financial instruments were identified. This analysis shows that no single instrument can cover all disaster management and climate change adaptation needs at any stage. This means that knowledge on the appropriate choice and combination of financial instruments and their usage is indispensable for policymakers. In addition, since the scale of disasters and their damages are increasing, some disasters will affect multiple areas and countries without regard for borders. In these cases, single financial institutions or countries will not be able to manage the damage. To cope with this, a funding pool mechanism is proposed. This funding pool mechanism serves three functions in supporting the government and financial institutions to play their expected role.

9.6.2 Policy Recommendations

This study identifies the following policy recommendations based on the above argument. Recommendations 1–3 refer to actions taken by financial institutions, while recommendations 4 and 5 are targeted at the national level, and recommendation 6 applies to regional action.

1. **Financial institutions should improve disaster risk management knowledge and skills as part of credit risk management.**
   In theory, financial institutions can play a significant role in managing risk. However, because of lack of knowledge and skills in managing disaster risks, they may not play a necessary role in disaster risk management. Therefore, it is recommended that financial institutions improve their disaster risk management skills as part of credit risk management by incorporating disaster risk analysis in their appraisal and due diligence process so that disaster risks are taken into consideration in financial decision making.

2. **Financial institutions should act as a 'goodwill' appraisal and monitoring agency to manage disaster-related risks.**
   Financial institutions play a 'goodwill' appraisal and monitoring role in managing credit risks. When they obtain sufficient knowledge and skills to manage disaster risks, they should serve as 'goodwill' appraisal and monitoring agencies, reflecting disaster risks. This may reduce the costs and damages borne by financial institutions as well as their clients.

3. **Financial institutions should develop better financial products to cope with disaster, based on lessons learned and good practice.**
   Financial institutions have developed several financial instruments applicable to precautionary, emergency, and recovery and reconstruction actions. However, some of them may not apply to Asia and the Pacific. Therefore, regional financial institutions should develop or improve financial instruments to cope with disaster in Asia and the Pacific.

4. **Governments should create an enabling environment for financial institutions to play their roles in disaster risk management.**
   One of the key roles of governments is to create an enabling environment for financial institutions to fulfil their role in their respective country and the region. To facilitate this, governments should review their legal and institutional systems, and update them where necessary so that financial institutions may play their roles in disaster risk management efficiently and effectively.

5. **Governments should recognise the role of financial institutions and enhance their knowledge of financial instruments.**
   For better partnering with financial institutions and effective use of financial instruments, the government should recognise the role of financial institutions and enhance their knowledge of financial instruments so that they can provide adequate support for financial institutions and choose appropriate financial instruments at specific stages of disasters.

6. **The proposed funding pool mechanism should be developed to share the risks and information on disasters.**
   Regional collaboration in disaster finance is the key for Asia and the Pacific. As highlighted at the 2nd Meeting of the ASEAN Cross-Sectoral Coordination Committee on DFRI, discussing the next phase of the ASEAN DRFI Roadmap and Programme, the establishment of a regional risk insurance pool in the region is critical to share the risk amongst the countries. The proposed funding pool mechanism will work as leverage for disaster finance as well as a platform to share disaster information to avoid asymmetry of information amongst stakeholders.

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CHAPTER 10

Strengthening Institutional Capacity for Disaster Management and Risk Reduction Through Climate-Resilient Agriculture

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10.1 Introduction

The frequency of natural disasters, especially storms and floods, has been increasing globally over the last several decades (Asian Development Bank (ADB), 2013). In the Asia-Pacific region, the number of hazard events increased from around 80 per year during 1990–1992 to 130 during 2015–2017 after peaking at 144 during 2005–2007 (Food and Agriculture Organization of the United Nations (FAO), 2018). Developing countries are especially vulnerable to such disasters but are often the least capable of coping with the associated impacts because of their limited adaptive capacity (Davies et al., 2008). Despite the increased interest in strengthening institutional capacity, it remains a challenge for many developing countries. Institutional capacity for disaster management and risk reduction can be built through various mechanisms. One key approach is via the agriculture sector, where climate-resilient agriculture (CRA) has become an effective tool for adapting to climate change and developing resilience in the long run – resulting in increased capacity for disaster management and risk reduction at the system, institutional, and individual levels. In this chapter, we provide examples of different technologies and practices being adopted to reduce the negative impacts of climate change. Using this information, we explore the potential interventions needed to build institutional capacities for scaling up such practices and develop an institutional framework that can be used to build capacity.

International research has increasingly demonstrated the devastating risks of climate change in coastal regions – particularly for countries with extensive, low-lying stretches of coastal land – caused by rising sea levels. The damage caused by climate change will affect agricultural land, and consequently food security, in many developing countries. However, despite the increased attention given to climate change issues at the global level, there has been minimal organised effort to react appropriately through policy action at the country level. All food policy interventions are designed and implemented by domestic actors (Timmer, 2013). There is a pressing need to understand what is required to develop and implement effective policies that promote CRA, i.e. policies targeting disaster management and risk reduction.

Evidence on the negative impact of climate change on crop production and food security continues to mount (Porter, et al., 2014). This is especially bad for marginal and small farmers in developing countries. Hunger appears to be on the rise, affecting about 11 million people globally, and climate change is expected to increase both the quantity and intensity of extreme climate hazards such as extreme temperatures, floods, droughts, heatwaves, wildfires, and storms (FAO, 2013).

To address the issue, the concept of CRA was launched in 2009 with the aim of providing globally applicable principles for sustaining agriculture productivity to meet the demands of the growing population despite climate change (Lipper and Zilberman, 2018). CRA refers to a bundle of interventions in agriculture, with the aim of increasing yields, placing more carbon in soils, and achieving greater resilience to heat and drought (FAO, 2010).

Certain techniques and practices are being adopted in both developing and developed countries to decrease the negative impact of climate change and greenhouse gas (GHG) emissions while sustaining crop productivity and profitability. This chapter provides examples from four countries (Bangladesh, Ghana, India, and Viet Nam) of different CRA practices and techniques currently being implemented. Further, this study identifies the major constraints and challenges faced by these countries in scaling up CRA practices. While the chapter discusses difficulties faced at the individual, institutional, and system level, we primarily focus on institutional challenges.

Policymakers and institutions face constraints such as lack of awareness amongst farmers, inability of famers to understand and adopt CRA techniques, and lack of government support to scale up efforts to increase climate-smart techniques. Further, all four countries have limited human and institutional capacity to adopt and implement CRA (Babu and De Pinto, 2017). It is crucial to identify the barriers faced by different countries to scale up CRA techniques and practices since they have implications for food security.

Despite increased emphasis on enabling farmers to cope better with the changing climate while increasing yield, farmers continue to suffer because of changing climate patterns. Results from the case studies show a lack of incentives for farmers to adopt CRA techniques and a lack of awareness of their benefits (for both farmers and the environment). There is a need to transform the current food system to meet the demand of the growing population and to sustain agricultural productivity and profitability despite the negative impacts of climate change.

The rest of the chapter is organised as follows. Section 2 provides examples of new technologies and practices being adopted in developing countries and identifies areas for building institutional capacity. Using the information in section 2, we develop a framework which can be applied to strengthen institutional capacity for disaster management and risk reduction. For the purpose of this chapter, we have focused on strengthening capacity for building the resilience of the agriculture sector to climate change and variability as an example. However, this framework can be applied to different sectors to build institutional capacity as an early warning system. The concluding remarks are presented in section 4.

10.2 Strengthening Institutional Capacities for Disaster Management and Risk Reduction

In this section, we first explain why building the capacity of the agriculture sector is a crucial mitigating risk associated with climate change and variability. We then identify technologies and practices adopted by farmers from Bangladesh, Ghana, India, and Viet Nam to build resilience in agriculture for climate change and variability. Using this information, we identify capacities needed at the institutional level that need to be built to reduce the cost associated with natural disasters and mitigate risk.

Agriculture is the engine of growth in many developing countries. The impact of climate change is predicted to be most significant in communities that rely primarily on agriculture for their livelihoods. Hence, it is important for countries to reform and develop policies in agriculture and aligned sectors in order to adapt to and mitigate climate change while continuing work towards food security.

According to estimates, with the current rate of increase in the world's population, food production needs to increase 60% by 2050 (FAO, 2014). Additionally, climate change is making it difficult to increase production capacity. Farmers need to adapt quickly to changing the natural environment and build resilient food systems (Babu and Blom, 2014). They also need to increase productivity, with less damage to the environment, by using sustainable solutions which work in the long term.

A number of attempts have been made to develop models for analysing capacity in the context of climate change and agriculture. Zurek et al. (2014), for instance, use the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation (REDD+) in Developing Countries framework and apply it to the agricultural sector to test the 'agricultural climate change readiness'. Wollenberg, Zurek, and De Pinto (2015) took this study a step further and identified six work areas for national readiness in agriculture. Similarly, Richerzhagen and Scholz (2008) structured their study on China's capacity for mitigating climate change on three pillars: structural features of the economy and society, the political and institutional infrastructure for climate change, and the information flow on climate-related matters.

Development efforts over the past few decades clearly indicate that a country's capacity to develop and enforce effective, evidence-based policies is a crucial factor in achieving economic growth, reducing poverty, and building ecosystem resilience and sustainability. Agriculture continues to be the main engine of growth in many developing countries. The influence of climate change is predicted to be larger on communities that rely primarily on agriculture for their livelihoods. Within this context, there is an increased need to reform existing policies and develop new policies on agriculture and aligned sectors to adapt to and mitigate climate change while continuing to work towards food security (World Bank, 2008). However, weak and inadequate organisational and institutional capacities in developing countries severely challenge their ability to develop and enforce policies to manage disasters (Byerlee, de Janvry, and Sadoulet, 2010; Adebayo, Babu, and Rhoe, 2009; World Bank, 2008).

Most importantly, the population most vulnerable to climate change relies on agriculture for its livelihood. The FAO (2018) identifies how climate-related shocks have impacted the employment and wages of people in Asia and the Pacific; and estimates the number of people directly affected in Fiji, Myanmar, the Philippines, and Sri Lanka. Hence, developing countries face a number of challenges in adopting sustainable agriculture policies and practices. On one hand, these countries are burdened with food security issues caused by the increasing population and low agricultural production. On the other, they are under pressure to adopt agricultural practices that cause less harm to the environment. To overcome these challenges, we need to tailor practices for different agricultural zones, making additional financial investments and developing skills. Weak policymaking capacity is also evident in many developing countries. Targeted capacity building programmes can play an influential role in preparing a country's agriculture sector to deal with increasing threats of climate change. The concept of CRA encompasses the challenges mentioned above, giving a more holistic dimension to issues in agriculture.

The transformation of CRA involves many challenges. Policymakers often have to weigh up the costs and benefits of adopting or implementing certain policies. In the case of climate change, trade-offs are a major issue, especially because efforts in the present are realised much later in the future. In particular, if climate adaptation and mitigation goals are pursued separately from those of agricultural production, problems become more difficult to diagnose (Rosenzweig and Tubiello, 2007; Verchot et al., 2007; Smith and Olesen, 2010). This is because, on one hand, agriculture is the biggest contributor to GHG emissions in developing countries, but on the other, transformation towards CRA can mitigate climate change risks to a great extent.

CRA is location- and time-specific. This means that climate-smart practices will differ by region, the crop grown, and over time. Hence, overarching solutions are not useful for countries with diverse agroecological zones. Additionally, since CRA is a bundle of practices, its adoption and implementation require farmers' capacities to be built. Streck, Burns, and Guimaraes (2012) identify three major types of barriers to the adoption of improved agricultural practices amongst farmers – investment, social/institutional, and technological. According to the authors, incentives for farmers to change practices should be tailored according to local realities and supported through general enabling socio-economic conditions. While they write in the context of smallholder farmers, these barriers are also applicable to farmers with large landholdings.

The literature on capacity development, with slight variations in terminology, appears to come to the consensus that capacity has three dimensions: individual capacity, organisational capacity, and system capacity/enabling environment (Organisation for Economic Co-operation and Development–Development Assistance Committee (OECD–DAC), 2009). This commonly used three-pronged approach will form the basis of our definition of capacity, hence moving away from including 'networks' as an additional dimension (OECD, 2005; OECD, 2011; Baser and Morgan, 2008).

Individual capacity is often thought of as one's knowledge, skills, and attitudes, i.e. one's awareness and understanding of a particular situation, issue, or area; one's technical ability to react, predict, analyse, or solve in a critical way; and one's personal motivation to apply oneself to the task at hand. Individual capacity in the context of CRA can range from the capacity to write a policy that reflects potential adverse events, to the capacity to research and develop CRA practices, to the capacity to negotiate and resolve a conflict. The specific capacities needed depend on the role of the stakeholder and the threats to the food system.

Organisational or institutional capacity, seen through the 5C approach by Baser and Morgan (2008), is an organisation's capability to act and commit, deliver development objectives, adapt and self-renew, relate to external stakeholders, and achieve coherence (Babu and Blom, 2014). Each of the capabilities is required for organisations and institutions involved in CRA. Well-articulated CRA goals need to be set and pursued with commitment. Techniques and practices promoted through CRA programmes need to evolve constantly with the changing capacity needs of agricultural zones in which they are applied. This requires the engagement of all stakeholders. It is also important for organisations to commit to coherence in the achievement of objectives, to ensure that outcomes are achieved in the most efficient way.

Lastly, system capacity refers to the context in which changes are taking place (Baser and Morgan, 2008). In other words, through this dimension, we assess whether (and to what extent) the current conditions promote capacity strengthening for CRA. As in the case for Babu and Blom (2014), this includes the smooth functioning of different stages of the policy process (identification, research, strategy development, implementation, monitoring and evaluation, and strategy revision). However, for our purposes, we include larger systemic issues such as the existence of platforms for collaboration; media to synthesise efforts to mitigate climate change with other sectors; and an enabling social, political, and economic environment.

Country Examples

Although we need to build capacity at the individual, institutional, and system level, for the purpose of this paper, we will be focusing on building capacity at the institutional level. In the paragraphs below, we provide examples of CRA practices being applied in four countries (Bangladesh, Ghana, India, and Viet Nam) and their impacts. All four countries discussed in this study are agriculture-based economies with a majority of marginal, small, and medium-sized farmers; and are thus extremely vulnerable to climate change. Despite the continuous decline in agriculture as a percentage of gross domestic product (GDP), it still contributes a large portion of GDP for all four countries (World Bank, 2016). Notwithstanding similarities, the countries discussed are different with respect to their agriculture systems, cropping patterns, and policy processes.

Even with the increase in interest and awareness regarding CRA, the adoption of CRA intervention remains low in all four countries because of weak individual, organisational, and system level capacities (Babu and De Pinto, 2017). Capacity for conducting research, the adoption of innovation, and monitoring and evaluation for scaling up is crucial for making agriculture in developing countries climate-smart. Apart from human and institutional capacity gaps for climate-resilient agriculture (Babu and De Pinto, 2017), other factors such as poor understanding of climate-smart practices, limited awareness of technology's benefits, and lack of government support, decrease the rate at which CRA practices are being adopted and implemented.

Bangladesh

Bangladesh is primarily an agrarian country, with long coastlines, making it one of the most susceptible countries to climate change. In Bangladesh, Chapai Nawabgonj in the north-west is a drought-prone area (Ramamasy and Baas, 2007), Bagerhat in the south-west is a saline-prone coastal area (Miah et al., 2011) and Kurigram is flood-prone (Bose and Navera, 2017). Soil salinisation in river water and soil in south-west Bangladesh has increased over time and is aggravated by the increase in sea level caused by climate change (Dasgupta, 2017). In terms of employment, this sector provides livelihoods to about 60% of the population. Despite the formation of the Climate Change Cell (CCC) in 2004 under the Ministry of Environment, Forest and Climate Change, the adoption of CRA techniques and practices remains low. Bangladesh has developed plans and strategies to minimise the adverse impacts of climate change on agriculture and food security. The Bangladesh Climate Change Strategy and Action Plan, 2009 is the de facto policy document which provides strategic direction for work on climate change related issues.

CRA practices in Bangladesh include alternate wetting and drying (AWD), row cropping, the adoption of stress-tolerant and high-yielding seed varieties, urea deep placement, and aquaculture/floating agriculture. Excessive production of rice under irrigated conditions is the top contributor of GHG emissions, and the AWD technique can be used to limit emissions. AWD is a systematic management practice in rice production which involves periodic drying and reflooding of the field. This technique has been field tested and achieved positive results.

The yields of farmers using AWD increased by 9%–12% more than those of farmers using conventional irrigation, while water savings reached 22%–26% (De Pinto et al., 2017).

Even though AWD decreases GHG emissions and other environmental impacts, there are several constraints to scaling up AWD in Bangladesh. Institutional in nature, these include arrangements for water payments. This could be done by having a fixed seasonal rate or by paying a fixed share of the crop. Providing economic incentives for farmers to decrease the use of electricity and water can also help to reduce the carbon produced during agricultural production. However, there is a lack of willingness to promote AWD nationally. Other barriers to increasing AWD adoption include the lack of willingness of farmers to seek incentives, unlevelled farm fields, low awareness of the benefits of technology, and lack of government support (Basak, 2016; Lampayan et al., 2015).

Ghana

Even though sub-Saharan Africa does not contribute significantly to GHG emissions compared with other regions, adverse impacts of climate change are anticipated in this region, particularly in West African countries since they are heavily dependent on rain-fed agriculture. The impact of climate change on agriculture is manifested in four main ways: rising temperatures, declining rainfall totals and increased variability, rising sea levels, and high incidence of weather extremes and disasters. The distribution of rainfall is considered the single most important factor affecting agriculture in Ghana (Government of Ghana, 2010). Reduced and increasingly erratic rainfall in the country's ecological zones has adverse effects on the agricultural economy and livelihoods because agriculture in Ghana is largely rain-fed.

The CRA cocoa initiative in Ghana has focused on building support for climate-resilient agriculture interventions within the context of national REDD+ readiness activities. Agriculture is widely recognised as a major source of emissions. Using CRA practices can result in increased rural economic development and food security as well as climate adaptation and mitigation. The primary benefit to smallholder farmers who adopt climate-smart best practices will be a 50%–60% increase in yield and a potential annual revenue increase of $1,000 (Forest Trends, 2013).

Land use management practices have a significant impact on crop production in Ghana's ecological zones (Asuming-Brempong, 2010). Peterson (2014) conducted a household survey in villages of north-west Ghana to examine farmers' awareness of and willingness to adopt CRA practices. All the households surveyed were willing to adopt crop rotation, manure management, use of chemical fertilisers, and organic pest management. Ghana's Council for Scientific and Industrial Research introduced crop rotation as a technique to improve soil fertility and increase pest and disease resistance.

Despite these efforts, farmer adoption remains low because of limited awareness. Poor access to information regarding CRA practices and the limited capacity of Ghana's agriculture extension and advisory services to disseminate timely information are the key areas in which we need to strengthen capacity.

India

In the past 6 decades, Indian agriculture has undergone a major transformation. The country has moved from dependence on aid and food deficits to becoming a net exporter of food and maintaining an average growth rate of 3% (except for fiscal years 1997–2005). Despite this, food security remains a top priority for the agricultural sector because of the increasing population. In 2008, India took its first big step towards decreasing climate change risks by adopting the National Action Plan on Climate Change in 2008 (Government of India, Prime Minister's Council on Climate Change, 2008). The plan charts eight priority 'missions', one of which is the National Mission for Sustainable Agriculture. This lays down goals until 2017, but it does not clearly mention the steps required to achieve them. India is also a party to various international treaties such as the Paris Agreement, which came into force on 4 November 2016 (United Nations Framework Convention on Climate Change (UNFCCC), 2017; Patra and Babu, 2017).

Taneja et al. (2014) assessed farmers' preferences and willingness to pay for different smart interventions in India. The results of their study show that preferred interventions include laser land levelling (LLL), crop insurance, weather advisory services, direct seeding, zero tillage, and irrigation scheduling. The LLL technique has several impacts on climate change mitigation by reducing emissions through decreased pumping time, reduced cultivation time, and fertiliser savings (Gill, 2014). Farmers using the LLL technique saw a decrease in irrigation time of 45–55 hours per hectare (ha) for rice fields and 10–12 hours per ha for wheat fields (Aryal et al., 2015. An increase in yield of 340 kilograms/ha for rice farms and 320 kg/ha for wheat farms was also observed (Aryal et al., 2015; Gill, 2014).

Even though farmers expressed interest in adopting new technology that can decrease carbon emissions, large-scale adoption of such techniques requires access to funding (Taneja et al., 2014). Further, we need to build the capacity of the extension system to increase awareness amongst farmers regarding the positive impact of such technologies on yield and income.

Viet Nam

The Vietnamese government has taken various steps to combat the risks of climate change. While the focus has been on broader climate change issues, CRA is also given a lot of emphasis in current policies and programmes. Examples of policies that incorporate CRA techniques and practices include the Green Growth Strategy; the National Action Plan of Climate Change Adaptation; and the National Strategy for Natural Disaster Prevention, Response and Mitigation. As climate change could reverse the substantial economic progress made in agriculture in Viet Nam, the Ministry of Agriculture and Rural Development issued a decision in 2011 to promulgate an action plan for climate change with respect to the agriculture and rural development sector for 2011–2015. It has also implemented the Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector for 2008–2020. At the international level, the Vietnamese government ratified the Paris Agreement and the Kyoto Protocol, by directing its agencies to lay down a legal foundation for preventing and mitigating natural disasters and coping with climate change.

AWD is a popular technique in Viet Nam since the country is a major rice producer. Along with limiting GHG emissions, AWD adopters in Viet Nam experienced a 20% decrease in production costs compared with conventional techniques (Quicho, 2013) and an increase in profit of 17–41% (Quicho, 2013; Ha, 2014), mainly because of the drop in irrigation and labour costs. Multiple studies reported a decrease in GHG emissions as a result of the adoption of AWD (Pandey et al., 2014; Narayan and Belova, 2014).

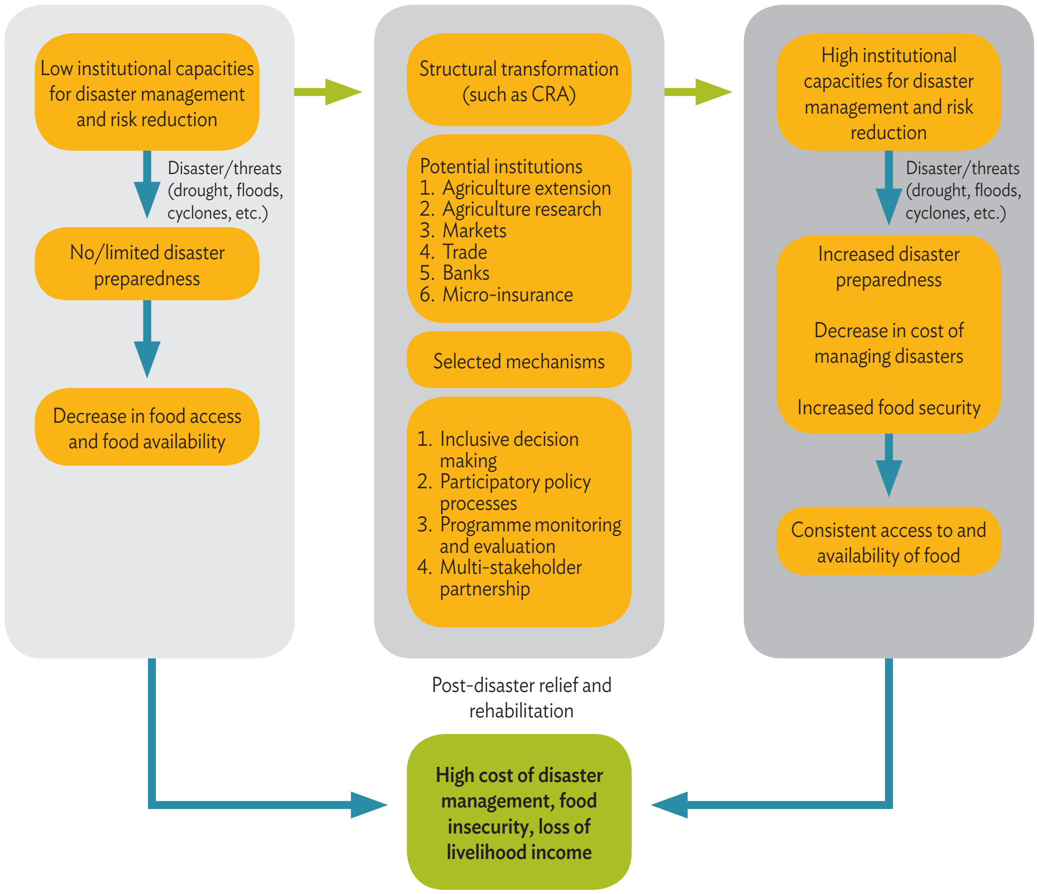
Viet Nam faces similar challenges to Bangladesh in promoting AWD amongst farmers. The payment of water remains a key challenge. Barriers to adoption are similar to those found in other countries where farmers pay for water from private pumps. Since incentives for AWD are directly linked to the irrigation system, capacity must be built for improved irrigation.

For example, the National Irrigation Administration in the Philippines developed and improved irrigation canals as part of a nationwide plan while local governments developed policies providing economic incentives for farmers to reduce water consumption.

10.3 Institutional Strengthening Framework for Disaster Management and Risk Reduction

From the country examples provided in the above section, we identify capacities needed at the institutional level to reduce the costs associated with natural disasters and mitigate risk. Institutional capacity includes elements such as effective leadership, human resources management, resource allocation, incentive structures that reward high-quality work, and a collaborative work environment. Using these examples, we have developed a consistent and user-friendly framework for strengthening institutional capacity for disaster management and risk reduction. The figure below shows the pathways through which institutional capacity can be built.

Figure 10.1: Strengthening Institutional Capacities for Disaster Management and Risk Reduction



CRA = climate-resilient agriculture.

Source: Adapted from Babu and Blom (2014).

Since farmers do not see a distinction between risk reduction and adaptation (FAO, 2013), scaling up CRA practices can help decrease threats to livelihoods and increase institutional capacity for disaster management and risk reduction. Institutions must be able to utilise the individual capacity of their employees effectively.

Developing countries face a number of issues and challenges in building adequate capacity for disaster management and risk reduction. In the context of climate-resilient agriculture, determining a country's optimal capacity for the design and adoption of CRA requires an understanding of how the system works. There are multiple pathways through which one can influence the system towards CRA: bringing forward policy issues and presenting data to demonstrate problems, conducting research to support evidence-based policymaking, and using media to influence politicians and constituents alike. Alternatively, more immediate small-scale change can occur at the community level by working with local governments, civil society organisations, and farmer-based organisations to design and implement CRA initiatives. Yet, without adequate capacity for designing and implementing effective programmes in farmers' fields, CRA innovation may remain on the shelves of laboratories.

Once the policies and programmes for CRA are in place, countries require efficient governance and institutional structures to sustain capacity development. Capacity, being a dynamic concept, needs institutions that can constantly adapt to changing circumstances and technological developments. Similarly, accountability and transparency (clarity in roles and functions) in the functioning of institutions and key actors is required at the national, regional, and local levels. This is important in sustaining programmes not just financially, but also in terms of their credibility. Additionally, avenues for coordination and collaboration are an essential component of this element in avoiding the duplication of efforts.

Investing financial and human capital in information monitoring and knowledge management systems is a tested way of building institutional capacity. This is important for using resources effectively and efficiently. For instance, the development of reliable methods of measuring, monitoring, and accounting for emissions across various agroecological zones is important to assess the progress of CRA programmes. That would help inform decisions regarding resource allocation for future such reforms. In a world of trade-offs, regular and reliable monitoring is the only way to guide informed resource allocation.

