Chapter 7

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

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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

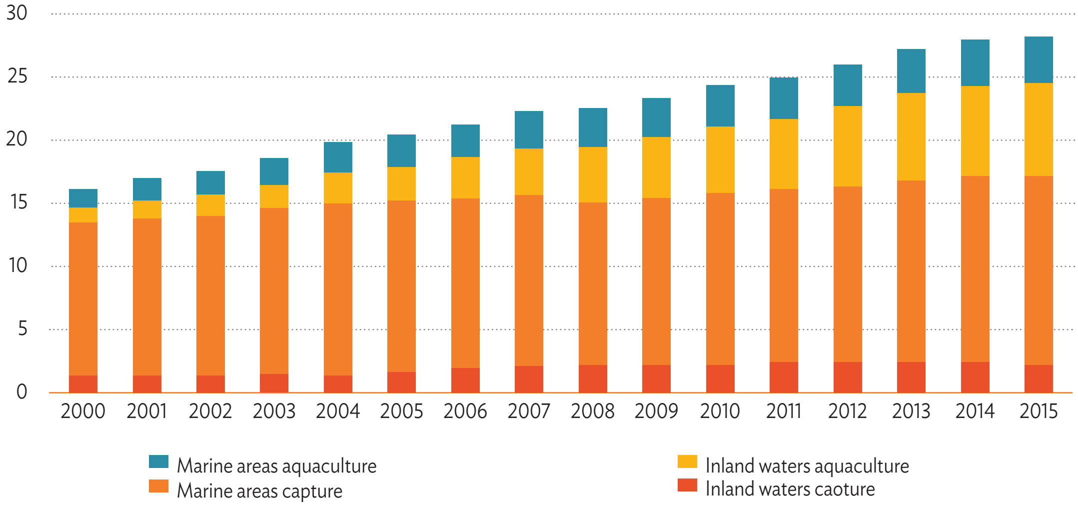
ASEAN Member State	Per capita fish consumption (kg)	Fish production (metric ton)	Estimated number of fishers
Brunei Darussalam	31.46	2,44	523
Cambodia	32.04	471,000	-
Indonesia	37.70	9,052,127	2,231,967
Lao PDR	24.86	145,687	99,617
Malaysia	63.30	1,753,310	140,358
Myanmar	64.40	3,168,630	3,201,923
Philippines	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

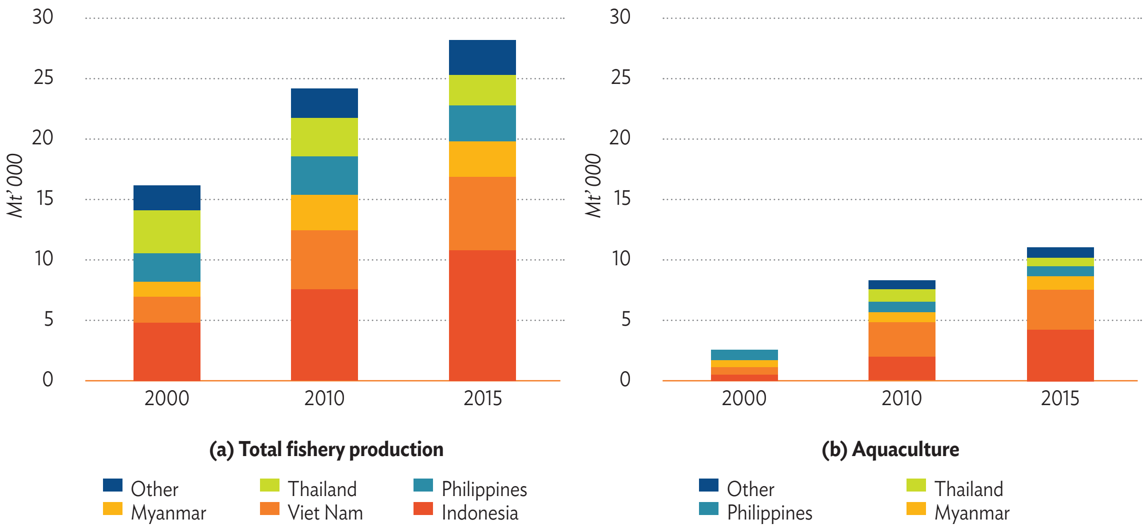
Marine capture fishery production in ASEAN increased slightly (1.6%) from 2000 to 2015, compared with the 11% average increase in value during the same period. In 2015, Indonesia remained the largest producer, accounting for 33.8% of the region's total production volume, followed by the Philippines (16.3%), 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

