

How to do

Fisheries, aquaculture and climate change

Guidance for adaptation and mitigation

Environment and climate change



How To Do Notes are prepared by the IFAD **Policy and Technical Advisory Division** and provide practical suggestions and guidelines for country programme managers, project design teams and implementing partners to help them design and implement programmes and projects.

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The **How To Do Notes** are "living" documents and will be updated periodically based on new experiences and feedback. If you have any comments or suggestions, please contact the originators.

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Acronyms

ASAP	Adaptation for Smallholder Agriculture Programme
BMPs	best management practices
CBF	culture-based fisheries
COSOP	country strategic opportunities programme
DANIDA	Danish International Development Agency
FAD	fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
MSC	Marine Stewardship Council
M&E	monitoring and evaluation
PM&E	participatory monitoring and evaluation
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

Introduction

Fisheries and aquaculture are important contributors to food security and livelihoods at household, local, national and global levels. However, while aquaculture production is growing rapidly throughout the world, particularly in Asia and Africa, many of the world's fisheries are at grave risk from human pressures, including overexploitation, pollution and habitat change. Climate change is compounding these pressures, posing very serious challenges and limiting livelihood opportunities.

Climate change is transforming the context in which the world's 55 million fishers and fish farmers live and work, posing a major threat to their livelihoods and the ecosystems on which they depend. For millennia, small-scale fisheries and fish farmers have drawn on their indigenous knowledge and historical observations to manage seasonal and climate variability but today the speed and intensity of environmental change is accelerating, outpacing the ability of human and aquatic systems to adapt.

The changes already being witnessed include warming of the atmosphere and the oceans, changes in rainfall patterns and increased frequency of extreme weather events. The oceans are becoming increasingly saline and acid, affecting the physiology and behaviour of many aquatic species and altering productivity, habitats and migration patterns. Sea level rise, combined with stronger storms, severely threatens coastal communities and ecosystems. The world's coral reefs are threatened with destruction over the coming century. Some inland lakes and water bodies are drying up, while in other areas destructive flooding is becoming a regular occurrence. In many cases, it is the poorest communities in the poorest countries that are most vulnerable to these changes.

Avoiding and managing climate risk is a prerequisite for poor rural people to move out of poverty.

Poor rural people are less resilient because they have fewer assets to fall back on when shocks occur. In an environment in which long-standing risks, such as ill health, market volatility, food insecurity and poor governance, are compounded by the degradation of natural resources and climate change, opportunities for growth are beyond the reach of most poor rural people. Innovative policies and investment programmes are needed to help the rural poor respond and adapt to a changing climate, and anticipate, absorb and recover from climate shocks and stresses.

Over the past several years, there has been a rapidly increasing awareness of the need to address climate change through IFAD operations, which has led to the formulation of the Climate Change Strategy in 2010¹ and the Environment and Natural Resource Management Policy in 2011,² and perhaps most significantly, the launch of the Adaptation of Smallholder Agriculture Programme (ASAP) in 2012.³

This How To Do Note describes a range of multiple-benefit options for integrating climate change adaptation and mitigation into IFAD interventions in the fisheries and aquaculture sectors, based on a review of relevant literature on climate change, the fisheries and aquaculture sectors, and related activities of other international organizations. Most of the proposed measures are not new concepts or ideas but have been proven time and again in practice to provide a range of benefits to and increase the resilience of small-scale fishers and fish farmers, as well as the ecosystems on which they rely. This approach is in line with the ASAP's first principle of scaling up tried and trusted approaches.

Key issues/questions

What climate changes are happening?

The evidence of change in the earth's biophysical systems is unequivocal. The latest Intergovernmental Panel on Climate Change (IPCC) report, published in 2013, stated that greenhouse gas (GHG) levels are at their highest for 800,000 years and predicted warming of the earth's surface by 1° C to 5° C above pre-industrial levels by 2100, changes in patterns and seasonality of rainfall, increases in temperatures and in

¹ <http://www.ifad.org/climate/strategy/e.pdf>

² http://www.ifad.org/climate/policy/enrm_e.pdf

³ <http://www.ifad.org/climate/asap/asap.pdf>

the frequency of heat waves, and increase in frequency and intensity of extreme weather events, particularly in the wet tropics.

As a result, the oceans are warming, especially in tropical and subtropical areas, and are ten times more acidic than in pre-industrial times due to the ocean's absorption of increased levels of atmospheric carbon. Changes in salinity are predicted, with highly saline areas becoming more saline and vice versa due to changes in evaporation and precipitation. Sea level rise is occurring and the rate is accelerating, from 1.7 millimetres per year in the early twentieth century to the current rate of 3.2 millimetres per year.

There are opportunities for mitigation to limit the extent of climatic changes. However, impacts of GHGs that have already accumulated in the atmosphere will continue for hundreds of years, particularly ocean acidification. Adaptation actions to build resilience and adaptive capacity are, therefore, already necessary and need to continue into the future, regardless of future emission scenarios.

What does climate change mean for fisheries and aquaculture?

Fisheries, possibly more than any other modern food production system, depend on the health and natural productivity of the ecosystems on which they are based. They are vulnerable to physical and chemical changes in temperature, salinity, acidity and water levels and flows (IPCC 2007, FAO 2008). Aquaculture, as practised on a small scale by the rural poor in developing countries, is also heavily dependent on ecosystem services for feed, seed and adequate supplies of clean water, and is often exposed to extreme weather events (IPCC 2007). The major impacts are described in the following pages, categorized by: (i) climate change effect; (ii) ecosystem; (iii) sector; and (iv) region.

Box 1: Climate change facts (IPCC 2013)

- Earth's surface has warmed 0.85° C since 1880.
- Oceans are warming by 0.11° C every decade.
- GHG (carbon dioxide, methane and nitrous oxide) concentrations are at their highest in 800,000 years.
- Seawater has become 10 times more acidic since 1970 (pH has declined by 0.1).
- Sea levels are rising at 3.2 centimetres every 10 years and accelerating.

Categories of impacts on fisheries and aquaculture

By climate change effect

Climate change effect	Impacts
Warming of oceans and other water bodies	Changes in productivity, with an overall increase in fish production at global level, but declines of up to 40 per cent in the tropics, as fish are forced to migrate to cooler waters. Localized extinctions where fish cannot migrate, for example, in lake fisheries. Changes in fish migration paths, affecting small-scale fishers who do not have suitable vessels to pursue them. Thermal stratification of freshwater lakes, particularly in the tropics, reducing nutrient cycling and productivity of fisheries. Warmer water increases spread of disease, reduces oxygen and increases risk of toxic algal blooms and fish kills, destroying aquaculture production. Widespread destruction of coral reefs, their associated ecosystems and fisheries due to increased temperatures and more frequent coral "bleaching." For some farmed species, there is potential for increased growth rates, food conversion efficiency and duration of the growing season.
Sea level rise	Inundation and more frequent flood and storm damage in megadeltas, small island developing countries and low-lying coastal areas. Damage to wetlands, mangroves, coastal nursery grounds and fish habitats, and accelerated coastal erosion. Increased salinity of groundwater, higher water tables and drainage problems due to saltwater intrusion, damaging agriculture but increasing area available for brackish-water aquaculture.

Climate change effect	Impacts
Changes in salinity	Weakening of immune systems with severe effects for some aquatic organisms such as zooplankton living in coastal lagoons and wetlands, with severe implications up the marine food chain.
Ocean acidification	A major systemic threat, resulting from the absorption of CO ₂ which may be irreversible in terms shorter than millennia. Leads directly to destruction of coral reefs, reduces productivity of shellfish and zooplankton, as they cannot form hard shells, and has run-on impacts throughout the food chain. There are also potential impacts on fin fish, but this is not fully understood.
Changes in rainfall patterns and evaporation rates	Leads to changes in run-off, water levels, water availability and quality, and sedimentation patterns in inland and coastal water bodies. Changes flood risk, water stress and droughts, and alters ecosystems and habitats and the productivity of fisheries in those habitats.
Increase in extreme weather events and their frequency, location and seasonality	Increased storm damage, destruction of assets and ecosystems such as coral reefs and mangroves, and lost earning opportunities. Small-scale fishers and fish farmers in remote areas often lack access to weather forecasts, lack infrastructure to protect boats and other assets, and lack insurance. Damage to ecosystems affects fish nursery and feeding grounds, and reduces coastal protection. Aquaculture equipment will be damaged and crops lost. Fish escapes increase the risk of disease and parasitic infestation of wild stock, as well as impacting biodiversity.

By ecosystem/aquatic habitat

Ecosystem/Aquatic habitat	Impacts
Coral reefs	About 30 million people in coastal and island communities are reliant on reef-based resources for food, income and livelihood. Coral reefs are vulnerable to rising sea temperature, acidification, changes in quality or salinity of water, and siltation, all of which increase coral mortality and reduce productivity of coral reef ecosystems. Bleaching events, when sea surface temperatures exceed the long-term summer average by 1° C for 4 consecutive weeks, reduce coral resistance to disease and potentially kill the reef. In 1998, a global bleaching event killed 16 per cent of the world's coral. By 2030, 60 per cent of the world's coral will be at risk of death.
Wetlands and seagrass beds	Wetlands and seagrass beds are natural carbon sinks and can sequester significant amounts of carbon. Seagrass also has potential for acidification buffering. However, degraded wetlands can become a significant source of GHG emissions. Wetlands are vulnerable to damage by severe storms and can also suffer from changes in flood and run-off patterns, as well as saline intrusion.
Mangroves	Mangrove ecosystems provide a wide range of ecosystem services: habitat for aquatic and terrestrial plants and animals (75 per cent of all tropical commercial fish species spend part of their lives in the mangroves); coastal protection from strong winds, waves and flooding; soil stabilization; filtration of sediments and pollutants; sequestration of CO ₂ ; supply of medicines, food, firewood, charcoal and construction materials. Mangrove ecosystems are affected by changes in air and sea temperatures, as well as sea level rise and storms. Increasing poverty also threatens mangroves through their exploitation for firewood, building material and grazing for animals.
Deltaic areas	Particularly vulnerable to the impacts of climate change. Sea level rise will displace millions of people living in deltaic regions of the Ganges-Brahmaputra, Nile and Mekong megadeltas and disrupt important aquaculture and fishing industries.

