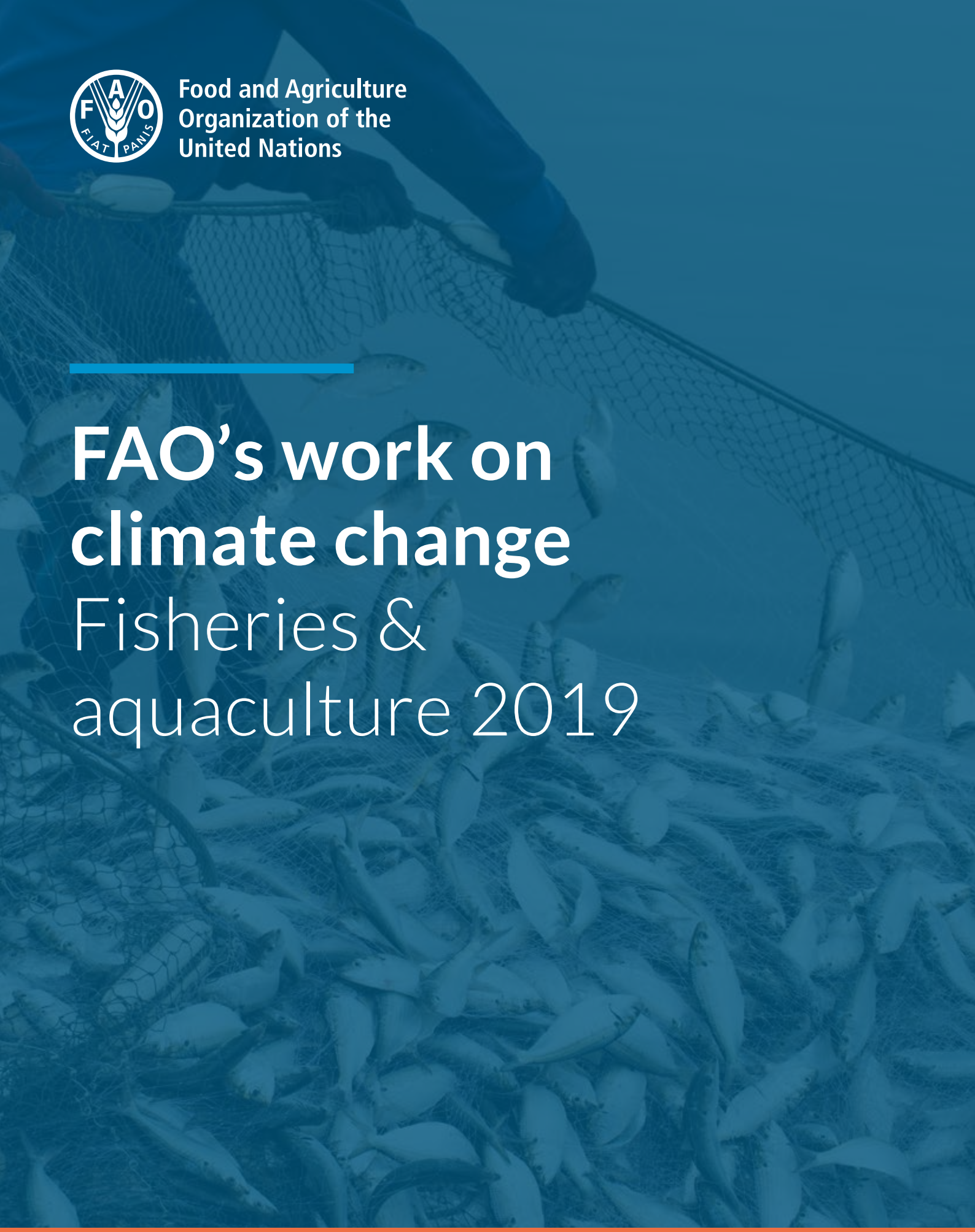

Food and Agriculture Organization of the United Nations

FAO's work on climate change

Fisheries & aquaculture 2019

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Contents

Introduction

Fisheries and aquaculture and their dependent communities are at the forefront of climate change impacts, calling for concerted efforts in mitigation and adaptation.

Climate change is one of the greatest challenges of our time. The September 2019 Special Report on the Ocean and Cryosphere (SROCC) of the Intergovernmental Panel on Climate Change (IPCC) is a key milestone in the knowledge of climate change impacts on oceans and seas. The report confirms the multi-decadal trend of ocean warming and the rise of global mean sea level at a rate that has tripled over the last century as a result of ice and glacier melting at global scale.

The report also indicates that cryospheric and associated hydrological changes have impacted and will continue to impact terrestrial and freshwater ecosystems in high mountain and polar regions with major shifts in species distributions, as a result of the appearance of land previously covered by ice, changes in snow cover, and thawing permafrost.

The SROCC singles out the fisheries and aquaculture sector as one of the human activities exposed and vulnerable to climate drivers and analyses impacts and responses, echoing the most relevant messages of the FAO Technical Paper 627, Impacts of climate change on fisheries and aquaculture – synthesis of knowledge, adaptation and mitigation options. Climate change will lead to significant changes in the availability and trade of fish products, with potentially important geopolitical and economic consequences, especially for those countries most dependent on the sector.

The extent of the impacts of climate change on the fisheries and aquaculture sector, including climate change-induced extreme events, will largely be determined by the sector's ability to develop and implement mitigation and adaptation strategies. Although a relatively small global contributor, fisheries and aquaculture have a responsibility to limit greenhouse gas (GHG) emissions as much as possible through mitigation measures such as reducing energy consumption, better feed and feed management, and low-impact fishing methods and gears. As far as adaptation is concerned, FAO has provided an adaptation toolbox, which comprises institutional adaptation, measures addressing livelihoods, and measures intended for reduction and management of risk which thereby strengthen resilience.

Efforts to mitigate and adapt to climate change must be human-centred. Millions of people are struggling to maintain reasonable livelihoods through fisheries and aquaculture. These are the people who are the most vulnerable to the impacts of climate change, which adds to the many threats and obstacles that already confront them in their day-to-day lives. While effective mitigation and adaptation will be required across all scales and sectors of fisheries and aquaculture, particular attention needs to be given to the most vulnerable if the sector is to continue to contribute to meeting global goals of poverty reduction and food security.

FAO has implemented and will continue to implement a range of activities aiming at supporting member countries and partners to effectively mitigate and adapt to the impacts of climate change for fisheries, aquaculture and aquatic ecosystems, through knowledge development and exchange, policy development, practical demonstration and capacity-building. Impacts of climate change may be intensifying, but so are FAO's efforts. FAO is stepping up to address the climate challenge in the fisheries and aquaculture sector.

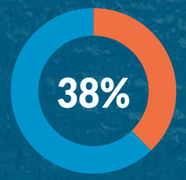
Facts and figures

172.6 MILLION TONNES

Excluding aquatic plants, global production of fish, crustaceans, molluscs and other aquatic animals continued to grow and reached **172.6 million tonnes** in 2017, an increase of **4.1 percent** on 2016.

World marine capture fisheries production reached 80.6 million tonnes in 2017, an increase of more than 3.2 million tonnes on 2016.

USD 156 BILLION



A large share of all fish production enters international marketing channels – about **38 percent** (live weight equivalent) **was exported** in 2017. In the same year, world exports of fish and fish products reached **USD 156 billion**, a new record high.

World aquaculture production of aquatic animals enjoyed an average annual growth rate of **5.9 percent during 2001–2010**. The annual growth rate reduced to an average of **4.8 percent during 2011–2017.** The contribution of aquaculture to the total production of aquatic animals from capture fisheries and aquaculture combined has risen steadily from **25.7 percent in 2000 to 46.4 percent in 2017.**

92.5 MILLION TONNES

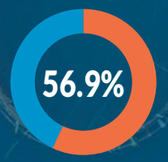
Capture production was 92.5 million tonnes in 2017, an increase of 3.5 percent on the previous year.

11.9 MILLION TONNES

Global capture fisheries production in inland waters reached 11.9 million tonnes in 2017. Although its upward trend seems continuous, its share in total global capture production remains below 13 percent.

59.7 MILLION PEOPLE

In 2017, **about 59.7 million people were engaged in the primary sector of capture fisheries and aquaculture**. Of this total, 40.4 million people were engaged in fisheries and 19.3 million in aquaculture.



Inland farming of finfish species was the most important sector in the world aquaculture of aquatic animals. The production of **45.6 million tonnes** of finfish from inland aquaculture represented **56.9 percent** of world total aquaculture production of aquatic animals in 2017.

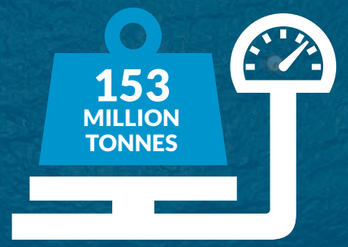
80.1 MILLION TONNES

Aquaculture production was 80.1 million tonnes in 2017, up by 4.9 percent from the previous year.

50%

The total engagement of **women across both fisheries and aquaculture was over 50 percent** when including the secondary sector.

In 2017, **89 percent (>153 million tonnes)** of total fishery production was used for **direct human consumption.** The remaining 11 percent (19 million tonnes) was destined for non-food products, mainly for the manufacture of fishmeal and fish oil.



The share of developing countries in total fishery exports was about **54 percent by value and 59 percent by quantity** (live weight equivalent) in 2017.

USD 383 BILLION

In 2017, **the total first sale value of total production was estimated at USD 383 billion**, of which USD 238 billion was from aquaculture.

The percentage of marine **fish stocks fished within biologically sustainable levels** has exhibited a decreasing trend, **from 90.0 percent in 1974 to 66.9 percent in 2015.** In contrast, the percentage of stocks **fished at biologically unsustainable levels** increased **from 10 percent in 1974 to 33.1 percent in 2015.**

Preliminary estimates for 2017 indicate a further growth in **per capita consumption** from 19.7 kg in 2016 to about **20.3 kg.**

04

Impacts of climate change on fisheries and aquaculture

Climate change is poised to transform marine and freshwater ecosystems. The livelihoods of millions of fishery-dependent people are at risk.

Impact pathways of climate change

Climate change is having profound impacts on fishery and aquaculture-reliant communities and the ecosystems they depend on, especially in tropical regions. Climate change drivers are causing and are expected to continue to cause potentially significant changes in ocean currents, sea level rise, acidification, rainfall, river flows, lake levels and thermal structure, as well as changes in the severity and frequency of storms (Figure 1).

In turn, these changes are affecting the production ecology and biodiversity of aquatic systems, resulting in changes in species composition in catches, reduced production and yield (especially in the tropics), increased yield variability, diseases, coral bleaching, calcification and distribution.

Moreover, these changes are also impacting the socioeconomic status of the fisheries and aquaculture sector in many parts of the world and the poverty and food insecurity of areas dependent on fish and fishery products, as well as the governance and management of the sector and wider society.

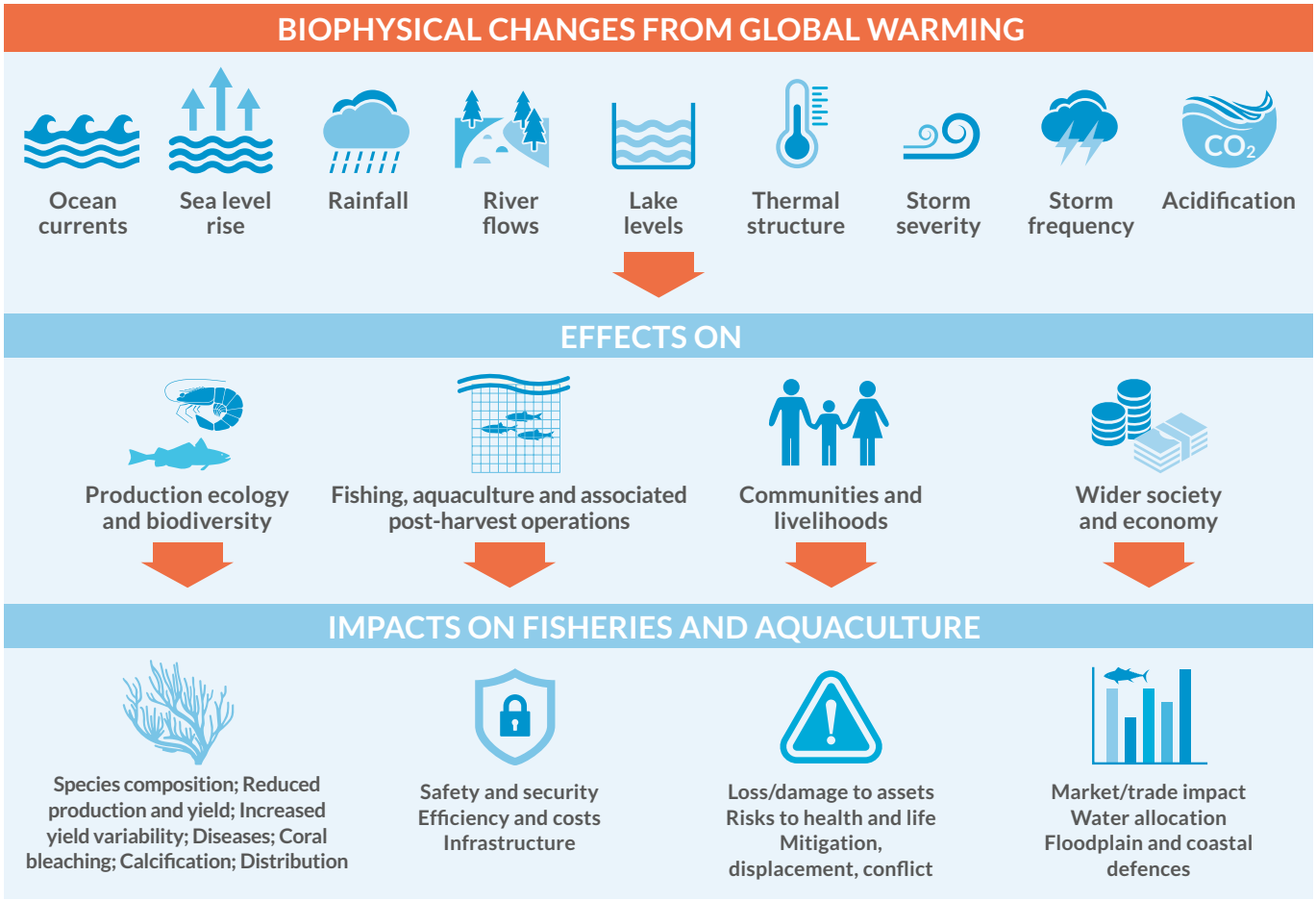


Figure 1: Impact pathways
(Source: adapted from Badjeck *et al.*, 2010)

