Food and Agriculture Organization of the United Nations

ADDRESSING FISHERIES AND AQUACULTURE IN NATIONAL ADAPTATION PLANS

[Supplement to the UNFCCC NAP Technical Guidelines]

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Foreword

November 2020

Marine and freshwater aquatic ecosystems play an increasingly important role in our global food systems and socio-economic landscape. First, they are vital sources of food and nutrition security, providing protein and micronutrients to billions of people. Second, they support the livelihoods of 60 million people engaged in the capture fisheries and aquaculture sector, many of whom belong to vulnerable communities with limited alternative income opportunities. Third, they are major carbon sinks, having the potential to contribute to our efforts to mitigate anthropogenic climate change.

Nonetheless, the fisheries and aquaculture sectors are under stress from pollution, habitat degradation, overfishing and harmful practices. Adding to this is the emergence of greater threats caused by climate variability, climate change and ocean acidification. Global emissions of carbon dioxide and other greenhouse gases are not only changing global climate trends, but are also changing the physics, chemistry and biology of oceans, seas and freshwater ecosystems, compromising their ability to deliver ecosystem services for current and future generations. Climate change is increasing the frequencies and intensities of natural hazards such as tropical storms, and contributing to rising sea-levels, greatly increasing the risks and vulnerabilities of communities dependent on the fisheries and aquaculture sectors. Additionally, climate-driven redistribution of fish resources could render some fish stocks inaccessible to certain capture fisheries, often used as an emergency safety net for communities experiencing adversity in agriculture.

The centrality of climate change adaptation to ensuring fisheries sustainability and resilience cannot be over-emphasised. Adaptation as a means to safeguard the most vulnerable communities without alternative livelihood options can manifest in a variety of ways. For example, simple solutions such as improving the safety of fishing vessels and fishers, coastal housing and infrastructure, can not only build resilience to disaster risks in fishing and fish farming communities, but also support fisheries sustainability. Aquaculture, when well-planned and managed, also has great potential for adaptive and sustainable growth in the face of climate change, providing healthy food and nutrition with a comparatively low greenhouse gas footprint.

Fortunately, we have sufficient technical guidance available to countries to build and maintain resilience in the fisheries and aquaculture sectors. Effective and targeted climate change adaptation options are already outlined within the frameworks of the FAO Code of Conduct for Responsible Fisheries and its integrated ecosystem approaches, as well as the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication. However, in order for such outlined adaptation options to be adopted, the fisheries and aquaculture sectors need a framework for identifying and prioritizing medium and long-term adaptation options, as well as for creating an enabling environment which promotes institutional, technological and operational changes towards more sustainable use of natural aquatic resources.

In response to this need, the international community has established the National Adaptation Plan (NAP) process for Least Developed Countries (LDCs) and for other developing countries as part of the Cancun Adaptation Framework in 2010. NAPs are considered to be a core vehicle for delivering on countries' adaptation priorities, including those articulated in their nationally determined contributions (NDCs) under the Paris Agreement. Because it is an economy-wide process, the NAP process provides the opportunity to consider interactions between all sectors – and their implications on planning and implementation – in a coordinated and coherent way. It offers considerable opportunities for a more holistic and integrated approach necessary for effective adaptation.

In 2013, the Least Developed Countries Expert Group (LEG) of the United Nations Framework Convention on Climate Change (UNFCCC) invited international participants to develop supplementary sectorial guidelines to complement the generic LEG technical guidelines for the NAPs process. As a response, the Food and Agriculture Organization of the United Nations (FAO) launched the publication ***Addressing Agriculture, forestry and fisheries in National Adaptation Plans – Supplementary guidelines*** **in 2017.**

Building on these FAO guidelines, this document, ***Addressing Fisheries and Aquaculture in National Adaptation Plans***, also responds to the LEG call, focusing specifically on the fisheries and aquaculture sectors. It also serves as a complementary publication to the upcoming ***Addressing forestry and agroforestry in National Adaptation Plans***. It provides a structured process for these sectors to present their adaptation potential and engage with other sectors to discuss synergies and trade-offs of actions affecting the interlinked socio-ecological systems. In order to realise maximum potential of the NAP process, the sector must be equipped with the best available and concerted knowledge on impacts and vulnerabilities, as well as best practices for prioritising, monitoring and evaluation of climate change adaptation actions for fisheries and aquaculture. The fisheries and aquaculture supplement therefore aims to support:

- fisheries and aquaculture institutions enabling adaptation planning within the sector; and
- national planners and decision-makers working on climate change to understand the specific vulnerabilities and priorities for adaptation in the fisheries and aquaculture sector as part of the national development and adaptation system.