By subsector

Subsector	Impacts
Inland fisheries	Fisheries in lakes, rivers, dams and flood plains are influenced by changes in rainfall and run-off (erosion, siltation and drainage), temperature, evaporation, river flow, lake levels and water chemistry. Impacts will generally include reduced biodiversity, habitat loss and lower productivity. Increased upstream adaptations such as dams and irrigation will have major impacts on aquatic species and on fisheries and aquaculture.
Inland aquaculture	Changing patterns of rainfall, drought periods and more intense storms will cause variations in water levels, salinization, water temperatures and oxygen levels. This will lead to changes in productivity and a higher risk of disease and mortality, and may physically damage aquaculture infrastructure and allow fish to escape.
Coastal fisheries	Changes in productivity and distribution of fish species, as well as damage to the ecosystems upon which coastal fisheries depend, such as coral reefs and mangroves. Shallow coastal waters will experience the greatest levels of warming and damage to fish populations. Coastal communities are highly vulnerable to storm damage caused by wind, waves and accelerated coastal erosion, exacerbated by sea level rise. Fishing zones and post-harvest industry locations are often mismatched, with negative impacts and increased costs for the subsector.
Coastal aquaculture	Small-scale aquaculture operations are threatened by extreme weather conditions, storm surges, coastal erosion and mangrove destruction. Increased acidification will affect shell formation of cultured molluscs and crustaceans such as pearl oysters. Seaweed farming may also be affected, as higher water temperatures increase the risk of disease. Increased frequency of toxic events such as harmful algal blooms, red tides and low oxygen conditions, leading to greater incidences of fish kills.

By region

Region	Impacts
Africa	Coastal fisheries are threatened by increased water temperatures and shifts in fish migration. West Africa is the worst affected, while Somalia and South Africa may actually benefit from an interplay of the nutrient-rich upwelling Benguela Current from the western coast and the warmer Agulhas Current from the eastern tropical coast, providing better conditions for a large variety of fish. Inland river and lake fisheries severely threatened by declining rainfall and increased temperatures (e.g. Lake Chad, Lake Malawi and Lake Tanganyika). Sea level rise will threaten large areas of low-lying coast in eastern Africa and coastal deltas such as the Nile. Heat waves and droughts will severely affect crop and livestock production and will force communities to increase pressure on water and fish resources for livelihoods. On the other hand, increased precipitation could lead to aquaculture expansion.
Asia	Water stress will affect many millions of people along the large river basins, especially areas with a high density of population and high levels of poverty. South and East Asia will be exposed to more frequent and extreme heat, and increasingly irregular and intense rainfalls. Coastal communities will be impacted by more frequent cyclones and storms and – in delta areas – by sea level rise and associated salinization of groundwater. Fisheries and aquaculture are at great risk in deltas due to sea level rise, erosion and saltwater intrusion.
Latin America and Caribbean	Low-lying areas, particularly those on the Pacific coast, will be impacted by sea level rise and extreme weather events associated with El Nino, which will affect the La Plata estuary, coral reefs, mangroves and the productivity of the pelagic stocks along the coasts of Peru and Chile. This puts uncertainty on the future global supply of fishmeal and oils used for feed by the aquaculture industry, most of which comes from small pelagic fish (e.g. sardines and anchovy). The coral reef ecosystems of the Caribbean are likely to die off almost entirely by 2070.
Pacific	Climate change will cause declines in coastal fishery resources through higher ocean temperatures and acidification, and loss of habitats, such as coral reefs, seagrass beds and mangroves. Infrastructure and coastal ecosystems will suffer storm damage. This will affect the distribution and abundance of various species.

Region	Impacts
Small Island Developing States	Fisheries will be affected by rising sea surface temperatures, rising sea level, and damage from tropical cyclones. Degradation of coral reefs will impact on local livelihoods, affecting fishing and tourism. Agricultural land and food security will be affected by sea level rise, inundation, soil salinization, seawater intrusion and decline in freshwater supply.

Vulnerability to climate change. In 2001, in its Third Assessment Report, the IPCC combined the prevailing key elements of vulnerability from the various schools of thought and defined vulnerability as a function of a system’s exposure to change, its sensitivity to such change and its capacity to adapt to it. Seen through this lens, the vulnerability of the fisheries and aquaculture sectors (and dependent communities or economies) is based not only on the physical effects of global warming and GHG accumulation (e.g. changes in fish abundance due to temperature changes) but also on its sensitivity to such changes (e.g. the dependence of the sector on an affected species) and on the sector’s capacity to adapt to change (e.g. the ability to shift to other species).

It is important to remember that it is difficult to establish a unique causal chain between particular climate change effects and the impacts on fisheries and aquaculture. Rather, it is the cumulative effects of climate change, other drivers of change and human responses that count (De Silva and Soto 2009). For example, where a fish stock is already heavily exploited or overexploited by fishing, stress from climate-induced changes in ocean conditions or ecosystems may push the stock to a “tipping point,” causing the total collapse of the stock.

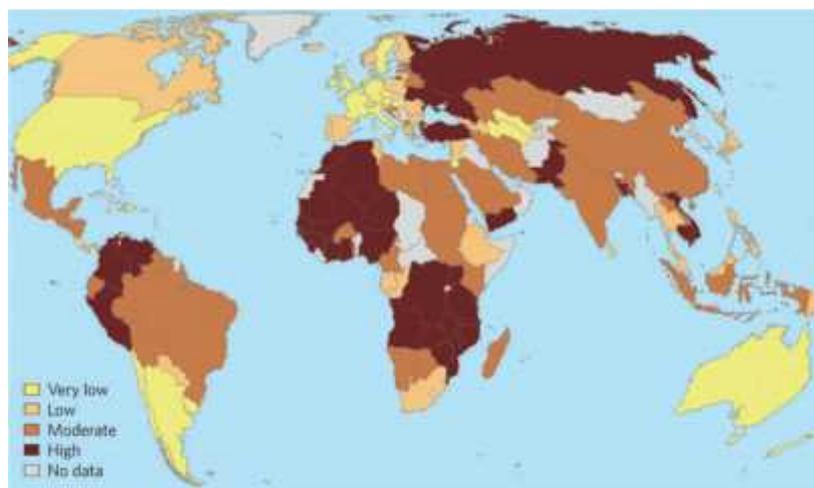
One of the first global vulnerability assessments for the sector attempted to understand the relative vulnerabilities of national economies to climate change (i.e. temperature changes) in association with fisheries and aquaculture (Allison et al. 2009). The study was useful in showing that vulnerability comes from the combined effect of predicted warming (exposure), the relative importance of fisheries to national economies and diets (sensitivity), and limited societal capacity to adapt to potential impacts and opportunities (adaptive capacity). Table 1 lists the most vulnerable countries, all of which are lower or middle-income countries, and most are least developed countries. The majority are also located in Africa. Countries where IFAD is active (29 out of 32) are highlighted in bold font.

Table 1: National economies most vulnerable to impacts of climate change on fisheries and aquaculture

Rank	Country	Rank	Country	Rank	Country	Rank	Country
1	Angola	9	Niger	17	Zimbabwe	25	Ghana
2	DR Congo	10	Peru	18	Côte d'Ivoire	26	Guinea-Bissau
3	Russian Federation	11	Morocco	19	Yemen	27	Viet Nam
4	Mauritania	12	Bangladesh	20	Pakistan	28	Venezuela
5	Senegal	13	Zambia	21	Burundi	29	Algeria
6	Mali	14	Ukraine	22	Guinea	30	Cambodia
7	Sierra Leone	15	Malawi	23	Nigeria	31	Tanzania
8	Mozambique	16	Uganda	24	Colombia	32	The Gambia

Source: Allison et al. (2009) after IFAD (2010), modified⁴

⁴ Note: Small Island Developing States were not included in this study due to lack of data.



Source: Allison et al. (2009)

Figure 1: National economies' relative vulnerability to impacts of climate change on fisheries and aquaculture

Why does this matter to IFAD?

Fisheries and aquaculture are important global industries, representing a significant share of GDP in many countries and a key source of foreign exchange, as fish products are amongst the most traded products in the world. The World Bank (Sumaila and Cheung 2010) estimated that the fishing sector could face an annual loss in gross revenues ranging from US\$17 billion to US\$41 billion as a result of climate change. However, fisheries and aquaculture are of particular concern to IFAD due to: (i) their importance to food and nutrition security; (ii) their close relationship with the environment and natural resources; and (iii) their contribution to poverty reduction and employment, often in rural areas of developing countries where alternative economic opportunities are limited.

- **Fish products are essential for food security and nutrition.** While capture fish production is static, aquaculture is the fastest growing food sector in the world. Global fish production is expected to increase from 158 million tons in 2012 to 195 million tons by 2022, with aquaculture accounting for 57 per cent of total fish production for human consumption and 51 per cent of total fishery production (FAO 2014). Fish already provide essential nutrition for 3 billion people and 50 per cent of protein and essential minerals for 400 million people, mainly in poor countries.
- **Environmental degradation exacerbates damages from climate change impacts.** Poor management and weak governance have contributed to overfishing and environmental degradation globally. In 2011, it was estimated that 28.8 per cent of marine fish stocks were overfished, 61.3 per cent were fully fished at their biological limits, while only 9.9 per cent were underfished (FAO 2014). This damage to fish stocks, combined with pollution, unplanned coastal development, upstream water use, destruction of mangroves and other forms of environmental degradation, enhance the potential for and the magnitude of negative climate change impacts (Perez et al. 2013).
- **Small-scale fisheries and aquaculture are major sources of employment and self-employment in developing countries.** Fisheries and aquaculture are a source of income and livelihood to millions of people around the world. In 2012, it was estimated that 58.3 million people were engaged in the primary sectors of capture fisheries and aquaculture, split between them at 39.4 million and 18.9 million, respectively (FAO 2014). Globally, employment in aquaculture is growing at a far faster rate than in agriculture and it is growing fastest in Africa. However, the vast majority (more than 90 per cent) of fishers and fish farmers are still small-scale and around 90 per cent live in Asia. Overall, women accounted for more than 15 percent of all people directly engaged in the fisheries primary sector and up to 90 per cent in secondary activities such as processing and marketing. Including secondary activities, fisheries and aquaculture support the livelihoods of between 710 million and 840 million people (FAO 2014).

- **Small-scale fishers (including processors) and fish farmers will be among the first to be significantly impacted by climate change.** The World Bank estimates that losses for fisheries due to climate change could reach US\$25 billion per year in developing countries but only US\$11 billion per year in developed countries. A number of factors disproportionately increase the climate change vulnerability of small-scale fishers and fish farmers in developing countries: (i) reductions in productivity will be greatest at lower latitudes; (ii) species migration will lead to the greatest reductions in catches in inshore coastal waters where small-scale fishers operate; (iii) small fishing vessels have a smaller range and can go to sea fewer days a year, as they cannot cope with bad weather conditions; (iv) coral reef destruction will mainly affect small-scale fisheries; (v) small-scale fishers and fish farmers lack access to risk management tools (weather forecasts, insurance, savings accounts); (vi) the methods and technology used by small-scale fish farmers are often reliant on natural ecosystems (i.e. collection of wild seed) and less resilient to damage in storms, floods and drought (i.e. small shallow ponds which dry out quickly); and (vii) small-scale fisheries and aquaculture communities are often located in areas susceptible to other climate change impacts, such as sea level rise and negative effects of agriculture. The combined impacts will increase resource-use conflicts and impact also on fish value chain operators, especially women engaged in fish processing and marketing (Cheung et al. 2009).

