8. Fisheries-related Issues

8.1 Climate Change and Natural Disasters

Southeast Asia is one of the world's most vulnerable regions to climate change being in the tropics and embracing many countries that are in the so-called typhoon belt, and its people are the most at risk since a substantial portion of the populace and their economic activities are concentrated along the low-lying coastal areas. Climate change refers to changes inf climate incidences over extended periods typically ranging from decades to millions of years (IPCC, 2014). The Intergovernmental Panel on Climate Change (IPPC) reported that tchanges in many extremee weathers and climate events have been observed since 1950 (IPCC, 2014) and some of these changes have adverse impacts and are considered as disasters since they create widespread damages and serious disruptions in the normal functioning of communities or societies (IPCC, 2012). IPCC revealed evidence of observed changes in extreme cases, such as heatwaves, heavy precipitation, droughts, and tropical cyclones (IPCC, 2021b). The analysis of a multi-year time series of dissolved organic carbon exported from the tropical peatlands in the Sunda Shelf (Singapore) found that seasonal acidification is driven by 0.10 pH units and 20−30 % of such substance might be relatively refractory and exported to the open Indian Ocean (Zhou *et al*., 2021). IPCC and scientists also found that for each degree of additional global warming, the most extreme precipitation events currently recorded are anticipated to nearly double in frequency (IPCC, 2021a; Myhre *et al*., 2019). In addition, IPCC during its press conference for the 'Climate Change 2021: the Physical Science Basis' suggested that during this changing climate period, countries should not only look back at the historical data of extreme events, as new types and/or intensification of extreme events could happen more in magnitude, frequency, or timing, especially in regions that had never been encountered such events before but should also prepare for the occurrence of such events (IPCC, 2021b).

This section provides an overview of the current knowledge of climate change and its effects on fish, fisheries, and aquaculture, as well as on livelihoods, paying particular attention to Southeast Asia if and where the information is available. The following sections include reviews of the adaptation options, regional platforms and policies, national efforts to mitigate the impacts of climate change, climate-related activities undertaken by SEAFDEC, and the ASEAN Member States (AMSs).

Impacts of climate change on fish and fisheries

With extensive research studies and reviews on the impacts of climate change on fish and fisheries, major concerns still prevail, which could include: (1) changes in migratory routes of fishery resources; (2) alterations of fish reproduction and stress responses; (3) Increased risks of speciation, low survival, and immobility; and (4) habitat disruptions.

- *Changes in migratory routes of fishery resources*

Ocean warming leads to changes in species distribution and promotes multi-scale temporal and spatial changes in fish stocks (Cheung *et al*., 2013; 2016). Fish move towards colder waters resulting in increasing yields in high latitudes but decreasing catch in the tropics (Kibria *et al*., 2017). This could have adverse effects on the food security of tropical countries, especially on their small-scale fisheries sectors which are dependent on these resources.

- *Alterations of fish reproduction and stress responses*

Changes in salinity or water acidification affect the fish physiological functions especially reducing the sperm quality while changes in temperature are also directly involved in the quality of the released gametes and embryos development (Servili *et al*., 2020), especially in marine bivalves, *e.g.* oysters and mussels (Ishimatsu & Kurihara, 2011). Results of the study on heat stress in mangrove crab (*Scylla serrata*) across different sites of varying climate profiles in the Philippines, indicated population-specific differences in heat-stress responses (Shrestha *et al*., 2021).

- *Increased risks of speciation, low survival, and immobility*

Increasing sea temperatures and changes in seawater chemical composition also affect the marine species and the ecosystems, and the recovery of benthic and fish populations can vary greatly. Depending on the major species and impacts, fish populations could take 10 to 50 years or more to recover, albeit recovery would be dependent on improved fisheries management (Obura, 2017). The recent study of 150 million years of fish evolution revealed that commonly eaten fish species, *e.g.* anchovies and sardines are less likely to adapt and evolve in much warmer waters, increasing their risk of becoming extinct (Avaria-Llautureo *et al*., 2021).