Since development in techniques for CRA rests on technological development and innovation, building institutional capacity for research, testing, and dissemination of this information (through agriculture extension) is crucial. This includes inputs used by farmers in the field; inputs needed by researchers to conduct their studies; and technical support needed by policymakers to formulate, implement, and monitor CRA programmes.

10.4 Conclusion

To mitigate the risk associated with disasters, a holistic approach comprising elements of prevention, mitigation, and response is needed. Along with post-disaster relief and rehabilitation, it is important to consider disaster management and risk reduction comprehensively. The frequency of natural disasters has increased globally (ADB, 2013); and the Asia-Pacific region is projected to be the most affected by the impacts of climate change such as floods, drought, and cyclones (Davies et al., 2008). Developing countries are especially vulnerable to such disasters and are often the least capable of coping with the associated impacts because of their limited adaptive capacity (Davies et al., 2008). Therefore, it is necessary to build capacity at the individual, institutional, and system levels for disaster management and risk reduction to decrease the overall impact of natural disasters and costs associated with post-disaster relief.

Although it is important to build capacity at all three levels, building institutional capacity is crucial since it remains a challenge for many developing countries. While several approaches to build institutional capacity exist, this paper focuses on building institutional capacity for disaster management and risk reduction through the agricultural sector. Climate-resilient agriculture has become an effective tool for adapting to climate change and developing resilience in the long run – resulting in increased capacity for disaster management and risk reduction.

In this chapter, we identified technologies and practices adopted by farmers from Bangladesh, Ghana, India, and Viet Nam. From the country examples provided, we identified the capacities needed at the institutional level in order to reduce the costs associated with natural disasters and mitigate risk. Using this information, we developed a framework which can be applied to strengthen institutional capacity for disaster management and risk reduction. For the purpose of this chapter, we focused on strengthening capacity for building the resilience of the agriculture sector to climate change and variability as an example. However, this framework can be applied to different sectors to build institutional capacity such as an early warning system.

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CHAPTER 11

Ensuring Food and Nutritional Security in the Face of Natural Disasters and Climate Change: What are the Adaptation Solutions?

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11.1 Introduction

According to the Food and Agriculture Organization of the United Nations (FAO), 'food security exists when all of the people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, in order to meet their dietary needs and food preferences for an active and healthy life' (FAO, 1996). The FAO also identified availability, access, utilisation, and stability as four pillars of food security (FAO, 2008). Food security is influenced by several factors such as rising demand, higher commodity prices, soil degradation, climate change, and natural disasters, which cause food insecurity. On the other hand, food insecurity is defined by the United States Department of Agriculture (USDA) as the limited or uncertain availability of nutritionally adequate and safe foods or the limited or uncertain ability to acquire acceptable foods in socially acceptable ways (Bickel et al., 2000). The majority of the world's food insecure people live in countries that are prone to natural hazards and climate change. These people mostly depend on agriculture for a living. They have a significantly low asset base, which might increase the risk of exposure to natural disasters and climate change (FAO, 2015).

Natural disasters and climate change represent major risks for long-term food and nutritional security. Natural calamities such as droughts, storms, earthquakes, landslides, and floods occur every year, at any time or place, affecting human life and food security. These threats restrict food production by affecting crop yields, seed reserves, livestock, fisheries, farm equipment, infrastructure, supply systems, and food trade, which can result in economic losses and disrupt the internal equilibrium in vulnerable nations (De Haen, 2008; Sperling, 2008). Natural disasters affected more than 1.9 billion people in developing countries from 2003 to 2013, causing more than $494 billion in estimated losses. Agriculture absorbs about 22% of the aggregate economic impact of natural disasters (FAO, 2015). Beyond production losses, disasters create nutrient insecurity, especially in children, causing stunted growth during droughts and after floods (Silventoinen, 2003; Del Ninno, Dorosh, and Smith, 2003).

Climate change has a range of direct and indirect effects on all four dimensions of food security in countries vulnerable to hunger and undernutrition (Wheeler and von Braun, 2013). It aggravates the risks of hunger and undernutrition in several ways, with direct effects on crop production, livestock, and agroecosystems through warmer temperatures, changes in rainfall patterns, and frequent extreme weather events. Indirect effects include changes in markets, food prices, and supply chain infrastructure demanding more food production. The impact of climate change varies from location to location, depending on the degree of warming and associated changes in rainfall patterns.

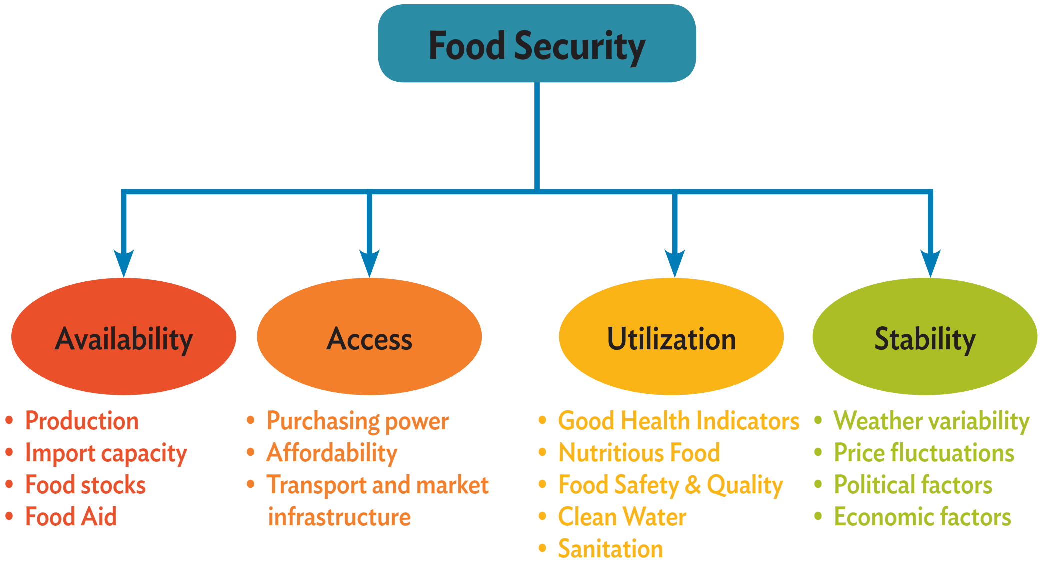
People who are food-insecure usually live in conditions in which a high risk of natural hazards coincides with high vulnerability. The capacity to adapt food production systems to reduce their vulnerability is essential because of the effects of natural disasters and climate change on food security. Adaptation strategies that manage disaster risk reduction and climate-related extreme weather events seek to reduce factors that contribute to the risks, thus supporting and promoting food and nutritional security. Improved systems of food production, distribution, and economic access may all contribute to coping with climate change, but in adopting such changes it will be important to ensure that they contribute to long-term agriculture sustainability (Wheeler and von Braun, 2013). In this chapter, we discuss the effects of natural disasters and climate change on food production, as well as the associated consequences on human food and nutritional security. The following sections also provide an overview of the adaptation strategies that are employed in a range of fields in the context of natural disasters and climate change to achieve food and nutritional security.

11.2 Food Security

11.2.1 Food Security and Components

Food security essentially deals with the constant availability of and access to food, in the appropriate quantity and quality, to meet people's dietary energy requirements (Pinstrup-Andersen, 2009). The most widely accepted definition of food security is that it is a condition in which 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, 1996). Four major pillars of food security are believed to be crucial in accomplishing sustainability: food availability, access, utilisation, and stability (Figure 11.1).

Figure 11.1: Food Security and its Components



Source: Authors.

Availability

This pillar refers to the constant availability of food in adequate quantities. Availability depends on food production; stock; and imports, including food aid (FAO, 2009). It is also associated with factors such as the availability of natural, human, and economic resources.

Access

Access is determined by people's initial ability to produce their own food or their purchasing power. It depends on their resources and opportunities in terms of physical and economic access to food through their own efforts, state interventions, or both.

Utilisation

Utilisation refers to the metabolisation and positive nutritional impact on people. Essentially, food utilisation depends on food preparation, storage, nutrition, food safety, quality, and water and hygiene practices.

Stability

This is the ability to procure food over time, through production and/or food transfer. Stability is usually affected by a lack of production, natural disasters, crop failure, price fluctuations, and civil conflict.

11.2.2 Food Security Score and Prevalence of Undernourishment

Food security focuses on food availability, access, utilisation, the stability of food security over time, or some combination of these domains. Due to the complexity of the factors that contribute to food security and their significance in understanding food security in different contexts, some institutions implement consultative methods for developing food security measurement tools. One such tool is the Global Food Security Index (GFSI), which is multidimensional and uses various indicators for assessing country level trends in food security. The GFSI was designed by the Economist Intelligence Unit and sponsored by DuPont. It uses 28 indicators within the affordability, availability, and quality domains of food security across 113 countries (Economist Intelligence Unit, 2016). Its scores are calculated each quarter based on shifts in food price data. The best and worst GFSI scores of countries are listed in Table 11.1 by region. The country with the highest food security (86.6) score and number one global rank is the United States (US), while Burundi in Africa has the lowest food security score (24.0) (Table 11.1). In Southeast Asia, Singapore has the highest food security score (83.9), ranked third globally, while the Lao People's Democratic Republic has the lowest food security score (32.7) and is ranked 103rd globally (Economist Intelligence Unit, 2016) (Table 11.1 and Table 11.2).

Along with the food security score, the GFSI rank shows the prevalence of undernourishment in all 113 countries. This indicates the percentage of the population that does not meet the required minimum number of calories for an average person stipulated by the FAO along with the World Health Organization and the United Nations in 2001. The lowest and highest rates of prevalence of undernourishment are listed in Table 11.1, with Haiti having the highest prevalence of undernourishment at 53% (Table 11.1). Amongst the Association of Southeast Asian Nations (ASEAN) member countries, Singapore has 0% prevalence of undernourishment while the Lao People's Democratic Republic has 18%. The prevalence of undernourishment for the rest of the ASEAN countries (Table 11.2) was 5%–14% (FAO et al., 2017).

The food security score and the prevalence of undernourishment provide a common framework for understanding the root causes of food insecurity by looking at the dynamics of food systems around the world. Many factors affect and will have significant impacts on food security – the changing climate, growing global population, availability of arable land, water resources, rising food prices, and environmental stressors (Premanandh, 2011).

Table 11.1: Countries with the Best and Worst Food Security Scores in Each Region

Region	Country	Global rank (1 to 113)	Food security score (1 to 100)	Prevalence of undernourishment (%)
North America	US	1	86.6	5
	Mexico	39	68.1	5
Central and South America	Chile	24	74.4	5
	Haiti	108	29.4	53
Europe	Ireland	2	84.3	5
	Ukraine	63	55.2	5
Middle East and North Africa	Israel	17	78.9	5
	Yemen	100	34.0	26
Sub-Saharan Africa	South Africa	47	62.9	5
	Burundi	113	24.0	0
Asia and the Pacific	Singapore	3	83.9	0
	Lao PDR	103	32.7	18

Lao PDR = Lao People's Democratic Republic, US = United States.

Source: Economist Intelligence Unit (2016).

Table 11.2: Food Security Score of ASEAN Countries

Country	Global rank (1 to 113)	Food security score (1 to 100)	Prevalence of undernourishment (%)
Singapore	3	83.9	0
Malaysia	35	69	5
Thailand	51	59.5	7
Viet Nam	57	57.1	11
Indonesia	71	50.6	7
Philippines	74	49.5	13
Myanmar	80	46.5	14
Cambodia	89	39.8	14
Lao PDR	103	32.7	18
Brunei Darussalam	-	-	-

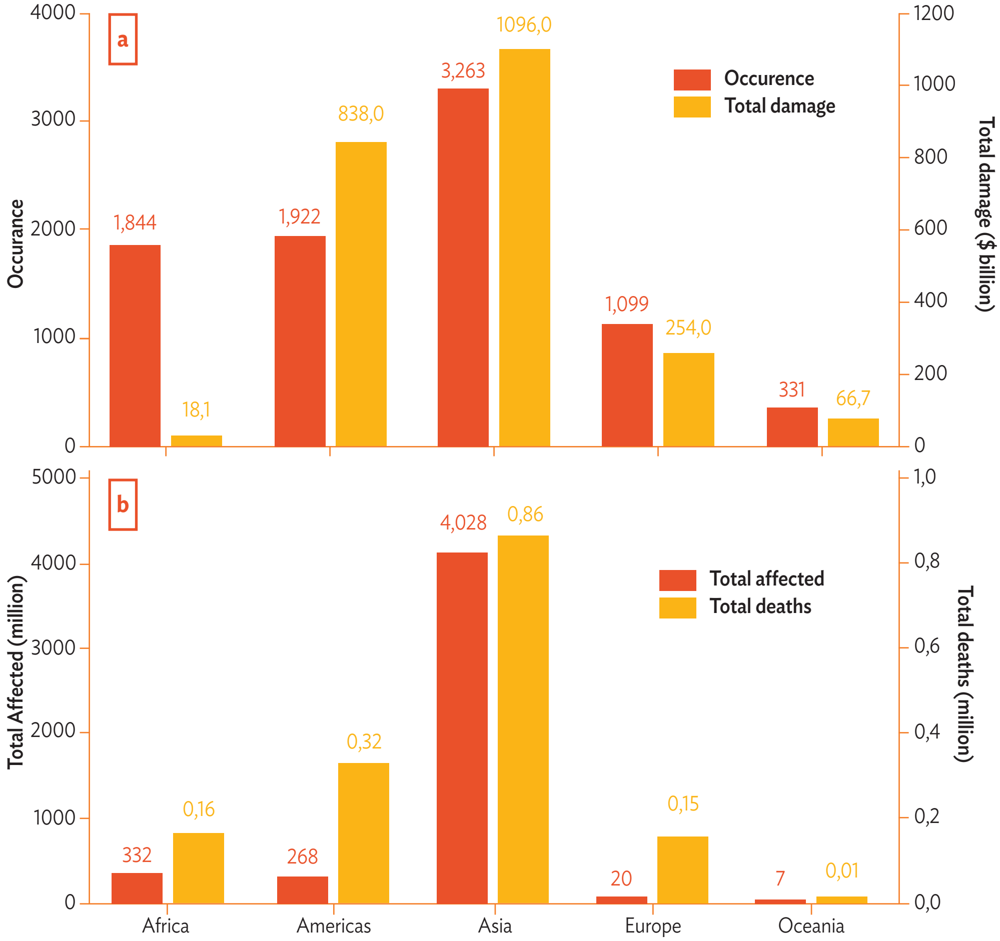
ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Source: Economist Intelligence Unit (2016).

11.2.3 Effect of Natural Disasters on Food Security

A natural disaster is any natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (United Nations International Strategy for Disaster Reduction (UNISDR), 2009). A natural disaster event often occurs unexpectedly, causing great damage and destruction, devastating local capacity, and demanding external aid at the national or international level. Natural disasters are biological, geophysical, meteorological, climatological, and hydrological. Major factors that account for the increase in the rate and severity of natural disasters are climate change, urbanisation, and environmental degradation. The majority (70%) of the world's disasters take place in low-income countries (Gaire et al., 2016). East Asia and the Pacific are the world's most disaster-prone areas and face increasing risks of natural disasters. The chance of disasters such as earthquakes, landslides, floods, avalanches, and glacial lake outbursts in these regions are high partly because of the Himalayas. People living in the drainage basin of the Himalayan rivers might experience floods and severe droughts in the coming decades (Kim et al., 2015). According to the Emergency Events Database (EM-DAT, 2017), 301 country level disasters occurred in 2016, affecting 102 countries. The effects of 8,459 natural disaster events during 1996–2016 caused up to 1.49 million deaths and affected 4,657 million people, causing damage totalling $2,274 billion in economic losses (Figure 11.2(a) and Figure 11.2(b)). China was the country most affected by natural disasters, with 29 events in 2016, which killed an estimated 1,151 people and affected 13 million people (Centre for Research on the Epidemiology of Disasters (CRED), 2016). The Global Climate Risk Index (CRI), developed by Germanwatch, analyses the quantified impacts of extreme weather events in different countries both in terms of fatalities as well as the economic losses that occurred. Based on the 2017 CRI, six countries from Asia (Table 11.3) are in the top 10 lists with long-term high CRI (Kreft, Eckstein, and Melchior, 2016).

Figure 11.2: The Impact of Disasters in Different Continents, 1996–2016



Source: EM-DAT (2017).

Table 11.3: Long-Term Climate Risk Index of the 10 Most Affected Countries, 1996–2015
(annual average)

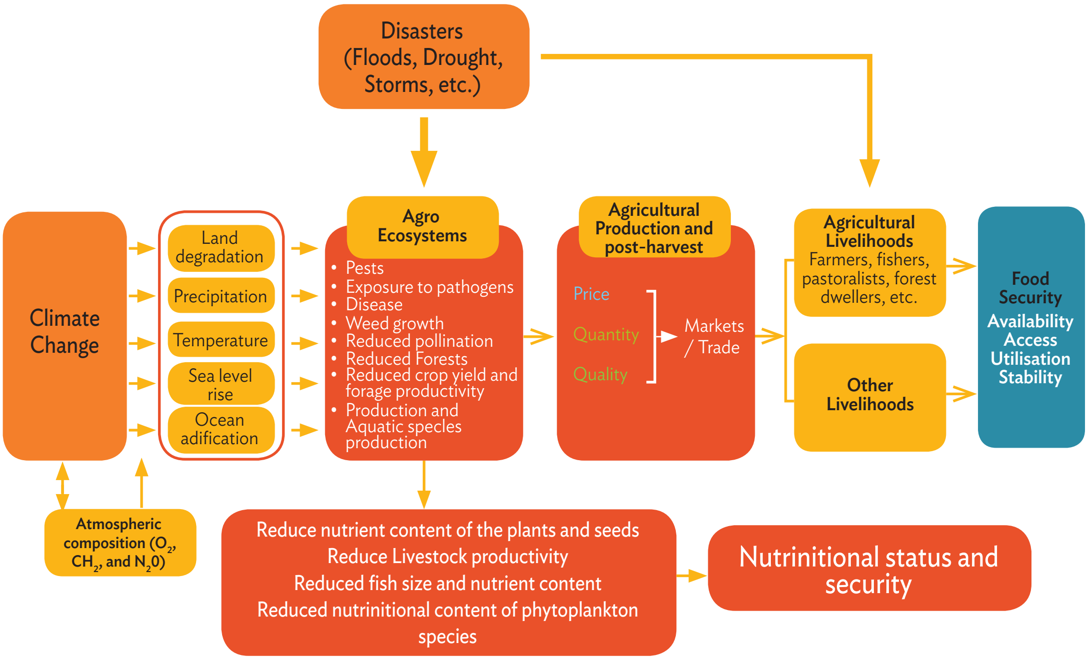
CRI	Country	CRI score	Total losses ($ million)	Losses per unit of GDP (%)	Number of events
1	Honduras	11.3	568	2.10	61
2	Myanmar	14.2	1,300	0.74	41
3	Haiti	18.2	221	1.48	63
4	Nicaragua	19.2	234	1.19	44
5	Philippines	21.3	2,761	0.63	283
6	Bangladesh	25.0	2,283	0.73	185
7	Pakistan	30.5	3,823	0.65	133
8	Viet Nam	31.3	2,119	0.62	206
9	Guatemala	33.8	401	0.47	75
10	Thailand	34.8	7,574	1.00	136

CRI = Climate Risk Index, GDP = gross domestic product.
Source: Kreft, Eckstein, and Melchior (2016).

Natural disasters are a leading cause of food insecurity. They affect all components of food security, reducing economic and physical access to food availability, utilisation, and stability. They also affect agroecosystems by causing losses in crop production, fisheries, and livestock. Natural disaster events may spread diseases and make it difficult to control pests (Figure 11.3). It is fundamental to manage agriculture systems to preserve ecosystem services, such as their capacity to ensure food security. The intensity and frequency of climate-related natural disasters is projected to increase. Poor people, including many smallholder farmers and agricultural workers, are more vulnerable to the impacts of such disasters. Severe droughts or floods can sharply reduce incomes and cause asset losses, which erode future income-earning capacity. Food supply chains are also affected by natural disasters, with an effect on food prices. For example, the value of the FAO Food Price Index more than doubled from 2002 to 2011, suggesting a continuous rise in agricultural commodity prices since 2002. This was due to the occurrence of three droughts in Australia from 2001 to 2007, a heatwave during the summer of 2010 in central Asia, and other calamities (Caldecott et al., 2013).

No significant effect of natural disasters on overall gross domestic product (GDP) was observed using 5-year growth averages during 1961–2005. However, the impact of droughts was negative while the impact of floods was positive. The positive effect of the floods may be due to the availability of water after floods – benefiting the crops, balancing the localised damage from flooding, and providing additional nutrients carried from uplands to lowlands (Israel and Briones, 2012). Floods also temporarily create a larger water habitat for inland fish and other aquatic animals. This positive effect can disappear in the case of more severe flooding, however, which can damage farm infrastructure, supplies, facilities, and stored seeds (Loayza et al., 2012). The differing impacts of natural disasters usually depend on the type and severity of the disaster (Fomby, Ikeda, and Loayza, 2013). For instance, the detrimental effect of droughts on crops caused production losses of about 90% in sub-Saharan Africa where the agriculture sector on average contributes a quarter of GDP. Total crop and livestock production losses after major droughts were equivalent to more than $30 billion during 1991–2013 in this region (FAO, 2015).

Figure 11.3: Overview of Impacts of Natural Disasters and Climate Change on Food and Nutritional Security

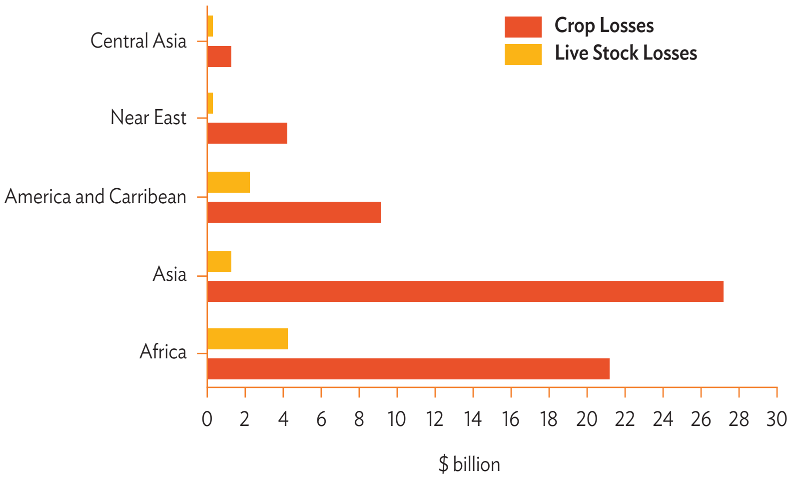


Source: Authors (modified from FAO, 2015).

A statistical analysis using FAO agricultural databases helped to quantify crop and livestock production losses, as well as changes in trade flows and the performance of agriculture value-added growth. The analysis considered 140 medium- and large-scale disasters from 2003 to 2013 which occurred in 67 developing countries, affecting at least 250,000 people (Figure 11.4 and Figure 11.5). The disasters resulted in losses of about $80 billion, which are mainly due to damaged agriculture production including crop yields and livestock production. The majority of the agriculture production losses accounts for the reduction in the crop yield. Asia had major crop losses, with production losses of about $27 billion, followed by Africa with $21 billion in crop losses (Figure 11.4). Disasters also caused major livestock losses in Africa, amounting to about $4 billion. Central Asia experienced the lowest crop losses as a result of disasters during 2003–2013, at $1 billion, and zero livestock losses. The production losses correspond to 333 million tonnes of cereals, pulses, meat, milk, and other commodities. This is equivalent to about 7% of national per capita dietary energy supply after each disaster. These losses are significant at the national level and highly significant at the regional level. The estimated losses in calories increase the chance of household food insecurity, and appropriate measures need to be taken to compensate and fill the gap in dietary energy supply (FAO, 2015).

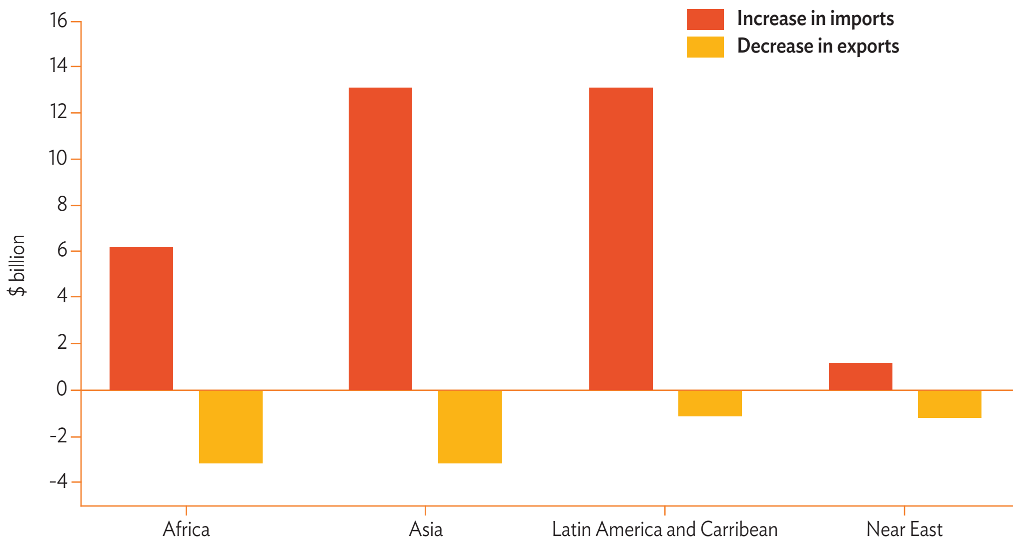
Agricultural and livestock production losses after natural disasters can induce changes in agricultural trade flows, which can increase imports and decrease export revenue – affecting countries' economies. The disasters analysed were closely correlated with rises in food imports and drops in food exports. Asia was found to have the highest increase in imports and decrease in exports (Figure 11.5). Increases in imports amounted, in relative terms, to 28% of their projected value, while decreases in exports represented about 6% of the projected value of exports. Expenditure caused by higher imports and lower export revenues can negatively affect the national balance of payments, the economy, and GDP. The analysis also revealed significant negative trends in agriculture value-added growth for 55% of the disasters considered. Each disaster was followed by an average loss of 2.6% of national agricultural value-added growth in the countries affected, with a much more significant impact likely at regional levels (FAO, 2015).

Figure 11.4: **Crop and Livestock Losses by Region, 2003–2013**



Source: FAO (2015).

Figure 11.5: **Changes in the Trade Flow of Agricultural Products after Major Disasters by Region, 2003–2013**



Source: FAO (2015).

11.2.4 Effect of Natural Disasters on Nutritional Security

The significant influence of disasters on crop yield, livestock, and fisheries also lowers the nutritional quality of food as an outcome in the long term (Figure 11.3). This is a problem in both developing and developed nations, where deficits in the availability and quality of food lead to hunger (Cutter, 2017). This can rapidly turn into a food and nutrition crisis, causing a major impact on children, from which it takes many years to recover. Poor nutrition and lack of clean water keep people in cycles of hunger and poverty, preventing them from achieving sustainable development and recovery. The loss of assets caused by disasters, as well as poverty, affect families' ability to pay for nutritious food and healthcare. This prevents children from reaching their growth potential, resulting in stunted growth, a reduced life span, and low levels of education (Gaire et al., 2016). Studies have shown the influence of disasters on nutrition – causing severe detrimental impacts, especially during the drought season. Empirical evidence shows that children born during a drought are most likely to face malnourishment. For instance, children born in drought-affected areas of Ethiopia are 35.5% more likely to be malnourished and have a 41.0% chance of being stunted. This was also observed in Kenya, where children born in drought periods have a 50.4% likelihood of being stunted and a 71.1% probability of being severely stunted. Malnourishment was found to be even worse amongst preschool children, with more than double the negative effects (Fuentes and Seck, 2007). A high prevalence of undernourishment in children was observed in Ethiopia during drought periods (Delbiso et al., 2017); the Philippines after typhoons (United Nations Children's Fund (UNICEF), 2011); India after floods (Rodriguez-Llanes et al., 2016); and Nepal after an earthquake (Gaire et al., 2016).