How do fisheries and aquaculture contribute to climate change?

Capture fisheries make a minor, though still significant, contribution to global GHG emissions. Overfished stocks result in lower catch rates, so fishing trips become longer and more fuel is used to catch ever-declining amounts of fish. Both the fuel efficiency of vessels and the management of resources tend to be weaker in low-income countries. With improvements in fishing technologies, techniques and fisheries management, the huge amount of fuel consumed by the global fishing fleet – and, consequently, CO₂ emissions – can be significantly reduced.

Aquaculture's contribution to climate change includes damage to mangroves and coastal wetland ecosystems, as well as the consumption of energy required for the production of processed feeds and to pump water. However, overall, the production of aquatic animals is far less carbon intensive than the production of other livestock, such as cattle, due to better feed conversion ratios. Some extensive low-input aquaculture systems, such as seaweed and shellfish farming, are actually carbon sinks.

However, the greatest fuel use in both fisheries and aquaculture sectors comes further along the value chain, specifically in the processing, storage and trading of fish products worldwide, which requires the use of air freight, shipping and refrigeration. Hence, development plans for the fisheries and aquaculture sectors should aim to reduce carbon emissions and explore appropriate mitigation options.

Key concepts to keep in mind

Vulnerability, Adaptation and Resilience. According to the IPCC, vulnerability is “the degree to which a system is susceptible to climate change and is unable to cope with the negative effects of climate change.” The vulnerability of a target household or community to climate change is a function of: (i) **exposure to impacts** – the nature of climate change and the degree to which fisheries, fish farms and communities are exposed to climate change; (ii) **sensitivity** – the degree to which a system will respond to a change in climatic conditions; and (iii) **adaptive capacity** – the ability to change so as to cope with climate stress. For a given change, differences in risk and vulnerabilities are due mainly to non-climatic factors, such as poverty, lack of assets, unstable incomes, few livelihood options, poor health, lack of education, lack of information, voice or political representation, and even physical location.

For communities identified as vulnerable to climate change, **adaptation efforts** should address some or all of the three aforementioned variables: exposure, sensitivity and adaptive capacity (Allison et al. 2007; Daw et al. 2009). At the most basic level, such efforts should aim to ensure **resilience** – that is, the ability to absorb climate change-induced disturbances while retaining a sufficient quality of life. **Win-win or “no-regrets” options** build resilience to climate change while bringing other benefits at the same time, such as

maintaining or enhancing the natural resource base, creating economic opportunities and contributing to poverty reduction, food security and sustainable development goals.

These options would bring benefits even if predicted climate impacts do not materialize and so are especially appropriate where there is uncertainty about climate change impacts, as is the case with complex systems such as fisheries. Another factor which would encourage pursuing no-regrets options is the fact that climate change is only one of many interacting stresses for the fisheries and aquaculture sectors. Others include environmental degradation, weak governance, poverty, pollution and various other factors. Win-win/no-regrets adaptation options typically tackle these non-climatic stresses.

A **risk-based approach** is fundamental given high uncertainties and the complex interactions of climate impacts. Risks identified with high confidence by the IPCC – specifically those which affect the fisheries and aquaculture sectors and the communities which depend on them – are:

- risk of death, injury, ill health or damaged livelihoods in low-lying coastal zones and Small Island Developing States due to storm surges, coastal flooding, sea level rise and inland flooding in some areas
- risk of food insecurity and breakdown of food systems linked to warming, drought, flooding, precipitation variability and extremes
- risk of loss of marine and coastal biodiversity, ecosystems and ecosystem goods, and the functions and services they provide for coastal livelihoods, especially those of fishing communities in the tropics and the Arctic
- risk of loss of terrestrial and inland water biodiversity, ecosystems and ecosystem goods, and the functions and services they provide for livelihoods.

Adaptation falls into two categories. **Autonomous adaptation** refers to the measures taken by target groups to adapt to changes they experience or anticipate, without external influence and mainly using existing knowledge and technology – for example, changing the timing or location of fishing, as species migrate earlier or later or shift to new areas. **Planned adaptation** refers to deliberate measures taken by governments, NGOs, private-sector organizations and other bodies that directly contribute to adaptation, to increase adaptive capacity and/or establish conditions favourable for effective autonomous adaptation and investment in new technologies and infrastructure – for example, institutional strengthening, research, updating of policy and strategy frameworks, physical infrastructure works, etc.

It should be emphasized that not all climate change effects are negative, hence some adaptation actions should position the affected groups to better take advantage of opportunities created by climate change.

Lessons from experience

Pilot projects on climate change adaptation in the fisheries and aquaculture sectors have been under implementation for some time now and are beginning to yield results and useful lessons. Keeping in mind that adaptation is place- and context-specific, with no single approach appropriate in all settings, the following general lessons can be applied in most situations:

- Resolve existing environmental problems first. Ecosystems which are already weakened by overexploitation, pollution and poor management are most vulnerable to further damage or collapse due to climate change. Climate threats increase the urgency of addressing these existing problems.

Box 2: Inland fisheries in Africa: the Lake Chad Basin

Ovie and Belal (2012) reviewed the vulnerability and current and potential adaptation measures of communities living around the Lake Chad Basin. Severe droughts are causing shrinking of the lake and reduction in catches. Future climate change is expected to worsen these problems. Current coping/adapting strategies include: (i) livelihood diversification, including small-scale aquaculture; (ii) improved preservation and storage of food products; (iii) seasonal economic migration for alternative employment; (iv) changing fishing strategies, including target species, fishing grounds and types of gear; and (v) fisheries co-management arrangements to improve stocks.

- Ecosystem-based adaptation strategies are the most cost-effective. Investing in ecosystem rehabilitation, repair and development – for example, mangrove reforestation – is, in almost all cases, more cost-effective than investing in hard infrastructure for the protection of coastal zones, reduction of erosion, etc. (Perez et al. 2013).
- Planned adaptation measures must complement and encourage autonomous adaptation, not crowd it out. Autonomous adaptation taking place in high-risk areas will accelerate as climate impacts become more visible and awareness spreads. However, poorly-designed government-led planned adaptation projects can, and often do, crowd out autonomous adaptation measures such as self-protection or self-insurance. Nevertheless, autonomous adaptation can be too expensive in economic activities with low profit margins, so public investments which reduce adaptation costs are necessary. In general, an enabling environment for autonomous adaptation requires strong social capital, effective community-based organizations, strong collaboration and coordination of a wide range of diverse interest groups.
- Assessments of economic rates of return for pro-poor climate adaptation projects must take into account non-economic or non-quantifiable values. The low incomes and limited assets and property of poor households mean that investments to protect the latter against climate threats often cannot be justified on purely economic grounds. Justifications based on non-economic values and concern for social justice and human rights are a stronger basis for such investments, rather than a traditional cost-benefit analysis (Perez et al. 2013).
- The greatest impact of extreme weather events on the poor is not damage to assets but loss of income. Analysis of impacts from climate hazards in South-East Asia found that the major impact of extreme weather events on the poor is a reduction in income-earning opportunities, not damage to assets. The study found that the value of foregone income was far higher than the value of damages to assets and property (Perez et al. 2013). In general, the poor have few assets or property of any significant value but can be severely affected by extended periods without income. For instance, when bad weather prevents fishing, they are quickly driven to coping strategies such as sale of assets and taking debt, as they have limited savings or insurance.

Guidance for design and implementation

Fisheries and aquaculture within IFAD's response to climate change

IFAD's Climate Change Strategy aims to maximize impact on rural poverty in a changing climate. As recognized in the ASAP, responding to climate change does not mean throwing out or reinventing everything that has been learned about development. Instead, it requires a renewed effort to tackle wider and well-known development challenges and putting a proper appreciation of risks at the centre of the development agenda. It is about doing more of the things that work and doing these things better; hence, the ASAP's first principle is to scale up tested and trusted approaches to rural development.

Box 3: Post-tsunami fisheries and aquaculture rehabilitation in Aceh, Indonesia

Following the tsunami that hit Indonesia in December 2004, FAO led efforts to rehabilitate aquaculture and fisheries in tsunami-affected areas. One project aimed to: strengthen the government capacity to coordinate, promote and plan sustainable fisheries and aquaculture practices; foster the partnership between local fishers, the community and the state in order to establish effective co-management arrangements; improve extension services for aquaculture; promote integrated aquaculture systems such as shrimp-milkfish-seaweed polyculture; and improve the fish handling and processing methods used by fishers, traders and processors (FAO 2011).

However, climate change response also requires the introduction of new approaches to improve the effectiveness and impact of development programmes in a changing and uncertain climate, including the use of downscaled climate models and community-based climate vulnerability and capacity analysis. Other important measures are: improvements in the collection, analysis and dissemination of meteorological data; provision of access to risk transfer and insurance schemes; and re-assessments of infrastructure, land and

water use management plans. Climate change response also involves taking into account new and emerging risks such as sea level rise and changes in water quantity and quality.

In line with this logic, **IFAD's response to the climate change challenge focuses on:**

- basing projects and policies on an in-depth risk assessment and a better understanding of the interconnections between small-scale fishers and fish farmers, the ecosystems on which they rely and the competing demands of other users
- substantially scaling up successful multiple-benefit approaches, which both build resilience to climate shocks and contribute to other goals, such as reducing poverty, conserving biodiversity, increasing production and lowering GHG emissions
- enabling small-scale fishers and fish farmers to become significant beneficiaries of climate finance.

Box 4: Adaptation for Smallholder Agriculture Programme (ASAP) – links to fisheries and aquaculture?

ASAP goal: Poor smallholder farmers are more resilient to climate change.

Purpose: Scale up multiple-benefit adaptation approaches for poor smallholder farmers.

Key ASAP indicators applicable for fisheries and aquaculture:

- number of poor smallholder household members whose climate resilience has been increased
- number of individuals (in particular women), community groups and institutions engaged in climate risk management, environment and natural resource management, or disaster risk reduction
- US\$ value of new or existing rural infrastructure made climate-resilient
- tons of GHG emissions (CO₂) avoided and/or sequestered.