- *Habitat disruptions*

Coastal ecosystems have been impacted negatively by sea level rise and extreme events, such as typhoons and storm surges, especially the coastal habitats that serve as hatcheries and nursery grounds for juvenile fish (Kibria *et al*., 2017). The study on the spatial and temporal relationship of ocean biophysical parameters with habitat utilization of the Indian mackerel (*Rastrelliger kanagurta*) in the Exclusive Economic Zone (EEZ) of Peninsular Malaysia found that although an increase in temperature of 1.8 °C resulted in high potential catch areas for the Indian mackerel in the said EEZ, elevated temperatures of 2.6 °C and 3.3 °C would decrease the potential catch areas for such

species (Kamaruzzaman *et al*., 2021). With the increasing sea level, it was estimated that about 20 - 90 % of global coastal wetlands will be lost by 2100 (IPCC, 2019). Sea level rise also results in a saltwater intrusion in estuaries, driving and relocating marine species to upstream areas (IPCC, 2019). Marine heatwaves and ocean acidification have caused coral bleaching that triggers loss of calcifying species and biodiversity as well as limits habitat suitability (IPCC, 2019). In addition, oxygen minimum zones in the tropical Pacific and Indian Oceans have been progressively expanding because of a reduction in ventilation and oxygen solubility in warmer water, resulting in more stratified oceans. These increasing zones could limit the areas for fish habitats of the tropical pelagic species (Stramma *et al*., 2012).

In the inland water habitats, climate change causes fluctuations in water temperature, dissolved oxygen, streamflow, and circulation (Cisneros *et al*., 2014) which are important growth-related factors for freshwater fishes. Devkota & Kathayat (2020) reported that increased temperature along with hypoxia is expected to have significant impacts on the sex determination of the tropical fish (zebrafish, *Danio rerio*). Scientists also estimated that a 3.2 °C increase in global mean temperature would jeopardize more than half of the habitats for one-third of world freshwater fish species (Barbarossa *et al*., 2021). They also found that increases in maximum water temperature are more hazardous to freshwater fishes than changes in minimum water temperature or high and low flow conditions (Barbarossa *et al*., 2021). Floods and droughts brought about by extreme weathers could result in an excess amount of freshwater and water availability or the less of it, while typhoons would increase the risk of rain-generated floods which could eliminate fish habitats and farm facilities, *e.g.* in the case of Viet Nam (Johnson & Hung, 2020). Extreme drought episodes could also reduce the proportion of land surface, lessening the aquatic ecological habitats and decreasing the density and biomass of freshwater fish species, as in the case of Borneo, Indonesia (Wilkinson *et al*., 2019). Sea level rise is projected to extend the areas of salinization of groundwater and estuaries, resulting in decreased availability of freshwater and suitable ecosystems in the inland areas of the Mekong Delta (Toan, 2014). The impacts of climate change and natural disasters could negatively affect the various stakeholders in inland fisheries, considering that most of the production from inland waters is small-scale, especially the numerous subsistence fishers whose productions are consumed locally, a situation which is common in several developing countries of the Southeast Asian region (Funge-Smith & Bennett, 2019; Harrod *et al*., 2018).

Impacts of climate change on aquaculture

The impacts of climate change on aquaculture could be direct and indirect. The direct impacts could include physical and physiological distresses of the fish stocked in confined systems, while indirect impacts could include disruptions in primary and secondary productivity, input supplies, and fish prices among others (Maulu *et al*., 2021). While climate conditions would differ in each season, fluctuations in temperature and intensity of solar radiation and precipitation affect the water quality in outdoor fishponds or fish cages. These changes in turn, directly impact the sustainability of aquaculture production in both negative and positive ways, although the negative effects often outweigh (Maulu *et al*., 2021).

In the studies carried out by SEAFDEC/AQD on the gonadal development and spawning of rabbitfish, it was observed that the gonadal development and spawning of the fish were affected when exposed to a temperature of 33 °C as the females with oocytes were atretic while the spawned eggs did not hatch. Another research on the embryonic development of important marine fishes, *i.e.* milkfish, rabbitfish, and the Asian sea bass found that embryonic development was aborted when incubated at 33 °C temperature. Moreover, increased temperature also affects the survival of mud crab (*Scylla serrata*) which was significantly lower when exposed to 33 °C temperature than at 31 °C and ambient temperature (AQD, 2013).

The study on the effect of acidification on shrimp post-larvae (*Litopenaeus vannamei*) revealed that the survival, growth, feed index, biochemical constituents, and hemocyte populations decreased significantly inCO_2drivenn acidified seawater while the level of antioxidants and metabolic enzymes increased significantly under oxidative and metabolic stresses. This indicated that more acidic seawater can produce harmful effects on the biology and physiology of economically important shrimps (Muralisankar *et al*., 2021). Results of the study on marine shrimp exposed to acidic seawater at 1,000 ppm CO_2 for 30 weeks indicated that survival was only 55 % compared with 90 % in the control. Acidic seawater coupled with higher temperature did not only delay the gonad maturation of sea urchin but also significantly suppressed maturation (Ishimatsu & Kurihara, 2011). From the study on the effects of low pH on survival, growth, size distribution, and carapace quality of the freshwater prawn (*Macrobrachium resenbergii*) postlarvae, negative effects were observed at pH 4−5 resulting in failure of the prawn to metamorphose (Kawamura *et al*., 2015). The low pH also reduced the tactile sense of the prawn postlarvae (Kawamura *et al*., 2018).