Catch potential in fisheries

Climate change could substantially alter the provision of the goods and services obtained from freshwater and marine ecosystems. The largest impacts to inland fisheries are likely to be driven by competition for scarce water resources with other more valued economic sectors. As an additional stressor, climate change impacts, such as increasing water temperature and altered discharge, are threatening approximately 50 percent of inland fish species, (Reid *et al.*, 2019) with decreased abundance in coldwater and coolwater fish as the most common directional response. (Myers *et al.*, 2017)

©FAO/Joerg Boethling

The regions and the countries supporting inland fisheries will undergo considerable changes induced by climate change. It is projected that China and India, major inland fishery producers, are likely to face considerable stressors affecting their inland fisheries in the future. In contrast, large groups of countries responsible for around 60 percent of global inland fisheries production are projected to face medium or relatively low future stress, and will not be subject to the most extreme impacts of climate change. (FAO, 2018a) However, even those countries with low future climate-related stress will be exposed to an array of other anthropogenic drivers of change, which can impact the capacity of fisheries to maintain food supply as much as, or even more than, climate change itself. These include overfishing, over-extraction of water, introductions of non-native fishes and other taxa, and the modification, degradation and loss of key habitats.

In marine ecosystems climate change is producing shifts in the distribution of aquatic species, and this trend is set to continue. Marine species have been expanding the leading edges of their distributions, generally poleward, by 72 km per decade on average; while the arrival of spring conditions in marine habitats has been advancing by 4.4 days per decade. (FAO, 2018b) Recent evidence indicates that poleward expansion will result in a net local increase in species richness (i.e. the number of different species represented in an ecological community, landscape or region) in most places, except in tropical regions, where strong decreases in species richness are expected. In the absence of fishing, mean global marine animal biomass is expected to decrease by 5-17 percent by 2100, depending on the emission scenario considered, driven primarily by increasing temperatures and decreasing primary production. (Lotze *et al.*, 2019) By 2050, biomass changes will result in decreases in maximum fish catch potential – which denotes ecosystem productivity – in the world's exclusive economic zones (EEZs) of 2.8-5.3 percent under a strong mitigation scenario, and 7.0-12.1 percent under a business-as-usual scenario. (FAO, 2018a) (Figure 2)

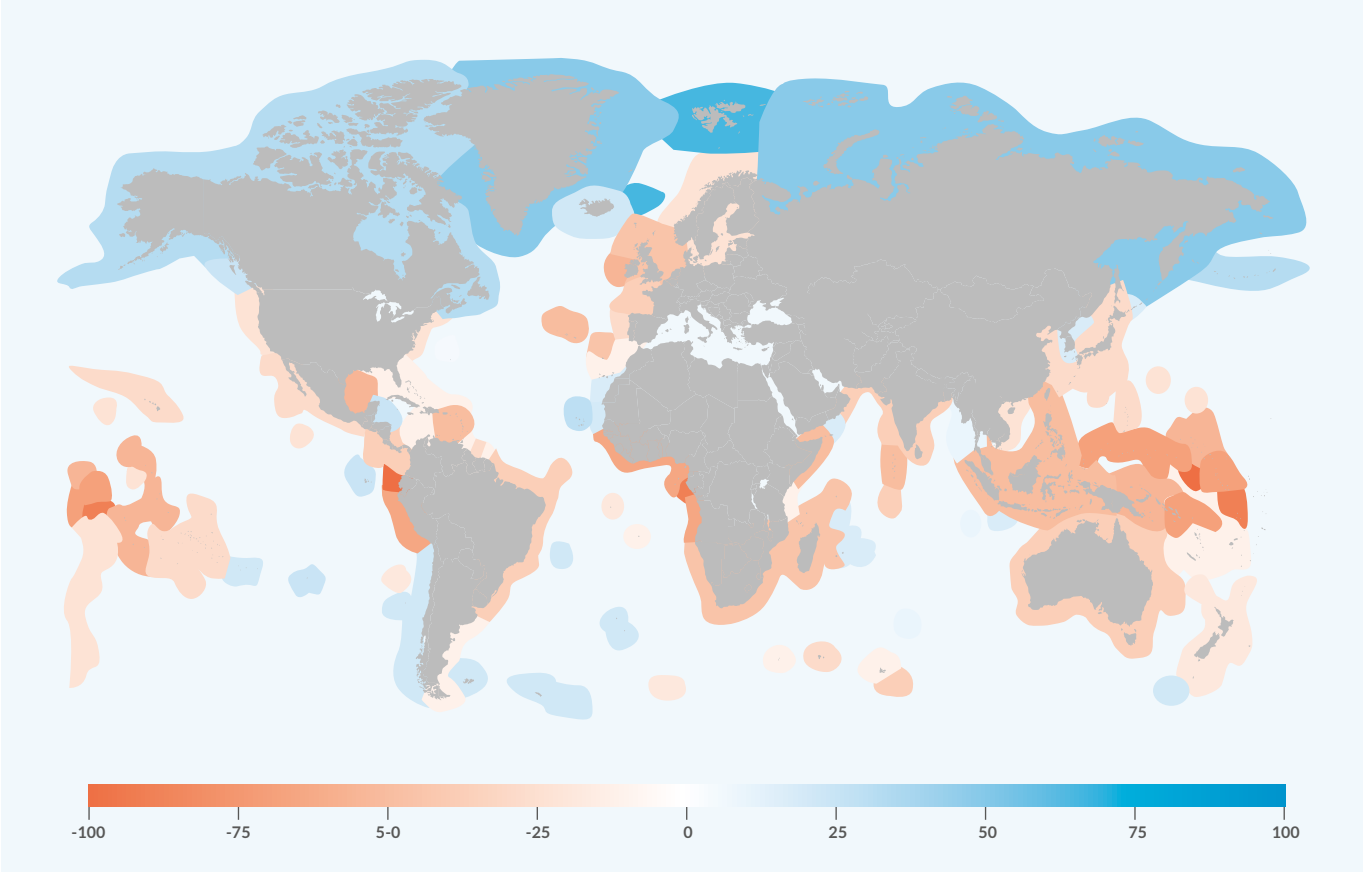


Figure 2: Projected changes in maximum catch potential (percent) under a business as usual scenario (RCP8.5) by 2050 (2046 to 2055) for the Dynamic Bioclimate Envelope Model (DBEM) projections
(Source: adapted from FAO, 2018a)

Maximum catch potential versus realized fish catch

The realized catch (i.e. the amount of fish actually taken) is a combination of maximum fish catch potential (i.e. the maximum catch that can be sustained given the productive capacity of the marine ecosystem), fisher activity, market demand, and particularly fisheries management actions. Thus, changes in realized catch in the future do not necessarily mirror changes in maximum fish catch potential, as they heavily depend on how management systems respond to climate impacts. The maximum fish catch potential should rather be seen as the upper limit of sustainable future catches.

This is particularly relevant when considering the projected global changes in maximum fish catch potential by 2050, estimated to decrease by 2.8-12.1 percent dependent on emission scenarios. Currently, because of ineffective fisheries management practices, the ocean's maximum catch potential is not fully achieved; realized catches are estimated to be 20 percent below the maximum catch potential. Improvements or deteriorations in fisheries sustainability in the future will thus condition future realized catch trends: even if maximum fish catch potential is projected to decrease, the realized catch can increase or decrease by virtue of the management response to productivity changes.

For this reason, it is crucial to recognize the importance of adaptive and effective fisheries management in addressing the current level of overexploitation as well as the anticipated impacts of climate change on fish species productivity. In this sense, climate change provides one of the most powerful arguments to improve fisheries management, and thus fisheries sustainability globally. (Barange, 2019)

Aquaculture

Climate-driven changes in temperature, precipitation, ocean acidification, incidence and extent of hypoxia and sea level rise, among others, will potentially have both favourable and unfavourable impacts on aquaculture. However, the available information indicates that unfavourable changes are likely to outweigh favourable ones, particularly in developing countries where adaptive capacity is typically weakest. (FAO, 2018a) Aquaculture's vulnerability to climate change can have significant geographical variability (Figure 3). For freshwater aquaculture, Asia is the most vulnerable area. In the case of brackish water production, Viet Nam, Egypt and Thailand emerge as having the highest vulnerabilities. For marine aquaculture, Norway and Chile have been identified as the most vulnerable. (Handisyde *et al.*, 2017)

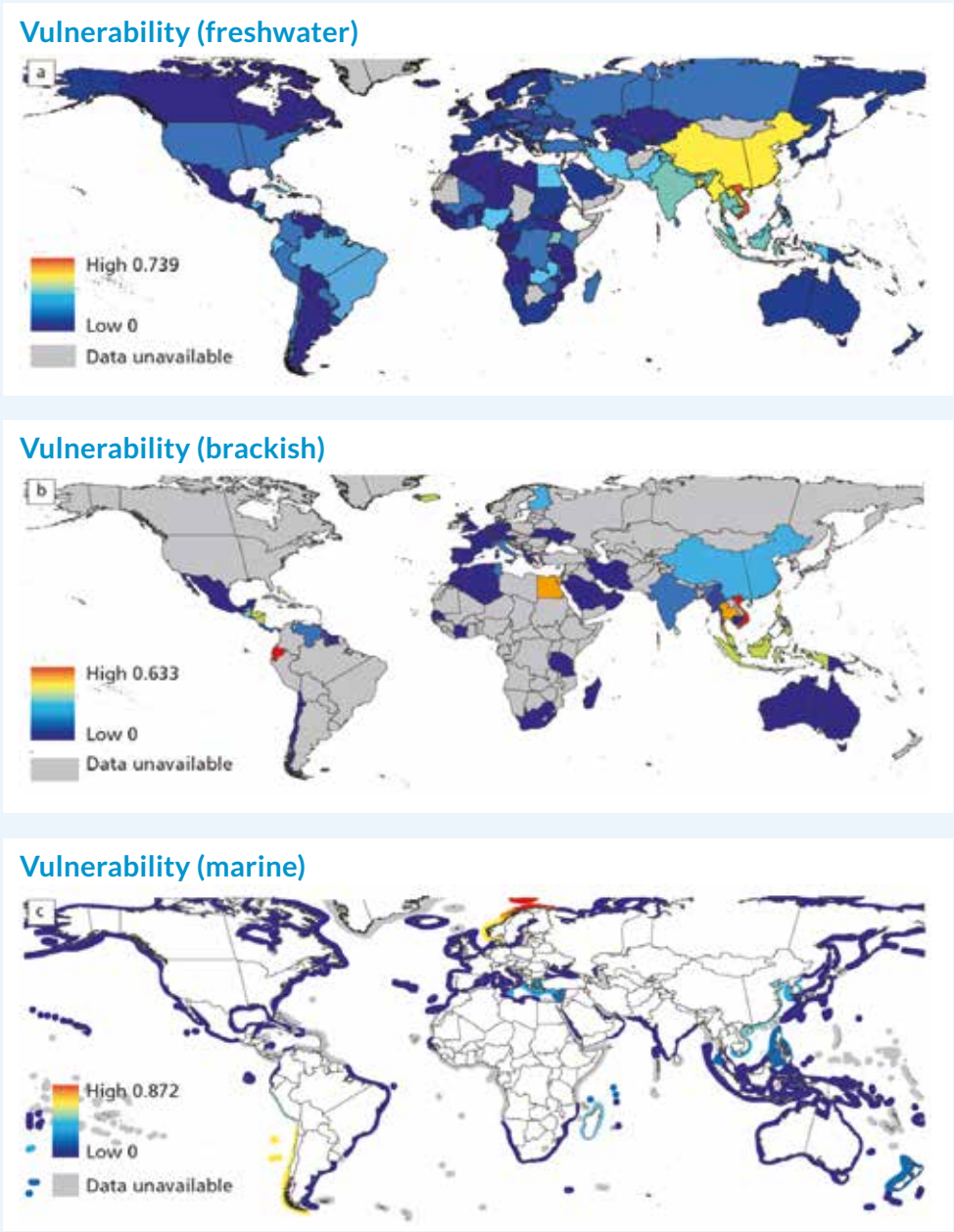


Figure 3: Relative vulnerability of aquaculture to climate change at global level; a) in freshwater, b) in brackish water, c) in the marine environment (shown as a 50 km buffer zone from coasts).
(Source: adapted from Handisyde *et al.*, 2017)

Impacts of climate change on food security

Climate change will have potentially significant impacts on the four dimensions of food security, namely food availability, food stability, food access and food utilization (Figure 4).