IFAD project cycle and linkages to the ASAP and climate finance. IFAD's operating model⁵ comprises a project cycle with two main stages: project development and project implementation. Project development includes three steps: (i) preparation of a project concept note, (ii) detailed project design and (iii) design completion or final design. Key milestones in project implementation are start-up, mid-term review and project completion. Project development and implementation are typically guided by a country strategic opportunities programme (COSOP), which is a framework for making strategic choices about IFAD operations in a country, identifying opportunities for IFAD financing and related partnerships, and facilitating management for results.

The guidance below is divided into steps which can be taken during: (i) COSOP/concept note development, (ii) project design and (iii) project implementation, providing a range of options for diagnosing and responding to climate threats to communities engaged in small-scale fisheries and aquaculture.

The options outlined below have been selected based on the project cycle described above. They have been identified through a review of best practices in climate change adaptation and mitigation, and are in general multiple-benefit approaches which offer solutions to climate threats and to the compounding problems affecting small-scale fisheries and aquaculture and the communities which rely on them.

They also contribute to the goal and purpose of the ASAP and would typically be eligible for financing through one or more of the climate funds which IFAD has access to, including the ASAP, as well as the Global Environment Facility (GEF), the Special Climate Change Fund (SCCF), the Least Developed Countries Fund (LDCF), the Adaptation Fund and other major sources of climate finance. For example, within the ASAP, there is the potential to finance activities such as: (i) rehabilitating natural ecosystems, mangroves, coastal wetlands, sand dunes and coral reefs to protect livelihoods in coastal areas against climate risks; (ii) using integrated water resource management to maintain and improve the healthy functioning of watersheds; (iii) providing communities with access to weather and climate information; and (iv) strengthening expertise in research and advisory and extension services on climate risk management and adaptation.

⁵ <http://www.ifad.org/operations/projects/projectcycle.htm>

Basic principles for design and implementation

The following basic principles for design and implementation can be applied in most contexts:

- **Avoid supporting activities which might increase fishing pressure, even by small-scale fishers**, unless there is very sound evidence that fishing can be increased sustainably. Where data on fish stocks are limited, it should be assumed that stocks are fully exploited or overexploited.
- **Projects should seek to promote and prioritize:**
 - implementation of the Code of Conduct for Responsible Fisheries (FAO 1995), the Ecosystem Approach to Fisheries and Aquaculture, the International Guidelines on Securing Sustainable Small-Scale Fisheries (FAO 2012), the Voluntary Guidelines on the Responsible Governance of Tenure (FAO 2012a) and the Voluntary Guidelines on Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (FAO 2015)
 - recognition of **the critical role of healthy, functioning ecosystems** in maintaining the resilience and adaptive capacity of fisheries and aquaculture in the face of climate change
 - **community involvement in planning and implementation** to ensure sustainability of all measures, integration of social/cultural factors and maximization of the value of local knowledge of the environment and local strategies and technologies for coping with environmental variation
 - **consideration of gender-differentiated impacts** of climate change arising from the existence of traditional gender roles, different levels of asset ownership, restrictions on coping strategies such as migration due to family care duties and varying availability of alternative livelihoods
 - **participatory management of natural resources**, taking into account the needs of various users and minimizing risks of conflict, overexploitation and degradation
 - **investments in stock assessments**
 - **investments in selective fishing gears** to avoid catching non-targeted species that may be wasted
 - **awareness and education to increase understanding of the environment** and ecosystems on which people's livelihoods are based and of the processes leading to climate change and environmental degradation
 - **livelihood diversification to reduce dependency on limited and threatened natural resources**, especially in areas where high levels of dependency exist
 - **low-cost, no-cost and win-win options** which contribute jointly to climate change adaptation and mitigation, IFAD's main objective of reducing rural poverty and the objectives of IFAD's Strategic Framework (IFAD 2011a).⁶

COSOP to concept note

At this stage, it is necessary to look at the bigger picture, identify major issues and develop a broad strategy for addressing them. Consideration of fisheries and aquaculture in an IFAD COSOP or concept note must begin with:

- **Stakeholder engagement and participation.** Ensure that target beneficiaries and stakeholders are involved at all stages and that their needs and viewpoints are addressed through a participatory approach. Their involvement is necessary to identify issues, opportunities and priorities from the communities' perspective and is key to ensuring ownership and long-term sustainability of interventions. In practical terms, this requires holding workshops, focus group discussions,

⁶ http://www.ifad.org/sf/strategic_e.pdf

extensive field visits and engagement with the target groups and their associations and organizations.

- **Awareness raising.** Begin raising awareness of climate change among stakeholders (including local authorities, communities and other resource user groups) and building consensus around the possible need to address climate risks within the country programme/project. The irreversible nature of some impacts should also be highlighted where this is certain – for example, ocean acidification, visible sea level rise and recorded temperature increases. This is a necessary step to ensure common understanding and commitment to action. Awareness and access to information enables stakeholders to prioritize actions, engage in autonomous adaptation and play a leading role in any development project, thereby improving sustainability of outcomes.
- **Vulnerability and preparedness assessment.** Climate change vulnerability assessments identify areas, sectors and communities where climate threats are most severe and adaptation needs are most urgent. Climate Change Country Profiles, available through UNDP or the World Bank Climate Change Data Portal, can provide preliminary information on predicted impacts. For more detailed participatory assessments, many tools have been developed, including the Community Vulnerability Assessment Tool by UNFCCC; the Climate Vulnerability and Capacity Analysis Handbook by CARE, the Training Guide for Gender and Climate Change Research in Agriculture and Food Security for Rural Development by FAO, Vulnerability Assessment Methodologies by FAO⁷ and IFAD's own Climate Resilience Analysis Checklist. Vulnerability assessments ask questions such as: What is the poverty status of this community? Are fisheries' resources depleted? Is the area prone to frequent disasters or extreme weather events? Do farmers understand the concept of climate change? Assessments should collect specific information about the climate of the area, any recent changes, and patterns of extreme weather events. Current coping strategies and autonomous adaptations should be documented and existing policies, strategies and practices analyzed for climate change readiness. Recent IFAD assessments, such as that completed for the Programme to Reduce Vulnerability in Coastal Fishing Areas in Djibouti, can also serve as examples.

Project detailed and final design

Below is a selection of activities which support adaptation (A), mitigation (M) and, in some cases, both adaptation and mitigation (A/M). They are listed under the following categories: (i) ecosystem approach and ecosystem services; (ii) fishing technologies; (iii) aquaculture technology and management practices; (iv) policy and partnership; (v) capacity-building and research; (vi) knowledge management; (vii) post-harvest and marketing; and (viii) gender.

Ecosystem approach and ecosystem services

1. **(A/M) Implement the ecosystem approach to management of fisheries and aquaculture, and promote ecosystem services.** The ecosystem approach is “a strategy for integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.” Fisheries, aquaculture and agriculture are considered within wider ecosystem management strategies, which include industrial and urban development, tourism and other competing uses of resources. The adaptation measures compatible with the ecosystem approach must be implemented in a coordinated manner and engage all relevant stakeholders in order to be fully effective.
2. **(A/M) Support conservation, restoration and improved management of important freshwater, marine and coastal ecosystems,** such as mangroves, coral reefs, seagrass beds, wetlands and shallow freshwater systems, and enhance the ecosystem services they provide, such as storm protection, erosion prevention, water retention, fish nursery and nutrient recycling. These ecosystems also act as a carbon sink, absorbing CO₂ from the atmosphere two to four times faster

⁷ <http://www.fao.org/docrep/018/i3315e/i3315e.pdf>

than mature tropical forests and storing it in the soil in a quantity three to five times greater. Protecting and/or rehabilitating freshwater, coastal and marine ecosystems can provide the multiple benefits of climate change adaptation, climate change mitigation and support to fisheries and aquaculture in a more cost-effective manner than hard engineering solutions. Ecosystem-based Adaptation (EbA), like the Living Shoreline Approach, is an example of this, capitalizing on the ability of natural systems to assist in human adaptation to climate change.

3. **(A) Establish marine protected areas and inland waters protected areas.** These may include zones where no fishing is allowed, zones for recreational fishing or zones where only artisanal and small-scale fishers have the right to fish. Also promote dialogue and collaboration on law enforcement and policy among the different sectors (i.e. fisheries, environment, tourism, etc.) around protected areas to ensure their effectiveness. Fishing communities must be engaged in their establishment and enforcement to ensure local ownership and access to local knowledge during the selection of suitable locations. FAO has prepared guidelines for the establishment and use of marine protected areas (MPAs).⁸
4. **(A) Increase benefits from ecosystem services.** Ecosystems which provide clear financial and non-financial benefits to users and communities through various services generate strong incentives for better management. Activities which highlight and enhance the services that people obtain from ecosystems, such as freshwater, fish, flood control, waste processing, nutrient cycling, coastal defences, and recreational and aesthetic values, create incentives to better manage those ecosystems. Payments for ecosystem services are one way to give rural communities a direct economic stake in the protection and sustainable use of valuable ecosystems. Schemes to provide sustainable financing for ecosystem services through the Payment for Environmental Services (PES) scheme and opportunities to promote carbon offsets on international voluntary carbon markets should be explored, as is being done by Worldfish for small areas of mangroves in the Solomon Islands and by the World Bank's Biocarbon Fund in Trinidad.
5. **(A) Promote culture-based fisheries (CBF) and stock enhancement practices.** CBF can be developed as a community activity that utilizes a common property water resource, such as a lake, lagoon, dam or reservoir. It uses aquaculture techniques to enhance natural production, for example, by collecting wild or farmed seed/larvae/fingerlings, growing them to sizes at which they have higher survival rates and then releasing them. This can play a key role in regions of Asia and Africa, where more frequent and longer droughts mean natural productivity will decline. Construction of sanctuaries or shelters to protect fish from predators and provide refuge during dry periods when lake levels decline is another option. At sea, man-made reefs can also enhance local fish stocks. However, CBF should be preceded by an appropriate risk assessment and an estimation of carrying capacity in order to avoid negative effects on biodiversity and ecosystem services.

Box 5: Example of multiple-benefit ecosystem-based adaptation in coastal ecosystems

- In Bangladesh, wetlands play a key role in flood protection. Conserving these ecosystems in Hail Hoar contribute to an 80 per cent increase in fish catch (TEEB 2010)
- In Samoa, a UNDP project helped a fishing communities to reduce vulnerability to rising seas levels and flooding by rehabilitating and replanting wetlands, improving water flow and providing fish breeding habitats (UNDP 2010).

⁸ <http://www.fao.org/docrep/015/i2090e/i2090e00.htm>

- (A) Identify and invest in infrastructure projects which increase climate resilience**, for example, by protecting assets from severe weather, reducing flood risk or preventing damage to roads during rainy seasons. A “no-regrets” approach, comprising actions that generate net social benefits under all future scenarios of climate change and impacts, is also important. Ecosystem-based adaptation options (including improved watershed management, living coastlines, etc.) should always be explored before going ahead with hard infrastructure investments.