Furthermore, climate change also impacts the socioeconomic well-being of the stakeholders, *e.g.* freshwater shortage and farm location conflicts could create competition

among the water and resource users. Water shortage and conflicts among water users could lead to the relocation of farms or even to the termination of fish farm operations. Meanwhile, the farming practices should also be adaptive to the changing climate, *e.g.* culture of fish species that are tolerant to high water temperature. In addition, a fish disease which is the major problem in aquaculture could be aggravated both in frequency and impact due to climate change (Marcos-López *et al*., 2010), and could even destroy the whole production before the stocks are harvested and return of investment is realized.

Impacts of climate change and natural disasters on livelihoods

Climate change is a major threat not only to the sustainability of the ecosystems and aquatic organisms but also to the sustainable livelihoods of people, particularly those engaged in the utilization of natural resources and aquaculture activities. Failure or changes in specific species or functions within a system will have knock-on effects on other species and functions, resulting in falling effects. This will result in decreases in adult fish stocks and production, as well as negative consequences for the fishing industry.

Because of the magnitude and extent of its impact on fisheries and aquaculture production, the threats brought about by climate change had become a regional concern. Such threats could lead to reduced diversity in rural livelihoods and increased reliance of stakeholders on non-farm and farm incomes. Moreover, population dislocation from the coastal areas could create insufficiency in terms of the workforce in the sector, while more incidences of droughts and floods could damage aquaculture production and fishing facilities, *e.g.* fishponds, cages, stationary fishing gears, fishing vessels, as well as houses. Considering that fisheries and aquaculture in the region are characterized as small-scale and dependent on natural resources, the impact of climate change on fisheries could adversely affect food nutrition, food security, and livelihoods of the region's populace.

Although the impacts of climate change are oftentimes long-term, the occurrence of sudden natural disasters such as typhoons, floods, or tsunamis could partially damage or even completely destroy fishing communities, fishing boats, and infrastructures such as fishing ports, processing factories, markets, and so on (FAO, 2021). For example, it was estimated that natural disasters in the Philippines had caused 23,000 deaths and affected roughly 125 million people from 2000 to 2016 (Jha *et al*., 2018). One of the most severe disasters that hit the Philippines was the typhoon Haiyan in 2013 where it was recorded that the country's fishing sector accounted for 20 % (about USD 280 million) of the total loss of USD 9.6 billion, represented mainly by destroyed boats and other assets (UNDRR, 2019).

Impacts of fisheries and aquaculture on changes in the climate

Several studies on the contribution of fisheries and aquaculture to climate change have determined that the sector plays a minor role in climate change and thus, a large focus on mitigation would not be necessary. In 2011, it was estimated that of the global food production sectors, about 4.00 % of the greenhouse gas (GHG) emissions was generated by the fisheries sector (compared with the emissions from agriculture and livestock production) but had increased by 28.00 % between 1990 and 2011 (Parker *et al*., 2018). In addition, aquaculture contributed about 0.49 % of human GHG emissions in 2017 (MacLeod *et al*., 2020). Overall, the net GHG contributions from fisheries, aquaculture, and related supply chain features, are relatively small. However, such minimal GHG emissions should not be taken for granted, considering that concerns about fuel prices, long-term energy availability, aquaculture intensity, and climate change have continued to grow, necessitating the importance of putting more emphasis on energy-saving strategies throughout the fisheries and aquaculture supply chain. Governments, civil societies, international organizations, and individuals, in general, have a priority and obligation to address excess GHG emissions and global warming, and other related issues.

Climate change adaptations

Although there is substantive research on the biophysical implications of climate change on aquatic habitats, little is known about how to address these implications in terms of the socioeconomic context of fisheries and aquaculture, as well as on how to implement these adaptations. In fact, the vulnerability of fishers and fishing systems to climate change is defined by their capacity to adapt to climate variations. Thus, as a first step toward establishing climate-adaptive fisheries management techniques, it is critical to understand the wide implications of climate change on biological systems and fisheries.

IPCC highlighted two major adaptation options for managing the risks of climate change relevant to the fisheries sector. These are: 1) development of ecosystem-based options which could include control of overfishing, promotion of fisheries co-management and community-based natural resource management, and enhanced assistance in species migration and dispersal; and 2) enforcement of laws and regulations, *e.g.* fishing quotas (IPCC, 2014). In addition, several gaps in legislation, notably in terms of the extent to which fisheries regulations can help with climate change adaptation should be identified (Hanich *et al*., 2018). Climate adaptation is best served by legislations that support and enforce regulations that help community transitions, especially in small-scale fisheries during these challenging times. These could include outlining the management approaches for emerging fisheries, providing safety and

disaster-response strategies, developing an integrated management framework that allows and accounts for effort flexibility and changing pressures, and facilitating management measures that take into account the response of different species on climate variability.