Availability of aquatic foods will vary, positively and negatively, through changes in habitats, stocks and species distribution.

Stability of supply will be impacted by changes in seasonality, increased variance of ecosystem productivity, increased supply risks and reduced supply predictability – issues that may also have large impacts on supply chain costs and retail prices.

Access to aquatic foods will be affected by changes in livelihoods and catching or culture opportunities combined with transferred impacts from other sectors (e.g. increased prices of substitute foods), competition for supply, information asymmetries, and rigid management measures that control temporal and spatial access to resources.

Utilization of aquatic products and the nutritional benefits produced will be impacted by changes in range and quality of supply, market chain disruptions, greater food safety issues, and reduced opportunities to consume preferred products.

Figure 4: Cimate change impacts on food security

Exacerbating these climate-driven impacts on food security, human population growth is likely to increase demand, and potentially increase prices, in the coming decades. While price increases may lead to a decrease in fish consumption globally, higher prices should provide an incentive for those engaged in fisheries and aquaculture to increase their production and efficiency.

Food security will also be positively affected by increasing the percentage of fish used for direct human consumption (versus fish used for feed) and reducing post-harvest losses through spoilage and waste. Climate change will add to the complexity of addressing these issues, and climate events may have a direct negative impact on the control of spoilage and waste.

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Regional variability of climate change impacts on fisheries and aquaculture

The impacts of climate change on fisheries and aquaculture are expected to have very significant geographical variability.

While these impacts will be predominantly negative in many fisheries-dependent tropical regions, temperate regions will also see some opportunities (Figure 5).

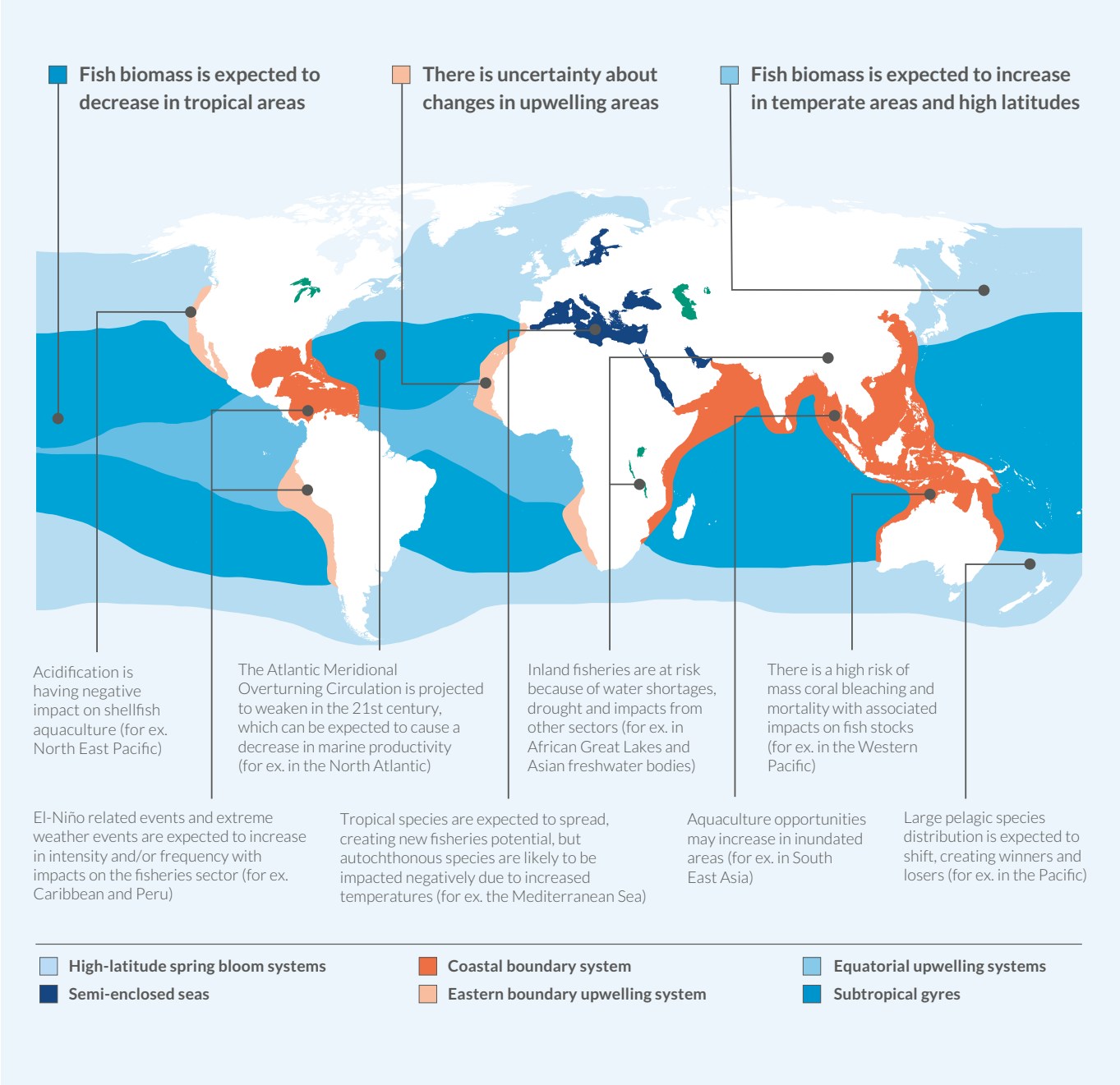


Figure 5:Examples of regional variability of climate change impacts on fisheries and aquaculture
(Source: modified from IPCC, 2014)

Impacts of climate-driven extreme events and disasters

Climate-related disasters now account for more than 80 percent of all disaster events, with significant social and economic impacts.

An extreme event is defined as the occurrence of a value of a weather or climate variable above or below a threshold value near the upper or lower ends of the range of observed values of the variable. Even if not extreme in a statistical sense, a weather or climate event – or two or more events occurring simultaneously – can be considered to be extreme if it has high impacts or consequences for people, the environment or infrastructure (Figure 6).

While the attribution of extreme events is frequently difficult, there is growing confidence that extreme weather events in a number of regions are on the increase, and that this increase is related to anthropogenic climate change. Climate-related disasters now account for more than 80 percent of all disaster events, with significant social and economic impacts, including both short- and long-term displacement of people and populations. Extreme events with significant impacts on fisheries and aquaculture include cyclones and storm surges, coastal and inland flooding, drought, and harmful algal blooms.

Aerial view of flooding and coastal damage in the Sundarbans Region following Cyclone Sidr.

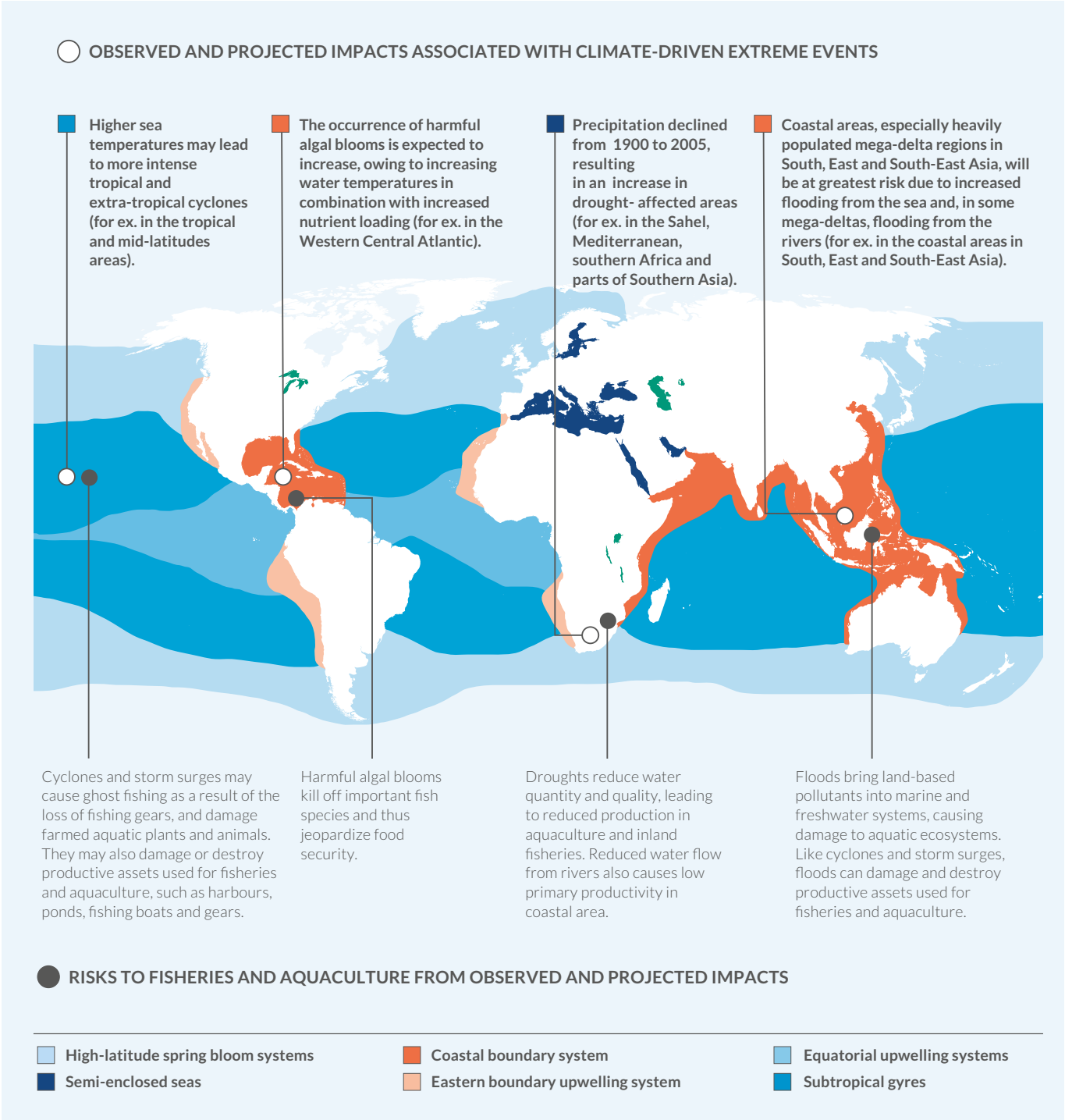


Figure 6: Examples of observed and projected impacts associated with climate-driven extreme events (top), with examples of risks to fisheries and aquaculture from such impacts (bottom)

Aerial view of an algae bloom on a tropical beach in the Caribbean

16

Vulnerability of fisheries and aquaculture to climate change impacts

Vulnerability assessments should give particular attention to individuals and groups with the highest levels of poverty who are almost invariably the most vulnerable to climate change.

Vulnerability is the propensity or predisposition to be adversely affected, and is often described in terms of exposure and sensitivity to negative effects (i.e. susceptibility to harm) mitigated by the capacity to respond, also known as adaptive capacity (Figure 7).

This understanding of vulnerability is commonly used in climate change vulnerability assessments in the fisheries and aquaculture sector to identify practical adaptation options to assist communities, countries and regions in their efforts to reduce vulnerability to climate change and optimize opportunities.

Fisheries and aquaculture activities have specific geographical, environmental and socioeconomic contexts that will each have different and unique vulnerabilities (Figure 8). While climate change will impact fisheries and aquaculture as a whole, the individuals and groups with the highest levels of poverty – especially small-scale fishers and fish farmers in developing countries – are almost invariably the ones who are most vulnerable to climate change. Therefore, vulnerability assessments should give particular attention to those people and groups.

For this reason, it is best to identify and assess the different groups within the system – according to, for example, socioeconomic status, poverty and food security, age and gender – in order to ensure that the most vulnerable are recognized and included in relevant plans and policies.