Box 6: Examples of integrated multi-trophic aquaculture

- Nha Trang Bay in Viet Nam: combination of fish, mussels, seaweed and snails in and around marine cage aquaculture systems (DANIDA 2005)
- Bay of Fundy, Canada: integration of salmon, mussel and seaweed production in a large commercial marine aquaculture (Chopin 2006; Barrington et al. 2009).

Fishing technologies

- (A/M) Support the transition to new fishing gear and identify and promote fisheries that target underexploited species.** Small-scale fishers often cannot migrate in search of new grounds and so need to adapt to changes in their local fishing grounds, for example, by adopting new gear, methods or species fished. This would require adequate extension and access to inputs. However, gears should only be provided in cases where there is clear evidence that stocks can support additional fishing pressure. Preference should be given to low-impact fuel-efficient (LIFE)⁹ fishing gear, which minimizes discards and is less damaging to the seabed or aquatic habitats. Passive gear can also potentially reduce fuel use compared to towed nets.
- (A/M) Install and maintain low-cost fish aggregating devices (FADs) for subsistence fishers**, as commonly practiced in the Pacific Island countries and Maldives, Mauritius and Indonesia. IFAD projects in the latter two countries have introduced FADs, increasing fishers' incomes, reducing fuel use and cutting time at sea, thus enhancing safety. FAO has prepared technical and policy guidance on FADs.¹⁰
- (M) Use more fuel-efficient boats** made with innovative materials and improved hull shape and equipped with more efficient engines and storage capacity to reduce the consumption of fuel. Simple practices, such as keeping the hull and propeller clean, will also reduce drag and keep fuel consumption down.

Box 7: Green growth agenda for fisheries and aquaculture

A green growth agenda in fisheries and aquaculture would focus on:

- Reducing the carbon footprint of the whole value chain, while maintaining its social and economic contribution and sustainability. Improving fuel efficiency of boats would make some contribution but the largest reductions in emissions can be achieved by reducing the use of air freight for fish products, for example, by boosting local markets. Making choices to improve the feed conversion ratio in aquaculture and reducing harvest and post-harvest waste are also important.
- Maximizing the capture of blue carbon, i.e. carbon sequestered in coastal vegetation systems such as mangroves and salt marshes, which also provide flood control, buffer coastlines against storms, improve water quality and provide habitat for juvenile fish. Tropical coastal vegetation is more effective per hectare at removing and keeping carbon out of the atmosphere than terrestrial systems such as rainforests.

Aquaculture technology and management practices

- (A) Promote best management practices (BMPs) and biosecurity in aquaculture production models** in order to adapt to increased disease risk. BMPs also increase farmers' creditworthiness and access to insurance by making the crop outcome more predictable. Additional benefits can come from improvement in feed conversion efficiency, better site selection and environmental monitoring of water quality and quantity, as well as temperature.

⁹ <http://www.sciencedirect.com/science/article/pii/S0165783611003870>

¹⁰ <http://www.apfic.org/fisheryissue/89-advice-on-anchored-artisanal-fads.html>

2. **(A) Upgrade aquaculture facilities to withstand extreme weather and disasters**, with features that minimize mass escapes of cultured fish during flooding, such as nets or higher dykes, and construction with robust materials able to withstand wave damage.
3. **(A) Support changes in aquaculture systems and species** in response to changes in climate and environment with extension, inputs and technology transfer, taking into account market demand and profitability.
4. **(A) Promote brackish-water aquaculture systems on flooded and/or salinized land and water bodies** for coastal agro-communities whose land has been lost. This can include cultivation of aquatic plants for consumption and for production of useful products, such as biofuel, plant protein and alcohols. In the longer term, such systems can rehabilitate the soil.
5. **(A/M) Encourage Integrated Multi-Trophic Aquaculture (IMTA)**, which combines species at different stages of the food chain, utilizing both fish feed added by the farmer (higher up the food chain) and the organic and inorganic wastes produced by the fish themselves (lower down the food chain). IMTA can be practised in small homestead fish ponds and in large commercial and capital-intensive initiatives. Culture of low-trophic-level species requires lower inputs and thus reduces GHG emissions compared to high-trophic-level, high-input systems. Bivalves and aquatic plants can contribute to carbon sequestration. The carbon extractive capacity per hectare of seaweed exceeds that of any other agricultural activity.
6. **(A) Encourage integration of aquaculture with agriculture**, for example, by farming fish in irrigation systems such as reservoirs and canals or encouraging rice-fish or poultry-fish integrated farming systems, traditionally common in Asia and South-East Asia. These systems are more productive and more resilient to crop disease outbreaks and pests, as fish help to control insects.

Box 8: Marine Stewardship Council (MSC) certification success in Viet Nam

The Ben Tre Clam Fishery in Viet Nam has set a successful example of how to achieve MSC certification. The Ben Tre Province, which covers a 65-kilometre coastal area and includes more than 4,800 hectares of protected mangroves, is a region of tremendous biodiversity. The clam fishery plays a vital economic role and is operated by local cooperatives that provide close management and surveillance of the brood stock and harvestable clams within their area.

The Ben Tre Clam Fishery received MSC certification in 2009, becoming the first small-scale community-based fishery in South-East Asia to meet MSC sustainability and management standards. The MSC label has given them an opportunity to access new markets domestically and worldwide, including in Europe, the United States, Japan, China and Taiwan. The certification increased farm-gate price for clams by 156 per cent between 2007 and 2010. The Ben Tre Clam Fishery model has demonstrated that it is possible to achieve profits while conserving resources and preserving the livelihoods of local communities.

Policy and partnership

1. **(A/M) Urgently reduce overfishing and excess capacity** (FAO 2008). Appropriate policies that promote sustainable fishing practices should be put in place, accompanied by capacity development efforts to strengthen monitoring, control and surveillance.
2. **(A) Shift management focus from the highly risky maximum sustainable yield (MSY) approaches to adaptive management** (WorldFish 2009). Stocks managed on the basis of MSY have little margin for error or buffer in the event of a shock. Faced with inadequate information on stock composition and distribution, adaptive management and precautionary principles offer more reliable approaches to avoid stock depletion. Stronger linkages should be promoted between the line ministries/ departments dealing with natural resources, weather and climate and the fisheries and aquaculture ministries.
3. **(A) Support fisheries co-management** to improve fisheries governance and promote the participation of local communities in the management of fish stocks. This requires a suitable legal framework for co-management, formation of fishers' and fish farmers' associations to participate in co-management, and development of skills and knowledge necessary for communities to effectively participate and fulfil their responsibilities. Effective fishers' and fish farmers' associations are a necessary foundation for

implementing a co-management regime. Advantages of co-management include empowerment of stakeholders, more responsive natural resource management, and facilitation of certification and traceability for aquaculture and fisheries operations through stronger associations.

4. **(A) Support intersectoral policy development** in order to ensure that fisheries and aquaculture are integrated into national policies for climate change, food security, coastal zone management and water management. This would include promoting Integrated Coastal Zone Management (ICZM) and Integrated Watershed Management (IWM) as tools for planning across land and water-based sectors and related administrative units. ICZM addresses limitations of sectoral approaches where different industries use the same resources. Mainstreaming of climate change adaptation and mitigation in policy and planning – from both the sectoral/intersectoral perspective and at the level of administrative districts and ecosystem units such as bays, river basins, lakes or estuaries – is also key.
5. **(A) Increase regional and cross-border cooperation and partnerships** among relevant agencies and governments, and implement bilateral and multilateral agreements on management of shared resources in freshwater, marine and coastal ecosystems.
6. **(M) Reduce direct and indirect fossil fuel consumption in fisheries and aquaculture** through policy measures to improve energy efficiency, upgrade old fuel inefficient technologies, source inputs (feed, seed, fertilizer, etc.) locally and make use of renewable energy. Subsidies in fisheries and aquaculture should be strongly discouraged as they encourage excess fishing.

Capacity-building and research

1. **(A) Develop capacity and promote the use of scenario-building methodologies** to enable policymakers to identify key features of fisheries and aquaculture production, as well as the drivers of change, and to understand vulnerability to climate change and climate variability. This helps to create responsive planning scenarios and design evidence-based and coherent adaptation policies and plans at all levels.
2. **(A) Strengthen the knowledge base and climate change advisory capacity of fisheries and aquaculture extension workers** and revise extension training material to take into consideration the effects of climate change. Such services play a crucial role in disseminating knowledge in remote fishing and aquaculture communities. Well-trained extension workers and extension material incorporating climate risks will be key.
3. **(A) Strengthen the capacity of relevant agencies and authorities to monitor and disseminate information on occurrence of disease in fish farms and harmful algal blooms**, including red tides and ciguatera, which may increase due to climate change, especially in areas known to be vulnerable to eutrophication (De Silva and Soto 2009).
4. **(A) Promote innovation, research and technology development:** adapt to changing environmental conditions by developing new strains of aquaculture species tolerant to low water quality, high temperatures and high salinity, and resistant to disease, while enhancing disease control systems in aquaculture. Steps should be taken to improve monitoring for disease and algal blooms and undertake research to fill critical knowledge gaps on adaptation to climate change (FAO 2008). Vulnerability assessments, stakeholder consultations, and participatory monitoring and evaluation (PM&E) will help to identify knowledge gaps and topics for research. Compilation and use of indigenous knowledge in fisheries should be promoted.

Knowledge management

1. **(A) Encourage knowledge-sharing using available platforms for communication about projects and research**, such as Africa Adapt (<http://www.africa-adapt.net/themes/4/>), Weadapt (<http://weadapt.org/subject/aquaculture>) and country-specific platforms such as the climate web portal for Bangladesh (<http://ccresearchbangladesh.org/>). Projects could also be encouraged to use social media platforms (e.g. Facebook, Whatsapp or emailing lists) to share information with stakeholders.