The recent publication of FAO on 'Adaptive Fisheries Management in Response to Climate Change' which is primarily aimed at policymakers, fisheries managers, and practitioners, provides preliminary guidance on effective responses of fisheries management to climate change. This publication adds to the overarching goal of strengthening fisheries resilience, lowering their vulnerability to climate change, and enabling managers to respond quickly to expected changes in marine resource and ecosystem dynamics. One of the recommendations about the publication is on the possible downscaling of climate change projections – to include social and economic scenarios – to match with the scales at which fisheries management occurs with a focus on low-capacity countries. This implies that there is an urgent need to localize the impacts of climate change and identify the local enabling factors that foster and accelerate the uptake of climate-adaptive strategies (Barhri, *et al*., 2021).

Regional platforms to address issues on climate change

Recognizing that climate change affects all economic sectors, the ASEAN Ministers on Agriculture and Forestry (AMAF) in 2009 endorsed the ASEAN Multi-Sectoral Framework on Climate Change (AFCC): Agriculture and Forestry towards Food Security, which covers agriculture, fisheries, livestock, forestry, and other relevant sectors such as environment, health, and energy. Under the AFCC, the ASEAN Ad-hoc Steering Committee on Climate Change and Food Security (AHSCCC-FS) was also set up in 2009 to serve as a platform for Chairs of different sectoral bodies under the different pillars, *i.e.* ASEAN Economic Community and the ASEAN Socio-Cultural Community, and international/dialogue partners, to exchange information, contribute to the development of significant regional guidelines, and discuss initiatives in addressing climate change adaptation and mitigation. AHSCCC-FS aims to develop and implement a comprehensive strategy and roadmap through a mutual learning process on climate change and food security. The TOR and rules of procedures of the AHSCCC-FS had been revised, while its mandate had been extended until 2030.

Another regional platform established in 1996 by the Asia-Pacific Economic Cooperation (APEC) is the so-called Agricultural Technical Cooperation Working Group (ATCWG) which is concerned about the issues of food security, sustainable development, climate change, and deterioration and shortage of natural resources. The tasks of the ATCWG include but are not limited to, networking as a dynamic team among the member economy officials, experts, business community officials as well as experts from the academe. Attention has been paid to the success factors of agriculture in fragile environments to adapt to climate change and mitigate its effects and increase resilience to natural disasters in accordance with international agreements. The specific strategy relevant to cope with impacts of climate change under the ATCWG's Strategic Plan 2021-2025 is to build climate-smart and resilient agricultural systems. The main objective of which is to deal with food security and agricultural risks, production resilience and adversity adjustment, value addition of weather information, and disaster prevention by establishing early warning systems. These would be done through capacity-building activities such as seminars, workshops, and training courses on climate and disaster risk and vulnerability assessment, risk mapping, climate change adaptation, surveillance, and preparedness for mitigating the risks, and disaster risk reduction strategies.

Regional policies on climate change adaptation and mitigation in fisheries

In 2020, the ASEAN-SEAFDEC Member Countries adopted the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region towards 2030 and underscored several actions relevant to climate change (SEAFDEC, 2020). These include:

1) enhance the resilience of fisheries communities in anticipating and adapting to changes in the environments of inland and coastal waters, and those caused by climate change;
2) monitor and assess the perceived impacts of climate change to fisheries and aquaculture; and adjust existing programs to take into consideration the effects of climate change and natural disasters;
3) formulate guidelines to promote the use of practical and simple indicators for inland/floodplain fisheries within the national inland fisheries management framework to facilitate adaptation to the effects of climate change within water bodies;
4) provide government support for R&D on assessing the impact of climate change on aquaculture; and
5) formulate and implement national policies and strategies that will enable the aquaculture sector to adopt measures to mitigate the potential impacts of climate change and environmental stressors by providing support to R&D on climate change, and other environmental-related issues to increase resilience, strengthening the overall capacity of various stakeholder groups and fostering cooperation within the aquaculture sector and with other sectors, and developing standard procedures for disaster risks reduction in aquaculture.