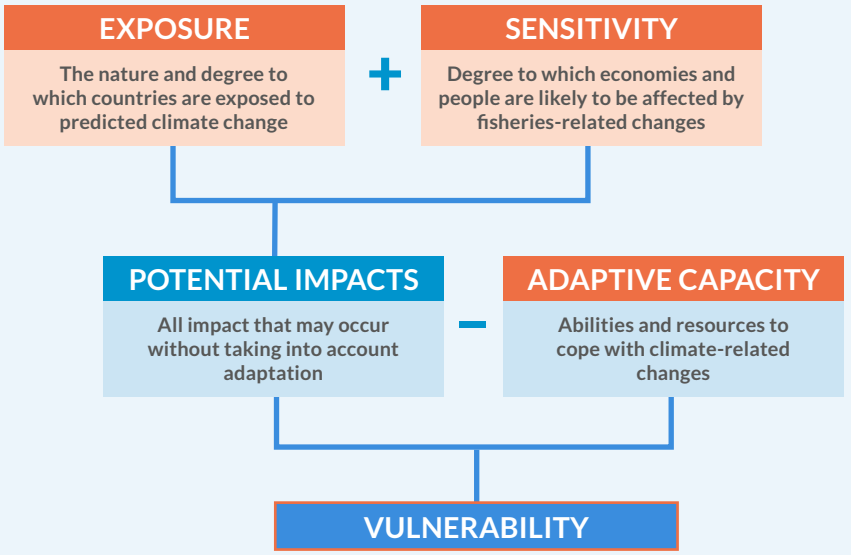


Figure 7: Interpretation and adaptation of the IPCC model of vulnerability to the context of fisheries and aquaculture
(Source: adapted from FAO, 2015)

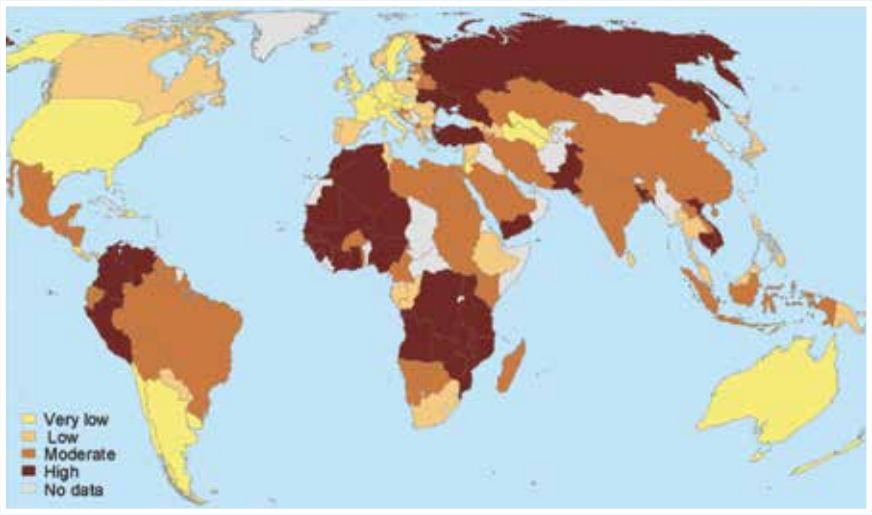


Figure 8: Global mapping of national economies' vulnerability to climate change impacts through fisheries
(Source: adapted from Allison *et al.*, 2009 and Daw *et al.*, 2009)

Carbon footprints of the fisheries and aquaculture sector

Fisheries and aquaculture have a relatively small overall carbon footprint compared with other land-based food production systems.

In 2012, the estimated global emission of carbon dioxide by fishing vessels, both marine and inland, was 172.3 megatonnes, which was about 0.5 percent of total global emissions that year. The aquaculture industry, including the emissions involved in capturing fish for feed, was estimated to have led to the emission of 385 megatonnes of carbon dioxide in 2010. (FAO, 2018a) (Figure 9).

Overall, the energy use of protein production per unit mass of fish is comparable to chicken, but is much less than that from other land-based systems such as pork and beef. Fisheries and aquaculture are therefore only minor contributors to emissions.

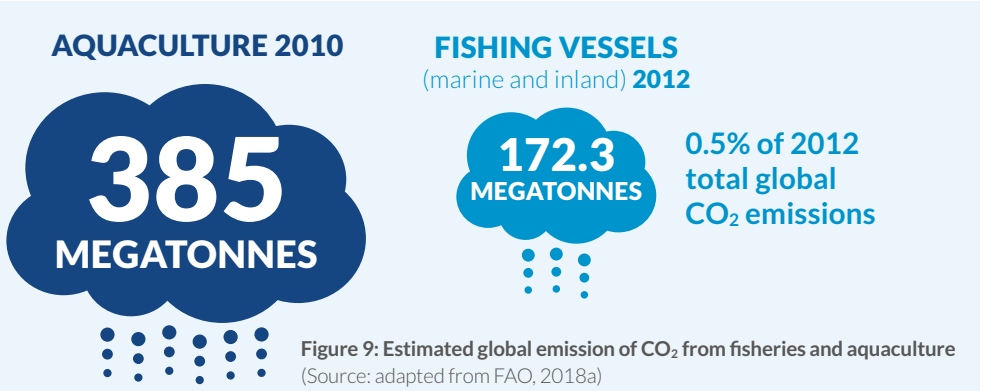
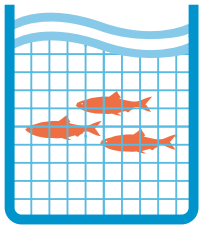


Figure 9: Estimated global emission of CO_2 from fisheries and aquaculture
(Source: adapted from FAO, 2018a)

CARBON FOOTPRINTS OF FISHERIES AND AQUACULTURE ACTIVITIES

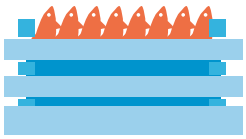
Fisheries operations:

- Industrial fisheries have much greater emissions than small-scale fisheries.
- CO_2 emissions ratio is estimated at around 3 tonnes of CO_2 per tonne of fuel used.
- Management measures that encourage a 'race to fish' create incentives to increase engine power.
- Overfished stocks at lower densities and smaller individual sizes require vessels to exert more effort, thereby increasing fuel use per tonne of landings.



Aquaculture production:

- Most aquaculture production only requires small amounts of fertilizer, often organic, and in some cases low-energy supplementary feeds, and therefore has a relatively small overall carbon footprint.
- The organic feeding materials used in aquaculture ecosystems to accelerate primary production, especially in tropical fishponds, can have significant effects on microbial processes, which in turn affect carbon biogeochemical processes that emit methane (CH_4).
- Some species and systems which are of high quality food value – such as shrimp, salmon and marine carnivores – have high feed energy or system energy demands, and consequently have very high carbon footprints.



Post-harvest practices:

- As in all food production sectors, post-harvest activities entail stocking, packaging and transporting: these create post-consumption waste, all linked with CO_2 emissions.
- Intercontinental airfreight may emit 8.5 kg CO_2 per kg of fish shipped, about 3.5 times the levels from sea freight, and more than 90 times those from the transport of fish consumed within 400 km of its source.

Mitigation

Opportunities exist for reducing fuel use and GHG emissions in capture fisheries and aquaculture.

Although they are a relatively small contributor in global terms, fisheries and aquaculture have a responsibility to mitigate GHG emissions as much as possible.

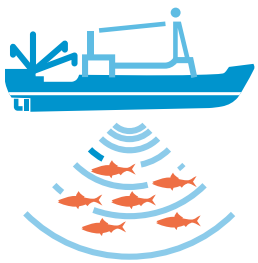
In the case of capture fisheries, a 10 to 30 percent reduction of vessel emissions is achievable with efficient engines and larger propellers, better vessel shape and hull modifications, and speed reductions. (FAO, 2018a) There are also opportunities to reduce GHG emissions in aquaculture, which include improving technological efficiency, reducing reliance on fossil fuel, replacing fish-based feed ingredients and improving feed conversion rates. Combining these approaches would result in a reduction of 21 percent in CO_2 emission per tonne of fish produced. (FAO, 2018a)

MITIGATION MEASURES IN CAPTURE FISHERIES AND AQUACULTURE

Mitigation measures in capture fisheries:

Fishing vessels

- Improving fuel efficiency in existing vessels through actions such as reducing vessel speed, utilizing waste heat, and improving insulation for heating and cooling
- Improving fuel efficiency in new vessels through actions such as selecting efficient engines and larger propellers, and creating better vessel shapes and hull dimensions
- Undertaking regular maintenance of engines and other machinery
- Lowering fuel consumption by slightly reducing steaming and/or towing speed

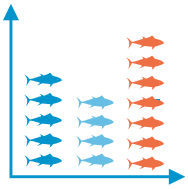


Fishing gear

- Replacing fuel-intensive gears with alternatives that require less fuel
- Modifying designs of towed fishing gears by using high-strength materials, efficient otter boards, larger mesh sizes and thinner twines
- Using electric stimuli for beam trawls and energy-efficient lights to attract fish
- Improving fishing instrumentation by using seabed-discriminating acoustic devices, gear monitoring and catch sensors, and positioning and tracking systems

Fishing port infrastructure

- Improving energy efficiency in cold storage and ice plants
- Using renewable energy systems such as solar and wind for land-based port facilities
- Designing port buildings with a low carbon footprint



Fisheries management

- Adopting and implementing fisheries management measures to reduce fishing effort and increase fish stocks through input control measures, output control measures, and fuel subsidies and incentives

Mitigation measures in aquaculture:

Production of feed materials

- Selecting feedstuffs with lower associated emissions (e.g. locally-sourced oilseeds, which are much lower than fishmeal and fish oil sourced from capture fisheries)

Feed mill energy use

- Improving management efficiency of feed mills
- Substituting high emission intensity fuels with low emission intensity alternatives

Feed conversion rates

- Optimizing the nutritional content of feed and its availability
- Improving feed management
- Increasing dissolved oxygen levels to increase feeding efficiency

Fish health

- Improving water quality management
- Maintaining appropriate fish stocking densities
- Implementing effective biosecurity measures
- Using medicines properly

On-farm N_2O emissions

- Adhering to fertilization guidelines in pond aquaculture
- Improving feed management to reduce uneaten food

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FAO technical officers and members of the Peruvian Production Ministry mesuring the size of the fishing nets as they carry out inspections aboard of fishing ships in the port of Callao-Pesquera Diamante

Adaptation

FAO has developed an adaptation toolbox for governments, industries and individual fishers and fish farmers.

Although different types of adaptation tools have been developed over the last two decades, there is minimal guidance available specifically aimed at developing adaptation strategies for the fisheries and aquaculture sector. FAO has filled this gap by providing a portfolio of tools and measures recommended and currently available for capture marine and inland fisheries and for aquaculture, as well as guidance for selecting, implementing and monitoring the effectiveness of adaptation actions while limiting maladaptation (Figure 10).

Adaptation toolbox

The FAO adaptation toolbox comprises institutional adaptation, measures addressing livelihood, and measures intended for risk reduction and management which thereby strengthen resilience.

Category 1: Institutional adaptation. For fisheries and aquaculture, setting out a design for change may require a change in existing public policies and legal frameworks. Moreover, climate change needs to be integrated into fisheries and aquaculture management, and institutional frameworks should be created or revised to ensure effective stakeholder participation and to enhance cooperation mechanisms between countries and other stakeholders.

Category 2: Measures addressing livelihoods. Livelihood adaptation includes a mix of public and private activities within the fisheries and aquaculture sector, as well as non-fish-related sectors. A common strategy is diversification within or outside the sector to reduce the vulnerability to change of fisheries-dependent livelihoods.

Category 3: Measures intended for risk reduction and management for resilience. Tools for risk reduction and resilience building include a mix of public and private activities to pool and transfer risk, promote early warning and information systems, improve risk reduction and preparedness, and enhance response to shocks from climate change impacts.

Using the toolbox

A key step in climate change adaptation is putting adaptation tools into practice. Decisions in relation to climate change are not a once-and-for-all event, but an iterative (or adaptive) process that is likely to continue over decades, where there will be opportunities for learning and mid-course corrections in the light of new information. The iterative process is represented in Figure 11 and explained in the steps below.

Step 1: Scoping and objective setting. To assess the vulnerability of fisheries and aquaculture to climate change, the relevant stakeholders should start with determining objectives and scope, then gather relevant data, information and expertise, and finally assess the components of vulnerability.

Step 2: Analysis of the results of the vulnerability assessment and development of a climate adaptation strategy. The results of the vulnerability assessment exercise can be used to develop an overall climate adaptation strategy or plan for a given context. In this step, adaptation tools are prioritized and selected, using standard methods which include scoping, expert elicitation, stakeholder consultation and economic analysis.

Step 3: Implementation, monitoring and evaluation. It is key to build measurable goals and indicators into implementation in order to continuously monitor and evaluate whether or not the tools are meeting the selected adaptation objectives.