The COVID-19 pandemic has further highlighted the vulnerabilities of our societies and food systems, bringing to the forefront the need to build resilience in order to be prepared for new risks. However, the coordinated response to COVID-19 shows that, together, we can work to reduce vulnerabilities of those most dependent on fisheries and aquaculture in order to sustain their livelihoods, food and nutrition security, and overall wellbeing. Together, we can find solutions to meet an ever-growing demand for fish in an era of limited natural resources. Together, we can adapt to a changing climate whilst unlocking the Blue Growth potential of our aquatic systems.

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Any omissions of contributors to this guide are unintentional.

If you seek more information related to the guidebook or would like to provide feedback, please contact: FI-Inquiries@fao.org

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Abbreviations and acronyms

AHP	Analytical Hierarchy Process
BMU	German Federal Ministry for the Environment, Nature conservation and Nuclear Safety
CARICOM	Caribbean Community
CBA	Cost-benefit analysis
CBD	Convention of Biological Diversity
CCAFS	CGIAR Research Programme on Climate Change, Agriculture and Food Security
CEA	Cost-effectiveness analysis
CGIAR	Consortium of International Agricultural Research Centers
CNFTPA	National Training Centre for Fisheries and Aquaculture Technicians in Senegal
COMNACC	Comité national sur les Changements climatiques
COP	Conference of the parties
CSO	Civil society organization
CSR	Corporate Social Responsibility
DRM	Disaster risk management
DRR	Disaster risk reduction
EAA	Ecosystem Approach to Aquaculture
EAF	Ecosystem Approach to Fisheries
EbA	Ecosystem-based adaptation
EESC	European Economic and Social Committee
EEZ	Exclusive Economic Zones
ENSO	El Niño Southern Oscillation

EPM	Ecological Pest Management
FAO	Food and Agriculture Organization of the United Nations
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse gas
GIS	Geographic Information System
ICZM	Integrated Coastal Zone Management
IE	Impact Evaluation
IKI	International Climate Initiative
IMTA	Integrated Multi-trophic Aquaculture
INDC	Intended Nationally Determined Contribution
INM	Integrated Nutrient Management
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
LDC	Least Developed Country
LDCF	Least Developed Countries Fund
LEG	Least Developed Countries Expert Group
LIFE	Low Impact and Fuel Efficient
MAM	Mangroves and Markets
MCA/MCDA	Multi-criteria (decision) analysis
M&E	Monitoring and Evaluation
MoDP	Ministry of Devolution and Planning
MPA	Marine Protected Area
MPEM	Ministry of fisheries and Marine Economy
NAP	National Adaptation Plan
NAPA	National Adaptation Programmes of Action
NDA	Nationally Designated Authority

NDC	Nationally determined contribution
NDMA	National Drought Management Authority
NGO	Non-governmental organization
ODA	Official Development Assistance
OMZ	Oxygen Minimum Zone
PEG	Progress, effectiveness and gaps
PES	Payments for ecosystem services
PPP	Public-private partnerships
PRA	Participatory Rural Appraisal
PSM	Problem Structuring Methods
R&D	Research and Development
RRA	Rapid Rural Appraisal
SBSTA	Subsidiary Body for Scientific and Technological Advice
SCCF	Special Climate Change Fund
SCORE	Strengths, Challenges, Options, Responses, Effectiveness
SDG	Sustainable Development Goals
SIDS	Small Island Developing States
SSF	Small Scale Fisheries
SWOT	Strengths, Weaknesses, Opportunities, Threats
TEC	Thanh Hoa Agriculture Extension Center
UN	United Nations
UNDP	United Nations Development Programme
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
UNITAR	United Nations Institute for Training and Research
VIFEP	Vietnam Institute of Economics and Planning

Introduction

Fishers, fish farmers and fisheries-dependent communities are already profoundly affected by climate change. Preparing the fisheries sector to take part in national adaption planning processes will help those dependent on the sector to plan for their own resilience.

GUYANA
A local woman is fishing with her family using a net in the shallows of the Rupununi River.
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SAO TOME AND PRINCIPE
Fishermen returning from the sea on a regular day of work.
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The *Addressing Fisheries and Aquaculture in National Adaptation Plans Supplement* provides technical guidance on the integration of fisheries and aquaculture in the formulation and implementation of National Adaptation Plans (NAPs) and complements FAO's *Addressing agriculture, forestry and fisheries in National Adaptation Plans – Supplementary guidelines* (referred to as NAP-Ag Guidelines, FAO 2017a). It aims to draw the attention of policy makers and government officers responsible for NAP planning and processes generally, as well as fisheries and aquaculture officers at country level, specifically. It collates and analyses relevant information from fisheries and aquaculture to support the sector's ability to take part in national climate change adaptation planning processes. In addition, the NAP-Ag Knowledge Tank[1] provides complementary tools and resources as guidance to the steps that form the formulation and implementation of the NAPs.