Meanwhile, the Strategic Plan of Action for ASEAN Cooperation on Fisheries 2021−2025 through its action programs, is expected to result in increased resilience

of fisheries and aquaculture to climate change, natural disasters, and other shocks. These could be achieved for example, through the development of regional guidelines on indicators for aquaculture and capture fisheries to facilitate ecosystem-based adaptation to the impact of climate change; and identification and promotion of green technologies for adoption, such as low greenhouse gas emission, carbon sequestration from marine waters technology for aquaculture, and the adoption of the integrated multi-trophic aquaculture (IMTA). The ASEAN Sectoral Working Group on Fisheries (ASWGFi) is expected to carry out the operations with the assistance of its technical sub-working groups. In collaboration with the ASEAN Secretariat, a Lead Country may be assigned to steer and commence the implementation of certain activities or priority deliverables. Priority initiatives may be supported by the ASEAN Member States and/or Dialogue Partners, as well as international and regional organizations. The progress of implementation of the activities and priority deliverables would be reported during the ASWGFi and SOM-AMAF annual meetings, with a final review in 2025.

Since changes in the climate could not be avoided, the ASEAN is therefore addressing the impacts of climate change on fisheries and aquaculture not only through the development of policies at the regional level but also by downscaling the applicability of such policies at the local level. With this concern, everyone could take action to reduce their contribution to global warming and the impacts of climate change. At the regional and national levels, research institutions including the public and privately-run, play important roles in the coordination and integration of research to assess, monitor, and develop projections of the perceived impacts of climate change on fisheries and aquaculture, and to move towards a future where relative impacts by the region can be compared on a hemispheric or global scale, as well as in raising recommendations on the mitigation and adaptation measures for such potential impacts. Government extension officials and civil societies could play a key role in promoting climate resilience practices to their people. The private sector and individuals, *e.g.* fishing boat operators/companies, aquaculture farms, could also take part in information sharing and in adapting fishing and farming practices that reduce GHG emissions. In addition, regional and national policies that would encourage the involvement of the private sector and industries to assist fishers/farmers in accelerating the transfer of climate-resilient innovations should be established.

National efforts to address the impacts of climate change

The Southeast Asian countries are Non-Annex I Parties of the United Nations Framework Convention on Climate Change (UNFCCC) and are also Parties of the Kyoto Protocol (UNFCCC, 2018). The Non-Annex I Parties are from developing countries, and the Convention recognizes certain categories of developing countries as being vulnerable to the negative effects of climate change, *e.g.* countries with low-lying coastal areas, and others, such as countries that rely largely on revenue from fossil fuel extraction and trade. The Convention promotes actions such as investment, insurance, and technology transfer that promise to address the needs and concerns of these vulnerable countries. Under the Convention, Parties develop strategies to address climate change and support cooperation in adaptation to the impacts. Under the Kyoto Protocol, Parties set binding targets and standards to reduce emissions of greenhouse gases. **Table 77** summarizes the country-specific national plans and regulations, and the priority concerns and actions relevant to the fisheries sector. In addition, FAO published the 'Addressing Fisheries and Aquaculture in National Adaptation Plans: Supplement to the UNFCCC NAP Technical Guidelines' to provide technical guidance on the integration of fisheries and aquaculture in the formulation of National Adaptation Plans (Brugere & De Young, 2020).

Moreover, each country has developed their respective projects and studies to address climate change issues in their fisheries sector. For example, Malaysia has implemented an annual coral reef monitoring program and established the Coral Bleaching Response Plan as well as identified the resilient areas. The country has also strengthened the fisheries management plan and its implementation corresponding to the migration of fish to preferred habitats. Concerning the severe weather variability that occurs in the country, a public awareness program has been established. Relating to sea level rise which could damage aquaculture infrastructures, the country has issued advisories for affected fish farmers to relocate their aquaculture farms.

In Myanmar, its Department of Fisheries in collaboration with FAO implemented the FishAdapt project supported by the Global Environment Facility (GEF) from 2017 to 2021 to build resilience and strengthen the adaptive capacity of livelihood-dependent communities on fisheries and aquaculture. Several activities had been carried out in the implementation phase including the preparation of three training documents both in English and Myanmar versions, namely: Handbook for Ecosystem Approach to Fisheries Management (EAFM) and Ecosystem Approach to Aquaculture Management (EAAM), as well as the EAFM Toolkit, and the subsequent completion of the National Level EAFM/EAAM and Capacity Plus Training, where the trained persons have been subsequently involved in formulating the community fisheries and aquaculture development plans. The project activities also included vulnerability assessment in respective areas that received different risks/impacts; training on drone and GIS mapping to support the assessment; development of national and regional level Early Warning and Early Actions (EWEAs); and Disaster Risk Management system analysis for fisheries and aquaculture (FishAdapt Project, 2020).