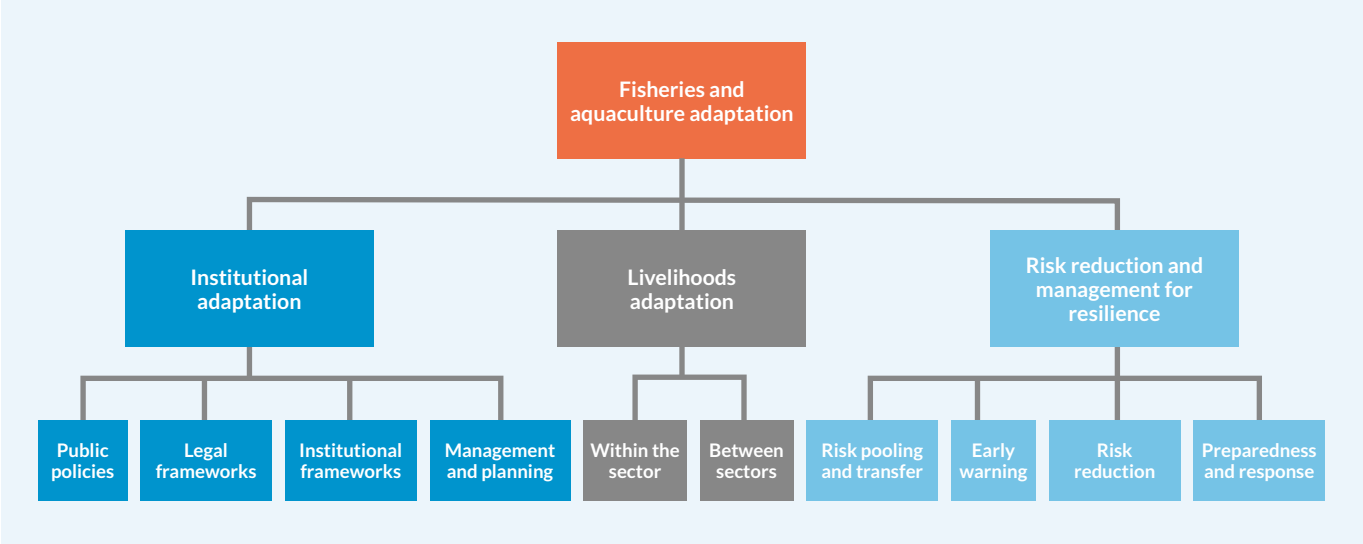

Figure 10: Categories of adaptation activities
(Source: adapted from FAO, 2018a)

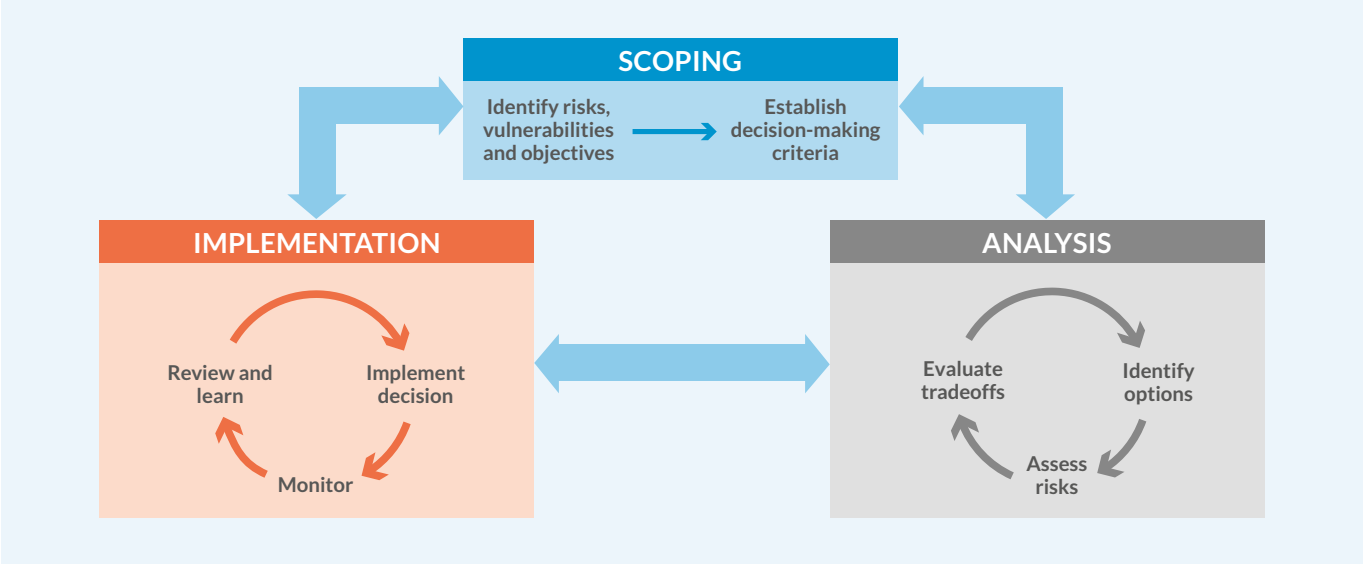

Figure 11: An iterative risk management framework incorporating system feedbacks
(Source: adapted from Jones *et al.*, 2014)

National adaptation plans

To advance global adaptation efforts, the Paris Agreement calls on all countries to prepare and implement National Adaptation Plans (NAPs). NAPs enable countries to identify their medium- and long-term adaptation needs and to develop and implement strategies and programmes to address those needs. NAPs are an important element in the identification and prioritization of adaptation priorities for countries, and will inform Nationally Determined Contributions (NDCs).

The mainstreaming of fisheries and aquaculture issues in national adaptation processes is improving, but often remains incomplete and superficial. The downscaling of the formulation and implementation of an adaptation plan that recognizes, integrates and addresses concerns specific to fisheries and aquaculture will lead to greater resilience for the sector and the communities it supports in the face of climate and other environmental threats. In addition to sector-specific adaptation plans, it is also important for the

fisheries and aquaculture sector to take part in a broader adaptation planning process, as there can be synergies and trade-offs across sectors (Figure 12).

In response to a call by the Least Developed Countries Expert Group (LEG) of the UNFCCC, inviting international actors to 'come forward in drafting supplementary materials to the NAP Technical Guidelines', FAO prepared supplementary guidelines addressing fisheries and aquaculture in NAPs. The supplementary guidelines will support fisheries and aquaculture institutions, enabling adaptation planning within the sector and helping national climate change planners and decision-makers to understand sector-specific vulnerabilities and priorities for adaptation as part of the national development and adaptation system.

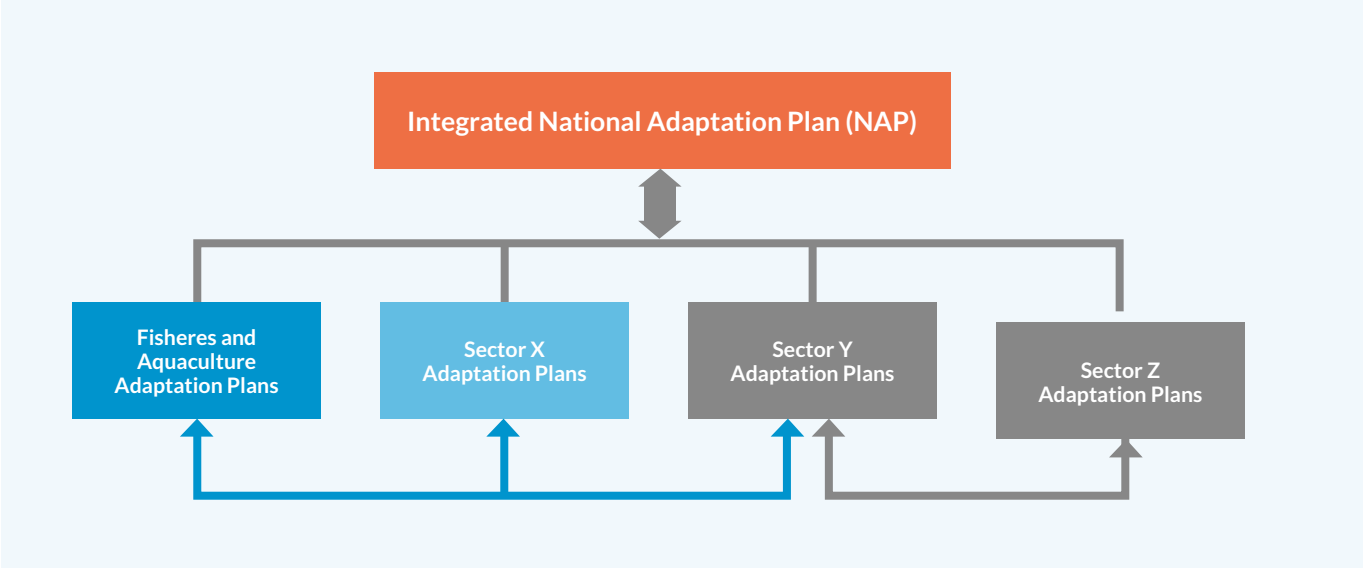

Figure 12: Links among sector-specific and national-level adaptation plans
(Source: adapted from FAO supplementary guidelines)

Increasing climate resilience through genetic improvements in aquaculture

FAO has reported on the state of the world's aquatic genetic resources for food and agriculture and reviewed their use both in capture fisheries and in aquaculture, in areas under national jurisdiction. (FAO, 2019) The report suggests that wider, appropriate and long-term application of genetic improvements in aquaculture, with a focus on selective breeding (e.g. species with high temperature tolerance), will help boost food production to meet a projected increase in demand for fish and fish products with increasing climate resilience and relatively little extra feed, land, water and other inputs.

Climate-smart approaches in fisheries and aquaculture address three key objectives, namely sustainable food systems, adaptation and mitigation.

Climate-smart agriculture (CSA) is an approach developed by FAO that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. The fisheries and aquaculture sector is likely to experience some of the greatest impacts on productivity and livelihoods as a result of climate change and climate variability and their influence on the distribution of resources. The impacts of climate change and adaptation options vary by region. Local context-specific, climate-smart agriculture solutions will be required to guide the sector toward a sustainable future.

Three objectives

Climate-smart approaches in fisheries and aquaculture address three key objectives, namely sustainable food systems, adaptation and mitigation. In particular, the first objective is connected to the overarching goal of achieving sustainable food systems, which encompasses the environmental, social and economic aspects of fisheries and aquaculture. The second objective focuses on the need for adaptation to climate change, including climate-induced extreme events and disasters, by reducing the sector's vulnerability and increasing its resilience. The third objective is to enable the sector, where possible, to contribute to the mitigation of GHG emissions (Figure 13).

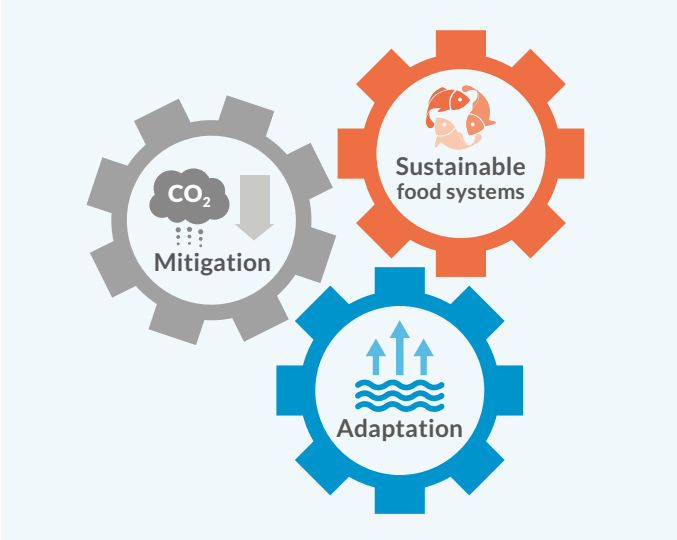

Figure 13: Three objectives of climate-smart approaches in fisheries and aquaculture

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Implementation: a four-step process

©FAO/Sia Kambou

Abidjan, Cote d'Ivoire - Fishermen offloading tunas after a fish catch at Abidjan's industrial fish port, an area supporting strengthening the fisheries sector's policy, legal and regulatory frameworks to incorporate environmental, social and economic sustainability considerations.

Climate-smart approaches in fisheries and aquaculture rely on a comprehensive process leading to the identification and dissemination of locally suitable practices and context-specific technologies. It includes four steps (Figure 14).

Step 1: Expand the evidence base. This step requires more detailed knowledge on the regional and sub-regional impacts of climate change, in order to understand the vulnerabilities of individual ecosystems, capture fisheries, aquaculture systems, food processing and trade, and the communities and societies that are directly or indirectly dependent on them.

Step 2: Support enabling frameworks. This step requires the development and implementation of well-structured, enabling policy frameworks and investment plans to identify and address specific gaps in capacity, efficiency and system resilience for the sector.

Step 3: Enhance financing options. This step requires innovative mechanisms (e.g. Green Climate Fund) that link and blend climate finance and investments to sector-specific needs.

Step 4: Implement practices in the field. This step calls for the integration of local fishers' and farmers' knowledge, requirements and priorities into climate-smart fisheries and aquaculture approaches. Suitable climate-smart strategies can be identified through the participation of fishers and farmers in local projects. Climate-smart approaches must be recognizable and actionable by policy agents in order to work effectively with practitioners and beneficiaries at all levels.