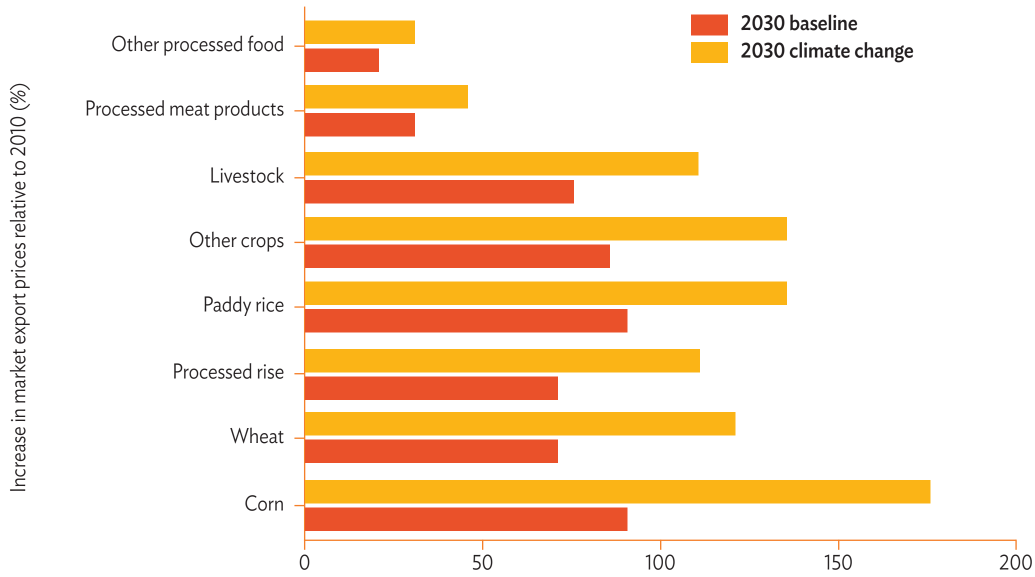
11.2.5 Effect of Climate Change on Food Security

Climate change has resulted in an increase in the global mean temperature and variations in regional precipitation, and these changes are expected to continue and intensify in the future (Solomon et al., 2007). The Intergovernmental Panel on Climate Change (IPCC, 2008) has predicted that climate change over the next century will modify river flows and sea levels throughout the globe, with an effect on rainfall. Researchers show that agriculture yield will likely be severely affected over the next century because of unusual rates of change in the climate system (Jarvis et al., 2010; Thornton et al., 2011). Change in the climate also alters the relationships amongst crops, pests, pathogens, and weeds. It declines the crop yield by influencing the pollinating insects, increasing water scarcity, increasing ground-level ozone concentrations, and decreasing the production of fisheries (Myers et al., 2017) (Figure 11.3). Despite the yield benefits caused by higher carbon dioxide (CO_2) in some crops, the higher temperature caused by increased CO_2 reduces the overall crop yield. Crop growth models – which study the effects of CO_2 combining with temperature, water availability, and limited nitrogen – predict average yield losses of 25% for maize and 15% for wheat if global temperatures increase by 4°C by 2100 (Rosenzweig et al., 2014; Reddy, Singh, and Anbumozhi, 2016). The changes in production caused by climate change are likely to affect food commodity prices, making it difficult to buy in vulnerable countries. Based on the simulation studies, average world market export prices will rise by a higher percentage in 2030 with climate change than without climate change (Figure 11.6), calculated against 2010 export prices (Willenbockel, 2011).

An increase in CO_2 concentrations alters the strength of plant defences against pests and pathogens (Zvereva and Kozlov, 2006). Extreme weather events caused by climate change can threaten agricultural production, compromising crop defences which permit pests and weeds to become established (Rosenzweig et al., 2001). There is an indication that rising CO_2 favourably selects invasive, noxious species of weeds within plant communities, stimulating their growth and making them difficult to control (Ziska and George, 2004). Climate change will also affect the abundance and distribution of pollinating insects, which may reduce the chances of pollination of flowering plants, lowering their production (Hegland et al., 2009).

Global sea level rise from glacier melting, caused by thermal expansion, will affect food security by flooding agricultural lands near coastal areas and increasing the salinisation of groundwater (Adams, 1989; Myers et al., 2017). For example, in Asia and North Africa, where the most vulnerable people live in the river deltas of Bangladesh, India, Egypt, Myanmar, and Pakistan, farming areas in coastal regions are exposed to sea level rise (Webster, 2008). Most of the population in these countries depend on farming and fishing, so the rise in sea levels will have an impact on their livelihoods. Rising sea levels also cause destructive erosion, wetland flooding, soil contamination, and lost of habitat for fish. Salinity levels in the soil can significantly influence plant growth and production as well as the quality of available drinking water (Adams, 1989; Myers et al., 2017; Shrivastava and Kumar, 2015).

Figure 11.6: Projected Increase in Market Export Prices of Different Food Commodities in 2030 Relative to 2010 – With and Without Climate Change



Source: Willenbockel (2011).

Climate Change and Pillars of Food Security

Several studies focus on understanding the sensitivities of agriculture to climate change. However, assessments of climate change effects on food security remain limited. While discussing food and nutritional security, it is essential to discuss access, utilisation, and stability rather than only availability (which basically deals with production).

Food Availability

As discussed in section 11.2.5, changes in climatic conditions have an effect on the production of some staple crops, livestock, and fisheries. Future climate change predictions threaten to intensify this effect, with more projected losses. Warmer temperatures will impact the crop yields while changes in rainfall could affect both crop quality and quantity. This reduced agricultural production in some vulnerable countries will affect dietary diversity and nutritional security.

Food Access

The decrease in yields resulting from climate change could increase the price of major crops in some regions. Lower agricultural output will result in lower incomes. The drop in income and increased food prices will make it difficult to access food, especially for vulnerable communities.

Food Utilisation

Inadequate calorie intake and protein, predominantly in areas where chronic food insecurity is already a significant problem, create vicious cycles of disease and hunger. This leads to reduced dietary diversity, poor sanitary practices, and health problems.

Food Stability

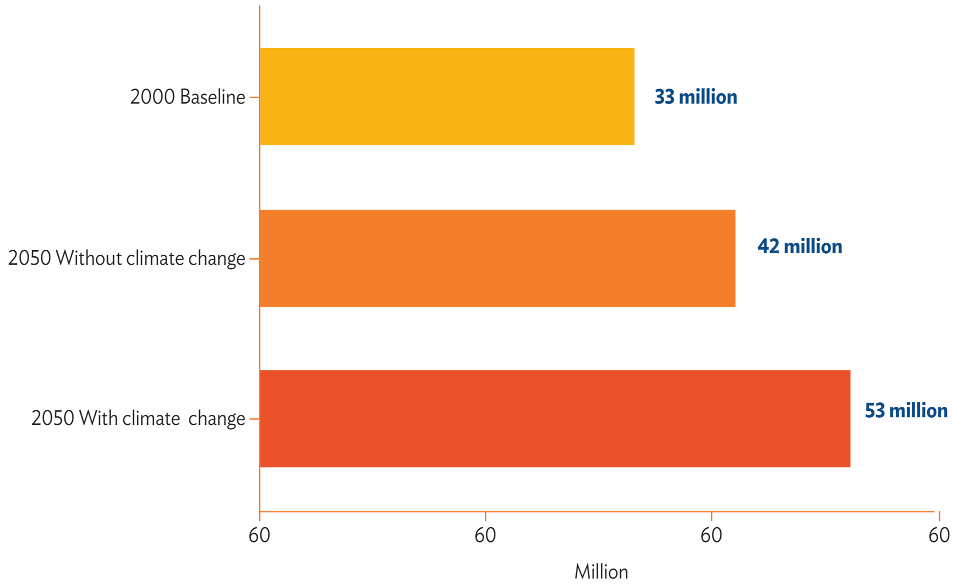
Extreme weather events can discourage the stability of people and governments' food security strategies. Agricultural production losses usually create instability in agricultural income and thus food supply chains.

11.2.6 Climate Change Effects on Nutrition

The increased CO_2 resulting from climate change can modify seed protein and mineral composition. It will also have an effect on the nutritional quality of livestock and aquatic animals (Chavez, Messié, and Pennington, 2011; Myers et al., 2014). The intake of food with low nutritional quality leads to nutritional insecurity in adults as well as children, with a high impact. Climate change could aggravate undernutrition, e.g. inadequate calorie intake caused by the unavailability of food could affect human health. Undernutrition usually increases people's susceptibility to and the severity of infectious diseases and thus ill health. Low availability of food and low calorie intake cause changes in health conditions and can lead to stunted growth and marasmus in children.

Inadequate healthcare practices could be intensified by the lack of clean drinking water and poor sanitation. The possible rise in food prices caused by climate change could reduce dietary diversity and hence the nutritional value of the diet. Simulation studies suggest that the number of people at risk of hunger in sub-Saharan Africa will increase by 10%–20% by 2050 compared with 2000. This accounts for 65% of the population of sub-Saharan Africa. The number of malnourished children could increase by up to 21% (Nelson et al., 2009) (Figure 11.7).

Figure 11.7: Projected Number of Malnourished Children in Sub-Saharan Africa in 2050



Source: Nelson et al. (2009).

11.3 Adaptation Strategies

11.3.1 Disaster Risk Management

It is important to consider both proactive and reactive measurements to achieve food security in the face of disasters. Proactive measurements are to anticipate disaster risks in development investments, by enhancing resilience before a disaster occurs. Reactive measurements are to take disaster risk as a given, invest in normal development, and repair the damage after a disaster. As defined by the UNISDR, disaster risk management 'is the systematic process of using administrative directives, organisational and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster' (UNISDR, 2009). Most natural disasters cannot be avoided, even with preventive measures, and the risk cannot be reduced to zero (World Bank, 2014). Hence, it is important to maintain definitive risk management strategies to mitigate natural disasters where risk cannot be avoided.

In any case, investing in resilience needs to be seriously considered and the benefits and costs need to be assessed. According to the Department for International Development of the United Kingdom (DFID), resilience necessitates social, institutional, and informational resources that allow a community to respond effectively to a disaster impact. It also includes early warning systems, monitoring, and evaluation for enhanced coping and adaptation (DFID, 2004). Disasters can greatly affect all four dimensions of food security because of the wide range of their impacts. Specific implications for food security depend on whether a disaster affects the availability of food, the physical and financial access to food, or both. During disasters, the extent of the shortfall in food availability depends on local food availability, access to regional food reserves, and food assistance from national and international organisation.

However, people in a remote area with a transportation system damaged by disasters often suffer significant shortfalls in food availability. The main objective of disaster risk management is to reduce the natural disaster risk impact and build resilience to food security, making food available to affected people. Some proactive and reactive measures to manage the disaster risk for food security are listed in Table 11.4.

Table 11.4: Proactive and Reactive Measures of Disaster Risk Management

PROACTIVE
Early warning: Monitor for natural disasters (weather forecasting)
Standardisation, coordination, and monitoring of food security data
Strengthen the capacities of countries to reduce hunger
Improve food storage for emergencies
Identify the nature of the disruptions (water, food storage) and better infrastructure to protect food reserves
Strengthen disaster preparedness for effective response at all levels
REACTIVE
Save lives in emergencies and minimise the immediate impact of disasters on food-insecure populations
Restore and rebuild lives and livelihoods in post-disaster situations by rebuilding livelihood assets and infrastructure to improve access to food
Work together with affected communities to recover
Build resilience to reduce long-term effects and withstand the impact of future disasters
Reduce chronic hunger and undernutrition to lessen the enduring impact of disasters, especially on children, by providing nutritious food
Focus on improving the nutritional status of food-insecure people

Source: Authors.

11.3.2 Adaptation Strategies to Natural Disasters and Climate Change for Food Security Management

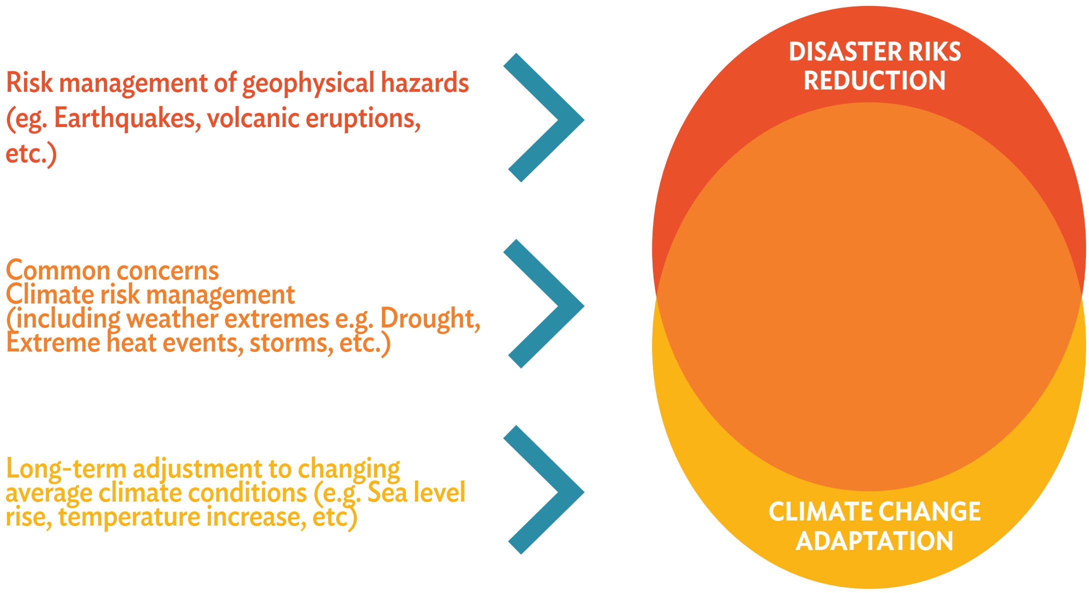
Global warming resulting from climate change is projected to increase the frequency and intensity of natural disaster risks by altering average climatic conditions, worsening climate variability, increasing extreme weather events, and posing greater overall risks for people in developing countries. Climate change is projected to result in decreased water availability and crop productivity in many parts of the world, as well as the loss of plant and animal species and associated ecosystem services. Every year, natural disasters and climate-related extreme events cause a substantial loss of life, economic damage, and social development.

Adaptation is a key factor that will shape the future severity of climate change impacts on food production (Chang, 2007). Adaptation to climate change and disaster risk management both seek to reduce risk factors and modify environmental and human contexts that contribute to climate-related risk, thus supporting and promoting sustainability in social and economic development (IPCC, 2012). An increase in disaster preparedness to manage risk also ensures climate change resilience. Both disaster risk reduction and climate change adaptation practices involve learning to deal with existing and projected future risk.

Several frameworks and strategies provide an integrated approach to disaster risk reduction and climate change adaptation. Natural disaster risk reduction and climate change overlap where there are common concerns such as drought, extreme heat events, floods, and storms (Figure 11.8). Adaptation strategies to implement disaster risk reduction should be established based on the evaluation and prioritisation of the risks that people face, as well as their ability to adapt to and resist the effects of those risks.

Below, we discuss different adaptation strategies and frameworks for climate change and disaster risk management for food and nutritional security.

Figure 11.8: Overlap between Climate Change Adaptation and Disaster Reduction Risk



Source: Birkmann and von Teichman (2010).

Monitoring, Evaluation, and Early Warning

In the developing world, the majority of the population depends on climate-sensitive sectors, such as agriculture and forestry, for their livelihoods and nutrition. The vulnerability of these countries is further increased by their limited capacity to assess climate risks and the lack of available weather information required to plan adaptive responses. Weak infrastructure, poor communication networks, intermittent electricity supply, low public awareness, and insufficient resources obstruct the provision of timely advice for early disaster warnings. Without such information, a proactive approach to risk management cannot be fully implemented. Understanding the multifaceted nature of both exposure and vulnerability is a prerequisite for determining how weather and climate events contribute to the occurrence of disasters, and for designing and implementing effective adaptation and disaster risk management strategies.

Disaster management usually depends on the source of information, monitoring, and early warning (Eiser et al., 2012). Improving the components of the monitoring helps to evaluate the situation and plan accordingly. Preparation based on monitoring, evaluation, and early warning will reduce possible effects of the extreme natural disaster events and save lives. Along with weather monitoring, it is essential to monitor food reserves in case of emergencies and be prepared for disasters. For better disaster risk reduction and climate risk management, evaluation of the possible impacts on crops, livestock, and fisheries is important. The measurements in food security management include livestock shelters, animal fodder reserves, bags for smallholder farmers to store seeds, improved seed storage facilities, raised seedbeds, and strategic animal fodder reserves.

Optimising Production

Natural disasters and climate change have a substantial effect on agricultural production – affecting food and nutritional security. Production gaps can be reduced through interventions such as better management of seeds, nutrients, and water. To optimise agricultural production, several knowledge-intensive forms of agriculture provide the technology and encouragement to make it feasible for farmers to accept and adapt them (Nelson, 2009). Preliminary study results by the FAO (2017) indicated that the combined application of several mutually reinforcing good practice technologies in the crop sector leads to economic benefits that are more than four times higher with respect to usual practices in disaster-prone areas. These include a combination of agronomic practices for soil and water management, infrastructure improvement, equipment for disaster risk management, and research and development for adapted crop seeds and technologies. The following are some of the strategies recommended to optimise agricultural production and secure food in case of disasters and climate change.

Communication and Technologies

Information and communication technology allows researchers to provide information and data to those who need it in a timely manner (Toya and Skidmore, 2015). As a result, decision makers and farmers are better equipped to make informed decisions about cropping schedules, water use, and disaster risk management. The use of satellites to measure the moisture level of the soil (especially after flooding) and monitor groundwater will improve the knowledge of water levels and give farmers choices regarding crop timing and varieties. This satellite information is usually available to the public via websites or apps. Some organisations are trying to provide hotline services for farmers in developing countries to reach, warn, and prepare farmers for extreme weather events (Kaur et al., 2015).

Adaptive Crop Varieties and Diversification

Drawing on indigenous knowledge and experience, smallholder farmers have responded to environmental changes in the past with gradual changes in their agricultural practices and the selection of adapted cultivars, and by mixing crops with trees and livestock to reduce the risk of crop failure (Ortiz, 2011; Sthapit, Padulosi, and Mal, 2010; Lasco et al., 2014). Nowadays, the adoption of agroforestry practices, crop diversification, early planting, increased use of early maturing varieties and stress-tolerant crop varieties, wild plant gathering, and mixed cropping production systems have been found to be some of the most common adaptation measures adopted by farmers in response to climate change (Altieri and Koohafkan, 2008; Verchot et al., 2007). Diversification is considered the best strategy for optimising crop production. In terms of agriculture, diversification is basically the addition of new crop varieties or livestock strains (Reddy and Anbumozhi, 2017). Several drought, salinity, and heat-tolerant varieties have been released by national and international agricultural research organisations. Choosing drought- and heat-tolerant varieties in drought and high temperature areas will increase production. The introduction of new varieties such as legumes through diversification improves soil fertility, assists in the consumption of proteins, and diversifies people's diets (Headey and Kennedy, 2012). In the case of livestock, trying new strains will be useful. Overall, diversification can offer resilience to agricultural systems.

Farm Practice Technologies

Farm practice technologies include soil and water management to optimise crop productivity. Alternative water resources, new irrigation techniques, and expanding irrigation help in handling drier climates. For example, watering and fertilisation through drip irrigation can reduce the environmental impact of irrigation and fertiliser application. Micro-irrigation or low-pressure irrigation systems – coupled with water filters, smart meters, and solar-based irrigation pumps – helped to deliver water and nutrients directly to the root zone of crops in sub-Saharan Africa. This has resulted in highly efficient use of resources to achieve high yields (Burney and Nolan, 2012). Farm practice methods involve crop varieties that use water efficiently (more yield/water used), drip or low-pressure irrigation systems to water crops, and lining waterways (canals/pipes) to decrease water losses in delivery systems and help target the water where it can be used most effectively (Pittman et al., 2011). The use of mulching and trenching, organic fertilisers, and organic pesticides will make the crops more resistant to climate constraints and improve productivity (FAO, 2017).

Farm Infrastructure

Participating in small-scale agricultural infrastructure is important for improving the resilience of smallholder farmers in risk-prone areas. In the livestock sector, building animal shelters to protect animals from extreme temperatures and disasters is one of the strategies. In the case of farming, rooftop water harvesting and water storage tanks are used to ensure the availability of necessary resources before or after a disaster (FAO, 2017).

Ecological Restoration

Integrating adaptation strategies and attributes could help improve ecosystem restoration and monitoring efforts under climate change. Ecosystem restoration can hasten adaptation to future climate change and disaster impacts by re-establishing the processes which promote natural variability and biodiversity within ecological systems (Hansen, Biringer, and Hoffman, 2003). Successful ecological restoration requires institutional frameworks to ensure that all stakeholders have fair access to benefits from the natural resources on which they depend for their livelihoods. Participating primarily in forest landscape restoration and ensuring proper management planning is vital. With the appropriate resources and policies, decentralising power and transferring resource management responsibilities to local communities can achieve sustainable success for restoration and sustainable agriculture (Kumar et al., 2015). Adaptation strategies for ecological restoration – including crop improvements, soil conservation, conservation agriculture, forest conservation (e.g. mangrove conservation), sustainable forest management, integrated pest management, livestock and fodder crops and fisheries management, and coral restoration – are based on ecosystems and minimise the scope for maladaptation in developed and developing countries (Keys and McConnell, 2005; Pretty, Toulmin, and Williams, 2011). Ecological restoration will have the potential to conserve the natural assets of agriculture through farmland improvement and ecosystem management (Reddy and Anbumozhi, 2017). Other ecological restoration practices include agroforestry activities such as planting trees, climate-smart landscapes, communal gardens, intercropping, and livelihood diversification in disaster-prone areas. Trees conserve soil and water; add nutrients to local diets; and provide materials for fodder, construction, and fuel. The restoration and development of ecosystems also minimise greenhouse gas emissions. Thus, the tree species chosen to restore communal areas must be able to meet a variety of environmental, social, and economic needs (Kumar et al., 2015). The strong relationship between soil health and food security calls for strategic and immediate action, especially at the local level, to reverse soil degradation in order to increase food production and alleviate food insecurity in the areas where it is most prevalent.

Food and Seed Reserves

The effects of climate shocks on national and regional food markets may also have consequences on humanitarian food assistance, government food reserves, and safety net programmes. Providing food is essential in times of need, especially in critical situations following storms, earthquakes, floods, drought, or other disaster emergencies. Investments are needed to establish and operate strategic food reserves as a means to balance food supply and demand, and ensure the availability of and access to food during a crisis. The purpose of food reserves is to provide emergency food assistance to transitory food-insecure households, support communities and farmers with storage facilities, assist producers in securing fair prices at harvest times, and contribute to domestic food price stabilisation (World Food Programme (WFP), 2015). Local food reserves specifically designed for emergency response are useful in situations of delayed assistance at the national and international level, and can be a temporary food support.

Another strategy is building a household seed storage facility or improving facilities to store seeds at home. Monsoon rains destroyed seeds after the earthquakes in Nepal (Dey, 2015) and Haiti (McGuire and Sperling, 2013) and following the floods in Pakistan (Doocy et al., 2013). Storage structures built in houses or mud granaries become wet during floods and spoil the stored seed, resulting in the loss of livelihoods (McGuire and Sperling, 2013). This damage destroys the local seed supply mechanism, making farmers vulnerable to seed crisis in the long term. Distributing inexpensive low-oxygen grain storage bags to the affected areas during emergencies could help farmers to store and save seed temporarily (Chapagain and Raizada, 2017). Developing community seed banks could provide repositories of local genetic diversity, which is often adapted to prevailing climate conditions, including biotic stresses.

Capacity Building

Capacity building is the process in which individuals, groups, organisations, institutions, and societies increase their competencies to perform core functions, solve problems, and define and achieve objectives. Capacity building is also useful to understand and cope with development needs in a broad context and a sustainable manner (Alcayna et al., 2016).

Experts are increasingly aware that building capacity efforts for food security involves enhancing the ability of individuals, groups, organisations, and communities to meet their food and nutritional security challenges sustainably. This cannot be successful in the long run without well-qualified local individuals and institutions to provide appropriate incentives for, motivate, and manage these efforts. It requires developing skilled, creative, and motivated individuals – and establishing effective institutions, both governmental and non-governmental – to engage people in problem solving. It entails fostering teamwork amongst farmers, extension agents, and scientists; and often amongst different government ministries and nations (Alcayna et al., 2016).

Local capacity building is also an essential and effective task, and there is a strong need to evolve proactive and reactive strategies (Table 4) and bring together diverse groups of people in relevant efforts to support adaptation capacities to mitigate the effects of natural disasters and climate change. Differences in community resources, livelihoods options, and assets affect local capacity and the extent to which capacity can be strengthened (Uy, Takeuchi, and Shaw, 2011). A case study in Iloilo City showed that community-driven disaster risk management required strong social networks, alternative finance facilities, technical professional networks that support community processes, and community-managed information systems (Carcellar, Co, and Hipolito, 2011). It has also been emphasised that schools and student groups could play an important role in capacity building for disaster and climate risk management (Fernandez and Shaw, 2015). Local communities are the first to respond when a disaster happens. Therefore, enhancing the disaster management capacity of the communities and local governments is the most effective way to improve disaster management and cope with disasters and the changing climate.

Financial Instruments

Managing the risk of extreme weather events and natural disasters to advance climate change adaptation through risk transfer is one of the adaptation strategies (IPCC, 2012). Financial instruments usually include insurance, government-managed contingency finance devices, and subsidies. Many policymakers and researchers agree that insurance, along with other financial instruments, plays a vital role in lessening exposure and vulnerability and enhancing resilience to the potential adverse impacts of climate extremes (IPCC, 2012). The United

Nations Framework Convention on Climate Change states that sharing and transferring risk through financial instruments will help people in developing and vulnerable countries to address climate change impacts (United Nations Framework Convention on Climate Change, 2013). Another study suggests that financial instruments such as risk sharing and transfer help to distribute the damage and loss caused by extreme weather events and disasters but do not play a role in reducing them (Linnerooth-Bayer and Hochrainer-Stigler, 2015). Basically, financial instruments support lessening the burden on the affected people where the reduction of losses by natural disasters and climate change can be expensive or impossible (Linnerooth-Bayer and Hochrainer-Stigler, 2015).

In the case of high-risk disaster events, people mostly depend on financial instruments such as government managed contingency and donor assistance offer relief. Austria has premium support (paid by income and corporate taxes) from a government relief programme to insure against natural disasters (Raschky and Weck-Hannemann, 2007). Other financial instruments for farmers are pre-disaster savings and post-disaster credit, which for the poor can take the form of stockpiles of food, grains, seeds, and exchangeable assets. This type of financing can be used only where the risk is medium. In the Philippines, a study indicated that pre-disaster savings or micro-savings supported women's economic empowerment, including decision-making power over purchases, family planning, and children's education (Ashraf et al., 2006). This enables the poor, smallholders, and most vulnerable farmers to make investments that increase their profitability.

Microfinance is another financial resource to encourage investments to farmers. It permits farmers to help themselves from potential disaster shocks to the production of crops, livestock, and fisheries (Morduch and Johnston, 2007). In adverse conditions caused by disasters and climate change, microfinance supports farmers through automated insurance payouts which encourage them not to sell their assets and livestock (Reddy and Anbumozhi, 2017). Public policymakers are encouraged to focus on government assistance regimes.