Post-harvest and marketing

1. **(A) Promote transition to new species** that: (i) are able to adapt to the changing climatic conditions; (ii) are easy to grow in local aquaculture situation on locally produced feed; (iii) can be processed/preserved using green energy; and (iv) are in demand on the local market.
2. **(A/M) Maximize catch value and minimize waste** by improving harvest and post-harvest technology, including improved fish storage, handling and processing equipment. Reduction of waste can help buffer the effects of legislation to prevent overfishing.
3. **(A) Finance, risk and livelihood diversification.** An insurance mechanism is especially important for aquaculture, as it could protect smallholder fishers against production and climate risks. Livelihood diversification is also an important mechanism to guard against shocks.
4. **(A) Increase availability of credit and saving products to enable financing of adaptation.** Credit systems will require appropriate financial institutions, better understanding of the sectors and building capacity to reduce risk. Saving and credit groups are alternatives to formal financial institutions.
5. **(A) Increase availability of life, medical, assets and income insurance, and access to social insurance.** Coverage against losses of assets and income, and sickness and injuries, as well as a social safety net that would provide support to families in the event of death, would greatly enhance the resilience of fishing and fish-farming communities to weather hazards.
6. **(A) Provide facilities needed to protect assets from damage,** including landing sites with breakwaters, storage facilities and equipment to take boats out of the water or off the beach. This is especially important where natural protection is not readily available.
7. **(A) Incorporate disaster risk reduction and preparedness into development planning** to reduce vulnerability of fishing and fish-farming communities to natural disasters and extreme weather events. FAO has prepared guidelines for fisheries and aquaculture emergency response¹¹ and emergency response assessment.¹²
8. **(A) Improve safety at sea** through better built boats, improved communication systems and basic safety equipment, as well as **improved weather forecasting and early warning** systems to inform fishers in a timely manner of bad weather.
9. **(A) Reduce aquaculture's dependence on wild resources** by improving feeds and investing in research and production of seed and fingerlings. Engaging smallholder farmers in fish nursing for livelihood diversification and to facilitate restocking after disasters is also an effective business model to accelerate disaster recovery, especially where there are seasonal ponds or in water-stressed and disaster-prone areas.
10. **(A) Encourage livelihood diversification,** especially among small-scale fishers in areas where stocks are overexploited - for example, through post-harvest processing or, preferably, activities not related to fishing, including aquaculture, microenterprise or wage employment in the tourism or other sectors.
11. **(A) Temporary or permanent migration** for wage labour, to find alternative fishing grounds or relocate homes due to sea level rise, coastal erosion or salinization of groundwater. Temporary migration is a common coping strategy for fishers around the world, especially those engaged in seasonal fisheries. Increasingly, people will likely be forced into permanent migration.

Gender

1. **(A) Mainstream gender concerns and empower women to contribute to adaptation and mitigation efforts,** building on an understanding of the different capacities and vulnerabilities of men and women. Actions could include strengthening women's leadership in fishery organizations, ensuring that new sectoral legislation and budgets reflect women's concerns, and providing women with financial and technical skills, and access to weather and environmental information, etc.

¹¹ <http://www.fao.org/3/a-i3432e.pdf>

¹² <http://www.fao.org/3/a-i3433e.pdf>

Project financial and economic analysis

All IFAD project designs include financial and economic analysis. Financial models of businesses to be supported are developed based on assumptions and data gathered during design. These models are aggregated and financial values are converted into economic values in order to estimate the overall economic impact of the project. The results of this process provide the central part of the rationale for funding and implementing the project.

In projects which address adaptation and mitigation, additional costs may sometimes be incurred. The financial and economic analysis must demonstrate that these additional costs generate additional benefits. For this purpose, financial and economic models must incorporate assumptions regarding the impact of climate change on the proposed investments with and without project intervention. This may include the following considerations:

Table 2: Impact of climate change on proposed investments with and without project intervention

Sector	Scenario	Incremental costs	Incremental benefits
Fisheries	Without project	<ul style="list-style-type: none"> ▪ Declining catches ▪ Increasing fuel use as stocks decline ▪ Fewer days at sea due to bad weather ▪ Higher depreciation or more frequent replacement of equipment due to weather damage 	<ul style="list-style-type: none"> ▪ This does not apply
	With project	<ul style="list-style-type: none"> ▪ Increased cost of safety/communication equipment ▪ Increased investment in improved equipment and vessels ▪ Contribution to costs of management measures ▪ Reduced days at sea due to management measures ▪ Insurance payments 	<ul style="list-style-type: none"> ▪ Stable or increasing catches ▪ Reduced fuel use ▪ Less risk of damage to assets ▪ Improved prices
Aquaculture	Without project	<ul style="list-style-type: none"> ▪ Declining yields ▪ Higher risk of disease and losses 	<ul style="list-style-type: none"> ▪ This does not apply
	With project	<ul style="list-style-type: none"> ▪ Increased cost of equipment ▪ Insurance payments 	<ul style="list-style-type: none"> ▪ Increased yields ▪ Reduced risks ▪ Higher prices

Typically, public good-type benefits such as improved natural resource management, ecosystem restoration and carbon sequestration are often mentioned in IFAD project design reports, and mid-term and completion reviews as “unquantifiable” benefits. However, where feasible, these values should be quantified and included in the estimations of project economic models in order to fully value project benefits. There are increasingly robust techniques for quantifying such benefits and, in many countries, there are studies already completed whose results can be used as the basis for such calculations. For example, FAO has developed the ex-ante carbon balance tool (EX-ACT),¹³ an appraisal system for providing ex-ante estimates of the impact of projects, programmes and policies on the carbon balance.

Project management and coordination

With regard to project management and coordination arrangements, key issues to consider are:

- **Developing partnerships and engaging stakeholders.** Ensure a wide range of stakeholders are represented on the project steering committee. Hold (at least) annual meetings, workshops or seminars in order to engage with many different stakeholders.

¹³ http://www.fao.org/docs/up/easypol/907/ex-act_private-sector-117en.pdf

- **Communicating about project activities** and plans to ensure broad awareness and opportunities for discussion and debate in advance of implementation, as well as to enable reflection on and refinement of project activities during and after implementation
- **Capacity and commitment of project staff.** As project staff will be responsible for implementing the project, their commitment to supporting climate change adaptation and mitigation must be assured. They may need specific training and support to ensure they have a sufficient understanding of climate change adaptation and mitigation options relevant for fisheries and aquaculture. They should stay up to date with the latest climate science and lessons learned from other climate change adaptation and mitigation projects.
- **Participatory monitoring and evaluation (PM&E).** Establish an M&E system to assess the success of adapting to climate change. Select site-specific, impact-oriented and easily verifiable indicators to measure progress and achievements, including outputs, outcomes and impact. The ASAP is a useful reference for this purpose. Ensure that the system is actually measuring the real project impact on the community, beyond achievement of the logframe outcomes and indicators. The PM&E strategy should be designed at very early stages of the project with the active participation of the targeted communities. M&E systems should generate lessons learned and inform management decisions. Within the ASAP, a new results-based management system has been developed to support the implementation of projects. In the case of fisheries projects, the use of the geo-referenced M&E would allow more precise knowledge of fishing grounds, aquaculture operations and environmental information. This is crucial to understanding and managing the sector and, mostly for aquaculture, to understanding the extent and spread of diseases. Such an approach would also help in understanding climate-related constraints and the impact of climate change and negative externalities (e.g. pollution, etc.).

Strategic recommendations

Climate change is a growing global concern that has implications not only for every aspect of human life but also for all living organisms. Climate changes already being witnessed include warming of the atmosphere and the oceans, changes in rainfall patterns and increased frequency of extreme weather events. The oceans are also becoming increasingly saline and acid, affecting the physiology and behaviour of many aquatic species, altering productivity, habitats and migration patterns. Sea level rise, combined with stronger storms, severely threatens coastal communities and ecosystems. The world's coral reefs are under threat of massive destruction over the coming century. Some inland lakes and water bodies are drying up, while in other areas destructive flooding is becoming a regular occurrence. In many instances, it is the poorest communities in the poorest countries who are most vulnerable to these changes.

IFAD has long recognized the necessity, urgency and feasibility of addressing climate change and associated impacts through its country-level operations. Concrete steps in this regard have been taken with the formulation of the Climate Change Strategy in 2010, the Environment and Natural Resource Management Policy in 2011 and the launch of the ASAP in 2012. These latest guidelines take these efforts further by offering a range of multiple-benefit options and best practices for integrating climate change adaptation and mitigation into IFAD interventions in the fisheries and aquaculture sectors. The proposed measures have been identified by means of a detailed study of relevant literature on climate change, the fisheries and aquaculture sectors, and relevant activities of other international organizations. In line with the ASAP's first principle of scaling up tried and trusted approaches, most of the proposed measures are not new concepts or ideas. They have been proven time and again in practice to provide a range of benefits to and increase the resilience of small-scale fishers and fish farmers, as well as the ecosystems on which they rely.

However, to ensure for real impact on climate change adaptation and mitigation, the solutions proposed above need to be implemented and adopted at scale. The key steps required for scaling up are outlined in numerous IFAD publications on this topic and can be applied equally to the fisheries and aquaculture sectors. These should consider the differences between planned and autonomous adaptation and mitigation, and policy/legislation-based versus market/individual/collective action-based drivers and mechanisms.

Additional resources and tools

IFAD resilience analysis checklist

The following is intended as additional guidance for IFAD project teams and stakeholders on how to undertake a climate resilience or climate risk analysis of proposed investments, including in fisheries and aquaculture. This checklist, which can be applied at all steps in the project process, is intended to be used in consultation with the beneficiaries.

The climate resilience analysis involves testing the assumptions governing a given investment against the basic climate change scenario, which predicts:

- changes in air and water temperatures
- lower rainfall in the spring and summer seasons
- changes in seasonality, intensity or frequency of extreme weather events
- increases in variability and uncertainty of climate within and between years
- changes in start and end of cropping seasons
- changes in start and end of fishing seasons/migrations
- changes in fisheries species
- change in number of rainy days during a wet season
- increased incidence of dry spells during the cropping season
- increased incidence of hot or cold nights and days
- changes in high and low water levels/flows in rivers and lakes
- more frequent or longer heat waves (several days in a row with temperatures above the annual maximum).

Analysing climate constraints

Undertaken together with communities, an analysis of constraints on production could involve asking the following questions:

(i) Water

- Is rainfall sufficient to ensure productivity in the targeted sector?
- Are the rainfall patterns seasonally regular?
- Is water available for irrigation and fish ponds?
- Has the water quality changed in recent years (e.g. become saltier)?
- Are there unusual occurrences of flooding?
- Have river or lake levels been unusually high or low in recent wet and dry seasons?

(ii) Land

- Is soil degraded or is land eroded (including coastal erosion)?
- Is there deforestation?
- Are the rangelands regenerating at a normal rate?

(iii) Climate

- Are crops and livestock (including fish) performing well under current temperatures?
- Have there been losses due to heat waves or early frost?
- Have there been changes in the quantity or composition of fish catches, or in the seasonality of catches of different species?
- Have crops, livestock, fish or other assets been destroyed or damaged recently by unusually extreme weather events?

If the answers to any of these questions are “yes,” then it may be opportune to adjust the proposed investment in order to address these constraints. Chances are the constraints of today will be exacerbated by climate change.

Understanding the impact of climate change on the proposed investment

A basic set of questions is proposed in this note to guide the analysis of resilience of proposed investments, taking a livelihoods approach that involves diversified/integrated farming models, including fisheries, aquaculture, livestock and crop systems.