The fisheries and aquaculture supplement to NAP guidance aims to:

- assist fisheries and aquaculture institutions to map their knowledge into the climate change world and language and articulate their needs;
- ensure that the economic and social values of fisheries and aquaculture in national development are captured adequately through the process of formulating and implementing NAPs;
- support the mainstreaming of fisheries and aquaculture in the NAP implementation; and
- more broadly, support adaptation planning within fisheries and aquaculture.

The guidance follows the principles of the United Nations Framework Convention on Climate (UNFCCC) NAP Technical Guidelines (LEG, 2012), i.e. recognising non-linearity in process, and allowing for flexibility and country-specific interpretation and adaptation of the guidance contents. It is anchored in the Code of Conduct for Responsible Fisheries, the Voluntary Guidelines for Securing Sustainable Small-Scale

[1] Available at: www.fao.org/in-action/naps/knowledge-tank

Fisheries (SSF) in the Context of Food Security and Poverty Eradication (SSF Guidelines), and adopts the principles of the Ecosystem Approach to Fisheries (EAF)[2] and the Ecosystem Approach to Aquaculture (EAA) (FAO, 2010) as overarching frameworks of reflection. The fisheries and aquaculture NAP supplement includes issues and methodologies designed specifically for the sector, along with examples from the field.

It is important to highlight that the NAP process in general aims to integrate into broader development processes and, therefore, moves away from an isolated approach in which climate change efforts are disassociated with other development efforts and frameworks. It is important to understand how climate change may impact our attainment of broader goals and how adaptation (and mitigation) options may contribute to their attainment. In the same vein, any individual sector, although facing specific climate implications and needing targeted adaptation efforts, should be considered as part of an integrated system. This supplement should be seen as ultimately supporting the understanding of implications of climate change and other drivers on the attainment of multiple Sustainable Development Goals (SDGs) through the fisheries and aquaculture systems. The SDGs include not only SDG 13 on Climate Change, but also SDG 1 "End poverty", SDG 2 "End hunger, attain food and nutrition security and sustainable agriculture", SDG 5 "Achieve gender equality", SDG 7 "Promote sustainable growth, employment and decent work" and SDG 14 "Life under water" among others. Climate change adaptation within the fisheries and aquaculture sector provides a building block to support the attainment of these goals in the face of climate change.

In terms of structure, this supplement is closely aligned with the structure of Element A, Element B, Element C and Element D of the UNFCCC NAP Guidelines (UNFCCC COP Decision 5/CP.17, annex, and UNFCCC/LEG 2012). Under each element, steps have been customised to better reflect the needs and functioning of the sector, whilst maintaining coherence and enabling a connection at any point between the sectoral and the national process to formulate and implement NAPs, as shown in Table 1.

TABLE 1.

Structure of the Fisheries and Aquaculture National Adaptation Plans supplement and corresponding elements in the National Adaptation Plans Guidelines

UNFCCC NAP GUIDELINES		FISHERIES AND AQUACULTURE SUPPLEMENT
Element A. Lay the groundwork and address gaps	→	**Institutional stocktaking and assessment**
Element B. Preparatory elements	→	**Technical assessment**
Element C. Implementation strategies	→	**Planning (integration in policies and strategies) and implementation**
Element D. Reporting, monitoring and review	→	**Communicating, Monitoring & Evaluation (M&E) and dissemination**

The elements of the NAP process are shown as a linear representation of what is in fact an iterative and likely circular process. Steps will, in most cases, be undertaken in parallel and in any logical order, with forward and backward feedbacks as appropriate. In addition, as adaptation is an iterative learning process, adaptation plans (whether NAP or sector plans) should remain a living document, requiring revision as new knowledge becomes available.

The supplement principally targets national policymakers within institutions and ministries addressing fisheries and aquaculture sector in the

[2] www.fao.org/fishery/topic/16034

hope that it may: (i) provide support in making the link to climate change within their work in fisheries; and (ii) enhance efforts to lead the recognition, promotion and inclusion of the fisheries and aquaculture sector in national adaptation planning. In addition, other stakeholders can make use of this supplement by understanding how to engage in and initiate climate change adaptation at the sub-national and local levels.

While this guidance is designed to capture the adaptation needs of fisheries and aquaculture at higher sectoral scales, the findings and prioritised activities resulting from undertaking a fisheries and aquaculture-specific process to formulate and implement NAPs should encapsulate needs at lower scales, specific for example to fishing communities or activities in geographically-defined areas, or to farming, processing activities or social groups more vulnerable to climate change.