Food Security Governance

One of the adaptation strategies for natural disasters and climate change is adjusting institutional structures and arrangements that facilitate national and local strategies, plans, and financial investments in favour of food security to disaster and climate change. Achieving adaptation at the global, national, and regional levels requires strengthening of the governance system to coordinate adaptation issues. This includes suitable national food security policies and legislative frameworks which involve cooperation between the public and private sectors in creating incentives, supporting activities, and policies that encourage risk reduction and climate change adaptation. Prioritising initiatives at the regional level, such as technologies that strengthen the resilience of farming systems to disasters, could help achieve sustainable agriculture through policy support.

Strengthening the relationship between policymakers, the scientific community, and professionals from all food-related sectors help in developing new decision support systems which can shape the capacity of farmers, fishers, and forest-dependent people to adapt their livelihoods to climate change and disasters (FAO, 2012). The migration of large groups of refugees, who have to leave their habitats because of changes in their natural environment as a result of sea level rise, extreme weather events, and drought and water scarcity, is expected by several researchers. In light of the climate migration crisis, preparing for the protection and resettlement of refugees is recommended through global governance (Biermann and Boas, 2010).

11.4 Adaptive Strategies to Nutritional Security

Natural disasters and climate change not only influence the crop yield but also the nutritional quality of food (Figure 11.3). High rates of malnutrition are considered the outcome of food insecurity in extreme weather events. Plants grown at elevated CO_2 conditions showed a reduction in their protein and mineral concentration (Myers et al., 2014; Loladze, 2014). The altered nutritional composition of plants also modifies the nutritional composition of livestock. Disasters and climate change not only influence the nutritional content of crops but also the nutritional composition of phytoplankton and the fatty acid composition of fish (Bermúdez et al., 2015; Chavez, Messié, and Pennington, 2011). Even though the overall effect of natural disasters and climate change on nutritional security varies according to the location and relevant policies, an adequate supply of nutritious food needs to be maintained to ensure human health, especially that of children. A number of strategies can be undertaken within households, communities, and countries to avoid nutritional insecurity. These include monitoring climate-related extreme weather events through early warning systems and preparing for food and nutritional security. Analysis of the dangers of extreme weather events is required for mitigation measures to achieve food and nutritional security. For example, long-term droughts cause aflatoxin contamination in the seeds of several crop species. Aflatoxin is toxic and causes neurological diseases, cancer, and stunted growth in children. Post-harvest handling and seed safety measures avoid aflatoxin contamination in stored seeds (Tirado et al., 2010). Other strategies include focusing on crop nutrient quantity, dietary diversity, maternal and child feeding practices, and children's health (Tirado et al., 2015). A model is required to predict the effects of climate change and extreme weather events on nutritional quality. This would help to breed the optimal crop varieties and livestock strains for adaptation and achieve better nutritional quality.

It is critical to identify promising climate change mitigation strategies that bring benefits in terms of nutritional security. Regional, national, and international educational institutions and researchers should create awareness about the importance of nutrition in vulnerable communities. It is essential to implement current agendas, policy frameworks, and initiatives to align with disaster and climate change adaptation to reduce hunger and undernutrition (Tirado et al., 2015).

11.5 Summary

Natural disasters and climate change affect all four pillars of food security: availability, access, utilisation, and stability. Extreme weather events intensify existing threats to food and nutritional security by decreasing agricultural production. Altered food production, combined with other factors, influences food prices. This affects the ability of poor households to access food markets and could reduce dietary diversity, affecting nutritional quality. Food and nutritional security to natural disasters and climate change requires the design of adaptation strategies which can reduce vulnerability and increase resilience. Adaptation approaches must incorporate actions targeted at climate change resilience and disaster risk reduction, as well as addressing the underlying causes of vulnerability. An integrated approach to adaptation involves disaster preparedness and relief, resilient infrastructure, and new agricultural technologies and farm practices to face disaster and climate change risks.

This chapter discussed various integrated adaptive strategies to natural disaster risk reduction and climate change adaptation to secure food and nutrition in vulnerable countries. These strategies include implementing early warning systems to monitor and evaluate the effect of disasters and climate change on agriculture, related production, and nutrition. It is also essential to optimise production through the diversification of livelihood and agriculture systems. Managing adaptation to achieve food security requires the research and development of new crop varieties and improving agricultural practices. Recommended agricultural practices include adopting tolerant and early maturity crop varieties, improving irrigation for efficient water utilisation, planting communal gardens, improving ecosystems, and using organic fertilisers. The efficient use of resources such as water and nutrients is beneficial, as it reduces input costs and provides some stability in resource supplies. Innovative technologies such as cellular (apps or texts) and satellite technology to monitor soil moisture and provide up-to-date information, as supported by researchers at the regional, national, and international levels, should be used. These technologies could contain a broad range of developments and play key roles in improving adaptation efficiencies. Financial instruments also play important roles in adaptation to natural disasters and climate change for effective risk sharing and transfer. Implementing food security policies to advance adaptive strategies addresses and minimises the adverse impacts of natural disasters and climate change on food and nutritional security.

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PART

IV

Policy Adoption

CHAPTER 12

Disasters, Health, and Food Security: Adaptation Options for ASEAN

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12.1 Disasters

Each year, millions of people are affected by natural and man-made disasters around the world. Natural disasters are of two kinds: (i) rapid-onset phenomena such as typhoons, tsunamis, floods, and volcanic eruptions; and (ii) slow-onset disasters such as droughts (Association of Southeast Asian Nations (ASEAN), United Nations Children's Fund (UNICEF), and World Health Organization (WHO), 2016). People's livelihoods are impacted by the various types of disasters, which can lead to the damage or destruction of human lives, crops, animals, fishing boats and gear, infrastructure, etc. The extent of the impact depends on the intensity of the hazard, the level of people's vulnerability, and their capacity to cope with these shocks and stresses.

The exact health effects of a disaster depend on the type of disaster, e.g. earthquakes can lead to critical multiple injuries, flooding can lead to outbreaks of diarrhoea, and droughts can lead to malnutrition. In general, children and the elderly are the most vulnerable, and disasters often exacerbate the most common causes of childhood mortality worldwide. These include acute respiratory illness, diarrhoea, malaria, measles, malnutrition, and neonatal causes. It is estimated that around 250 million people are affected each year by disasters, and this number is likely to increase to 350 million over the next decade (WHO, 2011a). Half of this number is thought to be children. Therefore, health and food security during disasters play a crucial role in building resilient communities.

12.1.1 Communicable Diseases

Communicable diseases and vector-borne illnesses are the most common causes of child mortality globally, including acute respiratory illness, diarrhoea, malaria, and measles (WHO, 2011a). These have been shown to increase when crises occur. Disasters can increase the risk of outbreaks such as cholera because of flooding and measles as a result of overcrowding following population displacement. Communicable diseases can cause epidemics and pandemics, which have the potential to overwhelm the capacity of communities; hence, they are also considered disasters (WHO, 2011b). Morbidity and mortality from communicable diseases are exacerbated when there is:

- Population displacement
- Collapsing health services
- Lack of disease control programmes
- Poor access to healthcare in urban and/or rural areas
- Malnutrition
- Interrupted supplies and logistics
- Poor coordination amongst agencies

The last 2 decades have seen at least 1 billion people affected by natural disasters, with millions suffering infection from communicable diseases. During the last century, four influenza pandemics have occurred, resulting in excess of 50 million deaths (WHO, 2011b). The risk of communicable diseases is associated primarily with the size and characteristics of the affected population, specifically:

- Amount and availability of safe water
- Functioning latrines
- Nutritional status of the displaced population
- Level of immunity to vaccine-preventable diseases such as measles
- Level of access to healthcare services

12.1.2 Non-communicable Diseases

Some 60% of all global deaths are as a result of non-communicable diseases (NCDs), 80% of which occur in low- to middle-income countries. During disasters, essential medications may be destroyed or lost, and evacuees may forget to take them (WHO, 2011d). When critical healthcare infrastructure is destroyed, or rendered inaccessible, access to chronic care treatment and medication is jeopardised. Acute care can be compromised by inadequately controlled NCDs (e.g. orthopaedic surgery carries a much higher risk if a patient has poorly controlled cardiovascular disease) (WHO, 2011d). Disasters can exacerbate existing NCDs including cardiovascular disease, diabetes, cancer, chronic respiratory disease, blood disorders (including sickle cell), renal disease, arthritis, and epilepsy (WHO, 2011d). Many NCDs can result from behavioural risk factors such as smoking, alcohol, lack of exercise, and poor diet; and are, therefore, preventable (WHO 2011d). People with NCDs often depend on a continuous supply of medication and/or treatments, which may be interrupted or stopped as a result of disasters. Interruption of power or safe water in an emergency can have life-threatening consequences for people who need to refrigerate medicines (insulin for diabetes) or attend dialysis (renal failure) (WHO 2011d).

12.1.3 Psychosocial Services

There is broad agreement that exposure to extreme stressors such as disasters is a risk factor for social and mental health, including common mental disorders (Inter-Agency Standing Committee (IASC), 2010). Mental health and psychosocial problems in disasters are highly interconnected. Psychological well-being is influenced by a variety of social factors such as dignified and safe provision of overall aid. Mental disorders are prevalent in all regions of the world and make major contributions to global morbidity and mortality. More than 10% of the global burden of disease, measured in disability-adjusted life years, is attributable to mental disorders. Generally, disasters result in large numbers of individuals suffering from minor emotional distress that tends to be self-limiting in nature (Bravo et al., 1990). However, some portion of the population may suffer from more severe forms of distress, especially anxiety and depression, and occasionally post-traumatic stress disorder, depending on their prior psychological state and the impact on them and their families (Siegel et al., 2000). A common error when working in this area is to focus exclusively on deficits and forget that people have resources and assets that protect against mental health and psychosocial issues (WHO, 2011c). Psychological first aid and psychosocial services to people affected by a disaster help them to recover holistically from the devastation (Box 12.1). Therefore, it is recommended to provide psychological first aid, which is a humane, supportive response for people who may need support (WHO, War Trauma Foundation, and World Vision International, 2011) (Figure 12.1).

Figure 12.1: **Working with Children During Disasters**

Children draw maps of their village in the Irrawaddy Delta, Myanmar. Two thirds of the children in the village were killed when Cyclone Nargis swept across the delta in May 2008.

Photo: Tina Salsbury, Save the Children.

Source: WHO (2011a).

Box 12.1: **Floods in Sri Lanka, 2016**

On 15 May 2016, Sri Lanka was hit by a cyclonic storm, causing extensive flooding and landslides across 22 districts. More than 400,000 people were affected by the floods, which destroyed homes and entire villages. More than 200 people lost their lives or remain missing. The floods had a considerable impact on the health sector – 90 healthcare institutions were either directly or indirectly affected. The World Health Organization, with the Ministry of Health, coordinated the public health response, maintaining critical services and surge capacity and providing urgent assistance and relief to those affected. Delivering mental health and psychosocial services to the people affected by the floods was a key priority. Mental health workers were trained and deployed as part of the mobile teams to provide psychological first aid and strengthen support services for the affected people.

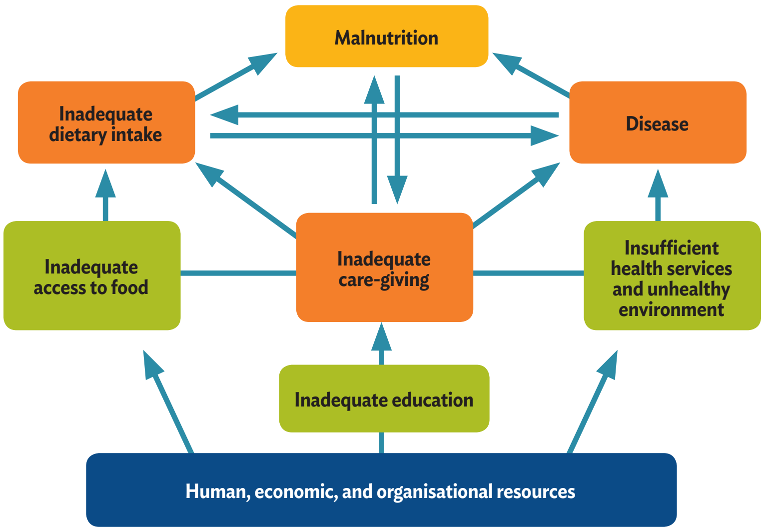
Source: WHO (2017).

12.1.4 Health Risks for Children

Children, especially those under the age of five, are particularly vulnerable to disasters as they depend on others to escape a hazard. They are more likely to be injured, lost, unable to access help or healthcare, or exposed to greater danger through separation from their families or caregivers. Globally, more than 86% of neonatal deaths are due to three causes: infections, prematurity, and birth complications. Many of these deaths could be prevented with healthcare before, during, and after delivery (WHO, 2011a). In a disaster, however, between a third and a half of the dead are children. Furthermore, disrupted access to healthcare increases the chance of complications for both mothers and newborn children (WHO, 2011a).

Malnutrition and micronutrient deficiencies have a significant impact on child mortality. This is not only because of the direct effects of the deficiency but also the reduced resilience caused by nutritional deficiencies, which makes children more susceptible to infections (ASEAN, UNICEF, and WHO, 2016). Babies separated from their mothers are of particular concern during disasters, as they are often unable to access breast milk, which leaves them at risk of diarrhoeal illness and infection (WHO, 2011e) (Box 12.2). The UNICEF conceptual framework of the causes and determinants of malnutrition mapped these risk factors to demonstrate how one vulnerability would exacerbate others (Figure 12.2).

Figure 12.2: UNICEF Conceptual Framework of the Causes and Determinants of Malnutrition (1998)



Source: United Nations System Standing Committee on Nutrition (2004).

Box 12.2: Indonesian Earthquake, 2006

Initial responses to the 2006 earthquake in Indonesia included large quantities of poorly regulated breast milk substitutes (BMS). Some 32% of infants aged less than 6 months had never consumed BMS before the earthquake compared with 43% afterwards. Diarrhoea prevalence was 25% amongst those who received BMS donations against 12% amongst those who did not. Responding to these problems, the Ministry of Health, with the support of the international community, devised a 'cascade' system of support for young mothers: front-line counsellors each supported six local lactation counsellors, who in turn supported five mothers. This led to improvements in breastfeeding practices.

Source: Assefaya et al., 2008.

12.1.5 Persons with Disabilities

People with disabilities make up at least 10% of the population (WHO, 2011f). The prevalence is increasing because of population ageing, e.g. more than 40% of people 65 years and older experience chronic illness or disability which limits their daily activities (WHO, 2011f). Disasters can also be a cause of disability, e.g. if injuries are not effectively managed. Disasters can make older people and people with existing disabilities more vulnerable (Box 12.3). Emergencies can severely disrupt social structures and ongoing formal and informal care of persons with pre-existing disorders. Therefore, the Convention on the Rights of Persons with Disabilities (Articles 11 and 32) mandates that all necessary measures, including those taken through international cooperation, ensure the protection and safety of persons with disabilities in situations of risk and humanitarian emergencies.

Box 12.3: **Vulnerable Populations**

In a disaster, everybody can be at risk but some groups are particularly vulnerable:

Infants: malnutrition amongst infants is a huge issue in disaster situations. Suboptimal breastfeeding is estimated to be responsible for 1.4 million child deaths and 44 million disability-adjusted life years.

Young children are highly dependent on others to escape and survive in disaster situations, and rapid growth and development requires an adequate diet to achieve full physical and mental potential. Severe acute malnutrition causes 1 million to 2 million deaths per year.

Pregnant and lactating women: nutrition impacts both maternal and child health, e.g. maternal folate supplements decrease the risk of infant neural tube defects.

Older people or those with **HIV, tuberculosis**, or other underlying chronic conditions. A major issue is the lack of medication during disasters. However, even small changes in hydration or nutrition can have major impacts on pushing them beyond their limits into a significant health risk.

Persons with disabilities have limitations on mobility during disasters, making them more vulnerable.

Source: WHO (2011f).

12.2 Role of Food Security

Every man, woman and child has the inalienable right to be free from hunger

The Universal Declaration on the Eradication of Hunger and Malnutrition, Rome, 1974

Eradicate extreme poverty and hunger

First Millennium Development Goal, United Nations, 2000

Food is different from other commodities in that there is no substitute. All humans require adequate food for survival. Security over the next meal is essential. The 1996 World Food Summit defined food security as existing 'when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life' (Asian Development Bank (ADB), 2013: 8). Food security, according to the WHO, rests on three pillars (ADB, 2013):

1. Food **availability** covers the supply side. Is there enough to feed people? Food availability is determined by food production and technology, inventory, efficiency of supply chains, and local and international trade.
2. Food **access** is the ability to obtain adequate quantities of food, the purchasing power needed, and adequate delivery mechanisms, including social safety nets.
3. Food **utilisation** refers to the need to meet dietary needs and cultural preferences.

Food security also means certainty about future meals. Not knowing where the next meal will come from alters economic behaviour. Providing for future meals takes precedence over other expenditures, such as education, health, and shelter (ADB, 2013). Beyond household concerns, food price inflation can trigger demand for wage increases, igniting a vicious inflationary cycle that could discourage private investment and slow economic activity in general. This reduces investment in human and physical capital, and can damage a country's long-run growth prospects.

Therefore, food security is a multidimensional issue. It has become increasingly complex and challenging with the impact of economic growth, changing demographics, consumption patterns, international trade, and environmental change all interconnected globally. In addition, public policy responses to these challenges can sometimes exacerbate problems (ADB, 2013).

A confluence of factors has contributed to the drastic rise in global food prices. Rapid income growth, along with growing populations in developing countries, has been a key driver behind increasing global demand (ASEAN, UNICEF, and WHO, 2016). In addition, the rising middle class is varying its diet with higher protein intake from a wider array of sources, increasing pressure on the livestock and feed industries (ADB, 2013). This growing demand highlights the reshuffled use of agricultural resources – such as land, water, and feedstock – not to mention the potential for increased damage to the environment.

On the supply side, the world must meet escalating demand for food on less land with limited access to water. Increased costs of fertiliser and fuel for storage and transport add further pressure. The only sensible solution is to enhance agricultural productivity through higher yields, using scarce natural resources better, and increasing the efficiency of product use – e.g. improving the efficiency of product delivery and minimising waste (ADB, 2013).

12.2.1 Impacts of Food Security

Climate Change

Climate change and its impact on agriculture is a challenge that cannot be ignored. Increasingly integrated global food supply chains imply that any regional shock could easily ignite ripple effects globally (World Food Programme, 2012). With more than 60% of the population relying on agriculture and food production as a source of income, the Asia and Pacific region is particularly sensitive to the potential damage caused by climate change (ADB, 2013). Agriculture, fisheries, and livestock will all suffer direct impacts, which could lower productivity and food output. Climate change threatens to exacerbate existing threats to food security and livelihoods because of a combination of factors that includes the increasing frequency and intensity of climate hazards, diminishing agricultural yields and reduced production in vulnerable regions, rising health and sanitation risks, increasing water scarcity, and intensifying conflicts over scarce resources, which would lead to new humanitarian crises as well as increasing displacement (Intergovernmental Panel on Climate Change, 2007). This is illustrated by the case study of crop yields, calorie consumption, and numbers of malnourished children in Pacific Island countries (Box 12.4). Thus, the need to address the effects of climate change on food security is urgent – requiring an immediate and appropriate response.

Box 12.4: Food Security and Climate Change – The Special Case of the Pacific

According to ADB (2013), the projected yield reductions in major staple crops resulting from climate change in the Pacific are substantial (Table 12.1). The very large effects on cassava yields are particularly serious, considering that cassava is a staple of the poor.

Table 12.1: Projected Impact of Climate Change on Crop Yields (% reduction by 2050)

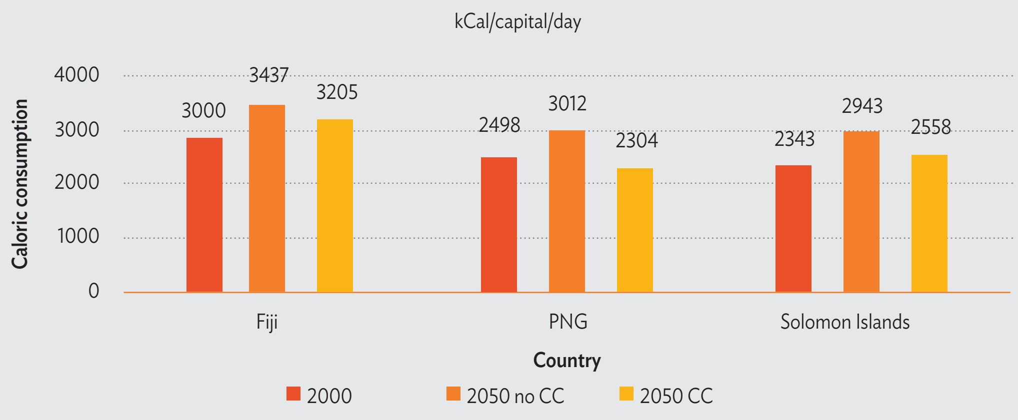
Crop	Fiji	PNG	Solomon Islands
Sugarcane	8	n.a.	n.a.
Rice	4	8	15
Taro	15	13	16
Cassava	37	30	28
Sweet potato	n.a.	11	15

n.a. = not applicable, PNG = Papua New Guinea.

Source: Rosegrant (2013).

These yield effects will, in turn, reduce caloric consumption in the Pacific island countries (Table 12.1 and Figure 12.2). The impact on Papua New Guinea and the Solomon Islands is especially large. In addition, reductions in caloric intake increase the number of people at risk of hunger (Table 12.2) and the number of children at risk of malnutrition (Table 12.3).

Figure 12.3: Projected Levels of Caloric Consumption in Pacific Island Countries



CC = climate change, kCal = kilocalorie, PNG = Papua New Guinea.

Source: Rosegrant (2013).

Table 12.2: Population at Risk of Hunger
('000)

Country	Fiji	PNG	Solomon Islands
PNG	2000	2050 no CC	2050 CC
Solomon Islands	45	114	165

CC = climate change, PNG = Papua New Guinea.
Note: Data on Fiji are not available.
Source: Rosegrant (2013).

Table 12.3: Population of Malnourished Children Under Age 5
('000)

Country	Fiji	PNG	Solomon Islands
PNG	172	138	217
Solomon Islands	9	6	10

CC = climate change, PNG = Papua New Guinea.
Note: Data on Fiji are not available.
Source: Rosegrant (2013).

If nothing is done to reduce the impact of climate change, agricultural productivity in Asia and the Pacific will drop, heightening the problem of food security. However, given the geographical heterogeneity of the expected effect – and the scientific uncertainty surrounding them – policy flexibility in adapting to climate change will be extremely important (ADB, 2013). Proactive adaptation policies and investments may include developing more drought- and heat-resistant crop varieties, using moisture-conserving tillage methods, and improving irrigation efficiency. Several adaptations could help cope with these daunting challenges (Aggarwal et al., 2012):

(i) better land and water resource management;
(ii) improved risk assessment and management, reflecting the increased risk from both floods and periodic drought;
(iii) adaptations that provide benefits from reduced greenhouse gas emissions; and
(iv) improved governance, including regional cooperation.

These will require new technologies, reclamation of degraded agricultural land, and community management of soil and water resources. What is clear is that doing nothing is not an option. Countries such as the Philippines may require untenably large shifts in seasonal agricultural activity. Investment in the knowledge base required for these location-specific adaptations must start now.

Disaster Risk Reduction

The concept of disaster risk reduction (DRR) was promoted by the United Nations Office for Disaster Risk Reduction (UNISDR) to address natural hazards (van 't Wout et al., 2014). According to the UNISDR (2009: 10), DRR is 'the concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events'. DRR interventions aim to avoid (prevention) or limit (mitigation and preparedness) the adverse impacts of hazards, thereby minimising vulnerabilities and disaster risks as well as facilitating early recovery after the shock (van 't Wout et al., 2014). In addition to being effective in terms of saving lives and livelihoods, DRR is also efficient and cost-effective: it is calculated that for every dollar spent on DRR, $2–$4 are saved which would otherwise be spent on disaster relief and rehabilitation (Department for International Development of the United Kingdom, 2006). DRR is a key concept for agriculture since the majority of the people vulnerable to natural hazards and disasters are the food-insecure and the poor, who derive their livelihoods from agriculture and its subsectors.

In this regard, the FAO (2014) has developed a DRR for Food and Nutrition Security (FNS) Framework Programme to strengthen capacities to absorb the impact of and recover from disasters. The programme aims to guide the implementation, scaling up, and acceleration of the FAO's DRR work at the local, national, regional, and global levels; and consolidate its technical cross-sectoral expertise on DRR in the wider context of resilience building. 'The goal of the FAO's DRR for Food and Nutrition Security Framework Programme is to enhance the resilience of livelihoods against threats and emergencies to ensure the FNS of vulnerable farmers, fishers, herders, foresters and other at risk groups' (FAO, 2013: viii) (Box 2 2, Figure 12.2.2). Modules such as these provide a supportive structure which can assist countries in becoming better equipped to be disaster-resilient.

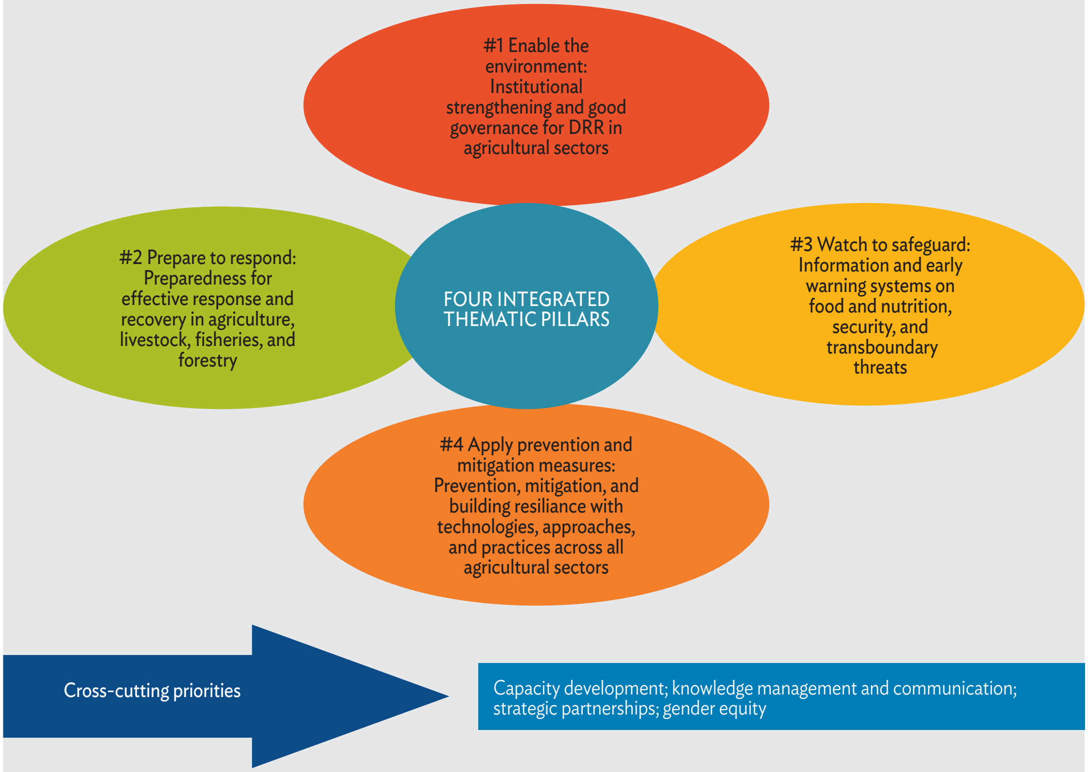
Indigenous Knowledge

Box 12.5: Food and Nutrition Security Framework Programme

The FAO (2013) FNS Framework Programme consists of four pillars, which integrate all agricultural sectors and promote cross-sectoral collaboration.