Table 77. Key national climate change regulations/policies of the AMSs and actions relevant to the fisheries sector

Country/National plans/Regulations	Priority concerned and actions relevant to the fisheries sector
Brunei Darussalam 2020 National Climate Change Policy (BNCCP)	Adopted in 2020, BNCCP has 10 key strategies on low-carbon and climate-resilient as a "Whole-of-Nation" approach to reduce Brunei Green House Gas emissions to more than 50 % by 2035 compared to the "Business-as-Usual" scenario. In particular, Strategy 8 has one of the strategic objectives to secure local food production and stocks by adapting to the impact of climate change. The number of fish stocks affected (in units) is regularly monitored (Brunei Climate Change Secretariat, 2020).
Cambodia 2013 Climate Change Strategic Plan (CCCSP) 2014 – 2023	CCCSP which was adopted in 2013, addresses a wide range of climate change adaptation and mitigation measures focusing on building institutional capacity and resilient capacity at the community level, including the fisheries sector (Royal Government of Cambodia, 2013): • Increasing the capacity to identify climate-induced opportunities in agricultural production systems, ecosystems, and natural protected areas to increase productivity such as in fisheries; • Improving the efficiency of the fisheries sector management; • Enhancing community fisheries management; • Ensuring the climate resilience of critical ecosystems (Tonle Sap Lake, Mekong River, coastal ecosystems, etc.) including promotion of conservation and management of fisheries and aquaculture in a sustainable way; • Improving human and institutional capacity on new technologies in fisheries that have the adaptive capability to drought, flood, temperature rise, saline intrusion, and destruction from insects and diseases; • Promoting human resource development essential to contribute to adaptation and reduction of impacts on fisheries resources; and • Enhancing the capacity and understanding of climate change in the fisheries sector.
Indonesia 2019 National Action Plan for Climate Change Adaptation 2020 – 2045	Climate Change Adaptation Strategies and Action Framework adopted in 2019, identified four priority sectors for climate change adaptation. One of the priority sectors is marine and coastal, where the strategy is for coastal area protection and maritime safety. There are several delivery strategies, *e.g.* combining the ecosystem-based adaptation and community-based adaptation; application of marine survey technology that is able to detect fish stocks, preventing a potential decline in fishing catches of fishers due to climate change using remotely operated vehicles; increasing the certainty of fishing time and reducing fishers' sailing hazards due to extreme waves by using small fiberglass fishing boats; providing alternative livelihoods for small fishers who cannot go to sea due to extreme waves by strengthening their capacity in cooperative and fishing groups as well as fishers' insurance (weather index insurance); increasing the capacity and information access of small fishers in reading marine climate information (Ministry of National Development Planning, 2019).
Lao PDR 2015 National Strategy on Climate (NSCC) and Intended National Determined Contribution	Adopted in 2015, NSCC's vision and goals identified national adaptation priorities to promote integrated actions on watersheds, reservoir management, water storage for agro-forestry, wildlife management, fisheries, and tree varieties, and the prevention of drought (Phongpachith, 2019).
Malaysia 2009 National Policy on Climate Change	Although the fisheries sector is not mentioned in the policy adopted in 2009, the sector provides food largely for domestic consumption (Ministry of Natural Resources and Environment Malaysia, 2014). Currently, the Climate Change Act is being drafted (Jalil, 2020).
Myanmar 2019 Climate Change Master Plan (MCCMP) 2018 – 2030	Myanmar Climate Change Strategy for the same period as MCCMP adopted in 2019, was developed including the Myanmar Climate Change Alliance (MCCA) website for public access to learning the said two important documents and policy brief. MMCMP identified high-priority activities, indicators, and responsibilities. One of the priorities is climate-resilient productivity and climate-smart responses in the agriculture, fisheries, and livestock sectors. Some activities are identified, for example, development of guidelines (tools, contents) to mainstream climate change into agriculture and fisheries; establishment of an institutional platform to exchange learning and share knowledge on climate-smart agriculture, fisheries and livestock; establishment and strengthening of cooperatives or farmer, fisherfolk, water-user, herder associations to collectively deal with climate change issues; development, integration and legalizing risk-based insurance system to cover the losses and damages on crops, and fisheries due to climate-induced disaster; and building the capacity to develop national and regional monitoring and surveillance plans for the fisheries sector.
Philippines 2008 Climate Change Act	The Act (The Republic of the Philippines, 2008) which was adopted in 2008, provides the policy framework to address the growing threats on community life and its impact on the environment. The national climate change framework strategy has been developed and translated into the National Climate Change Action Plan (NCCAP) 2011 – 2028 (Climate Change Commission, 2011). The immediate outcomes identified include enhanced climate change resilience agriculture and fisheries production and distribution systems, as well as enhanced resilience of agriculture and fishing communities from climate change. The key activities are, for instance, conduct research and disseminate knowledge and technologies on climate change adaptation; integrate and harmonize climate change adaptation and disaster risk reduction in national and local fisheries policies and plans; build the capacity of farming and fishing communities on adaptation and disaster risk reduction; and implement risk transfer and social protection mechanisms for the fishery.