Formulation and implementation of National Adaptation Plans

The NAP process

NAPs are "a means of identifying medium- and long-term adaptation needs and developing and implementing strategies and programmes to address those needs".[3] The process to formulate and implement NAPs was formally established at the 16th Conference of Parties (COP-16) of the UNFCCC in 2010 under the Cancun Adaptation Framework (UNFCCC COP Decision 1/CP.16, LEG, 2012)[4].

The agreed objectives of the NAPs are "to reduce vulnerability to the impacts of climate change, by building adaptive capacity and resilience", and "to facilitate the integration of climate change adaptation, in a coherent manner, into relevant new and existing policies, programmes and activities, in particular development planning processes and strategies, within all relevant sectors and at different levels, as appropriate." (UNFCCC COP Decision 5/CP.17, paragraph 1).

The NAP will include multiple sectors/systems and issues for a country. This supplement offers in-depth guidance on how to identify issues and options specific to the fisheries and aquaculture sector so that it is well prepared to take part in the broader national planning.

International and national commitments and processes toward climate change adaptation

The 2015 Paris Climate Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) was a turning point in the recognition of the urgency to increase countries' ability to impact climate change while fostering climate resilience and preserving food production. To implement the Agreement, countries are required to prepare at regular intervals Nationally Determined Contributions (NDCs), in which the fisheries and aquaculture sectors are included (Barange *et al.*, 2018). As a result of this, greater attention and emphasis have since been placed on the role fisheries and aquaculture could play in addressing these challenges. For example, out of the 157 NDCs and ten Intended Nationally Determined Contributions (INDCs) submitted by countries as part of their commitment to the 2015 Paris Climate Agreement as of 1 August 2019, 131 referred to greater adaptation in the agriculture sector, of which 68 referred specifically to crops and livestock; 103 to forestry, including related measures for land use planning and management; and 116 to fisheries and aquaculture, including oceans and coastal zone management (data aggregated from FAO internal NDC database, using methodology from FAO 2016a updated by Kalikoski *et al.*, 2018 and FAO, 2019c). Although the preparation of NAPs and NDCs are separate planning processes and do not substitute one another, their preparation is a highly complementary endeavour. In many cases, countries have explicitly mentioned the realisation of a NAP in their NDC as a way to implement their commitments to climate change adaptation (FAO, 2019a).

[3] See http://unfccc.int/adaptation/workstreams/national_adaptation_plans/items/6057.php

[4] See http://www4.unfccc.int/nap/Pages/national-adaptation-plans.aspx for national adaptation plans and strategies submitted to the UNFCCC.

Furthermore, and recognising the links between climate adaptation and the achievement of the Sustainable Development Goals (SDGs), the LEG invited countries to adopt an Integrative Framework for National Adaptation Plans and Sustainable Development Goals, the NAP-SDG iFrame, to enable explicit consideration of how the NAPs can contribute to progressing the Sustainable Development Goals (SDGs) and promote the use of integrated systems approaches to help ensure coherence and synergy of adaptation actions at multiple levels and multiple spatial and time scales (UNFCCC, 2018). An integrated approach can leverage change, and enable accounting for interactions with other sectors and broader spheres of influence. The present document intends to support the fisheries and aquaculture sector's ability to take part in such systems approaches.

Why address fisheries and aquaculture in National Adaptation Plans?

Fisheries are a vital source of employment, livelihoods and food security and nutrition in the developing world. In 2018, about 59.5 million people were engaged in the primary sector of capture fisheries and aquaculture – 39.0 million working as capture fishers in marine and inland waters (rivers, lakes, reservoirs, wetlands and inland saline water systems) and 20.5 million working in aquaculture (FAO, 2020). Up to a further 200 million households are involved in other activities connected to the fish value chain, including processing, marketing and supply (Cochrane *et al.*, eds., 2009). In addition to incomes and employment directly associated with fishing, there are forward linkages to other economic activities (e.g. trade, processing, transport and retail) and backward linkages to supporting activities (e.g. boat building, net making, engine manufacture and repair, the supply of services to fishermen and fuel to fishing boats) (Daw *et al.*, 2009). Overall, the highest numbers of fishers and aquaculture workers are in Asia (85 percent), followed by Africa (9 percent), the Americas (4 percent), and Europe and Oceania (1 percent each) (FAO, 2020).