- Pillar 1 – 'Enable the environment': good governance and institutional strengthening
  The objective of pillar 1 is 'to support the enabling environment of FAO's member states, with appropriate legislation, policies and institutional frameworks for DRR for FNS in agriculture, livestock, fisheries/aquaculture, forestry and natural resource management and to strengthen the institutional capacities to implement these initiatives'.
- Pillar 2 – 'Watch to safeguard': information and early warning systems
  The objective of pillar 2 is to 'strengthen and harmonise food and nutrition security information and early warning systems to better monitor the multiple threats and inform decision-making in preparedness, response, policy, advocacy and programming'.
- Pillar 3 – 'Apply prevention and mitigation': agricultural practices and technologies that prevent and reduce the adverse impact of hazards
  The objective of pillar 3 is 'to reduce the underlying risks to food and nutrition security through the application of technologies, good practices and approaches in farming, fisheries/aquaculture, forestry and natural resource management for prevention, mitigation and livelihood diversification'.
- Pillar 4 – 'Prepare to respond': improve preparedness for disaster response and recovery
  The objective of pillar 4 is to 'strengthen capacities at all levels – in preparedness – to improve response to, and recovery from, future threats to food and nutrition security, and to reduce their potential negative impacts on livelihoods'.

Figure 12.4: Disaster Risk Reduction for Food and Nutrition Security Framework Programme



DRR = Disaster Risk Reduction, FAO = Food and Agriculture Organization of the United Nations, FNS = Food and Nutrition Security.

Source: FAO (2013).

For generations, communities have relied heavily on their own indigenous knowledge systems in observing the environment and dealing with natural disasters (Iloka, 2016). These communities, particularly those in hazard-prone areas, have collectively generated a vast body of knowledge on disaster prevention and mitigation, early warning, preparedness and response, and post-disaster recovery (Briggs, 2005). This knowledge is acquired through observation and study, often based on cumulative experience handed down from generation to generation, and has helped to reduce disasters in local communities (Briggs, 2005). Indigenous knowledge plays a role in empowering local community members to take front-line roles in activities aimed at DRR (Mwaura, 2008). Community-led DRR policy frameworks comprising both scientific and indigenous knowledge, which facilitate effective participation from members of the community, have been shown to yield the best long-term results (Briggs, 2005).

In flood- and drought-prone areas in Dumangas, Philippines, indigenous knowledge is combined with scientific methods to help local communities to strengthen their food security and livelihoods. Farmers are taught to read the weather forecast, interpret satellite photos, set up their own weather stations – and decide what and when to plant based on timely information. The overall goal is to reduce disaster risks and enhance the capacities of local communities, especially rural women (Dubbeling, 2013).

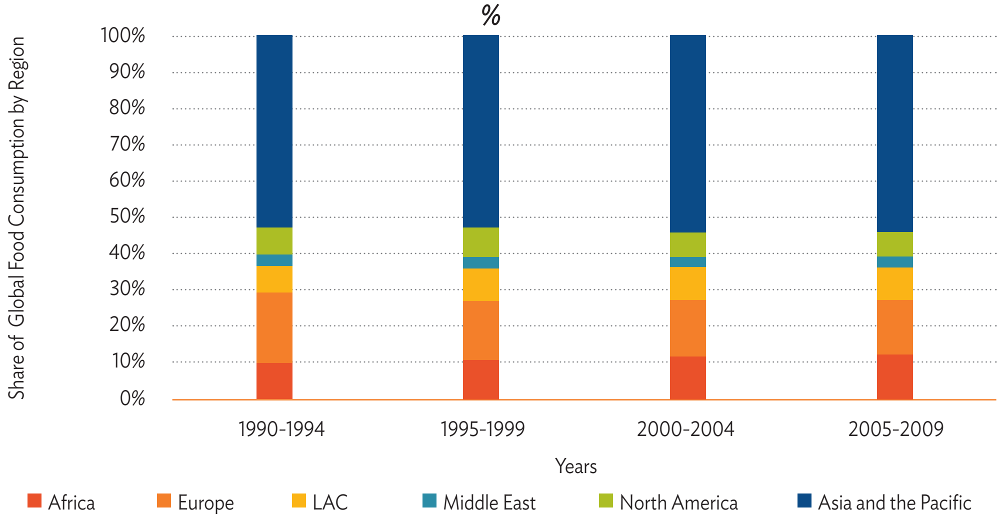
In many parts of the world, indigenous knowledge has been used in traditional medicine, agriculture and food production, engineering, and ecological management for natural resources (Domfeh, 2007). The safe and effective use of traditional medicinal practices and products to maximise the potential contribution to primary healthcare in disaster situations is increasingly being recognised as a vital resource for adaptation (Nurse, Sem, and Hay, 2001). Traditional medicine is defined as 'the health practices, approaches, knowledge and beliefs incorporating plant, animal and mineral-based medicines, spiritual therapies, manual techniques and exercises, applied singularly or in combination to treat, diagnose and prevent illnesses or maintain well-being' (WHO, 2002: 7). The WHO recognises this immense contribution of indigenous knowledge towards world health (WHO, 2012).

12.2.2 The Asia and Pacific Region

The Asia and Pacific region has been the epicentre of these global changes. Asia is continuing to experience a massive structural economic and social transformation, inevitably leaving a deeper footprint on global agricultural and ecological systems. Behind this curtain of prosperity and progress, however, remain more than 60% of the world's poor, facing widening inequality (Briones, 2011). While economic advancement and structural transformation create increasingly complex constraints on the agricultural resources needed for food security, huge areas continue to struggle against poverty and food insecurity (ADB, 2013). These 'two faces of Asia' make achieving food security far more complex and challenging for both Asia and the world at large.

According to ADB (2013), Asia's share in global food consumption, measured in calories consumed, is increasing – from a 52.9% average during 1990–1994 to a 54.3% average during 2005–2009 (Figure 12.5). Consumption per capita in Asia and the Pacific went up from 2,379 kilocalories per capita per day (kCal/capita/day) in 1990 to 2,665 kCal/capita/day in 2009 – an average annual increase of 0.6% compared with a 0.4% growth in global per capita consumption over the same period (ADB, 2013). The region's share in global food production (crops and livestock) also increased, from an average share of 40.9% in 1990–1995 to 46.3% in 2005–2009 (Figure 12.6). Food production in Asia and the Pacific increased from 0.8 tons per capita (t/capita) in 1990 to 1.1 t/capita in 2009. This annual 1.7% growth was the fastest amongst the world's various regions.

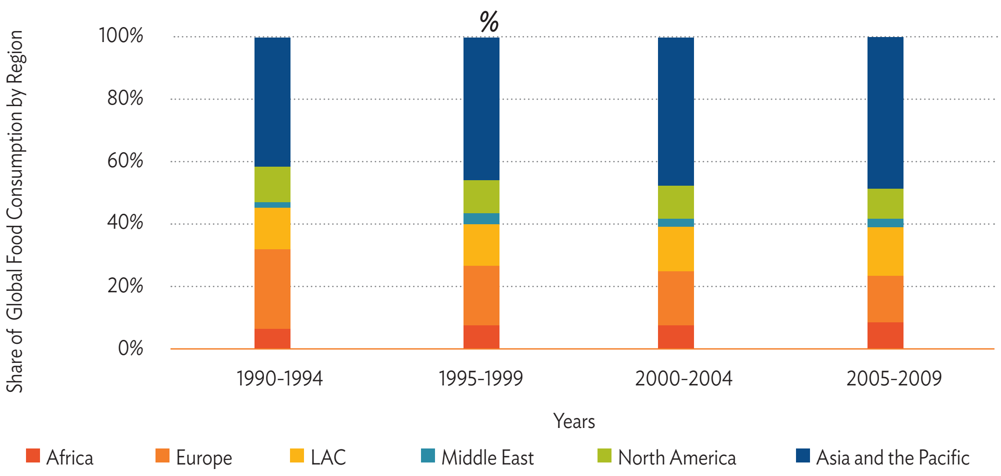
Figure 12.5: Share of Global Food Consumption by Region1990–2009



LAC = Latin American and the Caribbean.

Source: ADB (2013).

Figure 12.6: Share of Global Food Production by Region, 1990–2009



LAC = Latin American and the Caribbean.

Source: ADB (2013).

In Asia and the Pacific, food security is being fundamentally altered as patterns of food consumption and production change with the drive for global food sustainability. These forces stem from the region's huge population, changing demographics, and spectacular economic rise (ADB, 2013). The dramatic structural transformation economically, socially, and culturally holds important consequences for the global food system. Economic growth and food security have been mutually reinforcing throughout the history of development. However, experience illustrates that vulnerability to food insecurity cannot be fully addressed by economic success alone (ADB, 2013). Strong growth has been key to the sharp decline in poverty and undernourishment, but hunger remains stubbornly high in many countries and regions (ASEAN, UNICEF, and WHO, 2016). One in eight people goes to bed hungry at night, yet there is sufficient food to feed the world (ADB, 2013). Asia is home to more than 60% of the world's poor and hungry (ADB, 2013). Tackling undernourishment remains a challenge throughout the region. More than half a billion – or about 14% – of Asia's population are undernourished, more than all the undernourished in Africa (Briones, 2011). The severity of the food deficit for those undernourished is also above the global average – exceeded only by Africa (Briones, 2011). More than 40% of children in several Asian and Pacific countries are stunted (ADB, 2013). Focusing on nutrition – rather than simple caloric intake – is essential if food security in the region is to be achieved. This underscores the fact that food security is much more than raising food production. It is also about reducing distortions in global food markets and ensuring equitable distribution, particularly to food-deficit countries and people (ADB, 2013).

12.2.3 ASEAN

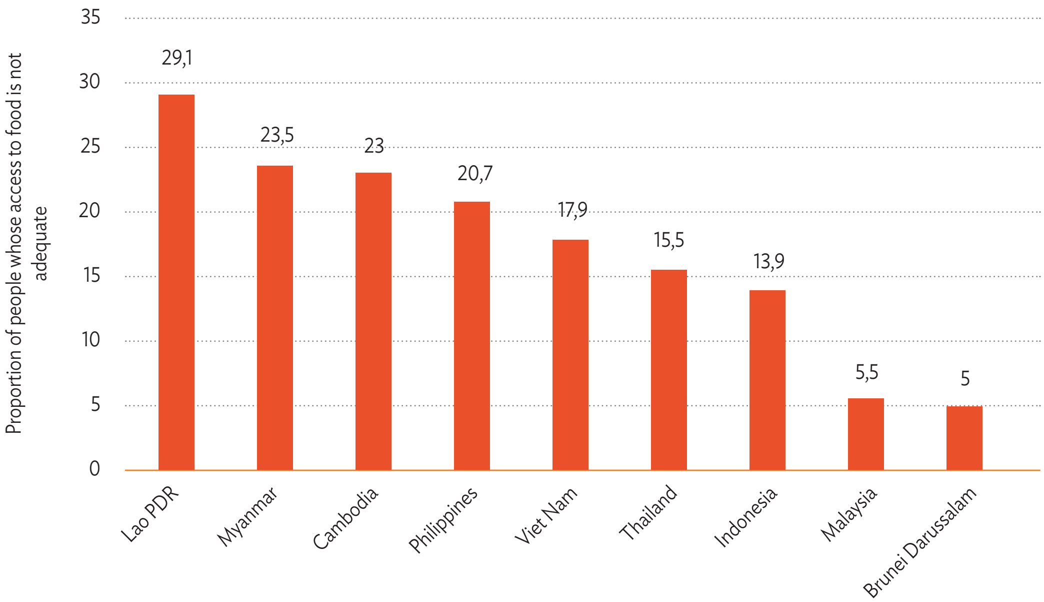
According to ADB (2013), the population in Southeast Asia will grow by 18% to more than 700 million from 2010 to 2030. The increasing population will have a long-term impact on the increasing demand for food (Figure 12.7). Thus, feeding the entire population will be a challenging task for ASEAN leaders. Nevertheless, the issue of food security is not merely giving food to people but also about reducing malnutrition amongst the population (ASEAN, UNICEF, and WHO, 2016).

As Southeast Asian economies grow, ASEAN Member States (AMS) tend to develop large amounts of infrastructure such as roads and buildings, which require land clearing. This leads to deforestation and land degradation, thus reducing the land available for agricultural purposes (The Habibie Center, 2015).

As one of the most vulnerable regions to climate change, ASEAN is no stranger to its negative impacts, such as droughts, floods, typhoons, rising sea levels, and long periods of heatwaves. These natural disasters undoubtedly create disruptions to food production in the region (The Habibie Center, 2015).

Therefore, food security is one of the most pressing issues in the region. In the aftermath of the 2007/2008 food price crisis, the 2009 ASEAN Summit put food security as a permanent and high policy priority. On the same occasion, ASEAN formalised the ASEAN Integrated Food Security (AIFS) Framework, 2009–2013 to provide a systematic guideline for cooperation in food security amongst the AMS (ASEAN, 2009). The AIFS covers a set of measures to ensure long-term food security in ASEAN and improve the livelihoods of ASEAN farmers.

Figure 12.7: Food Inadequacy in ASEAN Member States, 2014–2016



ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.
Source: ASEAN, UNICEF, and WHO (2016).

The ASEAN Secretariat, in collaboration with the World Economic Forum (2015), launched 'Grow Asia' in 2009, which aims to achieve 10 million farmers in the region by 2020, as well as increase their productivity, profitability, and environmental sustainability by 20%. This is crucial because rice is the staple of half the world's population, and about 70% of the world's poor. Some 90% of the world's rice supply is produced in Asia, much of it in ASEAN countries (Briones, 2011). Two of the world's largest producers and exporters of rice (Thailand and Viet Nam) as well as two of the world's largest consumers and importers of rice (Indonesia and the Philippines) are part of ASEAN (The Habibie Center, 2015). Moreover, access to food in each country can be seen from the prevalence of undernourishment indicators. Referring to data from the FAO, only Brunei Darussalam and Malaysia have a prevalence of undernourishment rate of less than 5%, which means they are close to eradicating hunger (The Habibie Center, 2015). Over the last 10 years, the prevalence of undernourishment rate in Indonesia has halved from 18.8% in 2005–2007 to 7.6% by 2014–2016. Among the other AMS, the Lao People's Democratic Republic (Lao PDR), Myanmar, and Cambodia have a high prevalence (The Habibie Center, 2015).

Food security is also highly correlated with securing food access. One of the main determinants of access is food prices. To ensure people are able to buy food, governments should reduce price volatility. From 2005 to 2014, price volatility in most AMS was not too high. However, Cambodia and the Philippines experienced volatility in certain years. Price volatility in the Philippines hit its highest record in 2011 as a result of natural disasters affecting the country and reducing food production (The Habibie Center, 2015). According to the Citizens' Disaster Response Center (2011), the Philippines was the world's most disaster-hit country in 2011 (Box 12.6).

Box 12.6: The Cost of Natural Disasters in the Philippine Agriculture Sector

Disasters in the Philippines have a high impact on its agriculture sector. From 2006 to 2013, the government estimates that disasters damaged more than 6 million hectares of crops. During this period, the total damage and losses in the agriculture sector were estimated by the government to be $3.8 billion, caused by 78 natural disasters (two droughts, 24 floods, 50 typhoons/tropical storms, one earthquake, and one volcanic eruption). Most of the production damage and losses were caused by typhoons/storms, amounting to $3.5 billion or 93%. Most of the damage and losses in the agriculture sector was in the crop subsector, at $3.1 billion.

Source: FAO (2015b).

It should be noted that food is a large part of the poor's total budget, so any increase in food prices will increase the burden on their finances. The food crisis in 2007–2008 led to thousands of people taking to the streets, demanding actions and solutions from their governments (The Habibie Center, 2015). As such lack of food supplies can create social instability, it is a major factor that can lead to social conflict and political violence (Desker, Caballero-Anthony, and Teng, 2013). Therefore, food security is undoubtedly crucial to ensuring not only human security but also regional stability.

Adequate infrastructure is also important for ensuring that people can access food. Road density is one of the indicators that provide information on the possibility of physical access to markets. Among the AMS, Singapore has the highest road density (The Habibie Center, 2015). As a result, people in Singapore have easy access to the food market. However, Myanmar has the lowest road density at 4–6 kilometres per 100 square kilometres of land area (The Habibie Center, 2015). Lack of infrastructure hinders people's ability to access the market for their food needs. Lastly, food security is not only about food availability or food access but also food utilisation. It is important to ensure that people take in adequate levels of nutrients. In addition, it is important to remember the link between nutrient absorption and food utilisation with water, sanitation, and hygiene (WASH) (The Habibie Center, 2015).

12.3 Impact on Health: (Immediate, Medium-Term, Long-Term)

One could argue a two-way relationship between long-term sustained growth and food security. Well-nourished people are likely to be healthier and less prone to illness, and therefore contribute to higher productivity and economic growth. Conversely, food insecurity can impede household investment in education and health, disrupting human capital formation and undermining long-term growth prospects. Food insecurity itself can create instability in households, communities, and nations – further impeding growth and development. Food insecurity and poverty incidence, however, differ in several important aspects.

First, poverty incidence relates to the consumption of a wide range of goods, of which food is only one, though the most important. Poverty line studies (which determine the per capita expenditure level below which one is deemed poor) particularly focus on the expenditure level which coincides with an adequate diet (ADB, 2013). A second, more basic difference is that poverty incidence refers to current circumstances, not expectations. At the time a household is surveyed, consumption levels of food and other goods either are or are not adequate (ADB, 2013). If they are not, the household is deemed poor. However, food security refers more to expectations than today's circumstances. Individuals or households may judge themselves food-insecure even if their present food consumption is sufficient (The Habibie Center, 2015).

Malnutrition can be the most serious public health problem in an emergency. According to the International Federation of Red Cross and Red Crescent Societies (IFRC), a food emergency exists if depleted food supplies are not replaced in the short term by food aid. A famine occurs in a population whose food consumption is reduced to the extent that the population becomes acutely malnourished and there is a rise in mortality (IFRC, 2007). Drought is the most common cause of food shortage in the world. Food crises may also be attributed to human causes, notably conflicts (ADB, 2013).

A nutrition emergency exists when there is the risk of or an actual rise in mortality as a result of acute malnutrition. In a nutrition emergency, where the prevalence of acute malnutrition amongst young children might be 10%–15%, and the prevalence of severe malnutrition could be 2%–3%, mortality rates can be very high (IFRC, 2007). Elevated crude mortality and under-five mortality rates are benchmarks for and definitions of a nutrition emergency (Table 12.4). Survival is at risk not only because of an inadequate and/or unbalanced diet but also because of disease outbreaks such as measles, tuberculosis, malaria, diarrhoeal diseases, HIV/AIDS, and respiratory infections – resulting in high death rates in the affected population (WHO, 2011b). There is a strong relationship between malnutrition and fatality because of these infections. Vitamin A deficiency, for example, increases the duration, severity, and complications of diarrhoeal disease in young children (IFRC, 2007). The mortality rates of displaced populations can be as high as 10 times the death rates for the same populations in non-emergencies. Peak mortality generally occurs some months into the emergency (IFRC, 2007).

Table 12.4: Benchmarks for Mortality Rates

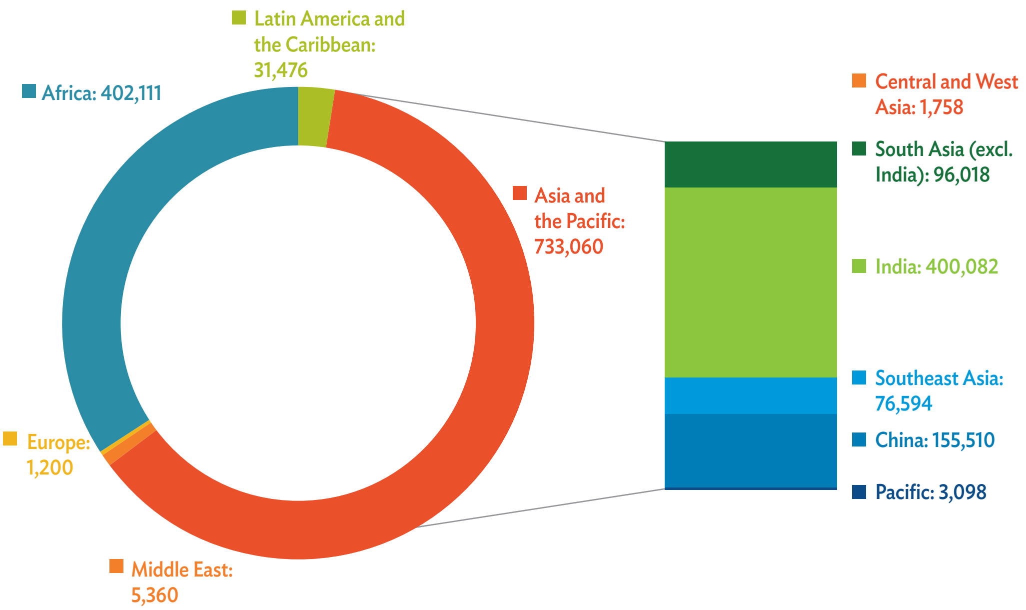
Crude mortality rate (deaths/10,000/day)	Under-five mortality rate (deaths/10,000/day)	Health and nutrition situation
0.5	1	Normal
<1	<2	Elevated
1–2	2–4	Serious
>2	>4	Very serious
>5	>10	Catastrophic

Source; IFRC, 2007.

12.3.1 Poverty and Undernourishment in Asia and the Pacific

Throughout Asia and the Pacific, poverty remains the most daunting challenge. Despite spectacular economic growth, developing Asia is home to more than 60% of the world's 1.2 billion people living on less than $1.25 a day (2005 purchasing power parity; Figure 12.3.1) (ADB, 2013). Two-thirds of the region's poor (or about 42.6% of the world total) are concentrated in South Asia. While various indicators of food security show impressive progress, undernourishment remains a serious problem. The region has 537 million undernourished people – about 62% of the global total (Figure 12.8) (ADB, 2013). Within Asia and the Pacific, regional disparities are large. Of Asia's malnourished, 299 million are in South Asia alone, more than the 237 million in Africa (ADB, 2013). The number of malnourished children is particularly alarming. Childhood stunting exceeds 40% in several Asian and Pacific island economies. This proportion is comparable with sub-Saharan Africa, but larger in absolute numbers.

Figure 12.8: The World's Poor, 2010 Estimates ('000)

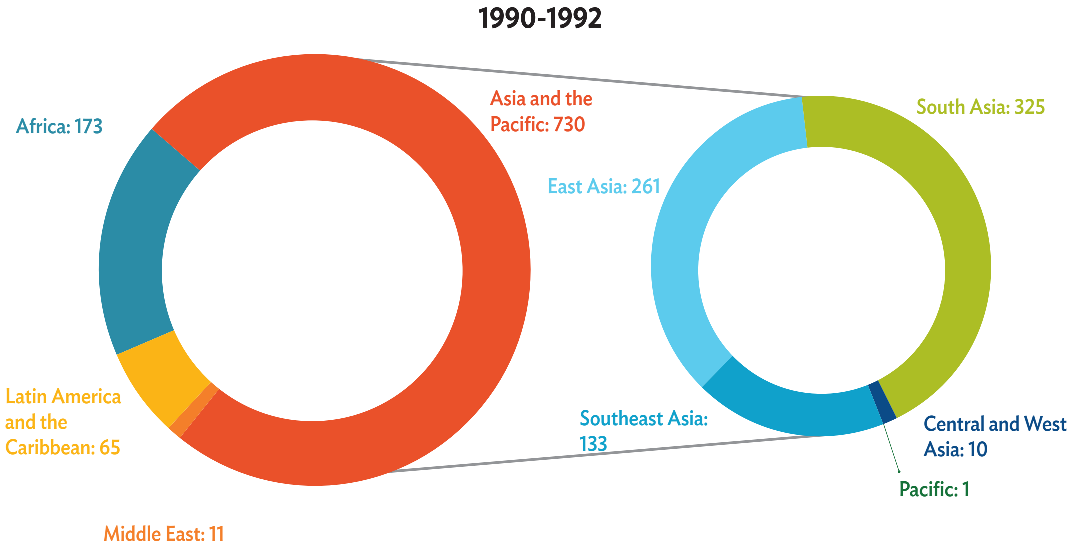


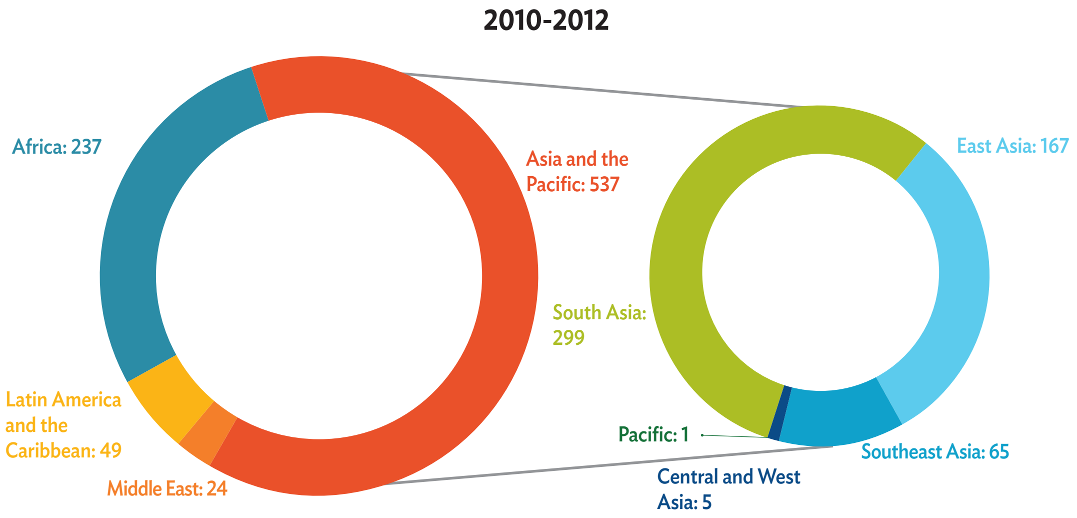
Note: The poor are those living on less than $1.25 a day (2005 purchasing power parity).

Source: ADB (2013).

What is striking is the difference in the rate at which undernourishment has declined in different parts of the world. From 1990–1992 to 2010–2012, the number of undernourished in Asia (Figure 12.9) was reduced by 26.5% – from 730 million in 1990–1992 to 537 million in 2010–2012. This far exceeded the global decline of 13.2% from 1 billion in 1990–1992 to 868 million in 2010–2012 (ADB, 2013). In Africa, the number of undernourished increased by 37% over the same period. Results also varied widely within Asia. In Southeast Asia, the absolute number of undernourished people declined by more than 50%, with East Asia not far behind at 36%. In South Asia, the decline – 8% – was much lower (ADB, 2013). Differences in poverty reduction could be one of the reasons. Economies which show a greater reduction in poverty incidence also show a greater decline in the prevalence of undernourishment (ADB, 2013). Improved economic access to food, combined with rapid growth and poverty reduction, was key to the decline in undernourishment.