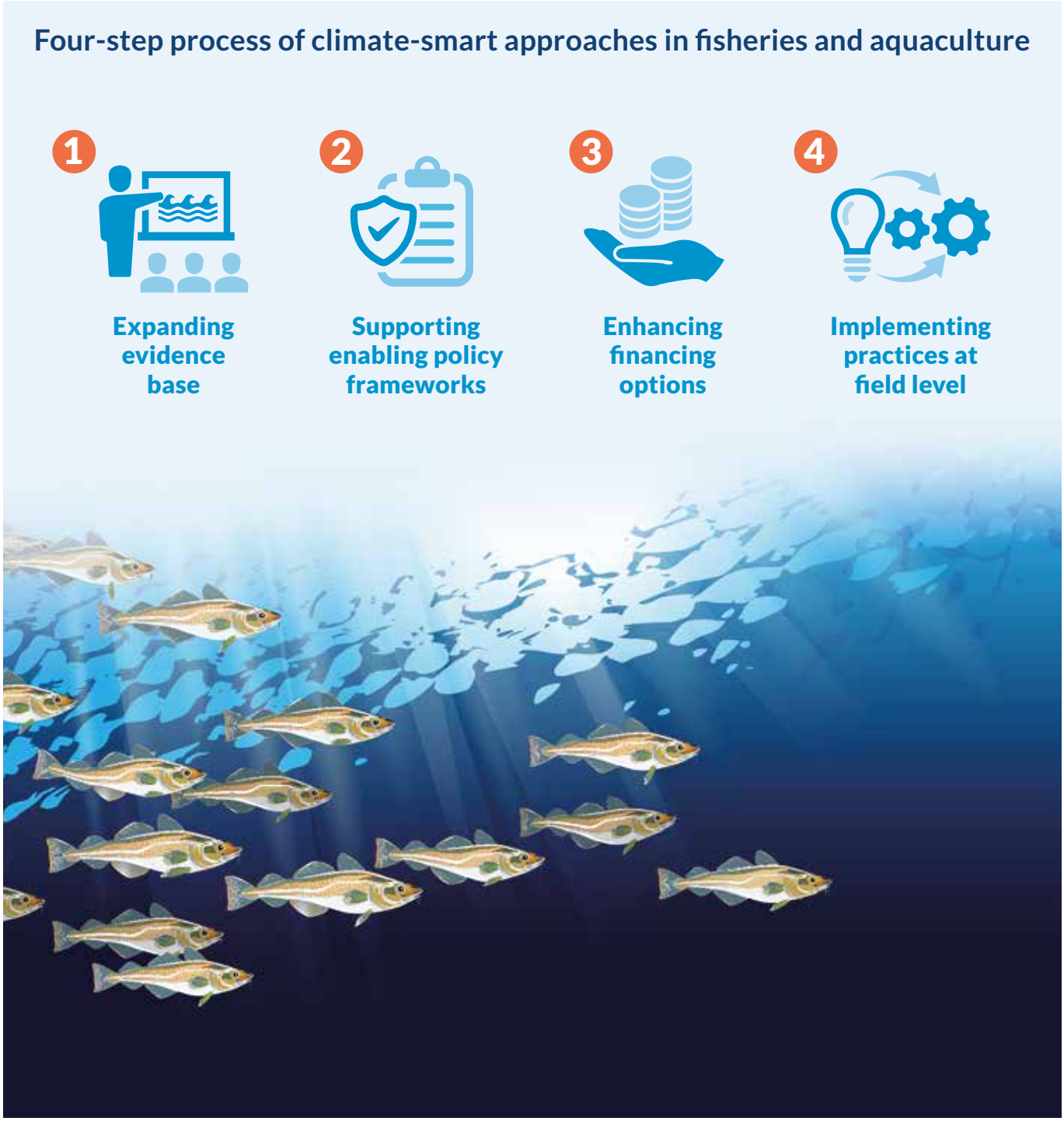


Figure 14: Four-step process of climate-smart approaches in fisheries and aquaculture
(Source: adapted from FAO, 2017)

Supporting countries on mitigation and adaptation

FAO provides guidance and support for member countries and partners to effectively mitigate and adapt to the impacts of climate change in the fisheries and aquaculture sector.

Strengthening the knowledge base and guidance for policy development

Climate planning can only work when decision-makers have the capabilities to forecast climate-induced changes and trigger alerts in fisheries and aquaculture. To make this possible, FAO and its partners have been working to identify climate change implications, vulnerabilities and context-specific adaptation and disaster risk management strategies to improve the resilience of aquatic systems and their dependent communities.

Important FAO publications include a comprehensive technical paper on the impacts of climate change on fisheries and aquaculture, a revised CSA Sourcebook to better guide policymakers and practitioners to make the sector more sustainable and productive while responding to climate change and food security challenges, and specific guidelines addressing fisheries and aquaculture in National Adaptation Plans.

Reducing vulnerability of fishing and fish-farming communities to climate change and natural disasters

The notable increase in the frequency of climate-related events over the past decades poses a significant challenge to fisheries and aquaculture systems, given their crucial reliance on climate. FAO seeks to continue providing updated and systematic data and analysis, in order to build a holistic information system on the impact of disasters on agriculture in developing countries. This will also contribute to implementing and monitoring the three main 2015 international agendas (Sustainable Development Goals, the Paris Agreement and the Sendai Framework for Disaster Risk Reduction), which recognize resilience as fundamental to their achievement.

Initiatives and actions undertaken by FAO include the development of a guide on spatial technology for emergency preparedness and response for aquaculture, and studies on insurance programmes for small producers to increase their resilience to climate risks and disasters.

Developing and implementing projects

FAO has developed and is implementing a number of projects to support adaptation, risk reduction and resilience building in marine capture fisheries, inland capture fisheries and aquaculture at global, regional and country levels. For example, Global Environment Facility (GEF)-funded projects through the Special Climate Change Fund (SCCF) and/or the Least Developed Countries Fund (LDCF) are underway in the Benguela Current, Malawi, Eastern Caribbean, Chile, Myanmar, Bangladesh, Cambodia and Timor Leste.

FAO also provides direct assistance to countries through Technical Cooperation Programme (TCP) and Regular Programme projects, such as rice-fish and climate-resilient tilapia, covering Bangladesh, Indonesia, the Philippines, Sri Lanka and Viet Nam.

Raising awareness of the emissions and mitigation potential from fisheries and aquaculture

Significant opportunities exist for reducing fuel use and GHG emissions in the fisheries and aquaculture sector, even though the GHG contributions of this sector are considered to be relatively small in overall terms. The first step of emission reduction in capture fisheries is to audit the energy used by fishing vessels to systematically evaluate the potential cost and environmental benefits of fuel-saving practices.

FAO has carried out an energy audit project in Thai trawl fisheries, which successfully identified some effective fuel-saving practices. It is recommended that similar projects be carried out in other developing countries to make the most of simple and cost-effective options for fuel-saving and emission reduction. In support of mitigation efforts in aquaculture, FAO has developed a tool for quantifying sector GHG emissions based on the results of a joint FAO-Global Salmon Initiative workshop.

Increasing visibility of fisheries and aquaculture in cross-sectoral and global climate change discussions

With the increasing recognition that oceans are part of the climate action agenda, discussions in international climate change fora involving the ocean community are now more focused on showcasing concrete actions and initiatives to illustrate potential responses of ocean-related sectors to climate change, rather than on advocacy.

FAO, with the support of partners and member countries, has showcased adaptation solutions through its efforts on the identification of climate vulnerabilities and context-specific strategies to improve the resilience of dependent communities and increase the relevant knowledge base. FAO will continue to work to strengthen international mobilization and cooperation for the conservation and enhancement of ocean resilience under the United Nations Framework Convention on Climate Change (UNFCCC).

©FAO/Roberto Faidutti

FAO has carried out an energy audit project in Thai trawl fisheries, which successfully identified some effective fuel-saving practices.

FAO action areas

FAO has developed and is implementing a number of projects to support adaptation, risk reduction and resilience building in marine capture fisheries, inland capture fisheries and aquaculture at global, regional and national levels.

Key icons

Subsectors

Marine capture fisheries

Inland capture fisheries

Aquaculture

Thematic areas

Strengthening knowledge on impacts and vulnerability

Building resilience of dependent and vulnerable livelihoods

Supporting adaptation planning and implementation

Ensuring sustainable fish production

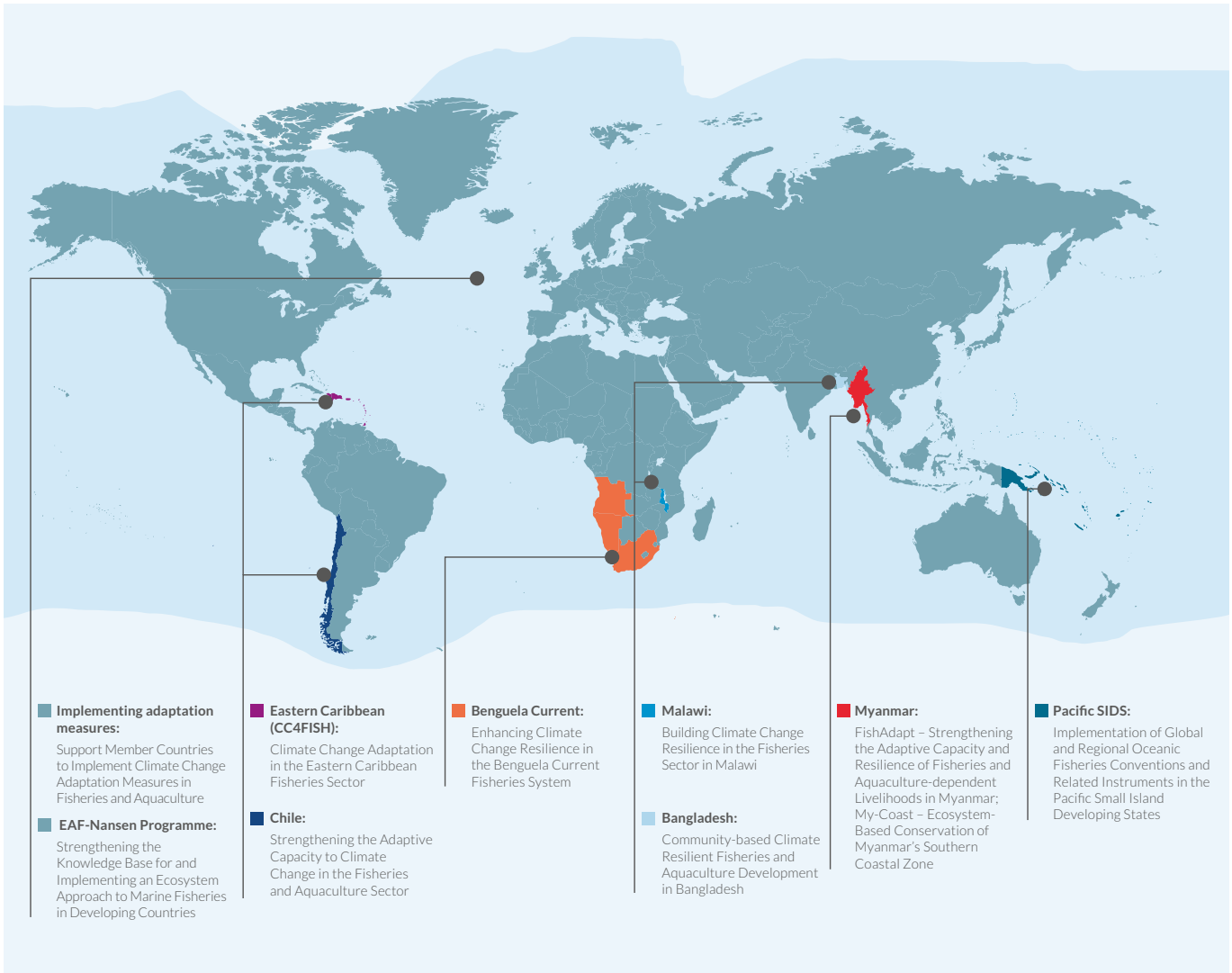
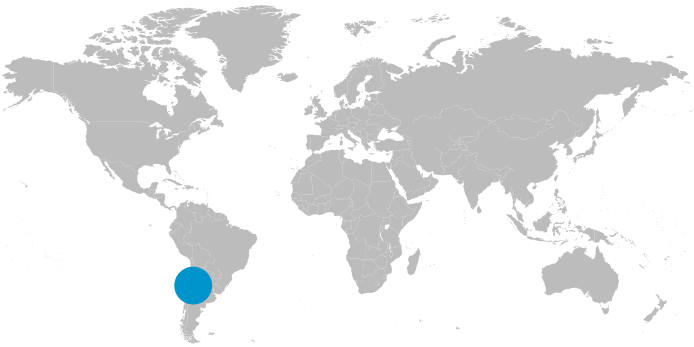


Figure 15: FAO climate change adaptation projects
(Source: adapted from FAO, 2018b)

Caribbean and Latin America

Chile



DONOR(S)

GEF – SCCF

OVERALL OBJECTIVES

The project ('Strengthening the Adaptive Capacity to Climate Change in the Fisheries and Aquaculture Sector') aims to reduce vulnerability to climate change in fisheries and aquaculture in Chile and increase their adaptive capacities.

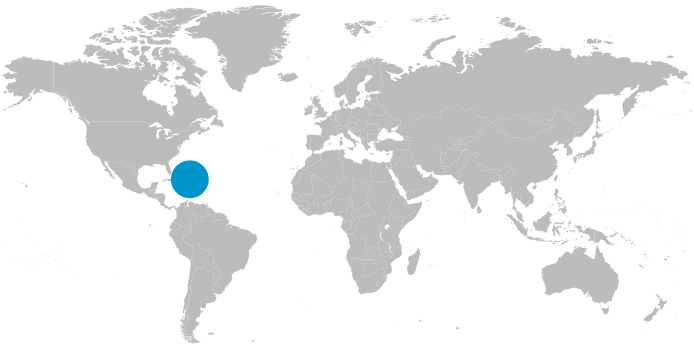
FACTS AND FIGURES

- In 2014, the volume of fisheries landings in Chile was close to 3.8 million tonnes, with end products generation in the order of 1.6 million tonnes.
- The fisheries subsector has a high impact on coastal communities, generating direct employment for 150 000 people in 2013, of which 47.3 percent were in artisanal capture fisheries, 26.2 percent in the processing industry, 24.2 percent in aquaculture and 2.2 percent in industrial capture fisheries.
- Aquaculture has grown considerably in Chile in terms of volumes and profits, from 184 000 tonnes in 1994 to 1.2 million tonnes in 2014.
- Of the total harvest in the aquaculture subsector, 78.6 percent (955 000 tonnes) is from salmon farming. This activity represents 36 percent of food exports and provides direct and indirect employment to more than 70 000 people.