However, the impacts of greenhouse gas (GHG) accumulation and climate change are triggering key chemical (e.g. salinity, oxygen [O_2] content, carbon uptake and acidification) and physical (temperature, sea level, ocean circulation, storm systems, floods) changes in oceanic, coastal and freshwater aquatic ecosystems. These changes are in turn affecting the health, distribution and productivity of all fish and shellfish stocks and rearing activities (FAO, 2016b, Barange *et al.*, 2018), and threaten short-, medium- and long-terms livelihoods and food security of the billions who depend on them (IPCC, 2014; FAO, 2016b, FAO, 2018, FAO, 2019b).

Extreme weather events can also cause major damage and loss to fisheries and aquaculture systems and livelihoods. Heavy winds, storms and hurricanes can disrupt the integrity of ecosystems (e.g. coral reefs and mangrove swamps) and reduce the shelter they provide for the biodiversity that lives there (FAO, 2016c). Storm surges, floods, waves and strong winds can destroy aquaculture systems (e.g. cages and long lines) and wash out fish stocks held in ponds (Cochrane *et al.*, 2009; Karim *et al.*, 2014, Barange *et al.*, 2018).

Whilst numerous studies point to the overall climate change sensitivity and vulnerability of the social-ecological systems within which fisheries and aquaculture are embedded, a wide range of threats, coping and adaptation mechanisms are at play which preclude generalisation (Barsley *et al.*, 2013; Brugere and De Young, 2015). This points not only towards a general need for greater adaptation in the sector, but in particular to its tailoring to national and sub-national contexts in order to take into account the specific threats, sensitivity and vulnerability of fisheries and aquaculture systems, and to enhance their adaptation potential and that of the communities and stakeholders who depend on them. Recognising, integrating and addressing concerns specific to fisheries and aquaculture will lead to greater resilience of the sector and of the communities it supports in the face of climate and other environmental threats.

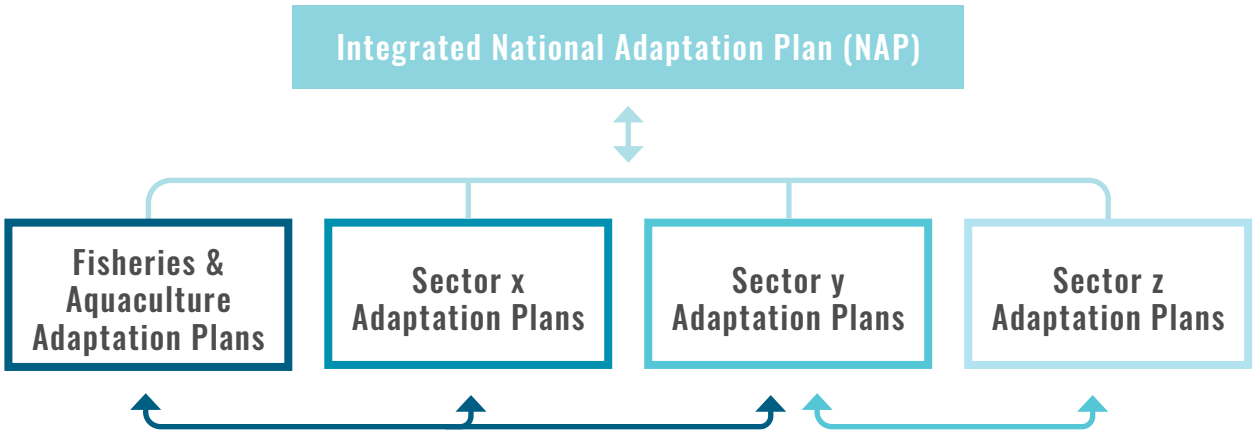
Until recently, the mainstreaming of climate change adaptation in national fisheries and aquaculture development and policies was weak and only slowly improving (see country case studies in Annex 1 and Garrett *et al.*, 2015 for the UK). The mainstreaming of fisheries and aquaculture issues in national adaptation processes was improving (see Annex 1 and Vadacchino *et al.*, 2011), but often remained incomplete or superficial. The signing of the 2015 Paris Agreement, and commitments

of countries to SDGs and the preparation of their NDCs, provided the impulse to give full consideration to the fisheries and aquaculture sector. Indeed, the downscaling of the formulation and implementation of NAPs to the sector creates an opportunity for fisheries and aquaculture to receive the attention they deserve in national planning processes, while feeding information of relevance for NDC planning. Although the process to formulate and implement NAPs promotes integrated adaptation planning, each sector needs to provide the building blocks for this to happen (see Figure 1). The fisheries and aquaculture sector, therefore, needs to be prepared to be one such building block of the NAP.