Figure 12.9: **The World's Undernourished (million)**



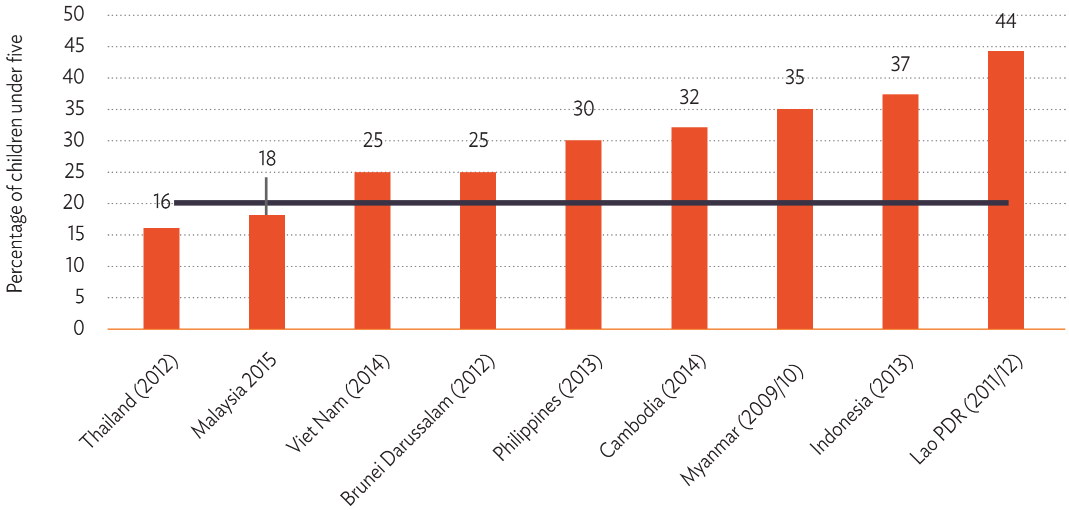


Note: The undernourished are those with a caloric intake less than the minimum daily requirement. Averages for 1990–1992 and 2010–2012 are shown.
Source: ADB (2013).

However, according to ADB (2013), there is an inverse relationship between per capita income and the percentage of stunted children aged 0–5. While nutritionists stress a proper mix of micronutrients, data on the 'average' nutrient intake do not accurately capture the importance of micronutrients for child development. Aside from contributing to premature death, childhood malnutrition plays a part in mental and physical impairment and a lifelong risk of chronic disease (WHO, 2011d). These cannot always be remedied by improved diets later.

While many ASEAN economies continue to struggle with maternal and child undernutrition, they also face the double burden of malnutrition – the coexistence of stunted and overweight children within the same community (The Habibie Center, 2015). Across populous countries in ASEAN – including Indonesia and the Philippines – the prevalence of undernutrition remains persistently high (ASEAN, UNICEF, and WHO, 2016). The Lao PDR shows the highest percentage of childhood stunting (Figure 12.10) while wasting is above the threshold of public health significance (5%) in eight out of 10 AMS (Figure 12.11) (ASEAN, UNICEF, and WHO, 2016). However, problems of over-nutrition are also surfacing, mainly in urban areas (FAO, 2012). It is estimated that 4.5 million children under five are currently overweight or obese in AMS (ASEAN, UNICEF, and WHO, 2016). While some ASEAN countries have low prevalence rates of overweight/obesity in children under five – Cambodia (2%), the Lao PDR (2%), and Myanmar (3%) – other countries have exceptionally high rates, such as Indonesia (12%) and Thailand (11%) (Figure 12.12).

Figure 12.10: Percentage of Children under Five who are Stunted in ASEAN Member States

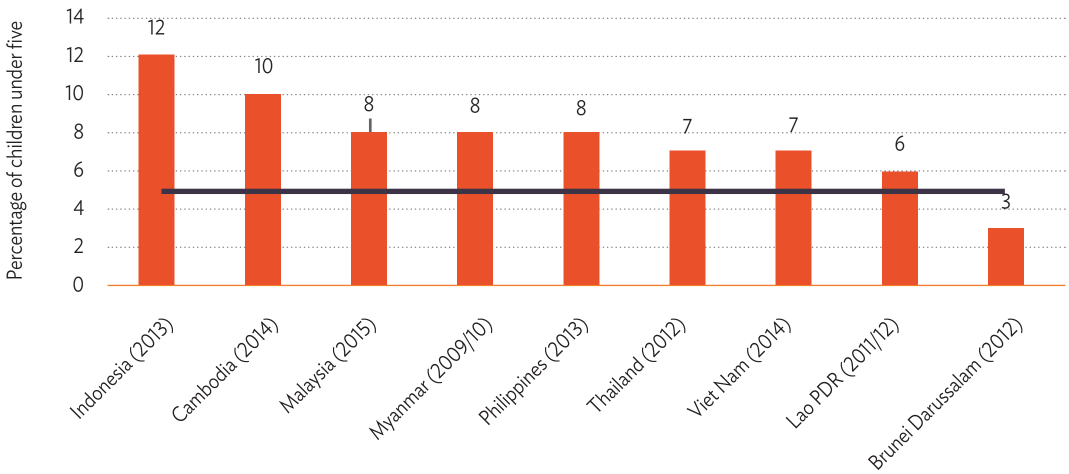


ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic, WHO = World Health Organization.

Note: WHO cut-off values for public health significance of stunting prevalence: > 40%: very high prevalence, 30%–39%: high prevalence of stunting, 20%–29%: medium prevalence, <20%: low prevalence (dark grey line).> 40%: very high prevalence, 30–39%: high prevalence of stunting, 20–29%: medium prevalence, <20%: low prevalence (dark grey line)

Source: ASEAN, UNICEF, and WHO (2016).

Figure 12.11: Prevalence of Wasting in Children under Five in ASEAN Member States

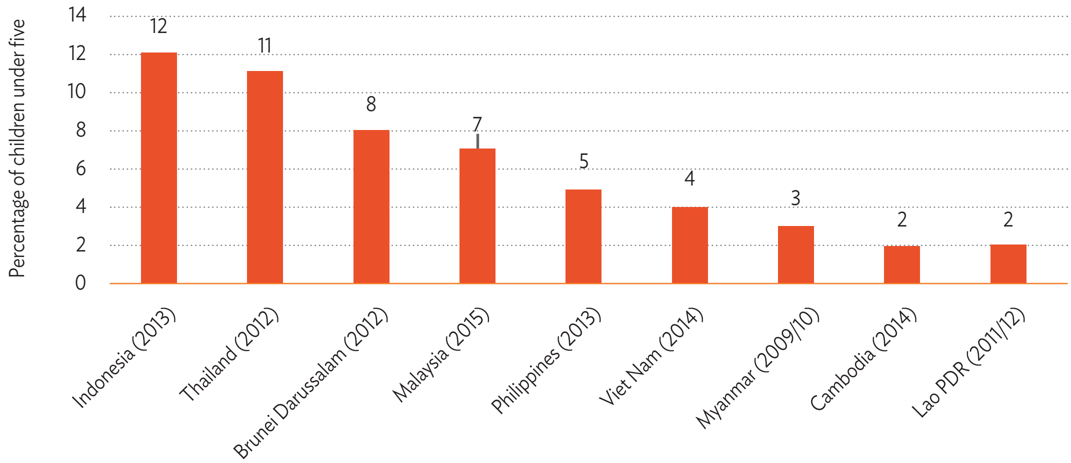


ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic, WHO = World Health Organization.

Note: Prevalence of wasting > 5% (dark grey line): public health 10 significance.

Source: ASEAN, UNICEF, and WHO (2016).

Figure 12.12: Prevalence of Overweight Children under Five in ASEAN Member States



ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic, WHO = World Health Organization.

Source: ASEAN, UNICEF, and WHO (2016).

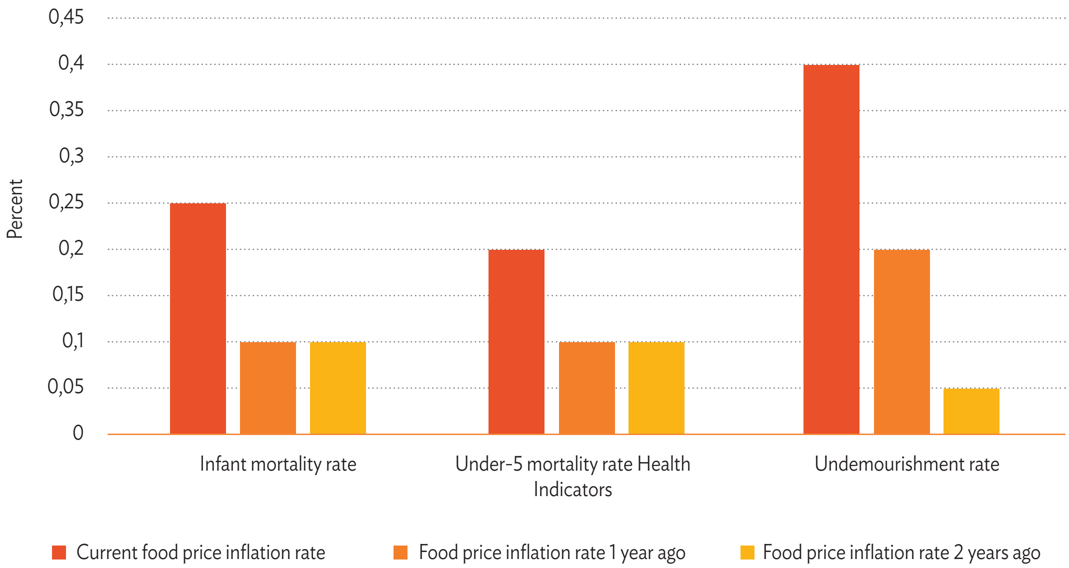
Changing dietary patterns in fast-growing Asian countries are worrisome. Together with accelerating growth in demand, more affluent Asians demand more protein-rich and resource-demanding food – not just meat and dairy products, but also vegetables and fruits (ASEAN, UNICEF, and WHO, 2016). While dietary diversity during the nutrition transition is welcome, ongoing dietary shifts have largely corresponded to increased fat content sourced from animal fat and oil. As such, the sharp increases in the consumption of sugar and other sweet products, changing dietary patterns, nutrition transitions, and lifestyles are contributing to growing rates of obesity, diabetes, and other NCDs (WHO, 2010).

Malnutrition, whether undernutrition or over-nutrition, is a significant threat to public health. Many developing countries must combat both simultaneously. Undernutrition and micronutrient deficiencies – especially amongst children – are stubbornly high in some pockets of the region. Where problems are emerging, effective control is key. The challenge is to develop effective programs and policies that are specific to a country context (ADB, 2013). For example, reducing child and adult undernutrition and micronutrient deficiencies should remain a top priority in Thailand, Indonesia, and the Philippines (Box 12.7). However, more focused efforts should also be initiated to limit the emergence of obesity in urban areas (WHO, 2010). In countries such as Indonesia, where obesity is rising and increasingly affecting children, efforts should be directed towards improving nutritional awareness, ensuring that healthy food options are affordable and accessible, and educating consumers about the long-term health impacts of obesity (ADB, 2013).

A comprehensive assessment of the effects of food price inflation and volatility on population health – measured by the infant mortality rate, child mortality rate, and prevalence of undernourishment – was carried out by ADB (2013). Using a panel dataset covering 63 developing countries from 2001 to 2010, the study found that a 1 percentage point increase in contemporaneous food price inflation leads to a 0.2% increase in infant and child mortality and a 0.4% increase in the prevalence of undernourishment (Figure 12.13).

Furthermore, the study showed that the impact of food prices is more severe in least developed countries, although the effect is moderated where agriculture has a greater share of gross domestic product (GDP) (ADB, 2013).

Figure 12.13: Impact of Higher Food Price Inflation on Health Indicators



Note: Figures show percentage change in health indicators for every 1 percentage point increase in the food price inflation rate.
Source: ADB (2013).

Box 12.7: The Cost of Food and Poverty – The Case of Thailand and Indonesia

Thailand is one of the world's largest food exporters. Its products include the region's dominant staple, rice. Indonesia is exactly the opposite. Most of its staple foods – rice, maize, cassava, soybeans, and sugar – are net imports. Its agricultural exports have tended to be estate crops such as rubber, copra, and coffee. Other things being equal, the balance between net consumers and net producers of food in net importers, like Indonesia, is more heavily weighted in favour of consumers than net food exporters such as Thailand. Therefore, the likelihood that food price hikes will raise poverty incidence would seem to be greater in Indonesia than in Thailand.

Warr (2010) has created general equilibrium models designed to estimate the impact of price changes on poverty incidence. The shocks applied to the two models are the percent changes in the international real prices of four commodities – rice, maize, soybeans, and sugar – from 2003 to 2008. During this period, real prices (the nominal price in United States dollars of the commodities deflated by the manufactures unit value index) increased by 212% for rice, 124% for maize, 117% for soybeans, and 62% for sugar (Table 12.5). Even though the international price shocks were large, the results show that their simulated effects on poverty incidence were small. This is because the impact is the net effect on populations, including groups that lose from price increases (net buyers) as well as those that gain (net sellers and others gaining from indirect income effects).

In Thailand, the increase in the producer price of rice benefits sellers, while the consumer price increase harms net consumers. For those close to the poverty line, net consumers outnumber net sellers, even in rural areas. Net consumers are all rural people who do not own cultivated rice land, including all landless laborers. They also include many small farmers who produce some rice but supplement consumption with purchased rice, using income derived from the sale of other agricultural products or, increasingly, non-farm sources of income. Urban poverty incidence increased marginally, from 3.2% to 3.4% of the urban population, while rural poverty incidence increased from 18.0% to 18.4%. The negative effect on poor consumers of rice outweighs the positive effect of the increased returns to fixed factors owned by poor rice producers and the small increase in unskilled wages.

In Indonesia, the estimated effects of the international rice price shock were very small. Its vulnerability to the price shock is determined by its policies on rice imports. Until the early 2000s, Indonesia was the world's largest rice importer. With the political shift to a more democratic form of government, the lobbying power of pro-farmer political groups initially led to heavy tariffs on rice imports. Then, in 2004, rice imports were officially banned, although limited quantities of imports are occasionally permitted (Warr, 2011). By 2006, this policy increased domestic rice prices relative to world prices by about 37% (Fane and Warr, 2009). The import quota on rice meant that world price increases for rice were barely transmitted to Indonesian domestic markets.

Table 12.5: Thailand and Indonesia – Simulated Effects of Food Price Shocks

Commodity		Rice	Maize	Soybeans	Sugar
Shock to international price (%)		212	124	117	62
	Before price shock	Headcount measure of poverty incidence (% of population) Simulated change in poverty incidence from price shock			
Thailand					
Urban	3.22	0.202	0.000	0.000	0.000
Rural	17.99	0.443	0.014	0.015	0.000
National	13.71	0.371	0.003	0.013	0.000
Indonesia					
Urban	13.60	0.008	0.016	0.044	0.049
Rural	20.20	0.001	0.179	0.047	0.066
National	17.19	0.004	0.105	0.045	0.058

Source: Warr (2010).

The Role of Social Safety Nets

Most Asian countries use social safety nets of some kind, intended to shield poor and vulnerable groups from severe deprivation. As a percentage of GDP, social protection expenditures vary across developing Asia (ADB, 2008) from 1.3% in the Lao PDR to 1.9% in Indonesia, 2.2% in the Philippines, 4.0% in India, 5.3% in Bangladesh, and 9.8% in Mongolia, amongst others. The share is 2% or less in 10 out of 31 Asian countries. On average, poorer countries allocate lower proportions of GDP for social protection. In the United States, the share is 9%; in Japan, 16%; and in the European Union, it reaches 19%. Reviews have shown four major categories of safety net programmes (Box 12.8):
(i) consumer food price subsidies
(ii) food-for-work programmes
(iii) feeding programmes
(iv) cash transfers

Box 12.8: Social Safety Nets and Food Programmes in Selected Developing ASEAN Countries

Indonesia: Indonesia's major safety net programmes are its Raskin rice subsidy programme; a programme providing free inpatient and outpatient care to households at primary health centres and hospitals; and a non-recurrent cash transfer scheme, Bantuan Langsung Tunai, used in 2005 and 2008 to help households cope with fuel price increases resulting from fuel subsidy cuts. Other cash transfers exist in smaller social assistance programmes targeting the poor, elderly, persons with disabilities, and youth. One is a conditional cash transfer scheme based on health- and education-related conditionalities for household mothers and their school-aged children.

Philippines: The Philippines' rice price subsidy, run by the National Food Authority, is the largest food programme in the country. Almost 90% of the rice under this programme is sourced from external markets. During the food, fuel, and financial crises in 2008, when there were more than 60 social programmes in the country, the National Food Authority subsidy accounted for 70% of the total social protection budget. Other social assistance programmes are school feeding programmes, where children attending accredited schools receive 1 kilogram of rice per day – and in selected schools are provided breakfast. A conditional cash transfer scheme (the Pantawid Pamilyang Pilipino (Filipino Family Assistance) Program (4Ps)) was initiated in 2007 with a pilot group of 6,000 households. To qualify, households must (i) be located in poor areas; (ii) be classified as poor through a proxy means test; (iii) have either a pregnant mother or at least one child aged 0–14; and (iv) meet conditions relating to education and health, such as 85% school attendance, health clinic visits, and deworming for children.

ASEAN = Association of Southeast Asian Nations.
Source: Jha, Kotwal, and Ramaswami (2013); ADB (2013).

ADB (2013) showed the presence of regional and ethnic biases in allocation schemes in social safety nets. There are practical problems in identifying qualifying households, as well as corruption. For example, the Public Distribution System for subsidised access to grains in India is said to have exclusion and inclusion errors of 70% (ADB, 2013). However, this does not mean that existing programmes are counterproductive, because at least some of the benefits reach the intended beneficiaries. Nevertheless, the associated wastage and corruption are major issues, which raise the question of whether programme objectives should be pursued in other ways (ADB, 2013).

12.4 Integration Strategies to Reduce Impact on Health

12.4.1 Interventions to Meet Immediate Needs

Social Safety Nets

Safety nets and social protection programmes can offer immediate relief to the poor during temporary bouts of food insecurity. However, the role of social protection for food security extends beyond providing essential assistance to mitigate the impact of short-term natural and economic shocks (Box 12.9). Properly designed and targeted, social protection can play a crucial role in breaking the vicious cycle of poverty and food insecurity, ensuring food security for all in the long run (ADB, 2013). A wide array of instruments can be employed to address the vulnerability of people's livelihoods – from social insurance and social assistance to labour market programmes. Social protection programmes can also help address market imperfections and failures (ADB, 2013). It is critically important to target these programmes more effectively and exclusively at the poor – to maximise their impact given limited budgets. One study shows that non-targeted direct cash transfers and food aid have increased dependency and eroded local capacity to generate sustainable incomes (Gilligan et al., 2009).

Box 12.9: The Role of Safety Nets in Reducing Hunger and Malnutrition

Hunger and malnutrition are key issues that cut across poverty alleviation interventions. Food insecurity and poverty are closely interrelated. Social safety nets may have the most direct effect on the poor, helping them cope with risks such as price increases or calamities. Without requiring any financial contribution from beneficiaries, safety nets take the form of instruments such as transfers and subsidies (see below) and are more often than not targeted at specific segments of the population – the poor, children, or mothers, for example. While social protection should be available to all, resource constraints necessitate targeting to ensure programme efficiency and cost-effectiveness (FAO, 2012). Transfers to beneficiary households may be based on the minimum food basket cost which provides the required calories and nutrition to household members. This will help guarantee that limited resources are well spent – and cash transfers used to ensure the minimum dietary intake.

Features of Transfers

- Can be preventive (insurance) or palliative (response or assistance)
- Can be cash or in kind (e.g. food or inputs to agriculture); in some cases, both
- Can be unconditional (no commitment from beneficiary) or conditional (dependent on school attendance, clinic visits, and so on)
- Can be given as payment for employment in public works or construction

Features of Subsidies

- Usually implemented by subsidising the commodity for a lower market sale value
- Subsidised commodity can either be a universally consumed good or one preferred by specific groups
- Sale of good can be universal (all can avail of the subsidised good) or targeted (only specific groups are able to avail through a mechanism such as vouchers or show of proof eligibility)

Cash Transfers

The targeting failures of existing social protection systems raise the question of whether these programmes could be replaced by something better. Cash transfer systems might replace in-kind programmes altogether (ADB, 2013), although there may be initial political resistance as beneficiaries from existing corruption and inefficiency can be expected to oppose change. Cash transfers can also encourage households to adopt beneficial behaviour – e.g. they could be conditional on household participation in education, health, or nutrition services. Indonesia has already used cash transfers to compensate for economic shocks. In 2008, it reintroduced the world's largest unconditional cash transfer system to shield households from the impact of reductions in fuel subsidies (ADB, 2013). With the assistance of the World Bank, Indonesia was able to develop a transparent system that worked. This well-documented programme could be adapted elsewhere (ADB, 2013).

Interventions Targeted at Nutrition

Poverty and limited access to food are major causes of inadequate food and nutrient intake. Tending to be more vulnerable to food price hikes and other shocks, the poor have to adjust their dietary choices to low-quality food, which might translate to lower nutrition (ADB, 2013). This damage is particularly severe amongst pregnant women and young children, given the elevated risk of both groups to malnutrition and undernourishment (ASEAN, UNICEF, and WHO, 2016). Urgent actions to improve food and nutrition security amongst the poor and vulnerable include improving incomes, providing targeted social assistance and safety nets, and promoting dietary education.

First, improving smallholder production and productivity can have a tremendous impact on food and nutrition security, not only increasing food supply but also raising rural household incomes (ADB, 2013). Smallholder farmers are responsible for the majority of domestic food production in most developing countries. Efforts to enhance farm production can also be combined with efforts to improve crop and dietary diversity to maximise the impact on nutrition security (FAO, 2003). As many smallholders are subsistence farmers, the diversification of small-scale production, cultivation of micronutrient-rich crops, and bio-fortification of staple food crops directly reduce nutrition and micronutrient deficiencies (ASEAN, UNICEF, and WHO, 2016).

Second, social assistance programmes should take into account the nutrition and dietary needs of beneficiaries. Food assistance, nutritional interventions, and safety net programmes can be designed in tandem with programmes that enhance economic opportunities and reduce poverty, such as school feeding and job creation schemes (ADB, 2013). Food assistance and related interventions can improve programme efficiency by targeting beneficiaries such as pregnant women, or lactating mothers and their children (ASEAN, UNICEF, and WHO, 2016).

Third, there has been an increasing emphasis on the role of health and education for nutrition security. National food security strategies often focus on agriculture and food supply, neglecting the importance of nutrition (ADB, 2013). However, evidence is clear that food supply alone may not guarantee that nutrition security will be achieved. In Mexico, for example, malnutrition and stunting persists despite relative food abundance (Neufeld, Chowdhury, and Ruel, 2012). Nutrition education and social marketing are essential to improving food and nutrition security, given the strong relationship between nutritional and health knowledge, and nutrition outcomes. Studies show that education and a mother's nutritional knowledge are particularly important for household food allocation and young children's nutritional status (Thomas, Strauss, and Henriques, 1991). A mother's nutrition and health also directly influence her child's nutrition and health. Pervasive gender bias is an important latent factor for malnutrition and the undernourishment of women and girls. Often, there is bias and discrimination against girls in household decisions over schooling, healthcare, and feeding. Education is critical in empowering women and reducing gender inequality (ADB, 2013).

Dietary Diversity and Nutrition: Better Income, Better Food

With affluence and urbanisation, Asians have developed an appetite for more nutritious and balanced meals. As income grows, so does dietary diversity – the relationship between the number of food groups consumed and total household per capita income is significant and positive (Hoddinott and Yohannes, 2002). Based on household surveys in developing economies (FAO, 2012), the households in the highest per capita income quintile have a more diversified diet. Nutritionists emphasise that food security is about more than just caloric intake. Nutrition security is about meeting, but not exceeding, dietary requirements across a range of essential nutrients. Nutrition insecurity can exist even in the presence of food abundance (Neufeld, Chowdhury, and Ruel, 2012). A growing number of studies suggest that the increased intake of meat and dairy products poses a public health problem in many developing economies (ADB, 2013). Adequate nutrition not only benefits individual health and survival, but also collective human capital and economic development.

12.4.2 Actions to Improve Medium- to Long-Term Resilience

Rural Development: Agriculture and Research

Poverty in Asia remains primarily rural. Thus, a rural-based growth strategy would seem to be an effective way to tackle both poverty and food insecurity. In the 1960s and 1970s, the Green Revolution was the proverbial stone that hit the two birds of poverty reduction and food security – by increasing rural incomes and lowering food prices (ADB, 2013). It showed that rural development and growth can help reduce poverty effectively. A new growth paradigm should focus on support for agriculture and increasing rural income opportunities, so they are on a par with those for urban dwellers (ADB, 2013). Rural incomes should also be diversified to improve stability, while urban–rural integration must deepen. Investment in rural roads and other infrastructure lowers transport costs, facilitates marketing, and encourages the flow of information. This can go a long way in advancing rural development. Investing in rural roads and other infrastructure. Public investment in infrastructure, especially roads, is critical for rural development. Good infrastructure lowers the cost and time for trade, and increases reliability, thus boosting flows and benefiting those who use infrastructure services more intensively (ADB, 2013). The costs of transit delays are especially high for time-sensitive goods such as perishable agricultural products. Reduced transport costs simultaneously raise earnings from output sales and lower the cost of inputs. Investment in new drainage systems, or the rehabilitation of existing ones, must also be prioritised, as good drainage is central to resolving waterlogging and salinity problems. While profitable irrigation systems can be developed by the private sector, the construction and maintenance of drainage structures are often unprofitable, requiring additional public support (ADB, 2013).

While it is important to produce more food to feed the world's growing population, it must be done with fewer natural resources – limited land and water – and less energy, fertilisers, and pesticides while coping with rapid societal change. Investing in agricultural research and development offers the most feasible long-term solution to this conundrum. Scientific research has been behind many innovations in agriculture, providing solutions to the problems of food security. It can again provide solutions in the future if people understand that investments need to be made now. The challenge for the research community is to develop resilient agricultural systems using rational, affordable strategies that not only increase production but also achieve food security for households and individuals. Research also needs to be interdisciplinary and to address the diverse needs of smaller farms.

In Asia and the Pacific, it is important to increase food production by diversifying crops and finding alternatives to rice and wheat. A case in point is the potato, which has emerged as one of the more important food crops in the region. Potato crops have high yields and produce more edible energy and protein per unit area and time than many other crops. It also fits well into multiple-cropping systems prevalent in the region. Research can contribute to developing potato varieties suited to tropical climates as well as production technologies and post-harvest processing.

Urban Agriculture

Some 20% of the world's undernourished live in cities; amongst this group, those who manage to get enough food do so at record costs (Iloka, 2016). The long supply chains that provide cities with food are easily severed by natural disasters, which are becoming more frequent (Fox, 2013). Research has shown that disaster survivors rely on emergency food supplies for months although they are only intended for a few weeks (Sioen et al., 2017). This disrupts urban food supply and food infrastructure, with an impact on food and nutrition security (FAO, 2011). Therefore, over the last 20 years, many countries have started urban agriculture programmes to address the health impact of food insecurity (Box 12.10).

Urban agriculture is broadly defined as the growing of plants and raising of animals in the city (Sioen et al., 2017). By growing their food locally, cities have managed to avoid food problems common to other urban areas (FAO, 2011). In Asia, for example, 60% of the vegetables consumed by city residents are grown within the city limits of Shanghai, China (FAO, 2011). On the island of Negros, the Philippines, malnutrition amongst urban children was reduced from 40% to 25% in 2 years after the start of urban farming (Smit, Nasr, and Ratta, 2001). In summary, localised production in the form of urban agriculture is recognised as a source of food and nutrition security for households and a buffer during disaster periods (Smith, 2013).