In the fisheries sector, examples of key questions could be:

- What are the main species targeted by fishers? Have there been changes in species composition, distribution, timing of seasons, etc.?
- What are the main locations where fishing takes place and do they include any of the following: freshwater – seasonal water bodies, shallow lakes, wetlands; marine – close to mangroves, coral reefs, wetlands or seagrass beds, or in lagoons? Have there been any changes in the habitats linked to fishing activities?
- Are fishing boats, fishing or post-harvest equipment, or landing sites at risk from floods, waves, coastal erosion or strong winds?
- Have fishing and post-harvest operations been affected by environmental factors over time?
- Are catches generally increasing, decreasing or stable?
- Have people become sick from eating shellfish or reef fish?
- Is the proposed infrastructure at risk from environmental factors?

In the **livestock/aquaculture sectors**, examples of key questions could be:

- Are the species or breeds vulnerable to frost, cold temperatures, heat waves or other environmental factors?
- Are the proposed livestock husbandry installations sufficient to ensure adequate water supply?
- Are the proposed installations at risk from strong rains, flooding, strong winds, temperature fluctuations/extremes and other environmental factors?
- Is the energy supply for production dependent on water or rainfall (e.g. hydropower)?
- To what extent is the availability of feed supply subject to climate conditions?

In the **crop sector**, examples of key questions could be:

- Are the varieties and seeds tolerant to droughts, floods or frost?
- Do the current crops/varieties have a limit of temperature tolerance?

- Would new pests or diseases emerge in case of drought or floods, or in case of increased temperatures, humidity and rainfall?
- Do the current or proposed water management practices promote water use efficiency?
- Do the proposed niche products tolerate climate extremes and variability such as increased rain, longer dry periods and strong rainfall events?
- Are the projected yields subject to climate conditions remaining the same?
- Are the proposed cultivars competing with others for water or soil?
- Will new varieties or crops significantly change planting and harvest dates; if so, will this have impacts on other activities?

In addition to asking the questions above, the communities should test the viability of the investment against the conditions listed below. This involves considering the viability of the commodity being produced (i.e. crop or livestock), as well as the means of production (cultivation practices, land husbandry, livestock husbandry, buildings, shelters, etc.). The key question to ask is whether the investment would continue to be viable/profitable/productive if there is:

- 5 to 10 per cent less rainfall
- more heat during the growing season
- early frost
- less soil moisture
- lower river flow
- later onset of rain
- longer rainless periods during the growing season
- flood
- drought
- change in water quality (temperature, pH, oxygen, etc.)
- rougher seas
- sea level rise.

If it is found that for one of the emerging conditions an element of the proposed investment is not viable (for example, the fish species to be promoted cannot withstand high variation in temperature, oxygen, pH, etc.), then an adaptation option should be proposed.

Understanding vulnerabilities

In addition to the impact pathways/risks/opportunities evaluated above, an assessment of vulnerabilities will help identify priority economies/sectors/communities for adaptation interventions. Examples of initial vulnerability questions and issues specific to fisheries and aquaculture are given in Box 9.

Making recommendations for adaptation

Recommendations for adaptation should focus on addressing both current and future constraints. A resilient investment is one that can withstand a maximum number of constraints at present and in the coming years. Recommendations for adaptation can include:

- changes in the fish species being farmed, for example, by selecting breeds that resist a larger temperature amplitude and a broader range of pH and oxygen levels, diseases, predators, etc.

Box 9: Example questions and issues specific to fisheries and aquaculture for use in a vulnerability scoping exercise

Understanding the exposure of the human and aquatic systems to change: Identification of the biophysical changes expected over different time scales (annual, decade, century) and their impacts on the system under evaluation and the larger communities dependent on the system

- Review of any existing climatic, oceanographic, etc., models predicting biophysical changes and system (ecosystem) impacts within the context of other drivers of change on the system (e.g. pollution, irrigation, land use, other users of the aquatic system, fishing).
- Analysis of the various pathways to impacts on the fisheries/aquaculture system and communities within the context of other drivers of change (e.g. globalization, changes in markets, war, policies). For example, fisheries management, use of resources by other sectors, pollution and runoff all affect the fisheries resources and environments. Social, political and economic drivers are also impacting fisheries and their communities.
- It would help to know to what extent change is climate change-driven and, further down, how sensitive the system is to the various drivers.
- How likely are these changes to occur?
- If no formal information is available, opinion and perceptions would be useful.

Understanding the sensitivity of the human and aquatic systems to change

- Description of the biological and ecological state of the resources in the system:
 - How sensitive are the ecosystem and fisheries species to changes in temperatures, sea level, salinity, precipitation, ocean circulation and other predicted impacts? What are the consequences to ecosystem well-being if the change comes about?
- Description of the social and economic contributions to, for example, food/nutrition security, livelihoods, employment, export earnings, and social stability, and dependence of the relevant communities (local, regional, national) on the system:
 - How sensitive are these to changes in the various drivers, including climate change? What are the consequences to human well-being if the change comes about?

Evaluating the current adaptive capacity of the human and aquatic systems

- Description of the resilience and adapting capabilities of the aquatic system, such as through indicators on biodiversity within the ecosystem, genetic diversity of species, biomass, age and size structures, water quality, amount of habitat destruction/rebuilding, proximity to threshold limits.
- Description of the adaptive capacity of the human economic–social system, such as:
 - The ability of institutions, communities and individuals to learn, use and store knowledge and experiences:
 - How is (market, climate, policy) information shared at the local level? National level?
 - What information is collected and how/when is it collected (e.g. research surveys, local knowledge surveys)?
 - How is this information used to assist management and manage uncertainty and change?
 - Flexibility in decision-making and problem-solving:
 - Are adaptive, participatory, integrated approaches to management in place?
 - Existence of power structures that are responsive, effective and consider the needs of all stakeholders:
 - Who is responsible for fisheries management?
 - Who is responsible for disaster risk management, general aquatic health, water management, coastal/lake/river/basin management?
 - Is it the same agency for all of the above items?
 - Do relevant plans exist and are they coordinated across institutions (e.g. does an integrated coastal management plan exist that incorporates disaster risk management)?
 - Who takes the decisions?
 - What are the consultation processes?
 - How is uncertainty built into the decision-making process?
 - Existence of alternatives and access to services:
 - Are there social safety net systems in place (e.g. community-level insurance, shared recovery costs)?
 - Alternative livelihoods availability? Job mobility? Training?
 - Access to alternative markets?
 - Alternative sources of food and nutrition?
 - Access to public services (potable water, health systems, education)?

Source: FAO (2013)

- changes in the inputs being used for production: for example, using more of locally farmed materials and minimizing the use of fish-based feed
- changes to the type of production means and assets: for example, using biomass energy and solar energy as alternatives to fuelwood, hydro-electricity.
- changes to management practices: for example, increasing water use efficiency, mobilizing new sources of water.

Testing for maladaptation

Maladaptations are investments or activities that seem like they are addressing a current constraint but are in fact aggravating a future constraint. For example, planting Eucalyptus to reforest degraded land may appear to be a viable solution today but Eucalyptus species are high water-consuming and they may contribute to water scarcity in the longer term, thereby impacting overall production.

In proposing investments and adaptation options, therefore, it may also be useful to answer the following key questions:

- Will the proposed action create additional demand on water, land or other natural resources?
- Will the proposed action create long-term costs or have long-term labour implications?
- Does the proposed action depend entirely on climate-sensitive services (for example, rainfall)?
- Will the proposed action introduce a potentially invasive species or variety?
- Will the proposed action compete for natural resources with the key productive sectors (for example, hydro-power dams, irrigation schemes, etc.)?
- Will the proposed action create potential resource-use conflicts?

Conclusion

There is no perfect adaptation solution, one that addresses all of today's risks and tomorrow's uncertainties. However, the resilience analysis can help determine which low-regrets or no-regrets actions can be deployed today to ensure ongoing benefits to the target communities. The result of the above analysis will, therefore, be the adoption of an adaptation solution that presents the least risk for those communities, the maximum benefit under current constraints and the most chances of continued viability under a climate change scenario.

Key features of climate-sensitive project design – checklist

Actions/Issues	Notes
1. The project design document builds on the national plan to develop fisheries and aquaculture and national strategy/framework to tackle the impacts of climate change.	
1.1 In the event that there is no national policy on climate change, or if climate change is not integrated into fisheries and aquaculture policy/planning, the project/programme document contains activities to support such a policy and to enhance capacity of key policymakers on climate change policy planning.	
1.2 The project will implement actions that are fully aligned, harmonized and integrated with national projects and programmes on climate change, fisheries and aquaculture, including the National Adaptation Programme of Action (NAPA) activities, and that are not in conflict with the different sectors.	
1.3 The project/programme will implement activities aimed at strengthening regional cooperation on matters related to climate change impacts and adaptation/mitigation.	
2. The project design document contains – and the project implementation is based on – a participatory assessment of the vulnerability of target communities to climate change and disasters.	
2.1 The project document describes the disaster risk preparedness of vulnerable target groups and climate-resilient livelihoods.	
3. The key elements of the ecosystems-based approach are evident in the project document:	
3.1 Key feasible infrastructure projects have been identified to counteract the impact of climate change on fisheries and aquaculture. Environmental impact assessments (EIAs) have been undertaken for heavy infrastructure projects.	
3.2 Measures have been included to protect, reserve, repair and enhance the ecosystems providing services to the target group.	
3.3 Measures have been included to improve the management of the ecosystems on which the communities livelihoods depend using a multi-stakeholder, cross-sectoral approach.	
4. The project document describes – and the project implements – operational measures to make the fisheries sector more sustainable and resilient to a changing climate, including the following:	
4.1 Measures to implement the Code of Conduct and the Ecosystem Approach to Fisheries, including ecosystem well-being – e.g. the reduction of overfishing, protection of aquatic systems (for example, adaptive, spatial and temporal tools), catch selectivity and by-catch reduction, as well as human well-being – e.g. social equity and economic and technical efficiency, as appropriate	
4.2 Actions to improve fishers' safety at sea, including the provision of early warning systems and safe boat structures and engines	
4.3 Measures to strengthen harvest and post-harvest technology for higher adaptability, better quality products and better shelf life in order to reduce waste/losses, and to transition to different species/products, if necessary	
4.4 Market-led mechanisms, including certification schemes, access to financial services, private-sector involvement and vertical integration	
4.5 Measures to enhance inland fisheries, such as the application of adaptive spatial and temporal tools, culture-based fisheries and stock enhancement practices, accompanied by appropriate EIAs	
4.6 Measures to foster fisheries action research involving key stakeholders and to promote underexploited species	
4.7 Measures to enhance livelihood diversity both within fisheries and in other livelihood strategies, including the provision of training in business management skills and the transfer of technological know-how	