IMPACT

This project is a response to the threats that climate change is exerting on the fishery resources and on the most vulnerable user group, the small-scale fishers. The outputs of this project are expected to increase the overall resilience of the Chilean commercial fishing and aquaculture industries, and will hopefully provide guidance to countries both neighbouring and further afield who face similar threats from the effects of climate change.

Eastern Caribbean (CC4FISH)



DONOR(S)

GEF – SCCF

OVERALL OBJECTIVES

The CC4FISH project ('Climate Change Adaptation in the Eastern Caribbean Fisheries Sector') aims to increase resilience and reduce vulnerability to climate change impacts in the Eastern Caribbean fisheries sector, through the introduction of adaptation measures in fisheries management and capacity-building of fishers and aquaculturists.

FACTS AND FIGURES

- The seven countries participating in this project (Antigua and Barbuda, Dominica, Grenada, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago) are Small Island Developing States.
- Fisheries in the Eastern Caribbean are mostly small-scale. Due to the high dependence on marine resources and the high vulnerability of fishers and fisheries infrastructure in the coastal zone, plus the increasing intensity of extreme weather events, there is rising concern over the consequences of climate change and climate variability for the fisheries subsector in the region.
- The aquaculture subsector is not well developed but is receiving more attention from the governments of the Eastern Caribbean states. However, the enabling policy framework to mainstream climate variability and change (e.g. the increasing intensity of storms and hurricanes) into aquaculture is often lacking.

IMPACT

This project aims to achieve three outcomes. First, it will carry out vulnerability assessments to increase awareness and understanding of climate change impacts and vulnerability. Second, it will introduce adaptation measures and support capacity-building to improve the resilience of fishers, coastal communities and aquaculturists. Third, it will mainstream climate change adaptation in multilevel fisheries governance.

The main project's beneficiaries will be 2 800 small-scale fishers and aquaculturists and their household members (including at least 40 percent women). Through climate change adaptation, these people will improve their livelihoods, their resilience capacity, their food security, and will receive higher incomes per family through increased fisheries production or higher value fish products.

Africa

Benguela Current

DONOR(S)

GEF – LDCF & SCCF

OVERALL OBJECTIVES

The Benguela Current project ('Enhancing Climate Change Resilience in the Benguela Current Fisheries System') aims to build resilience and reduce the vulnerability to climate change of the marine fisheries and mariculture (marine aquaculture) sectors within the Benguela Current Large Marine Ecosystem (BCLME), through adaptation strategies to ensure food and livelihood security.

FACTS AND FIGURES

- The BCLME involves three coastal states, namely Angola, Namibia and South Africa, and is one of the most productive marine areas in the world.
- The abundance and productivity of the marine living resources in the system provide the resource base for important and diverse fisheries, ranging in scale from subsistence to large-scale commercial activities and contributing to local food security and employment for hundreds of thousands of people, many of whom have few or no alternatives.
- The fisheries sectors in the three countries are facing a number of serious challenges to ensuring sustainable use of the productive but vulnerable marine resources that support them. These include over-exploitation of many of the marine resources by fisheries, habitat loss and pollution, and climate variability and change.

IMPACT

This project will generate five adaptation benefits. First, climate change adaptation actions in fisheries and fishery-dependent communities will be incorporated into key policies and programmes. Second, nine of the most vulnerable small-scale fishery communities in Angola and South Africa will have adaptation plans under implementation. Third, climate monitoring and early warning systems providing timely and relevant information to target fishery communities and relevant stakeholders will be established in the three countries. Fourth, at least three national or regional fisheries management plans will be revised to incorporate responses to climate variability and change. Fifth, at least 400 people from small-scale fishery communities, government, universities, non-governmental organizations and the industry will receive targeted training on climate change risks and adaptation.

Malawi

DONOR(S)

GEF – LDCF

OVERALL OBJECTIVES

The Malawi project ('Building Climate Change Resilience in the Fisheries Sector in Malawi') aims to build resilience in the beleaguered fisheries sector, especially among the riparian communities of Lake Malombe. The waters of Lake Malombe, connected to Lake Malawi in the north by the Upper Shire River, are heavily overfished. Combined with overfishing, local communities face the added pressures of climate change – making this project a matter of urgency.

FACTS AND FIGURES

- In Malawi, the fisheries and aquaculture sector contributes approximately 4 percent to national Gross Domestic Product (GDP). Capture fisheries dominate. The fisheries and aquaculture sector is of great importance to Malawi's economy as a source of employment, food, rural income, exports, import substitution and biodiversity.
- The sector directly employs some 59 873 fishers and indirectly it supports more than 500 000 people involved in fish processing, fish marketing, boat building and engine repair. Nearly 1.6 million people in lakeside communities derive their livelihood from the fishing industry.
- Lake Malombe is a heavily overfished ecosystem, and climate change adds more complexity. Numerous aspects of fish life cycles and habitat suitability, as well as species-specific biological and ecological reactions to temperature changes, can significantly impact this sector's biodiversity and economic performance.
- However, the impacts of climate change on the Lake Malawi ecosystem and its dependent communities are not yet fully understood, and are certainly not sufficiently integrated into national approaches to management in the fisheries and aquaculture sector.

IMPACT

This project is expected to achieve three outcomes. First, it will strengthen access to information and knowledge regarding climate change and its implications, in order to ensure a sound technical basis for policy work and field-level activities. Second, it will create an enabling environment of policies, plans, regulatory instruments and capacities for the promotion of climate change resilience among fishing communities. Third, this project will strengthen capacities at local level to increase the resilience of fishing communities to climate change. This resilience will be improved through a combination of community-based management and governance of capture fisheries in Lake Malombe, ecosystem restoration and management, climate-proofing of aquaculture, and support for the integration of sustainable water and fish management into the livelihood and farming systems of the poor.

Asia

Bangladesh

- Bangladesh is the most vulnerable country in the world to tropical cyclones and the sixth most vulnerable to floods.
- This project has selected two vulnerable intervention areas: (1) the south-west coastal area, which is increasingly affected by rising sea levels, saltwater intrusion and storm surges; and (2) the north-east haor wetland area that is increasingly affected by flash floods, erratic rainfall and drought. Both areas hold some of the largest fisheries, aquaculture production operations and sector-dependent communities.

DONOR(S)

GEF – LDCF

OVERALL OBJECTIVES

The Bangladesh project ('Community-based Climate Resilient Fisheries and Aquaculture Development in Bangladesh') aims to build and enhance the adaptive capacity and resilience of vulnerable coastal communities and deeply flooded haor wetland communities in Bangladesh dependent on fisheries and aquaculture for their livelihoods, so as to reduce their vulnerability and improve their resilience.

FACTS AND FIGURES

- The fisheries and aquaculture sector in Bangladesh provides about 60 percent of national animal protein, with more than 17.5 million people engaged in the sector on a full-time and part-time basis.

IMPACT

This project is expected to achieve four outcomes. First, it will develop the technical and institutional capacity of the relevant government officials and communities to face climate change risks and their implications with appropriate policy support at the national level. These will generate socioeconomic benefits for the environment, community and the local economy. Second, the project will improve the knowledge base of the relevant government officials and communities on climate change, and the early warning systems and coordination between government departments and institutions involved in ecosystem restoration and climate change adaptation. Third, it will implement site-specific climate-resilient fisheries and aquaculture interventions and alternative, diversified livelihood options. Fourth, this project will strengthen the capacity of the Climate Change Unit in the Department of Fisheries of Bangladesh to collect and share information (availability, accessibility and dissemination) on fisheries and aquaculture-related climate change risks and early warning systems.

Myanmar

DONOR(S)

GEF – LDCF (for the FishAdapt project); GEF Trust Fund (for the My-Coast project)

OVERALL OBJECTIVES

There are two ongoing adaptation projects in Myanmar. One is the FishAdapt project ('Strengthening the Adaptive Capacity and Resilience of Fisheries and Aquaculture-dependent Livelihoods in Myanmar'). The FishAdapt project aims to assist the government in enabling inland and coastal fishery and aquaculture stakeholders to adapt to climate change by understanding and reducing vulnerabilities, piloting new practices and technologies, and sharing information. The other project is the My-Coast project ('Ecosystem-Based Conservation of Myanmar's Southern Coastal Zone'), which seeks to improve coastal zone management to benefit marine biodiversity, climate-change mitigation, and food security.

FACTS AND FIGURES

- Myanmar, situated in South East Asia, has a population of around 51.4 million. It has one of the lowest GDPs in the world, with the World Bank estimating its poverty rate at 37.5 percent.
- Myanmar enjoys diverse climatic conditions including both subtropical and tropical zones, as well as low to high rainfall regions. As a result, the country produces a wide range of almost all crops, and livestock and fishery products.
- The fisheries and aquaculture sector in Myanmar is critically important to the country's food and nutrition security (61 kg/capita/year) and economy (9 percent of GDP). An estimated 1 million people directly and 3 million people indirectly are involved in this sector.
- For marine and inland capture fisheries, climate change impacts include changes in sea surface temperature, higher inland water temperature, changes in ocean currents, changes in the frequency of El Niño-Southern Oscillation (ENSO) events, sea level rise, and changing levels of rain and water availability.

- The aquaculture sector is also exposed to climate-related hazards such as salt-water intrusion, flooding of ponds, shortages in water supply, invasive species, and ad hoc development planning which alters local ecosystem dynamics and undermines their resilience, integrity and functionality.

- Myanmar is vulnerable to extreme climate events. They have caused significant loss of life and damage to infrastructure, and have also impacted fishers' and fish-farmers' livelihoods.

IMPACT

The FishAdapt project is expected to achieve three outcomes. First, stakeholder capacity to address climate change issues will be enhanced through improved national policies and strategies facilitating a climate-resilient fisheries and aquaculture sector. Second, fishers, including small-scale fish-farmers, in coastal and inland water regions of Myanmar will increase their knowledge of, and reduce their vulnerability to, climate change and disasters; and will develop and demonstrate critical adaptation practices and technologies. Third, enhanced understanding and access to adaptation practices and technologies will enable stakeholders to manage information and scale up adaptation in the fisheries and aquaculture sector.

The My-Coast project comprises two inter-related components. Under component one, national capacities will be built to develop and implement strategic coastal conservation management. Under component two, local capacities will be built, and demonstrations will be implemented.

Demonstrations contributing to holistic and integrated coastal zone management will be conducted within a specific geographic area (the southern Tanintharyi Region and Myeik Archipelago) to allow for the measurement of ecosystem-level impacts. The My-Coast project is currently in the project preparation phase. Activities supported during this phase will include the key information-gathering stakeholder consultation tasks that will result in the preparation of the documentation required for submission of the full-size project for endorsement by GEF and approval by FAO.

©FAO/Karina Coates

Teknaf Upazila fish drying on roadside .The Bangladesh project ('Community-based Climate Resilient Fisheries and Aquaculture Development in Bangladesh') aims to build and enhance the adaptive capacity and resilience of vulnerable coastal communities

Pacific

Pacific SIDS

DONOR(S)

GEF Trust Fund

OVERALL OBJECTIVES

The project ('Implementation of Global and Regional Oceanic Fisheries Conventions and Related Instruments in the Pacific Small Island Developing States (SIDS)') aims to support Pacific SIDS in meeting their obligations to implement and effectively enforce global, regional and sub-regional arrangements for the conservation and management of transboundary oceanic fisheries thereby increasing sustainable benefits derived from these fisheries, with the emphasis on implementation.

FACTS AND FIGURES

- The waters of the Pacific Islands region cover an area of around 40 million square kilometres, or around 8 percent of the Earth's surface. This is equivalent to about 30 percent of the area of the Earth's land surfaces.
- The waters hold the world's largest stocks of tuna and related pelagic species. The waters of the Pacific Islands region provide around a third of the world's catches of tuna and related species, and over half of the world's supplies for canned tuna.
- The waters of the region also contain globally important stocks of sharks, billfish and other large pelagic species, whales and other marine mammals, and turtles. The conservation of these globally important transboundary fish stocks, and the protection of the associated transboundary non-target species (especially of sharks, seabirds and sea turtles), while considering climatic variability and change, constitutes the global environmental benefit for this project.
- Climate change concerns include sea level rise, which can be expected to inundate the territories of some Pacific SIDS, and changes in the distribution of species such as tuna stocks in ways that would greatly affect the economic values of Pacific SIDS exclusive economic zones.

IMPACT

The project comprises three technical components, namely actions for ecosystem-based management at regional, sub-regional and national levels, and a project management component. Structured in this way, the project will support Pacific SIDS as the major bloc at the Western and Central Pacific Fisheries Commission (WCPFC) to adopt regional conservation and management measures. It will also support the innovative approaches being developed by Pacific SIDS at sub-regional level as they collaborate in fisheries of common interest and assist SIDS to apply measures nationally in their own waters and to their fleets.