Box 12.10: Urban Agriculture in Kathmandu, Nepal

Kathmandu promotes productive rooftop gardening, which provides an opportunity to grow food in inner-city areas in response to decreased agricultural land and a growing reliance on vulnerable food sources from other areas. The main reason for the city to develop such programmes is to ensure food and nutrition security. The city involves its engineers in the design of rooftop models suitable to the local context, trains masons in construction and building techniques, includes rooftop gardening in building codes, links gardeners to input supply and marketing enterprises, and promotes rainwater harvesting and composting of city waste. Radio programmes and information leaflets are developed to generate policy interest and encourage community participation. Case studies show that intensive rooftop production helps families to become self-sufficient in vegetables and herbs and to potentially sell some surplus produce.

Source: Dubbeling (2013).

Human Capital Investment: Education, Nutrition, and Awareness

Human capital investments in health, nutrition, and education – and investments in basic infrastructure like water and sanitation – are key to poverty reduction and food security (ASEAN, UNICEF, and WHO, 2016). While economic growth is a necessary condition for poverty reduction and consequently food security, the link between economic growth and food security may be weakened if the poor have limited access to human capital formation and basic infrastructure. Prioritising investment in basic education, health, and nutrition not only directly enhances individual welfare but also builds higher average incomes in the long run (ADB, 2013). Human capital development directly improves food security by ensuring a healthy agricultural workforce and providing farmers with the skills to adopt modern and more productive farming technologies (FAO, 2012).

Further, food security policies need to ensure that people have not only sufficient food but also the right kind of food. In many developing countries, trends in dietary patterns complicate the nutrition situation (ADB, 2013). Rapid income growth and urbanisation are causing a shift in dietary patterns away from traditional starches and cereals, and increasingly toward processed foods, animal products, sugars, fats, and edible oils (ASEAN, UNICEF, and WHO, 2016). For many developing countries, this nutritional transition has been accompanied by an increasing overweight incidence and risk of obesity in urban areas, while high rates of food insecurity and undernutrition continue in rural areas. Dietary diversification – including increased consumption of total calories and animal protein – is a boost for the poor, who have monotonous diets (ADB, 2013). However, nutrition education and awareness have to be strengthened during this transition, especially for low-income urban households, as highly processed food that is low in micronutrient content poses increased health risks. Overall, public health and education must be fully integrated into national food security strategies and policies.

Crisis Prevention and Risk Management

According to ADB (2013), managing and mitigating the risks threatening food security require a three-pronged approach. The first and arguably the most crucial step is risk assessment – understanding and prioritising risks, gauging their potential impact, and identifying who will be affected. The second is to provide safety nets and other disaster relief measures to mitigate the immediate impact for vulnerable people and communities. Third, a risk management system should have longer-term prevention and adaptation measures to help people and communities adapt to the changing new environment and build resilience to risks. Identifying who is food-insecure and vulnerable to food insecurity, where they are, and why they are insecure or vulnerable should be the first step, even before discussing what measures are needed to mitigate their vulnerability. The source of food security hazards – local, national, or international – and whether they are transitory or chronic in nature must be identified as well. Risk analysis and monitoring need to gauge the likelihood of these threats, the historical distribution of hazards, and the probable impacts on vulnerable populations (van 't Wout, 2014). Finally, all this information, once gathered and analysed, must be fed into a monitoring and early warning system which can help policymakers, firms, and households adapt to foreseeable hazards and take mitigation measures (ASEAN, UNICEF, and WHO, 2016).

Emergency Funds for Disaster Relief: Food Reserves

Building an emergency fund for communities and nations could also be considered part of the risk management system to provide a buffer during food crises. The fund could be used to finance safety nets for those suffering transitory food insecurity. The private sector can be offered incentives – such as tax deductions – to contribute to the fund, which can be run by a government agency in partnership with the private sector (ADB, 2013). The fund can be linked to insurance against natural disasters and other calamities, and used in conjunction with risk management to help mitigate the effects of crises and disasters.

As such, emergency food reserves and funding facilities can allow the rapid delivery of humanitarian aid to the most vulnerable countries or populations in the wake of a food crisis. Governments can improve emergency access to food by linking village and national stocks to regional and global stocks, and by facilitating the release of grain stocks to other countries in crisis situations. National and international food stocks, if strategically managed, can also help reduce food price volatility (ADB, 2013). The existence of market failures suggests that it may make sense for countries to maintain emergency stocks. Storage can be costly, of course. However, if these are released in a transparent, preannounced manner and only when prices are unusually high, national grain stocks can stabilise prices and help domestic food security (Briones, 2011). Nevertheless, releasing food stocks has only a limited and temporary effect on domestic price stability, if free trade allows the international price to be transmitted domestically. For example, when prices surge, an importing country might release rice stocks domestically to force the local price below international levels. Unless exports are prohibited, however, private agents would buy rice at the low domestic price and sell it internationally for profit (Briones, 2011).

After the 2007–2008 rice crisis, the AIFS framework and its implementing mechanism, the Strategic Plan of Action and Food Security in the ASEAN Region, were established. They aim to prevent or mitigate problems caused by extreme rice price volatility through regional and national food reserves, the expansion of food trade, the strengthening of market information, and an increase in food productivity (Briones, 2011; ADB, 2013). Other initiatives in the region are the ASEAN Plus Three Emergency Rice Reserve (APTERR), the ASEAN Food Security Information System project, and the ASEAN Rice Trade Forum (Briones, 2011). Designed to complement members' existing national rice reserves, APTERR helps mitigate supply shock effects using forward contracts and streamlined release procedures, helping countries respond more quickly to an emergency (Box 12.11). This multilateral effort to coordinate publicly held rice reserves – and the investment in developing rules, procedures, and the capability to anticipate rice shortages – is noteworthy.

Box 12.11: ASEAN Plus Three Emergency Rice Reserve

The Association of Southeast Asian Nations (ASEAN) Plus Three Emergency Rice Reserve (APTERR) was established in July 2011, in a ministerial agreement between the ASEAN+3 members – ASEAN (Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam), plus China, Japan, and the Republic of Korea.

APTERR is a buffer against immediate threats to food security caused by disasters and market volatility associated with calamities. Earmarked rice reserves total 787,000 tons. Voluntary donations in cash or rice comprise stockpiled reserves. APTERR stocks can be released to a member which is unable to cope with an emergency through its national reserves alone and is unable to procure needed rice supplies through normal trade. Day-to-day management is handled by a secretariat hosted by Thailand under the supervision of the APTERR Council.

Source: APTERR (2012); Clarete, Adriano, and Esteban (2013).

Coordinated Responses to Enhance Resilience

The 2007–2008 food crisis highlighted a number of weaknesses in international food markets. While fundamental and structural forces – including the growing populations, rising incomes, and increasingly constrained resources caused by climate change – have been behind recent surges in global food prices, reduced national grain stocks, export and import restrictions, and speculation in futures and commodity markets have aggravated market imbalances at times, amplifying price volatility (ADB, 2013). There is a clear need for countries to respond to global food crises in a coordinated manner and to comprehensively assess the impact of new policies and actions to prevent those that may have undesirable consequences for other countries and international food markets (The Habibie Center, 2015) (Box 12.12). The international community needs to strengthen cross-border cooperation for emergency support and better management of international food markets.

Box 12.12: ASEAN Moves Towards an Integrated Community

Each of the Association of Southeast Asian Nations (ASEAN) member states has their own strategy in responding to food crises because of their agricultural industry. Some countries such as Thailand and Viet Nam take on the role of rice exporters, while others like Indonesia and the Philippines are rice importers. Myanmar is working its way up to regain the agricultural competitiveness it had in the 1950s when the country led the region in terms of rice exports. Meanwhile, Brunei Darussalam and Singapore are rice importers but notably import only the best quality produce. Singapore has also started investing towards its goal of becoming the ASEAN centre for biotechnology. Although different in nature, these approaches are projected to achieve an ASEAN-wide framework for food security.

ASEAN has decades of experience to build on. Since the 1970s, the association has been, in fits and starts, organising and tinkering with the ASEAN Food Security Reserve – an agreement amongst members to set aside and share rice stocks in contingencies such as what is now being experienced. More recently, in 2009, members adopted the ASEAN Integrated Food Security (AIFS) framework and the Strategic Plan of Action on ASEAN

Food Security. The AIFS framework and the Strategic Plan of Action on ASEAN Food Security were set for a 5-year period (2009–2013), and the International Rice Research Institute (IRRI) was tasked to focus its contribution on agricultural innovation, which included proposing a rice action plan.

In 2013, the ASEAN Ministers of Agriculture and Forestry appreciated the IRRI's report, recognising the contribution of the Global Rice Science Partnership (GRiSP) which strives to ensure the affordability of rice for the poor while maintaining profitability for farmers. It was agreed that the Senior Officials Meeting of the ASEAN Ministers of Agriculture and Forestry would work with the IRRI to secure the resources necessary to implement GRiSP across ASEAN.

Source: The Habibie Center (2015).

Specific, urgent actions should be undertaken to address both short- and long-term issues. There is a pressing need to develop an overarching – if multi-layered – policy framework covering the array of strategic directions to address immediate, short-term needs, and to prepare for medium- to long-term issues. Priority actions are combating food insecurity and poverty, enhancing the efficiency of food market systems, promoting sustainable agriculture, and improving risk management and community resilience. In the short run, policies that focus on mitigating the immediate impact of high food prices on vulnerable groups, and that facilitate access to adequate, quality food through emergency measures – such as food assistance and cash transfers – will be most effective. In the longer run, scaling up agricultural productivity and investment, promoting rural development, and continuing to tackle the root causes of poverty can promote economic resilience and help build sustainable food security. At the same time, policies should be crafted to promote sustainable agricultural production and environmental protection. It is important to recognise that only planning and action now will be able to influence long-term outcomes. Delayed or inadequate decisions today will increase vulnerability to long-term food insecurity tomorrow. International food markets and governments must be prepared to respond to supply and demand shocks as well as the effects of climate change. These are already behind today's higher food prices and volatility.

12.5 Recommendations for ASEAN

12.5.1 Principles

- **Implementing food security** interventions and ensuring access to appropriate healthcare play a significant role in minimising the risk of undernutrition.

- Ensuring **food quality and food safety** is as important as ensuring adequate food quantity.

- **Addressing nutrition security while reducing poverty and vulnerability to food insecurity**, to ensure the ability to purchase sufficient and nutritious food; reducing the price impact on the real incomes of poor households; and providing effective social safety nets for those bypassed by rapid economic growth and poverty reduction efforts.

- **Establishing risk management systems and tools**, to provide food-based safety nets which offer immediate relief to disadvantaged groups during crises; building adequate emergency food reserves and relief systems as a buffer to natural and human-made disasters; and introducing risk management systems and tools such as crop insurance and futures contracts to help mitigate the effects of price volatility and crises.

12.5.2 Way Forward

1. ASEAN needs to strengthen its policy coordination and cooperation at the regional and global level. Global and regional cooperation can help ensure food security and reduce excessive price volatility in three broad areas: (i) establishing emergency food reserves and aid, (ii) sharing market information, and (iii) promoting trade. Food price instability often coincides with low stock levels. Multilateral cooperation is crucial to curb volatility in rice and food prices. The governments of AMS must share information on cross-country stocks and prospects that enable rational, moderate, and longer-term assessments of supplies and prices. Accurate and timely information on food markets and stocks is also critical to preventing market speculation from spiralling into a food crisis. Through regular dialogue, policymakers in the region can assess market trends and help coordinate policies in response.

2. ASEAN should strengthen its cooperation with other related stakeholders such as international organisations (the FAO, the International Fund for Agricultural Development, the World Food Programme, and the World Health Organization); the private sector; and smallholder farmers.

3. ASEAN must ensure that all components of a health system are strengthened to cope with local hazards and respond to the health needs of children following a disaster. Activities include training adequate numbers of health workers to manage the health problems of children following a disaster and ensuring that plans are in place for surge capacity; developing disease surveillance and early warning systems; and planning to ensure there are contingency stocks of drugs and other supplies which are appropriate to the needs of children. It is also important that health facilities are built safely and prepared to respond to the health needs of children in emergencies.

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CHAPTER 13

Mainstreaming Resilience into SDGs and Agricultural Trade Pacts: Why and How?

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13.1 Introduction

The exposure to and thus vulnerability of the agriculture sector to natural disasters is significant and increasing in the Association of Southeast Asian Nations (ASEAN). Several studies (Food and Agriculture Organization of the United Nations (FAO), 2015; Asian Development Bank (ADB), 2009; Anbumozhi et al., 2012; and Nelson et al., 2009) have clearly shown that the region's food production and distribution systems and thus food security will be severely impacted by climate-induced disasters, and about 25% of all damages caused by such disasters in the 10 countries from 2003 to 2013 affected the agriculture sector (FAO, 2015). In particular, droughts, cyclones, and floods have led to agricultural production structures – such as land, post-harvest facilities, and marketing channels – becoming temporarily unproductive. Loss of livestock, greater prevalence of pests, and reduced crop production add uncertainties to food security at the national as well as regional levels. According to Anbumozhi and Reddy (2016), 84% of the economic impact of droughts was borne by agriculture and livestock in ASEAN during 2003–2015. Such losses are projected to increase as disaster events become more severe and frequent, but also less predictable, as a result of climate change. It is likely that the impact of disasters will be concentrated in a limited number of hotspots along the local and global value chains (Anbumozhi et al., 2009).

However, greater openness to trade in staple commodities can also bring resilience to the agricultural value chains. This could happen at different interconnected levels. First, the level and variability of volumes and prices in the international markets are interlinked and could easily be affected by high-intensity low-frequency floods as well as low-intensity but high-frequency droughts (Von Braun and Tadesse, 2012). International food prices are often characterised by trends and volatility, with occasional upward and downward price spikes. The size of those spikes, which are determined in part by the small short-run elasticities of domestic demand and international supply, can be exacerbated by speculative behaviour in markets induced by disaster events such as El Niño and by changes in the trade policies of countries with large agricultural exports (Ghoshray, 2011). It is these vagaries, which emanate from disaster events occurring in one country and spill over into the food markets of another country if and when their economies are interconnected, which cause the linkage between trade policy and food security to be significant. Moreover, trade contributes to regional food security by balancing food deficits and surpluses across countries, thereby ensuring stable supplies and contributing to price stability. Considering the significant risks of climate change and disasters to crop production, livestock, and fisheries, agriculture trade is likely to become even more significant in the future as food demand grows in some regions where productivity gains will not be sufficient to meet demand growth (Breiling and Anbumozhi, 2017).

Nevertheless, the 2030 Agenda for Sustainable Development Goals (SDGs), agreed by all ASEAN Member States (AMS), has shaped a framework for global or regional governance on food security that responds to compound disasters and interconnected global economies. The SDGs recognise that trade is a key element in addressing fundamental issues such as food security, nutrition, and the promotion of sustainable agriculture (SDG 2); healthy lives and well-being (SDG 3); economic growth (SDG 8); inequality (SDG 10); ocean, seas, and marine resources (SDG 14); and a global partnership for sustainable development (SDG 17). Agriculture plays a major role, particularly in ASEAN, in enabling the conditions for facilitating structural transformation, mobilising different sources of finance, and ensuring job creation and social inclusion (Bellman and Tipping, 2015). However, to ensure that the potential of agricultural trade is used optimally to achieve sustainable development and build resilient systems, it is important to reinforce the trading system and ensure that resilience considerations are mainstreamed in trade policies and SDG strategies (Kuwornu, 2017).

The key questions that need to be addressed are:

- What opportunities does trade offer to enable the achievement of the SDGs related to agriculture, fisheries, food security, and nutrition?
- How should disaster risks be managed to ensure that the beneficial effects of agricultural trade are shared equally by countries and populations?
- What could be the effect of plurilateral and regional trade agreements in the agricultural trade framework? Could this support further the implementation of the SDGs?

In this chapter, it is argued that the most effective path for implementing the SDGs in the ASEAN region is to mainstream climate change and disaster resilience goals directly into planning for SDG targets and negotiating agriculture trade pacts. Mainstreaming in this study refers to the incorporation of disaster and climate risks into other policies, programmes, management systems, or decision-making structures that are not necessarily about climate change or disaster but actions and programmes on targeted SDGs and free trade agreements (FTAs). This allows the ASEAN community to develop an economically viable and socially engineered food security system. To understand why and how resilience can be mainstreamed into the SDGs and agriculture trade pacts, this chapter critically reviews ASEAN's current approaches for dealing with resilience issues, and analyses its capacity for mainstreaming principles and solutions on a regional scale. Then, it details the different levels of coordination needed for effective ASEAN actions in pursuit of resilience and food security, creating synergies between goals and actors.

13.2 Interlinkage Amongst Disaster Risks, Climate Change, and Food Security in ASEAN

Disaster risk is defined as 'the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity' (United Nations Office for Disaster Risk Reduction (GFDRR), 2010: 17). On the other hand, resilience is the ability of communities to respond appropriately to natural hazards, lowering the disaster risk (ASEAN, 2016). Currently, disaster risk is a threat to food security in AMS. Food security exists when all people, at all times, have access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2015). Underlying this definition of disasters and food production are a number of variables that contribute to the economic conditions that signify the existence of food security.

ASEAN food systems – both agriculture and aquaculture – will be heavily affected by the onset of climate change, the rise in temperature, and the increased intensity and frequency of disasters. Table 13.1 presents the predictions for changes in agricultural production in Southeast Asia under the effect of a global temperature increase. In terms of agriculture and aquaculture production, even a few degrees of change in temperature can make a difference for food security in ASEAN.

Table 13.1: Effect of Climate Change on Food Production, 2025

Mean global temperature increase (°C)	Agriculture production change	Aquaculture production
1.0	0.82	(0.12)
1.3	0.00	(0.28)
1.8	(0.82)	(1.39)
2.8	(1.58)	(1.17)
4.0	(2.62)	(1.83)
4.2	(2.78)	(2.04)
5.2	(4.78)	(3.15)

( ) = negative.

Source: Darwin (2001).

The current aim, as defined by the Paris Agreement, is to limit global warming to 1.5°C above pre-industrial levels. As the changes in production levels indicate, for ASEAN, this is the limit at which the effect becomes assuredly negative on agricultural production. After this, not only do both aquaculture and agriculture production decline, but they decline at a much higher rate for smaller changes in temperature. Moreover, climate change mechanisms include feedback processes such as ocean temperature, biodiversity changes, and carbon fertilisation, which amplify small temperature changes into bigger changes in agricultural production. Therefore, while aiming for 1.5°C stabilisation, ASEAN needs to prepare for potentially higher changes in temperature, which require important changes in food production systems and their efficiency in trade.

Tables 13.2 and 13.3 show that ASEAN agriculture is dominated by a few major crops such as rice. Apart from Brunei Darussalam, Malaysia, and Singapore, food security in other countries is related to paddy cultivation. Only a few countries, such as Thailand, Viet Nam, and to a certain extent Myanmar, seem to be constantly able to produce sufficient rice to feed their populations and have excess to export. In Brunei and Singapore, rice production is insignificant, so the policy for maintaining food sufficiency is straightforward – import from other countries. Malaysia and the Philippines are also rice-deficit countries, despite the considerable amount of rice production each year, so they need to import rice to meet domestic demand.

Table 13.2: Main Agricultural Products in ASEAN

Country	Main agricultural products
Brunei Darussalam	Indigenous chicken meat, hen's egg in shell
Cambodia	Rise, cassava
Indonesia	Rice, palm oil, natural rubber
Lao PDR	Rice, fresh vegetables
Malaysia	Palm oil, indigenous chicken meat, palm kernels
Myanmar	Rice, dry beans, indigenous chicken meat
Philippines	Rice, indigenous pig meat, bananas, coconuts, sugarcane
Singapore	Hen's egg shell, other bird's egg in shell
Thailand	Rice, natural rubber, cassava, sugarcane
Viet Nam	Rice, indigenous pig meat, green coffee

Lao PDR = Lao People's Democratic Republic.

Source: FAO (2015), FAOSTAT Agriculture Emissions Database. Rome: Food and Agriculture Organization of the United Nations. www.fao.org/faostat/en/#data/GT (accessed 8 April 2019).

As export rice is only cultivated in a few countries, ASEAN depends heavily on local producers. To safeguard food security in ASEAN, the region needs to protect production and distribution systems from the effects of climate change and natural disasters. Moreover, both soft and hard infrastructure allowing intra-regional and international trade can compensate for losses caused by disasters that are geographically distributed across national boundaries and their impacts across borders.

Table 13.3: Rice Production in ASEAN Member States, 2015

Country	Production ('000 tons)	Import ('000 tons)	Export ('000 tons)	Domestic Supply ('000 tons)	Stock Variation* ('000 tons)
Brunei Darussalam	1	330	0	343	12
Cambodia	5,010	82	4,720	83	(289)
Indonesia	51,412	7,786	293	56,031	(2,874)
Lao PDR	2,428	53	23	2,014	(444)
Malaysia	1,667	6,156	337	7,379	(107)
Myanmar	22,427	151	573	20,338	(1,667)
Philippines	17,569	5,068	46	20,645	(1,946)
Thailand	25,275	1,816	10,065	15,645	(1,381)
Viet Nam	28,279	2,192	4,651	24,557	(1,263)

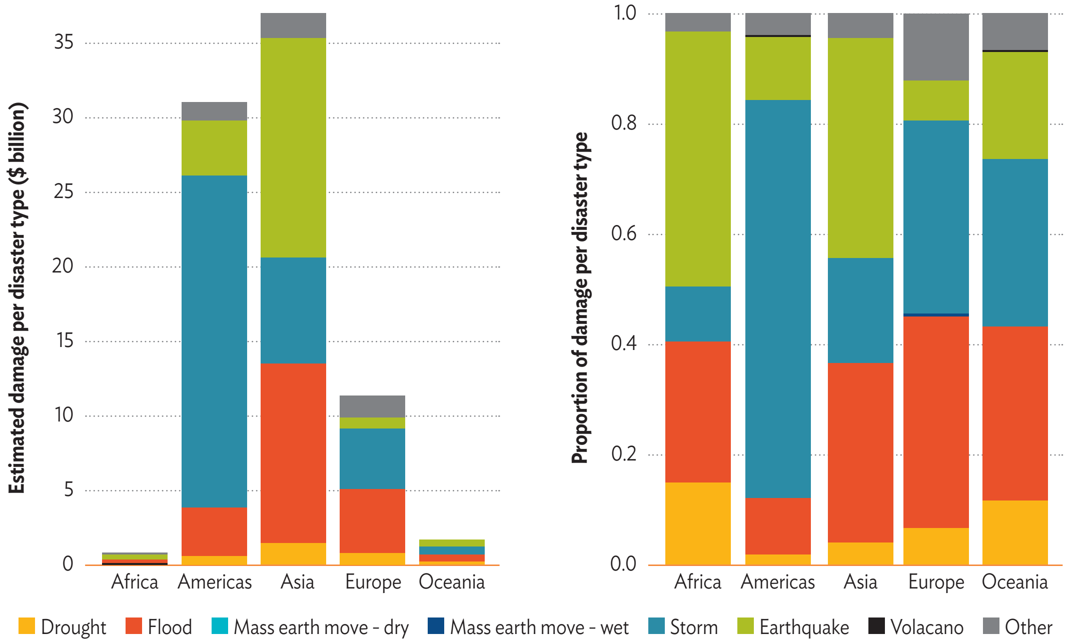
( ) = negative, ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

* Stock variation = [export + domestic supply] – [production + import].

Source: FAO (2015), FAOSTAT Agriculture Emissions Database. Rome: Food and Agriculture Organization of the United Nations. www.fao.org/faostat/en/#data/GT (accessed 8 April 2019).

Figure 13.1 shows the average annual damage caused by the natural disasters reported in the last century. There are different types of disaster events. ASEAN is more impacted by floods, storms, droughts, and earthquakes. According to the latest reports of the Global Climate Risk Index (2019), which ranks countries based on the impact of past extreme weather events such as floods and droughts, AMS have been some of the most exposed.

Figure 13.1: Average Annual Damage Caused by Reported Natural Disasters, 1900–2010 ($ billion)



Source: Modified from Centre for Research on the Epidemiology of Disasters (2017), EM-DAT – The International Disaster Database. https://www.emdat.be/database (accessed 25 January, 2019).

Four ASEAN countries rank amongst the most affected worldwide: Myanmar (2nd), the Philippines (4th), Viet Nam (7th), and Thailand (9th). The Global Water Partnership highlights similar trends. For example, Myanmar, Thailand, and Viet Nam are amongst the top 10 countries for flood risk exposure. Moreover, several studies (ADB, 2013; Anbumozhi and Reddy, 2015; World Bank, 2014) show strong evidence of ASEAN's growing vulnerability to climate change and disasters, and recommend a more comprehensive response to weather-related disasters. Recent major catastrophes – the 2008 Nargis cyclone in Myanmar, the 2011 floods in Thailand, the 2013 Typhoon Haiyan in the Philippines, and the 2015/16 El

Niño droughts in Viet Nam – have highlighted the impact of climate-induced disasters and their interlinkages to food security.

13.3 Interconnectedness of Resilience, Food Security, and Agricultural Trade

Natural disasters can have an impact on different stakeholders of the food supply chain, which has various entities such as food processing and packaging units, food distribution channels, retailers and grocers, and food processing houses. The value chain of food production starts with farmers and usually ends with consumers, who have less control over produce and the parameters that affect crop production. Any adverse impact on food production, such as climate-induced disasters, strikes the producers first – stopping food production temporarily in its first stage and blocking the food supply chain. However, disasters can also impact consumers through increased prices, disseminated at different stages of the post-recovery period. Finally, disasters can affect infrastructure and stop the transport of agricultural production to consumption areas. All in all, attempts to make more resilient food systems target improving the adaptive capacity of all stakeholders along the supply chain.

One of the measures to deal with the adverse impacts of disasters on agricultural production, at the regional level, is the ASEAN Plus Three Emergency Rice Reserve, through which countries pool rice reserves as a buffer against potential disasters (ASEAN, 2008). This way, even when agricultural production decreases because of unexpected weather events or fluctuations in supply occur, emergency provisions are available, assuming the transport infrastructure is made available immediately. However, as shown in Table 13.4, the quantities earmarked for the emergency rice reserve are inadequate to deal with the needs of the region. Individual countries' stock variations are shown in Table 13.3. Further, since the implementation of the ASEAN food security reserve in 1979, its amount has not increased sufficiently to reach the level necessary to ensure food security or improve the vulnerability of value chains against disasters. Because of the insignificant volume of the rice reserve and the difficult delivery request procedures, the reserve has very rarely been used, even during the 2008 food crisis.

Table 13.4: The ASEAN Food Security Reserve System

Country	Earmarked quantity (tons)
Brunei Darussalam	3,000
Cambodia	3,000
Indonesia	12,000
Lao PDR	3,000
Malaysia	6,000
Myanmar	14,000
Philippines	5,000
Singapore	5,000
Thailand	15,000
Viet Nam	14,000
ASEAN	**87,000**

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Source: ASEAN (2016), Intra- and Extra-ASEAN Trade, 2015. Jakarta: ASEAN Secretariat. https://asean.org/storage/2016/11/Table18_as-of-6-dec-2016.pdf (accessed 9 April 2019).

There are several reasons for that. For Thailand and Viet Nam, the main exporters in the region, the reserve option seems to be complicated. As much as the governments would like to earn foreign revenue by exporting rice, they have to bear in mind that domestic rice farmers can be affected by rice price volatility in the global market as a result of disasters. The governments' desire to ensure that domestic consumers do not suffer because of exports has resulted in various trade-restrictive practices. A summary of the policy measures taken by ASEAN governments to tackle the impact of the 2008 food crisis is in Table 13.5.

Table 13.5: Policy Measures Taken by ASEAN Governments to Tackle the 2008 Food Crisis

Strategy	Policy Measure		Cambodia	Indonesia	Malaysia	Philippines	Thailand	Viet Nam
Consumer oriented	Tax	Customs duty						
	Social support	Food assistance						
		Subsidies		X		X		
		Safety net						
	Market	Price control		X	X			
		Release stocks	X		X		X	
		Food procurement						
Producer Oriented	Production support	Producer credit		X	X	X		
	Market management	Minimum producer price			X	X		
Trade Oriented	Import	Tariff		X				
	Export	Quantity control	X	X				X
		Export price control through tax		X	X	X		

ASEAN = Association of Southeast Asian Nations.