Actions/Issues	Notes
<p>4.8 Measures to ensure that activities included in the project do not risk increasing the fishing effort or putting increased pressure on fully exploited or overexploited stocks</p>	
<p>5. The project document describes – and the project implements – operational measures to make the aquaculture sector more sustainable and resilient to a changing climate, including the following:</p>	
<p>5.1 Measures to implement the Code of Conduct and the Ecosystem Approach to Aquaculture (EAA) to ensure ecosystem and human well-being, including the development of integrated aquaculture and the transition to more diverse and low-energy systems</p>	
<p>3.3 Measures have been included to improve the management of the ecosystems on which the communities livelihoods depend using a multi-stakeholder, cross-sectoral approach.</p>	
<p>5.2 Measures to promote aquaculture integrated with agriculture, irrigation systems, flooded/salinized land and any other suitable water body, also via culture-based fisheries and stock enhancement practices</p>	
<p>5.3 Measures to promote the cultivation of “low in the food chain” species (such as herbivorous and planktivorous), carbon-sensitive species (such as molluscs) and fast-growing species, and stocking of larger seed, especially in disaster-prone areas</p>	
<p>5.4 Actions to promote climate-proof aquaculture production models, BMPs and biosecurity measures</p>	
<p>5.5 Market-led mechanisms, including certification schemes, private-sector involvement, and vertical integration</p>	
<p>5.6 Measures to foster aquaculture action research involving key stakeholders and to promote fish nursing and research of more salinity- and temperature-tolerant, yet commercially viable species</p>	
<p>5.7 Actions to promote energy-efficient technology and practices and to transition to energy-efficient equipment</p>	
<p>6. The project design report articulates – and the project implements – capacity-building measures, including the following:</p>	
<p>6.1 Measures to strengthen and enhance the capacity of management and extension services to understand and address climate change issues that challenge both fisheries and aquaculture</p>	
<p>6.2 Actions to raise awareness with regard to climate change and to deliver climate change-related training for vulnerable fishing and farming communities, local authorities, NGOs and other organizations working with the project beneficiaries</p>	
<p>6.3 Actions to strengthen the capacity of policymakers and managers in the use of scenario-building methodologies to achieve adaptation policies and management plans that are responsive to climate change at local, national and regional levels</p>	
<p>6.4 Measures to improve general environmental monitoring of the aquatic systems, including the monitoring of disease, algal blooms, red tides, ciguatera and other harmful occurrences due to a changing climate</p>	
<p>6.5 Measures to promote the formation of farmers’ groups, cooperatives and fisheries associations and the establishment of legal co-management and community-based management regimes, as appropriate</p>	
<p>7. The project document describes – and the project implements – actions aimed at introducing and/or improving financial and insurance mechanisms to enhance the resilience of vulnerable communities.</p>	
<p>8. The project’s M&E system includes specific adaptation and mitigation indicators, to be evaluated in a participatory manner and assessed during the mid-term review.</p>	

Summary of proposed measures

Table 3 provides a summary of proposed key interventions, grouped according to the main objectives that address climate-related risks. The choice of interventions should always be driven by the targeted communities and based on thorough risk and vulnerability assessments.

Table 3: Proposed key interventions by main objectives that address climate-related risks

Climate objective	Examples of adaptation measures
<p>Increase climate resilience of small-scale fishers and fish farmers</p>	<p>Implement the ecosystem approach to fisheries and aquaculture management:</p> <ul style="list-style-type: none"> ▪ Reduce overfishing and excess capacity and implement precautionary management based on adaptive management objectives. ▪ Establish natural resource co-management regimes involving community groups and fishers and fish farmers associations. ▪ Strengthen the knowledge base and climate change planning and advisory capacities of fishery and aquaculture extension workers and managers, as well as the private sector. ▪ Invest in key infrastructure and ecosystem rehabilitation projects, favouring a “no-regrets” approach. ▪ Encourage diversification of livelihoods and income sources, including activities that are not related to fishing and aquaculture. ▪ Invest in research to develop/identify new commercially viable strains of aquaculture species tolerant of low water quality, high temperatures and disease. ▪ Promote culture-based fisheries and integrated aquaculture systems, including using flooded/saline land and water bodies.
<p>Increase capacity to manage short- and long-term climate risks and reduce losses from weather-related disasters</p>	<p>Support risk reduction and risk management throughout the fisheries and aquaculture production and value chains:</p> <ul style="list-style-type: none"> ▪ Establish environmental monitoring and early warning systems, safety-at-sea and disaster risk reduction and preparedness plans. ▪ Rehabilitate coastal ecosystems which provide protection from storms and waves (e.g. mangroves, wetlands, marshes and coral reefs). ▪ Increase access to financial services and insurance mechanisms. ▪ Encourage establishment of small-scale fish nurseries to facilitate restocking after disasters and encourage farming of native fish species to reduce the impact of escapees. ▪ Improve aquaculture development and fisheries infrastructure planning and zoning.
<p>Reduce and/or sequester GHG emissions</p>	<p>Support GHG mitigation efforts within the sector:</p> <ul style="list-style-type: none"> ▪ Introduce more fuel-efficient boats and practices, including the encouragement of passive fishing gears over fuel-intensive gear types. ▪ Support improvements in feed conversion ratios in aquaculture. ▪ Promote the culture of low trophic level species and aquatic plants in polyculture and Integrated Multi-Trophic Aquaculture systems. ▪ Identify opportunities to access carbon finance for blue carbon, including through mangrove planting and/or restoration.

Glossary

These definitions are drawn from documents produced by IFAD's Environment and Climate Division. They are broadly based on the definitions most commonly used by the IPCC and the Adaptive Capacity Framework of the Overseas Development Institute (ODI).

Adaptation: Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Effective adaptation is essentially applying the principles of sustainable development prioritized through a climate change lens. An important distinction between climate change adaptation and mitigation is that the benefits of adaptation are typically local and private, while the benefits of mitigation are often global and public. As adaptation actions can entail significant costs relative to the short-term or guaranteed benefits, it is reasonable to prioritize no-regrets or low-regrets adaptation.

- No-regrets adaptation actions are investments that provide other benefits independently of their contribution to climate change adaptation. These other benefits are secured regardless of the climate scenario that materializes in the future, or are sustainable in a broader variety of climate conditions.
- Low-regrets adaptation includes moderate levels of incremental investment in projects which would take place anyway in order to increase the capacity to cope with future climate risks, e.g. over-specifying components in new constructions or refurbishment projects.
- Autonomous adaptation is adaptation that is in response to changes in ecological or human systems, but is not a conscious response to these stimuli (Shelton 2014).

Adaptive capacity: Adaptive capacity refers to the ability or potential of a system to successfully adjust, modify or change its characteristics or actions to moderate potential damage, take advantage of opportunities or cope with the consequences of a climate shock, climate stress or climate variability. It includes adjustments in both behaviour and in resources and technologies. Adaptive capacity varies with social characteristics such as gender and particularly with wealth.

Aquaculture: Farming of aquatic organisms, can be freshwater, brackish water or saltwater. Fish, crustaceans, molluscs and aquatic plants are commonly-farmed aquaculture products (Shelton 2014).

Carbon sink: Any process, activity or mechanism that removes a GHG, an aerosol or a precursor of a GHG or aerosol from the atmosphere. Sinks particularly refer to reservoirs that absorb carbon from the atmosphere. These could be natural, such as forests and oceans, or man-made, such as landfills and tree plantations.

Ecosystem services: Services provided by natural systems that benefit humans. These include water filtration, forest and fishery products, clean air and nutrient cycling (Shelton 2014).

ENSO: El Nino Southern Oscillation. A phenomenon associated with sea surface temperatures and atmospheric circulation. It affects global temperatures and weather and is most noticeable in the Pacific Ocean. Sea surface temperature and precipitation impacts are felt globally (Shelton 2014).

Fishery: An entity raising or harvesting fish or other aquatic species. It is often defined by the type of aquatic species, gear, area, social community, class of boats or a combination of these. It can refer to both wild captured fish and aquaculture (Shelton 2014).

Food security: Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

Hazard: Potential occurrence of a natural or human-induced physical event, or trend, or physical impact that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure, or economic, social or cultural assets in places and settings that could be adversely affected (IPCC).

Mainstreaming: This refers to the process of integrating climate change impact and adaptation objectives and strategies into policies and measures implemented at various scales (e.g. local, national, international) (Shelton 2014).

Maladaptation: Action that increases vulnerability to climate change, often via unintended consequences, and may be due to poor planning. This may occur outside the system or sector of focus, or to certain groups within the system (Shelton 2014).

Mariculture: A branch of aquaculture involving cultivation of marine organisms (rather than freshwater). It often involves open-ocean cage systems, or tanks, ponds or raceways filled with seawater. In addition to food, fishmeal, nutrient agar and jewellery are produced by mariculture (Shelton 2014).

Mitigation: Climate change mitigation is a human intervention to reduce the magnitude of human-induced global warming by reducing sources or emissions of GHGs or enhancing the sinks of GHGs – in other words, reducing the causes of climate change. It can include implementing policies to reduce and avoid GHG emissions and enhance sinks. Climate change mitigation potential is the amount of mitigation that could be realized over time. The technical mitigation potential is the amount that is technically feasible to achieve. Economic mitigation potential is the financially feasible subset of technical mitigation. In the context of disasters, mitigation means measures taken to limit the adverse impact of natural hazards and related environmental and technological disasters.

Polyculture: Agriculture using multiple crops in the same location to more closely mimic natural systems and reduce needs for external inputs or increase farm efficiency and productivity (Shelton 2014).

Resilience: Climate resilience refers to the ability of a system (such as a household, community, value chain or ecosystem) to anticipate, absorb, accommodate or recover from the effects of a climate shock or climate stress while retaining a sufficient quality of life. A resilient community has a secure future despite the effects of climate change. This is determined by the degree to which the social system is capable of organizing itself to increase its adaptive capacity for learning from past disasters for better future protection and to improve risk reduction measures.

Risk: Risk results from the interaction of vulnerability, exposure and hazard, combining the magnitude of the impact with the probability of its occurrence, and captures uncertainty in the underlying processes of climate change, exposure, sensitivity and adaptation.

Stakeholders: All the different people and institutions, both insider and outsider, who stand to gain or lose from a particular activity.

Stock: A subpopulation of a particular species where population dynamics are determined by intrinsic parameters (e.g. growth, fishing mortality, etc.). Extrinsic factors (e.g. immigration) are considered unimportant to population dynamics.

Vulnerability. Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system or social entity is exposed, taking into account its sensitivity and adaptive capacity.

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