Table 77. Key national climate change regulations/policies of the AMSs and actions relevant to the fisheries sector *(Cont'd)*

Country/National plans/Regulations	Priority concerned and actions relevant to the fisheries sector
Singapore The 2016 Climate Action Plan	Although no specific action for fisheries had been identified, the Plan which was adopted in 2016, stipulates the strategies and targets to meet the pledge to reduce GHG emissions intensity by 36 % by 2030 (compared to 2005). In addition, the 'Climate-resilient Singapore: For a Sustainable Future' explains what climate risks the country faces and proposes a 'Whole-of-Government' strategy to tackle them (Ministry of the Environment and Water Resources, 2011). This includes among others, the implementation of programs to boost productivity, and the conduct of research and development to aid technology adoption by local farms, *e.g.* closed-containment aquaculture systems such as recirculating aquaculture systems to enable fish to be protected from adverse environmental conditions.
Thailand 2015 Climate Change Master Plan 2015 – 2050	Adopted in 2015, the Plan consists of three key strategies: 1) Climate change adaptation, 2) Mitigation and low carbon development, and 3) Enabling environment on climate change management. The fishery sector appears in all these Strategies. For example, Strategy 1, focuses on research and development of long-range forecasting and prediction techniques for climate variation and extreme weather focusing on high-risk areas including fisheries habitats; establishment of climate risk insurance system for agricultural produce, livestock, and fisheries; promotion of ecosystem-based approach to fisheries to include proper training and management for sustainable fish stocks by stock assessment; and improvement and expansion of artisanal fisheries by promoting the participation of local fishing communities in marine and coastal resources conservation. Strategy 2 highlights the promotion of sustainable and eco-friendly farming and fisheries to reduce adverse environmental and ecological effects. Strategy 3 emphasizes the formulation of effective integrated strategies by examining the relationships and correlations between changes in the following factors as a result of climate change: the quality and quantity of output from farming, livestock, and fishery sectors (including changes in the growing and harvesting seasons); the commercial system of domestic and overseas markets, and supply chains.
Viet Nam 2017 Law on Fisheries	The Government and the Ministry of Agriculture and Rural Development (MARD) have issued many important strategies and policies to cope with climate change including the National Target Programme to Respond to Climate Change (2012), the National Climate Change Strategy (2011,) and the National Action Plan on Climate Change (2012) for the period 2012 – 2020. The Law on Fisheries (2017) also guides fishery activities to cope with climate change, and requires fishery activities to adapt to climate change, actively prevent and control natural disasters, ensure safety for people and means of fishery activities; prevent and control aquatic epidemics, and ensure food safety and environmental safety (National Assembly, 2017)

In the Philippines, FAO supported the climate-resilience of tilapia farmers through the project 'Building Capacities for a Climate Resilient Tilapia Farming in the Philippines' in 2015 –2017. Considering that the Philippines is one of the most vulnerable countries to extreme weather events and climate-related disasters, improvement of the capacities of national and local government officials is necessary so that with innovative knowledge and technical services, they would be able to effectively carry out their respective duties and responsibilities. Thus, the project facilitated the collation of evidence-based scientific information from experienced farmers and commodity experts on climate-related risks and mitigation. The project installed automatic weather stations to monitor real-time weather parameters locally and provided simple statistical analyses and early-warning messages through ICT-based applications to farmers. The project was able to provide early warning advisories such as thunderstorms, heavy rains, and extreme temperatures to tilapia farmers via SMS alerts. The project also explored the introduction of innovative crop insurance and other financial arrangements to enhance resilience. These exercises started with tilapia production but are being replicated to other commercially important aquaculture commodities (FAO, 2017).

In Thailand, although there are no direct studies on the impacts of climate change on fishery resources during the past decade, its Department of Fisheries has been monitoring the water quality in fishing grounds to indirectly evaluate the impacts of climate change in some areas. A review study on the impacts of climate and season on water quality and aquatic animals underlined how climate and season influence the water quality including water temperature, dissolved oxygen, and ammonia concentrations. These factors, in turn, affect the growth and survival of fish and increase the risks of aquatic diseases. Pond ecosystem models appear to be promising tools to understand and possibly project how pond aquaculture responds to climate variability and change, and thus, management options useful for maintaining suitable water quality conditions could be explored (Sriyasak *et al*., 2015). The Government of Thailand allocates financial support to disaster victims both fishers and farmers. In addition, the Government always issues notifications to fisheries and coastal communities on the worsening situation of climate change and severe coastal erosion.