Source: Authors (2018).

Various goals and policies on food security, resilience, and trade – when implemented simultaneously by the government of each country – can be far from complementary to each other. For example, Viet Nam's decision to restrict rice exports during the food crisis in 2008 served to worsen the food shortage situation in importing countries such as the Philippines. This suggests that ASEAN needs more effective mechanisms to achieve resilience and integrate with agriculture trade policies.

Food security is usually affected by climate-induced factors on one hand and trade facilitation factors on the other. AMS can act on the side of agriculture trade both to lessen vulnerability and exposure and to limit the impact of development on anthropogenic climate change. Agriculture trade flows frequently depend on the interaction between comparative advantage in food production – which is determined not only by climate change and disaster risks but also resource endowments such as land, water, and other inputs – and a wide-ranging set of local, regional, and national trade policies. Since adaptation to climate change and disaster-resilient measures result in new patterns of food production, agriculture's comparative advantage also changes, setting up the possibility of a change in trade flows as producers respond to changing constraints and opportunities (Yamaji, 2017). As with any change in comparative advantage, free trade allows comparative advantage to be more fully exploited in favour of market conditions and consumer behaviour. Trade restrictions risk worsening the effects of climate change and disasters while reducing the ability of producers and consumers to adjust. It is also important to point out that if climate change and disasters reduce the productivity of some crops in ASEAN and do not increase productivity in other regions, trade cannot fully compensate for the reduction in food security.

13.4 Opportunities to Enhance Resilience with Current Agriculture Trade Pacts

The treatment of climate and disaster risks in FTAs reflects the view that trade can, when well designed, contribute to sustainable growth. ASEAN's economic prosperity could be attributed to its openness to free trade (Baldwin and Kawai, 2013). During 1999–2009, regional trade in agriculture grew almost threefold to reach $1 billion (ASEAN, 2009). Starting in the early 1990s, successive ASEAN FTAs have pushed for economic integration between member states and with close trading partners (Table 13.6). This is due to a reduction in tariff barriers in real sectors and an overwhelming share of economic growth and a change in food consumption. This trend is likely to continue in the coming decades as income and the urban population continue to grow, often accompanied by a change in diet. The largest demand in the region will come from Indonesia, Thailand, and the Philippines, which are expected to exhibit a trade deficit for all commodities in 2025.

Table 13.6: ASEAN Free Trade Agreements

Name of agreement	Acronym	Year established	Tariff reduction deadline
ASEAN Free Trade Area	AFTA	1992	2020
ASEAN–China Free Trade Area	ACFTA	2002	2018
ASEAN–Korea Free Trade Area	AKFTA	2005	2046
ASEAN–India Free Trade Area	AIFTA	2010	2023
ASEAN–Japan Comprehensive Economic Partnership	AJCEP	2008	2018
ASEAN–Australia New Zealand Free Trade Area	AANZFTA	2010	2020

ASEAN = Association of Southeast Asian Nations.

Source: ASEAN (2012).

In the case of natural disasters, such trade links provide other sources of agricultural production uncertainties as well as alternate outlets for production in the areas, resulting in severe impacts on consumer prices. Moreover, the trade pacts push countries to build better soft and hard infrastructure for transporting goods – mitigating the possible impact of natural disasters and encouraging trade partners' cooperation. Therefore, one could say that the gradual trade integration observable in ASEAN provides resilience to the region as a whole by protecting food supply chains in a comprehensive way. Table 13.7 shows the state of intra-ASEAN trade links in 2015, against trade with countries outside the region. While the total trade volume varies across the countries, intra-ASEAN trade is lower than the volume of trade with partners outside the region.

Table 13.7: Inter- and Intra-ASEAN Trade Values in 2015

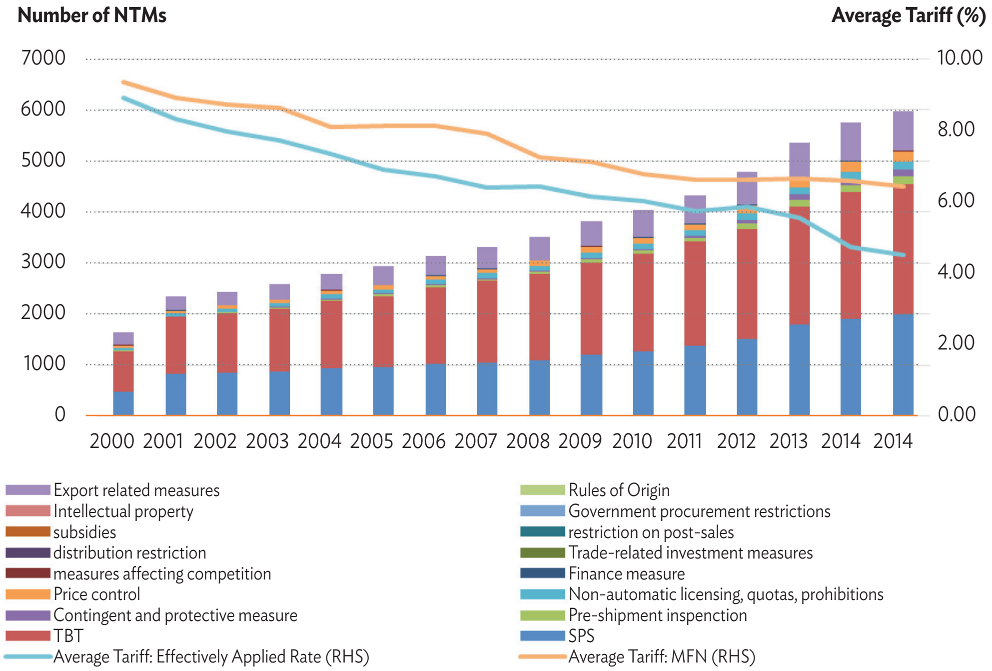
Countries	Intra-ASEAN trade		Extra-ASEAN trade		Total trade ($ million)
	Value ($ million)	Share of total trade (%)	Value ($ million)	Share of total trade (%)	
Brunei Darussalam	2,645	27.6	6,947	72.4	9,592
Cambodia	4,462	22.7	15,214	77.3	19,676
Indonesia	63,610	21.7	229,452	78.3	293,061
Lao PDR	4,357	64.4	2,407	35.6	6,763
Malaysia	102,848	27.4	272,321	72.6	375,169
Myanmar	11,467	39.4	17,637	60.6	29,104
Philippines	25,601	19.9	103,343	80.1	128,944
Singapore	182,051	27.5	481,059	72.5	663,109
Thailand	104,821	25.1	312,327	74.9	417,147
Viet Nam	41,891	12.8	285,853	87.2	327,744
ASEAN	**543,751**	**24.0**	**1,726,559**	**76.0**	**2,270,310**

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Source: ASEAN (2016), Intra- and Extra-ASEAN Trade, 2015. Jakarta: ASEAN Secretariat. https://asean.org/storage/2016/11/Table18_as-of-6-dec-2016.pdf (accessed 9 April 2019).

Intra-regional trade has been very dynamic in ASEAN, however, growing at an average of 10% a year – twice the pace in other regions (International Monetary Fund, 2016). Regional integration in ASEAN has been largely driven by the removal of tariff measures. The most favoured nation tariffs are progressively getting low (Figure 13.2).

Figure 13.2: Average Tariffs and NTMs in ASEAN



ASEAN = Association of Southeast Asian Nations, MFN = most favoured nation, NTM = non-tariff measure, RHS = rural household survey, SPS = sanitary and phytosanitary, TBT = technical barrier to trade.

Source: Ing and Cadot (2016).

Ing and Cadot (2016) analysed the tariff barriers and non-tariff measures (NTMs) and found that many NTMs stem from non-trade policy objectives such as food safety or environmental protection. To enhance regional security, they highlighted the need to streamline accompanying trade distortions in the form of rules of origin and NTMs such as sanitary and phytosanitary regulations and to remove export subsidies. Many countries have no intention of dismantling these measures. Meanwhile, export subsidies and NTM restrictions remain a major source of trade distortion, undermining investment in climate-smart disaster-resilient agriculture practices in ASEAN countries. Policy options for climate-smart and resilient agriculture include improved access to information, the availability of extension services, and price mechanisms with short- and medium-term targets (Table 13.8).

Table 13.8: Climate-Smart Options to Improve the Resilience of Agriculture Systems

Adaptation / Resilience Measure	Policy option
Crop insurance for risk coverage	Improved access to information, risk management, and revised pricing incentives
Near-term actions (5–10 years)	Rise, cassava
Crop/livestock diversification to increase productivity and protect against diseases	Availability of extension services, financial support, etc.
Adjust timing of farm operations to reduce risk of crop damage	Extension services, pricing policies, etc.
Changes in cropping pattern, tillage practices	Extension services to support activities, police adjustments
Modernisation of irrigation structures	Promote water-saving technologies
Efficient water use	Water pricing reforms, clearly defined property rights
Risk diversification to withstand climate shocks	Employment opportunities in non-farm sectors
Food buffers for temporary relief	Food policy reforms
Redefining land use, and tenure rights for investments	Legal reforms and enforcement
Medium-term targets (2030)	Rice, indigenous pig meat, green coffee
Development of crop and livestock technology adapted to climate stress: drought and heat tolerance, etc.	Agriculture research (cultivar, fish, and livestock trait development)
Develop market efficiency	Invest in rural infrastructure, remove market barriers, property rights, etc.
Irrigation and water resources consolidation	Investment by public and private sector
Promoting regional trade in stable commodities	Pricing and exchange rate policies
Improving early warning/forecasting mechanisms	Information and policy coordination across the sectors
Capacity building and institutional strengthening	Targeted reforms on existing institutions on agriculture and implementation of skill development programmes

Source: Anbumozhi and Reddy (2015).

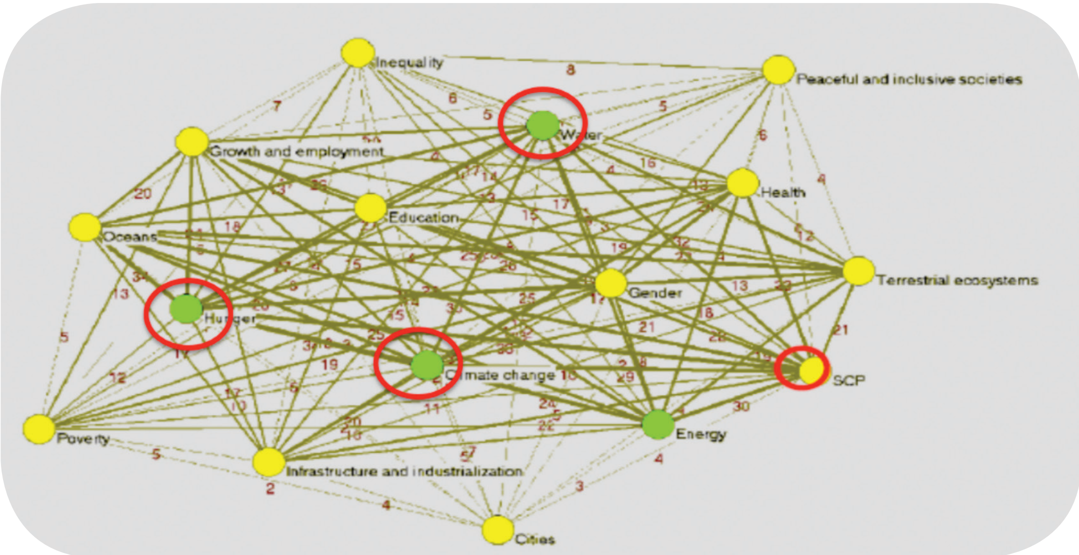
Some of the support programmes for the above climate-smart options in Indonesia, Malaysia, and Thailand appear to be designed to rectify problems arising from historical low productivity in the agriculture sector and to reduce the large disparity between urban and rural income. Current agriculture trade negotiations aimed at reducing tariffs and NTMs do not give due consideration to the technology and investment that target resilient agriculture. Moreover, regional trade agreements often exclude sensitive food products, which have more NTMs. Walz (2014) estimated that on average regional trade agreements increase agriculture and food exports from 32% and 48% when fully phased in.

In summary, food systems in ASEAN are threatened by climate change and growing disaster risk, but can be protected through smart trade policymaking. Current projects, such as the ASEAN Emergency Rice Reserve and the ongoing work of trade integration in the region, are moving in the right direction. However, there are still many policy options for ASEAN, which require mainstreaming of resilience into the SDGs.

13.5 Advancing Resilience and Trade Agendas in the Sustainable Development Goals

The 17 SDGs adopted in 2015 establish a set of highly ambitious goals and targets touching on a broad range of issues from food security to resilience. Taken together, they provide a critical framework for policy orientation for the next 11 years. In the absence of new international financial commitments, trade and more importantly policies that affect trade flows will have a significant role to play in the implementation process. Goal 2 mainly deals with food security, while Goal 13 is concerned with climate change issues. However, it would be a grave mistake to think of dealing with each development goal individually because they are all interlinked. Figure 13.3 links the different goals by the number of targets they share.

Figure 13.3: Interlinkages Between Climate Change, Hunger, Water, and Sustainable Consumption Related SDGs



SDG = Sustainable Development Goal.

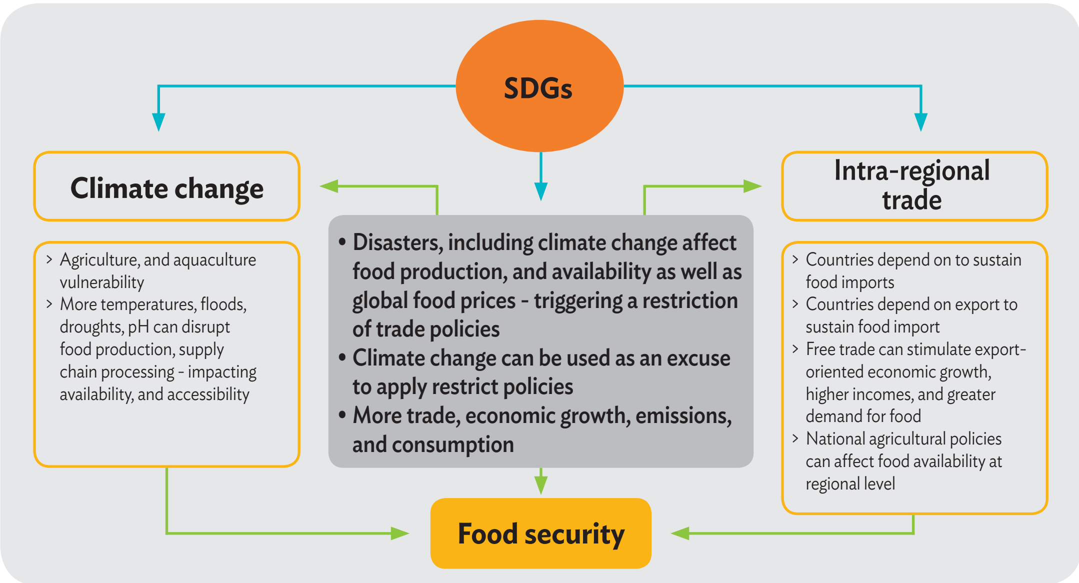
Source: ERIA (2017).

The linkages between SDGs show that dealing with them as a whole can be a source of positive externalities, as opposed to dealing with them individually and risking undermining other goals for the benefit of one goal in particular. To mainstream resilience building most effectively, it is important not just to fit the action into a single development goal but to understand how it relates to many of the goals – positively or negatively.

To achieve these goals in a cost-effective and timely manner, there is a need for a change in policies that provides access not only to food but also to land, inputs, knowledge and financial services, and market opportunities for value addition. These policies should also call for investments in resilient infrastructure, agriculture extension services, research and development, and measures to ensure the proper functioning of food commodity markets; and openness to trade that limit extreme price volatility within ASEAN.

Food security and liberalisation of trade are often mistakenly thought of as antagonistic interests, even though we showed earlier that liberalisation of trade is an important support for food systems in the wake of a disaster. Figure 13.4 shows some ways in which climate change, food security, and trade-related SDGs interact.

Figure 13.4: Nexus Between Disaster Risks and Trade as Perceived through the SDGs



SDG = Sustainable Development Goal.

Source: Authors (2018).

The SDGs crown the diagram because their success depends on the development of the economic system, but also the attainment of food security even in the face of climate change. The nexus of all these interests is a complicated mechanism which requires looking into all the possible interactions.

Advancing the SDG target of reducing trade-distorting support will therefore have to happen to enhance resilience. A first step might consist of eliminating export restrictions. The cost of locking into this policy commitment would be minimal as these measures do not retard the competitiveness of the domestic agricultural production. Another relatively easy policy option could be limiting export restrictions by ensuring that such measures do not affect the purchase of food for humanitarian purposes during disasters. As with the previous proposal, the cost of implementing this idea would be minimal, but it would help build trust and facilitate further engagement towards food security. A third measure is the prioritising of eight types of NTMs in the region and addressing them in a progressive and cost-effective way.

The SDGs, as a central preoccupation of development planning in Southeast Asia, are mentioned in each of the three blueprints of the ASEAN community – the ASEAN Economic Community, the ASEAN Socio-Cultural Community, and the ASEAN Political-Security Community. As illustrated in Table 13.9, the three ASEAN community blueprints show synergies and a nexus amongst different ASEAN mechanisms in reaching the SDGs. It is important to foster communication between the different ministries and councils of ASEAN to coordinate their actions and planning for different goals. All in all, the SDGs are a collection of goals which must be dealt with not just individually but also by understanding the interlinkages between different interests and fostering communication between the different agencies in charge of planning development policies. From the point of view of food security in ASEAN, it is especially interesting to find the nexus between the SDGs, food security, and the development of trade.

Table 13.9: Synergising the SDGs with the ASEAN Community Pillars

SDGs	Occurrence in the blueprints of ASEAN community			Corresponding mechanisms
	AEC	APSC	ASCC	
Goal 1 (Poverty)	x		x	Ministers' meeting of rural development and poverty eradication
Goal 2 (Hunger)	x		x	Ministers' meeting on agriculture and forestry
Goal 3 (Health)			x	Ministers' meeting on health development
Goal 4 (Education)			x	Ministers' meeting on education
Goal 5 (Gender)			x	ASEAN meeting on women
Goal 6 (Water)			x	Ministers' meeting on the environment
Goal 7 (Energy)	x			Ministers' meeting on energy
Goal 8 (Work)	x		x	Ministers' meeting on labour
Goal 9 (Innovation)	x		x	ASEAN committee on science and technology
Goal 10 (Inequality)			x	IAI task force (narrowing development gaps)
Goal 11 (Cities)	x		x	Ministers' meeting on development planning
Goal 12 (Consumption)	x		x	Ministers' meeting on the economy
Goal 13 (Climate)	x		x	Ministers' meeting on the environment
Goal 14 (Ocean)		x		Ministers' meeting on maritime issues
Goal 15 (Land)			x	Ministers' meeting on land and infrastructure
Goal 16 (Peace)		x		Ministers' meeting on foreign affairs
Goal 17 (Partnership)	x	x	x	All sectoral bodies

AEC = ASEAN Economic Community, APSC = ASEAN Political-Security Community, ASEAN = Association of Southeast Asian Nations, ASCC = ASEAN Socio-Cultural Community, IAI = Initiative for ASEAN Integration, SDG = Sustainable Development Goal.

Source: Authors (2018).

When so many objective actions towards SDGs are at stake, the question of how to identify possible interactions, trade-offs, and co-benefits is crucial. Both development pathways and trade policies need to be designed while keeping in mind inter-sectoral interactions, trade-offs, and co-benefits. These can be found by identifying and benchmarking existing best practices, e.g. in the 2030 Sustainable Development Agenda. More importantly, however, this is where the role of science and thinking outside the box comes into the equation. Through scientific research and looking into innovative ideas, we can eliminate negative externalities and create synergies between the different goals, such as SDGs and trade liberalisation goals. In summary, mainstreaming and implementing resilience building can be done effectively in the region if the nexus between SDGs, trade, and food security is correctly identified and researched, to avoid undermining goals while trying to reach others, and encourage possible and innovative synergies between different development goals in the region. This is only possible if the different actors in charge of planning for and reaching development goals communicate and coordinate their actions.

13.6 Enhancing the Capacity of ASEAN through the SDG Nexus Approach

The ASEAN Socio-Cultural Community framework in resilience was formed by a number of thematic guidelines and policy options for countries that wish to improve their adaptation capacities. The challenging part is that while countries struggle to deal with imminent threats in the form of short-term actions, there is less capacity to plan for long-term actions, especially because the information is still incomplete about the long-term effects and impacts of climate-induced disasters. Working together within the framework of ASEAN allows policies to take into account the broader context and a larger time frame, while pooling resources for research and information gathering. Another difficulty with resilience policies is that every country is limited in its actions by several factors that affect disaster resilience. The box lists the five defining factors for improving the adaptive capacity of ASEAN.

Box 13.1: Defining Factors of Resilience in Food Value Chain

- **Scale factors** – whether producers and consumers can adapt to disruption up to a certain population or geographic scale, with elements breaking down beyond that point
- **Scope factors** – whether the producers and consumers can adapt to disruption for particular types of inputs to a certain level, with elements breaking down beyond that point
- **Temporal factors** – whether the producers and consumers can manage a resilient response to a disruption for a certain period, with elements breaking down beyond that point

- **Distributional factors** – whether the supply chain is resilient for some sections of the community rather than others (e.g. low-income households and tourists)
- **Industry factors** – whether some sections of the industry, by function or product type, are less resilient than others given their particular circumstances, and any dependence across industries

Clearly, every ASEAN member country has its strengths and weaknesses in different factors, and should look at their particular context to know what to prioritise. Working together as ASEAN allows countries to point out their differences and share information about effective policies with which to address their particular weaknesses.

AMS can also support each other when faced with an emergency, increasing certain factors of resilience in a way that is impossible to achieve when acting as a single country.

As discussed earlier, mainstreaming disaster risks through the above five defining factors through a nexus approach will bring tangible benefits. For disaster risk and climate issues to be mainstreamed, it is possible to categorise the constraints into three groups: (i) information gaps, (ii) capacity gaps, and (iii) financing gaps. The capacity-building needs under each category of challenges, as derived from stakeholder consultation (Economic Research Institute for ASEAN and East Asia (ERIA), 2017), are presented in Tables 13.10a, b, and c to mainstream climate change and disaster issues successfully in the region.

Table 13.10a: Information Gaps and Capacity-Building Needs for Enhanced Resilience

Challenges and Gaps	Capacity Needs
• Imbalances between supply and demand for information to support mainstreaming at all levels of government • Lack of horizontal and vertical information flow • While national level information is available to support decision making, at local levels, information is lacking with respect to generating, managing, and using information • Monitoring, reporting, and accountability are not sufficiently linked to disaster risk and climate change objectives	• Improved data collection, analysis, and dissemination to all stakeholders • Ensuring timely information generation and exchange across sectors, amongst departments and subnational level stakeholders • Ensuring public access to research information and reports • Local level disaster and climate information management, analysis, and application • Systems to hold implementing agencies accountable for achieving goals

Source: ERIA (2017).

Table 13.10b: Decision-Making Capacity and Capacity-Building Needs for Enhanced Resilience

Challenges and Gaps	Corresponding Capacity Needs
• Predominance of sector-based planning • Visions, policies, and plans are mostly short-term and do not consider the long-term perspective • Planning tends to be budget-driven rather than mission-driven, thereby perpetuating sector planning • Insufficient evidence-based planning • Process of engaging stakeholders in planning is not well established • Insufficient opportunities for international cooperation and sharing best practices in mainstreaming resilience	• Structures and process to require cross-sectoral, integrated planning • Process to institutionalise integrated planning and multi-perspective analysis • Systems and process to decentralise policy making and planning process effectively and efficiently for improved vertical communications • Development of indicators and data sets to support evidence-based planning • Creation of networks and communities of practices to support mainstreaming process

Source: ERIA (2017).

Table 13.10c: Financial Capacity and Capacity-Building Needs for Enhanced Resilience

Challenges and Gaps	Capacity Needs
• Inadequate funding to support mainstreaming • Financing gaps to implement SDGs, Sendai commitments, and climate change adaptation plans • Insufficient private sector investments in pursing resilient infrastructure options	• Improved capacity of sectoral agencies to communicate the importance of mainstreaming to the political level. • Capacity to design investment packages that derive co-benefits by exploiting the linkages • Evidence-based resource allocation and investment prioritisation • Greater private sector engagement in SDG policy formulation and programme development • Improved incentive package and ability to encourage private sector involvement

SDGs: Sustainable Development Goals.

Source: ERIA (2017).

This programme of action is quite comprehensive, and it is understandable that individual countries in ASEAN could struggle with implementing all of it. To lower the cost of these investments for individual countries, it is important to foster communication between member states and find possible synergies between disaster management goals and other interests of the region.

To obtain the maximum benefit from this nexus approach, AMS should pool their resources and look at the broader picture, both in terms of goals and time frame. ASEAN can work to fill in the knowledge, capacity, and finance gaps that will allow the mainstreaming of resilience issues into policymaking on a regional basis. However, to mitigate the cost of integrating those issues, we need to understand the possible synergies between resilience and other goals of development policies.

13.7 Conclusion

The resilience and trade-related targets included in the SDGs are not fundamentally new for ASEAN, as they tend to repeat earlier commitments made by member states which have substantial implementation deficits. As governments start implementing the 2030 agenda, the relevance of resilience and full trade liberalisation must be assessed in a strategic and selective way. Critical capacity-building needs for improving resilience and trade facilitation will require policy coordination at different levels. In the past, regional responses to make adaptive and resilience measures against climate change and disasters were progressive, but elusive of achieving the targets. As governments attempt to design new terms of policy engagement through SDGs and FTAs, food security will become a cost-effective solution.

To lower costs and augment the benefits of this mainstreaming process, two sorts of coordination will prove crucial: (i) finding the nexus between existing targets of ASEAN planning, such as SDGs and agriculture trade pacts, with goals for natural disaster resilience; and (ii) coordinating the member countries amongst themselves and with public and private actors inside the countries. Through this coordination, the principles of resilience building can be directly included in ASEAN mechanisms for regional economic development and protect ASEAN food systems in a durable way by adapting to new developments of climate change as they happen.

As a conclusion, this paper proposes a six-point agenda for policymakers, which gives entry points for the nexus approach to the mainstreaming process:

1. **Alignment with national planning and policy frameworks.** This is about figuring out the context the government or planning agency has to deal with, and how to integrate disaster resilience planning with existing policies and mechanisms.
2. **Identifying trade-offs and co-benefits for evidence-based actions.** This point is to be based on scientific research to understand which interests and issues are likely to create trade-offs with disaster resilience or have the potential to create co-benefits.
3. **Accelerating frameworks with interlinkages and efficiencies.** Once issues with potential co-benefits are identified, this point relies on research and out-of-the-box thinking to find innovative policies to tackle related issues effectively together.

4. **Benchmarking with SDGs, the Sendai Framework, the Paris Agreement, and FTAs such as the Regional Comprehensive Economic Partnership.** This point uses the existing literature and global commitments to find best practices and benchmark existing solutions for disaster resilience, which can be adapted to the situation at hand.
5. **Integrating climate change adaptation, disaster risk reduction, and trade pacts.** This point emphasises the role of trade negotiations in mainstreaming issues related to climate change, such as food security.
6. **Horizontal and vertical policy coherence.** This is about making sure actors at all levels of the public and private spheres are included in the mainstreaming process, for better information flows and implementation of policies.

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