Global

Implementing adaptation measures

DONOR(S)

Government of Norway

OVERALL OBJECTIVES

The project ('Support Member Countries to Implement Climate Change Adaptation Measures in Fisheries and Aquaculture') aims to assist partner countries and key stakeholders, including trade and industry experts, policy and management experts, fishers and fish workers, to adapt to climate change effectively while ensuring the socioeconomic development of the fisheries and aquaculture sector. The ultimate goal of this project is to support partner countries in the development and implementation of their NDCs and NAPs under the Paris Agreement.

FACTS AND FIGURES

- The project recipient countries, including Small Island Developing States (SIDS), will be identified within the following broad regional areas: Southern Africa, Eastern Caribbean and South East Asia.
- NDCs are the formal commitments member countries will make towards achieving the mitigation and adaptation objectives of the Paris Agreement, and countries are expected to provide their first mandatory submission in 2020.
- NAPs are member countries' medium and long-term adaptation plans submitted to UNFCCC.

IMPACT

This project will improve countries' capacity to develop and implement climate change adaptation plans and actions, which promote socioeconomic development with specific attention to poverty reduction and food security in the fisheries and aquaculture sector. The project is expected to deliver four outputs. First, selected countries will understand their adaptation gaps. Second, the FAO Adaptation Toolbox will be piloted in selected countries to develop a national adaptation roadmap. Third, capacity to implement the climate change adaptation roadmaps will be developed. Fourth, lessons learned will be used to refine national climate policies (NAPs and NDCs) and review and refine the FAO Adaptation Toolbox.

Global

EAF-Nansen Programme

DONOR(S)

Government of Norway

OVERALL OBJECTIVES

The EAF-Nansen Programme ('Strengthening the Knowledge Base for and Implementing an Ecosystem Approach to Marine Fisheries in Developing Countries') offers an opportunity for coastal countries in sub-Saharan Africa to receive support from FAO for the implementation of an ecosystem approach to fisheries (EAF) management. The project aims to assist participating countries to develop national and regional frameworks for EAF, and acquire additional knowledge on their marine ecosystems for use in planning and monitoring. It includes a climate change component that aims mainly at increasing the knowledge base on climate change impacts and assessing vulnerability of fisheries-dependent communities in selected areas.

FACTS AND FIGURES

- Unsustainable fisheries, climate change and pollution are undermining livelihoods and food security in many developing countries, especially in Africa. In the Gulf of Guinea and several other countries of tropical Africa, coastal communities live primarily on fish as a source of food and livelihoods.
- FAO estimates that fish provides 22 percent of animal protein intake in sub-Saharan Africa, this share exceeding 50 percent in the poorest countries (especially where other sources of animal protein are scarce or expensive).
- In countries with upwelling regions, such as Mauritania or Namibia in northwest and southwest Africa respectively, fisheries represent a high percentage of GDP. However, there is conflicting information as to the consequences of climate change on coastal upwelling, a crucial element in the biological production of many areas of the African coastal zone.

IMPACT

This project is expected to achieve the long-term objective that people in partner countries are food and nutrition secure. It will work towards the overall outcome that fisheries in partner countries are sustainably managed based on ecological, socioeconomic and governance considerations. Three sub-outcomes are expected. First, fishery research institutions will provide relevant and timely scientific advice for management. Second, fisheries management institutions will have appropriate management processes and policies in place according to the EAF principles. Third, partner institutions will have appropriate and adequate human and institutional capacity to manage fisheries sustainably. Furthermore, this project is expected to improve understanding of the impacts of climate change and other anthropogenic impacts on fish stocks and ecosystems, including setting up monitoring systems. It will also provide technical assistance to support socioecological assessments of the vulnerability of coastal communities to climate variability and change.

©FAO/Joerg Boethling

Djerba Island, Tunisia - Fishermen in the port of Ajim. Blue Hope – Blue Hope Initiative project sites in Zarzis. Supporting Mediterranean small-scale fishing communities in transforming vulnerable coastal zones into engines of stability and hope.

Selected publications

Impact of climate change on fisheries and aquaculture

This publication is a synthesis of current knowledge on climate change implications for marine fisheries, inland fisheries and aquaculture. It provides the fundamentals of observed and projected changes in the climate system and their consequences for the marine and freshwater systems. The technical paper recognizes the importance of contextualizing the topic of climate change in fisheries and aquaculture in terms of poverty alleviation and existing policy commitments such as the 2030 Agenda for Sustainable Development and the Paris Climate Agreement, and on our current and expected socioeconomic dependencies on the sector.

The state of world fisheries and aquaculture 2018

The 2018 edition emphasizes the sector's role in achieving the 2030 Agenda for Sustainable Development and the Sustainable Development Goals, and measurement of progress towards these goals. It notes the particular contributions of inland and small-scale fisheries, and highlights the importance of rights-based governance for equitable and inclusive development.

Fisheries and aquaculture in the climate-smart agriculture sourcebook

The purpose of the sourcebook is to further elaborate the concept of climate-smart agriculture and demonstrate its potential, as well as its limitations. This sourcebook is a reference tool for planners, practitioners and policymakers working in agriculture, forestry and fisheries at national and subnational levels, dealing with the effects of climate change.

Assessing climate change vulnerability in fisheries and aquaculture

This publication provides an overview of vulnerability assessment concepts and methodologies. It sheds light on the different vulnerability assessment methodologies that have been developed, and on how these are conditioned by the disciplinary traditions from which they have emerged. It also analyses how these methodologies have been applied in the context of fisheries and aquaculture, with illustrative examples of their application. It also proposes a series of practical steps to assess vulnerability in the fisheries and aquaculture sector.

The state of the world's aquatic genetic resources for food and agriculture 2019

This report reviews our use of aquatic genetic resources both in capture fisheries and in aquaculture, in areas under national jurisdiction. The first-ever global report of its kind is based on information provided by 92 countries, together representing 96 percent of global aquaculture production and over 80 percent of capture fisheries production.

Guidance on spatial technologies for disaster risk management in aquaculture: a handbook

This document addresses the use of spatial technologies that support those working to reduce disaster risks and respond to emergencies in the aquaculture sector. It describes the principles for using spatial technologies in disaster risk management and will therefore remain relevant, even in the context of rapid technological innovation and the advancement of these technologies.

Fisheries and aquaculture climate change adaptation examples

This circular contains a selection of current and recent climate change adaptation activities and measures in the fisheries and aquaculture sector. Descriptions for 26 current or recent activities and programmes focused specifically on or benefiting fisheries and/or aquaculture (and other sectors if relevant), primarily in developing countries, highlight the diversity of potential adaptation actions at the local to regional scales.

EAF Toolbox – The ecosystem approach to fisheries

The EAF Toolbox is aimed at national and local fisheries management authorities, including fishery managers, scientists and stakeholders looking for practical solutions they can apply given their circumstances and resources.

Ecosystem approach to fisheries management training course (Inland fisheries) Volume 1: Handbook for trainees

This Ecosystem Approach to Fisheries management training course (Inland Fisheries) is designed as a complete training course for the sustainable management of inland fisheries using the ecosystem approach. It is targeted at middle-level fishery and environment officers, extension workers, facilitators and other stakeholders engaged in the planning and management of inland fisheries.

Addressing agriculture, forestry and fisheries in National Adaptation Plans – supplementary guidelines

The guidelines outline four elements and related steps for preparing the agriculture sectors' contributions to National Adaptation Plans.

Addressing fisheries and aquaculture in National Adaptation Plans – supplement to the UNFCCC NAP Technical Guidelines

This document provides technical guidance on the integration of fisheries and aquaculture in the formulation and implementation of National Adaptation Plans. It aims to draw the attention of policymakers and government officers responsible for National Adaptation Plans planning and processes generally, as well as fisheries and aquaculture officers at country level specifically. It collates and analyses relevant information from fisheries and aquaculture to support the sector's ability to take part in national climate change adaptation planning processes.

FAO yearbook of fishery and aquaculture statistics 2017

The FAO Yearbook of Fishery and Aquaculture Statistics is a compilation of statistical data on capture fisheries and aquaculture production, employment, commodities production and trade, apparent fish consumption and fishing fleets.

Unloading Thai fishng boats

References

Allison, E.H. *et al.* 2009. Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries*, 10(2): 173-196. (also available at https://doi.org/10.1111/j.1467-2979.2008.00310.x)

Badjeck, M.-C., *et al.* 2010. Impacts of climate variability and change on fishery-based livelihoods. *Marine Policy*, 34(3): 375-383. (also available at https://doi.org/10.1016/j.marpol.2009.08.007)

Barange, M. 2019. Avoiding misinterpretation of climate change projections of fish catches. ICES *Journal of Marine Science*, fsz061. (also available at https://doi.org/10.1093/icesjms/fsz061)

Daw, T., Adger, W.N., Brown, K. & Badjeck, M.-C. 2009. Climate change and capture fisheries: potential impacts, adaptation and mitigation. In K. Cochrane, C. De Young, D. Soto & T. Bahri, eds. *Climate change implications for fisheries and aquaculture: overview of current scientific knowledge,* pp. 107–150. FAO Fisheries and Aquaculture Technical Paper No. 530. Rome, FAO. 212 pp. (also available at www.fao.org/docrep/012/i0994e/i0994e00.htm).

FAO. 2015. *Assessing climate change vulnerability in fisheries and aquaculture: available methodologies and their relevance for the sector*, by Cecile Brugère and Cassandra De Young. FAO Fisheries and Aquaculture Technical Paper No. 597. Rome. 86 pp. (also available at http://www.fao.org/3/a-i5109e.pdf).

FAO. 2017. *Climate-smart agriculture sourcebook*. Second edition. (also available at http://www.fao.org/climate-smart-agriculture-sourcebook/en/)

FAO. 2018a. *Impacts of climate change on fisheries and aquaculture*. FAO Fisheries and Aquaculture Technical Paper 627. Rome. 628 pp. (also available at http://www.fao.org/3/i9705en/i9705en.pdf)

FAO. 2018b. *The state of world fisheries and aquaculture*. Rome. 210 pp. (also available at http://www.fao.org/3/i9540en/i9540en.pdf)

FAO. 2019. *The state of the world's aquatic genetic resources for food and agriculture*. Rome. 251 pp. (also available at http://www.fao.org/3/ca5256en/CA5256EN.pdf)

FAO. Forthcoming. *Addressing fisheries and aquaculture in national adaptation plans – supplement to the UNFCCC NAP Technical Guidelines*. ("FAO supplementary guidelines")

Handisyde, N., Telfer, T.C. & Ross, L.G. 2017. Vulnerability of aquaculture-related livelihoods to changing climate at the global scale. *Fish and Fisheries*, 18(3): 466–488. (also available at https://doi.org/10.1111/faf.12186).

IPCC. 2014. *Climate change 2014: Synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report on the Intergovernmental Panel on Climate Change*. Core writing team, R.K. Pachauri & L.A. Meyer. Geneva, Intergovernmental Panel on Climate Change. 151 pp. (also available at https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf)

Jones, R.N., Patwardhan, A., Cohen, S.J., Dessai, S., Lammel, A., Lempert, R.J., Mirza, M.M.Q & von Storch, H. 2014. Foundations for decision making. In C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee *et al.*, eds. *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, UK and New York, Cambridge University Press. pp. 195–228.

Lotze, H.K. *et al.* 2019. Global ensemble projections reveal trophic amplification of ocean biomass declines with climate change. *PNAS*, 116(26): 12907-12912. (also available at https://doi.org/10.1073/pnas.1900194116)

Myers, S. S., Smith, M. R., Guth, S., Golden, C. D., Vaitla, B., Mueller, N. D., *et al*. 2017. Climate Change and Global Food Systems: Potential Impacts on Food Security and Undernutrition. *Annual Review of Public Health,* 38: 259-277. (also available at https://doi.org/10.1146/annurev-publhealth-031816-044356)

Reid, A.J. *et al.* 2019. Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews*, 94(3): 849-973. (also available at https://doi.org/10.1111/brv.12480)

The Food and Agriculture Organization of the United Nations (FAO) works towards ending hunger and poverty while using precious natural resources sustainably. The fisheries and aquaculture sector makes substantial contributions to food security, livelihoods and global trade. Global production of fish and other aquatic animals continued to grow and reached 172.6 million tonnes in 2017, and about 59.7 million people were engaged in the primary sector of capture fisheries and aquaculture. Fishery net exports generate significantly more revenue for developing countries than other agricultural commodities such as rice, coffee and tea.

Millions of people are struggling to maintain reasonable livelihoods through the fisheries and aquaculture sector. These are the people who are the most vulnerable to the impacts of climate change. Climate change adds to the many threats and obstacles that already confront them in their day-to-day lives. Particular attention must be given to be the most vulnerable if the sector is to continue to contribute to meeting global goals of poverty reduction and food security.

This publication presents FAO's work on climate change and fisheries and aquaculture. It includes examples of FAO's support to countries so that they are better able to adapt to the impact of climate change in the fisheries and aquaculture sector. It also brings together FAO's most up-to-date knowledge on climate change, including a portfolio of adaptation tools and measures used to support countries' climate commitments and action plans.

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