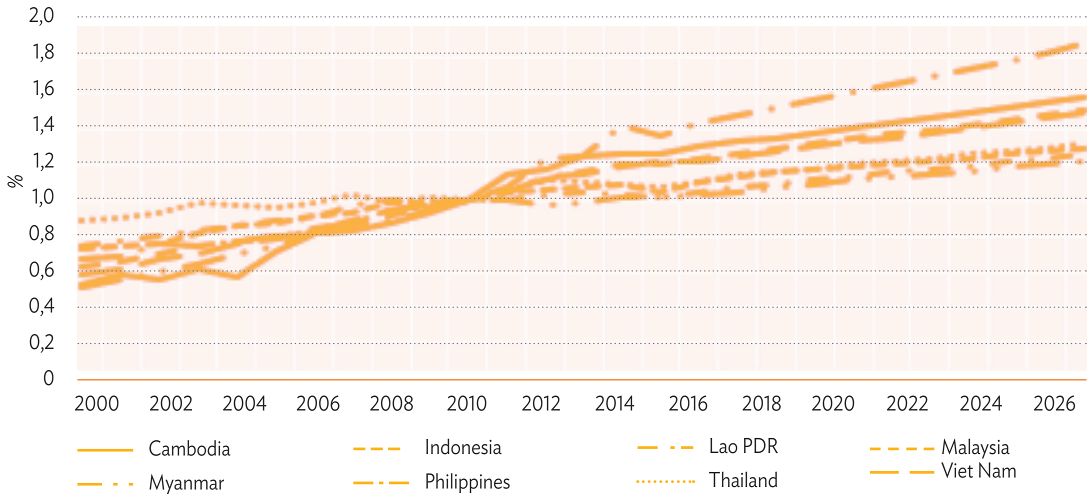
The main equipment for marine fishery harvest in ASEAN is trawling and purse seine nets. Although all ASEAN countries still use driftnets and bottom gillnets, pole and line, as well as jigging in coastal fisheries, most marine capture fishery production comes from trawling and purse seine nets. They 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