It is particularly important for the sector to take part in the broader NAP processes as there can be negative trade-offs and synergies between adaptation (and GHG mitigation) across sectors. Adaptation measures in one sector could negatively affect livelihoods in other sectors. For example, freshwater fisheries can be negatively affected from increased crop irrigation water needs. However, reduced water demands from adaptation targeting increased irrigation water-use efficiency or increased use of alternative low-water-use crops could simultaneously reduce vulnerability in both systems.

FIGURE 1.

Links among sector-specific and national-level adaptation plans



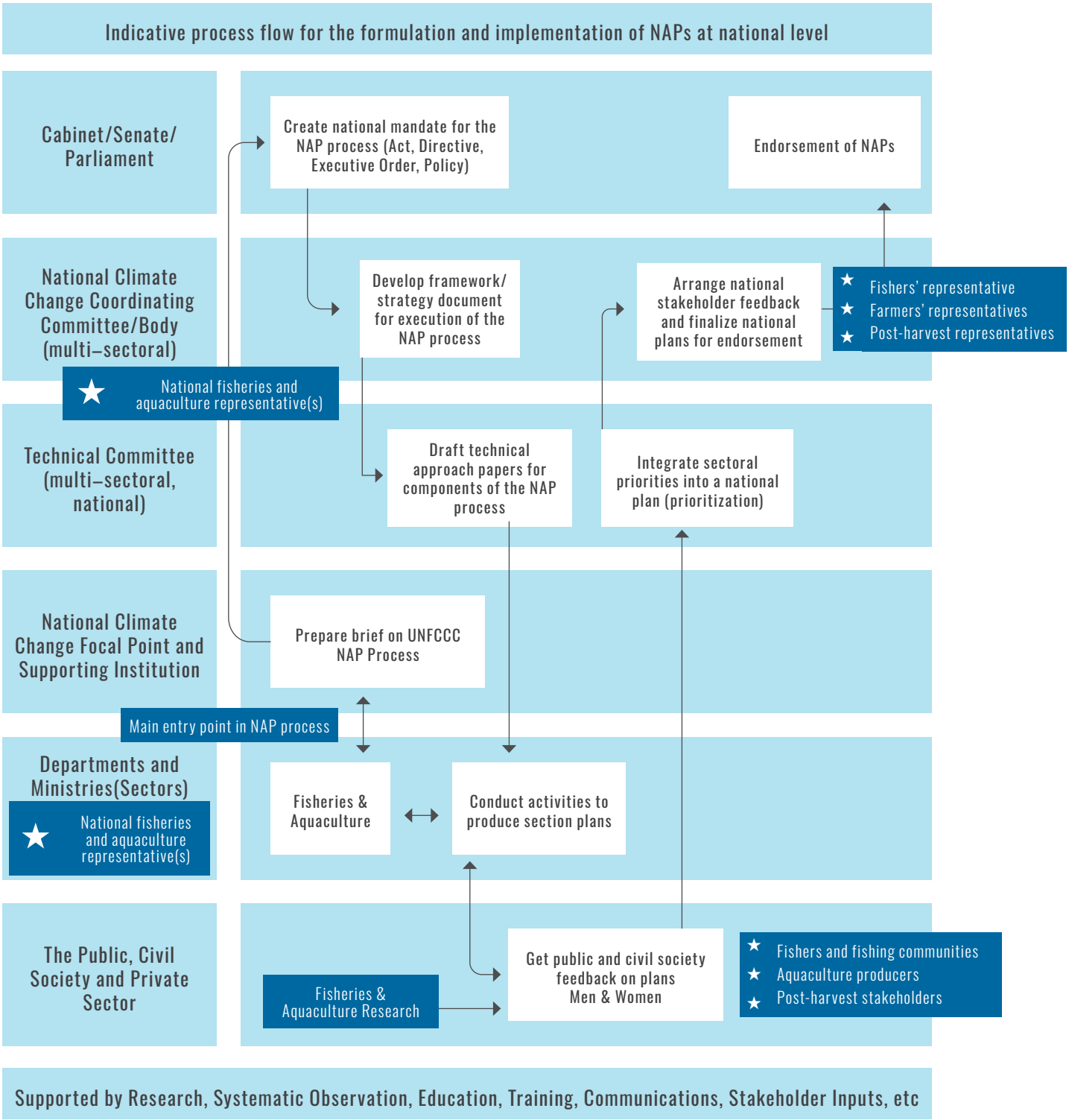
Role of fisheries and aquaculture in a given country