Activities of SEAFDEC on reduction of GHGs emissions from fisheries and adaptations to impacts of climate change

Fishing gears such as trawls and dredges require high fuel consumption and thus, their operations greatly impact the environment. Some activities of the project 'Responsible Fishing Technology and Practice' implemented by the SEAFDEC/TD from 2020 to 2024 and funded by the Japanese Trust Fund, had been initiated to address these concerns. The project activities, for example, include the modification and application of fishing gear and practices to mitigate their impacts on the marine ecosystem and optimize the use of energy by the fishing vessels and fishing practices. Such activities are aimed at transferring appropriate and applicable technologies and knowledge to fishers and fisheries officials to optimize energy use in fishing activities.

With the intensification of aquaculture systems in several Southeast Asian countries and the environmental challenges such as those resulting from climate change, both factors – genetic quality and culture management, are equally important. SEAFDEC/AQD, therefore, carried out the project 'Adapting to Climate Change Impacts' from 2016 to 2020 to generate, verify and promote technologies that ensure sustainable production of quality seedstocks for aquaculture and stock enhancement purposes. Many activities had been undertaken, *e.g.* culture of fast-growing species that are disease resistant and can be stocked at high densities; use of recirculating aquaculture systems and integrated multi-trophic aquaculture; implementation of zoning, monitoring, early warning systems; promotion of seaweeds and mollusk farming; and mangrove reforestation for carbon absorption. Furthermore, information on the impacts of climate change has been incorporated in the training courses organized by SEAFDEC/AQD and also in the extension materials that SEAFDEC/AQD has produced.

Way Forward

The characteristics and severity of the impacts of climate change and extreme climate events on the fisheries and aquaculture sector will most likely increase, affecting the most exposed and vulnerable countries and communities that depend on the sector for their livelihoods. It is therefore important that coherent and convergent adaptation and mitigation measures including preparedness for climate disaster response and recovery be mainstreamed in the fisheries and aquaculture sector as a matter of urgency and at an appropriate scale. The region also envisions to focus its plans on monitoring and assessing the perceived impacts of climate change on fisheries and aquaculture, especially through the formulation of guidelines that simplify indicators for inland/floodplain fisheries operations, enhancing the resilience of fisheries communities in anticipating and adapting to changes in the environments, as well as building climate-smart responses in fisheries. The AMSs join the global effort to mitigate the impacts of climate change by establishing ambitious objectives and targets as part of their national policies and plans. These initiatives will aid in the realization of a paradigm shift toward low-emission and promotion of climate-resilient development in all sectors including the fisheries sector.

8.2 Aquatic Pollution

Water is one of the renewable resources crucial for the existence of all beings on earth and is also an essential part of the global ecological system. However, problems on the quality of water have become major concerns in all countries, because of water pollution. As defined, "water pollution is the presence in groundwater of toxic chemicals and biological agents that exceed what is naturally found in the water and may pose a threat to human health and/or the environment. Additionally, water pollution may consist of chemicals introduced into the water bodies as a result of various human activities. Any amount of those chemicals pollute the water, regardless of the harm they may pose to human health and the environment" (Environmental Pollution Center, 2021). Therefore, water pollution or aquatic pollution occurs when the released substances interfere with the beneficial use of the water or with the natural functioning of the ecosystems. Water bodies could become polluted by domestic sewage also known as municipal solid wastes, toxic wastes, sediments, or thermal and petroleum substances. Aquatic pollution could occur not only in marine but also in freshwater environments.

In marine environments, aquatic pollution occurs when substances used or spread by humans, such as industrial, agricultural, and residential waste, particles, noise, excess carbon dioxide, or invasive organisms, enter the ocean and cause harmful effects (Sheppard, 2019). Most of the marine pollution comes from land sources and is washed or blown into the ocean. This pollution damages the environment, the health of all organisms, and economic structures worldwide (National Geographic, 2021). The types of marine pollution can be grouped into marine debris and plastic pollution, ocean acidification, nutrient pollution, toxins, underwater noise, and others. Marine pollution has become an essential issue since at least 8 million tons of plastic end up in our oceans every year (IUCN, 2021), and in 2021, at least 80 million kg of plastics used in the Southeast Asian region will become marine pollution (One Green Planet, 2021).

Similarly in freshwater environments, aquatic pollution happens when toxic substances enter water bodies such as lakes, rivers, and so on, getting dissolved in them or lying suspended or depositing on the bed degrading the quality of the water. These pollutants could seep through and reach the groundwater ending up in our drinking water. The most common pollutants in marine and freshwater environments are municipal solid wastes and industrial discharges.