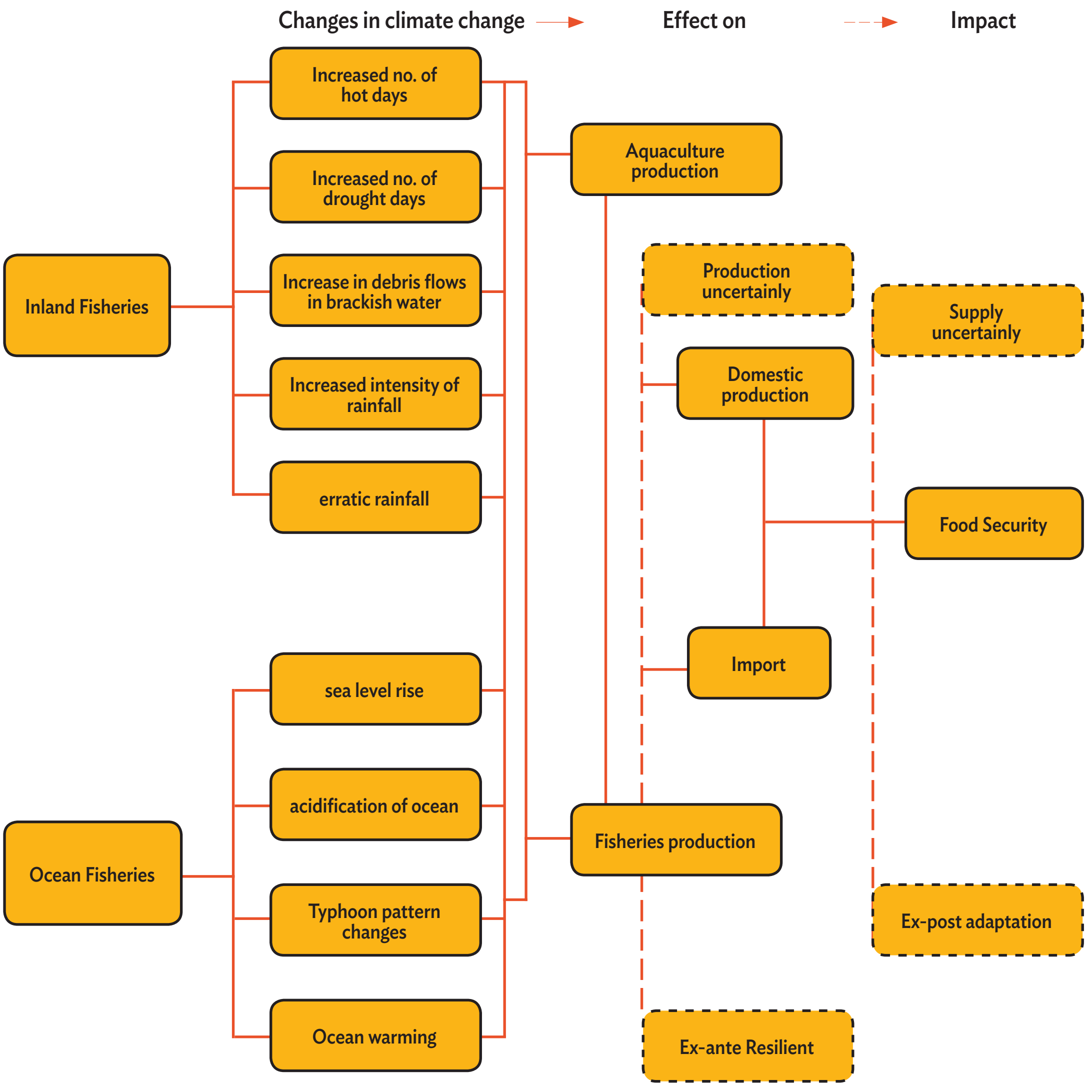
7.4.1 Cause and Implications of Disasters and Climate Change on Fish Production

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.

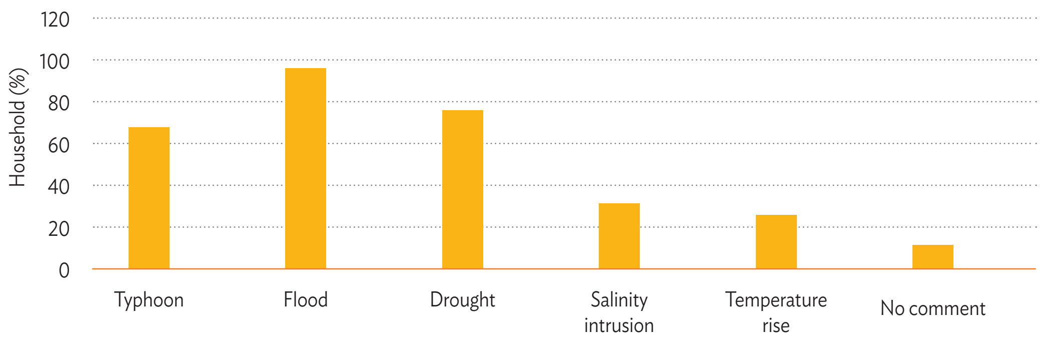
Source: Department of Agriculture and Rural Development (DARD, 2012).

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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