The first step should be a representation of the role of fisheries and aquaculture in the socio-economic fabric of the country. Identification of specific systems or value chains will guide how to consider fisheries and aquaculture in the NAP in countries where their production is important. An initial entry point to the NAP process will be at the level of the administration (ministry or department) in charge of fisheries and aquaculture, coordinated by the national government officer(s) in charge of the sector (Figure 2). The presence of fisheries and aquaculture representatives in both a multi-sectoral technical committee and a national climate change coordinating committee will be particularly important to ensure the effective coverage of fisheries and aquaculture adaptation concerns in the early stages of the process to formulate and implement NAPs.[5] This may include providing available information on climate change implications specific to the sector and its dependent communities, or the identification of knowledge gaps that the NAP process would aim to fill. At later stages of the process, these representatives will work to ensure that fisheries and aquaculture adaptation priorities are adequately

[5] If responsibilities for capture fisheries and for aquaculture are shared by different ministries, there will be a case for having a representative of each of these two sub-sectors in both committees.

FIGURE 2.

Placing fisheries and aquaculture in a process to formulate a National Adaptation Plan



Source: Adapted from UNFCCC, 2012. Arrows represent inputs to be sought from key stakeholders of the fisheries and aquaculture sector at different steps of the process.

represented among national priorities for adaptation. This is especially important because fisheries and aquaculture, in particular inland capture fisheries, cannot adapt in isolation from other sectors: discussions and negotiations have to take place with all water users, basin planning, irrigation and hydropower management authorities, as well as coastal resources users and managers.

It is also important that fishers and their communities, aquaculture producers and stakeholders from the post-harvest sector (e.g. traders, processors), both male and female, are consulted and provide inputs into the fisheries and aquaculture climate change adaptation plan, so that their knowledge and views are represented and feed into the prioritisation process of adaptation activities. A higher level of consultation and feedback should also involve them through their associations' (or similar) representatives at the time of the finalisation of the NAP.

Elements and steps to address fisheries and aquaculture in the formulation and implementation of National Adaptation Plans

Each section for Elements A through D will contain:

- steps to guide the user under each element;
- guiding questions for each step;
- examples of outputs, expectations, and achievements for each step; and
- practical examples illustrating steps and elements of the guidance.

TABLE 2.

Overview of elements and steps for addressing fisheries and aquaculture in a National Adaptation Plan

Element A. Lay the groundwork and address gaps	❑ A1 Fisheries and aquaculture institutional and individual capacity assessment to participate in the NAP development and implementation ❑ A2 Assessment of prior and current engagement of fisheries and aquaculture in climate change adaptation processes
Element B. Preparatory elements	❑ B1 Stock-taking of available information in support of the inclusion of fisheries and aquaculture in the NAP ❑ B2 Analysing future impacts of climate change on fisheries and aquaculture ❑ B3 Assessing the contextual vulnerability to climate change of fisheries and aquaculture systems and the people they support at appropriate levels ❑ B4 Synthesis and ranking of fisheries and aquaculture climate change risks, impacts and vulnerabilities to determine adaptation goals ❑ B5 Identifying, reviewing and prioritisation of fisheries and aquaculture adaptation options
Element C. Implementation strategies	❑ C1 Identification of the policy mechanisms in support of institutional adaptation, livelihood adaptation and risk reduction and management for resilience ❑ C2 Integrating fisheries and aquaculture adaptation options and supporting policy measures ❑ C3 Mobilisation of funds and human resources for implementation ❑ C4 Feeding the fisheries and aquaculture adaptation plan contents into the general NAP and national fisheries and aquaculture development policies
Element D. Communicating, monitoring and reviewing	❑ D1 Dissemination and communication of climate change adaptation ❑ D2 Monitoring and evaluation

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Element A: Lay the groundwork and address gaps

Fisheries and aquaculture institutional stock-taking and assessment

The focus of this element is on setting the scene for addressing fisheries and aquaculture in NAPs and engaging key stakeholders in the process of formulating and implementing NAPs. It is crucial to note the work that has been carried out to date and what structures are in place, or needed, from an institutional point of view, in a country's fisheries and aquaculture sectors to embark on the effective mainstreaming of fisheries and aquaculture in the process to formulating and implementing NAPs.

While Element B will provide an overview of knowledge on impacts, vulnerabilities and adaptation options specific to fisheries and aquaculture sectors, this element takes stock of the capacities of fisheries and aquaculture administrations to participate in NAP processes – through a capacity assessment – and reflects on past experiences of the sector in engaging in climate change adaptation planning processes.

A country-driven institutional capacity development approach for the formulation, implementation and monitoring of NAPs allows for more impactful and sustainable climate adaptation action (FAO and UNDP, 2018). Such an approach calls for a participatory institutional capacity needs assessment to improve cross-sectoral collaboration and coordination mechanisms between ministries and relevant stakeholders while identifying country strengths and needs for NAPs (ibid.). It is all the more important to recognise that "climate change adaptation in the fisheries and aquaculture sector is a governance challenge where the actors at different levels and sectors…would need to engage in an interactive process through which pathways and policies are defined and implemented" (Kalikoski *et al.*, 2018: 33). This requires multiple institutions to step out of the 'business as usual' modus operandi to address climate change and associated challenges in a holistic manner (ibid.).

Anticipated outputs and outcomes of Element A:

- ❑ Entry points for engaging fisheries and aquaculture in the NAP process.
- ❑ An outline of opportunities fisheries and aquaculture to engage in the process to formulate and implement NAPs, i.e. where the entry point to the process to formulate and implement NAPs for the sector is and how to access it.
- ❑ An agreed policy, and organisational gaps to be addressed, to support adaptation planning within the fisheries and aquaculture sector and participation of the sector in broader, cross-sector climate change adaptation planning.
- ❑ A dedicated focal point, unit or task force or other officially recognised mechanisms or bodies mandated to spearhead the mainstreaming of fisheries and aquaculture in the process to formulate and implement NAPs (i.e. lead the process of going through elements A–D of this guidance).[6]
- ❑ A list of identified skill gaps and a strategy to fill them (e.g. recruitment and/or trainings that need to be undertaken to strengthen individual skills in support of this).

[6] This may take several years.

	Steps	*Guiding question*
A1	*Fisheries and aquaculture institutional and individual capacity assessment to participate in NAP development and implementation*	Are the necessary institutional and individual skills and mechanisms available to support the mainstreaming of fisheries and aquaculture in the process of formulating and implementing NAPs?
A2	*Prior and current engagement of fisheries and aquaculture in climate change adaptation processes*	To what extent have fisheries and aquaculture participated in earlier climate adaptation planning and efforts so far, and how can this be capitalised upon?

Step A1. Institutional and individual capacity assessments for addressing fisheries and aquaculture in National Adaptation Plans

Guiding question for Step A1:
Are the necessary institutional and individual skills and mechanisms available to support the mainstreaming of fisheries and aquaculture in the process of formulating and implementing NAPs?

Answering this question will enable understanding of how the sector is prepared 'from within' to support climate change adaptation.

Key actions for addressing Step A1 would consist of (from Mackay *et al.*, 2015):

- identifying and describing existing skill sets (management, technical and participatory);
- locating these skill sets at different implementation levels (policy, organisational and operational); and
- identifying the gaps where additional skills development is required.

A starting point could be the United Nations Institute for Training and Research (UNITAR) framework, which consists of an institutional capacity assessment inclusive of an assessment of individual skills and capacities. This framework, adapted in Tables 3a and 3b to assess the capacities of institutions and individuals involved in fisheries and aquaculture, helps determine the level of existing capacity and skills to engage in broader NAP processes, to formulate and implement climate change adaptation planning within the sector, as well as to fund and monitor effectiveness of fisheries and aquaculture adaptation actions. Formulating and answering such questions can:
(i) provide an effective way of collecting and analysing information on a country's existing skills profile; and (ii) identify gaps and capacity building strategies (Mackay *et al.*, 2015). In addition, the institutional capacity assessment can be carried out following the FAO and United Nations Development Programme (UNDP) methodology and sample questionnaire developed under the NAP-Ag Programme and presented in the Briefing Note (2018) Institutional capacity assessment approach for national adaptation planning in the agriculture sectors (FAO and UNDP, 2018).

TABLE 3A.

Example questions for assessing fisheries and aquaculture institutional capacity for climate change adaptation planning

FISHERIES AND AQUACULTURE INSTITUTIONS	
Cross-sectoral NAP engagement readiness of the fisheries and aquaculture sector	Is there a requirement (or invitation) for the fisheries/aquaculture sector to take part in national, cross-sectoral adaptation planning and implementation (e.g. NAP development)?
	Is the fisheries and aquaculture sector represented in the cross-sectoral NAP body at national or sub-national levels?
	Is the process and timeline for NAP development and implementation clear to the fisheries/ aquaculture sector?
	Is there a cross-sectoral NAP engagement strategy for the fisheries and aquaculture sector?

FISHERIES AND AQUACULTURE INSTITUTIONS	
NAP policy readiness of the fisheries and aquaculture sector	Is there a clear understanding/agreement of the climate change impacts/risks[6] for the fisheries and aquaculture systems, sectors, communities?
	Is there a requirement/demand for the development of sector-specific adaptation plans/NAP?
	Are impact and vulnerability assessments in fisheries and aquaculture required by the policy/legal framework for use in adaptation planning?
	Is there a fisheries and aquaculture climate change adaptation plan (e.g. fisheries and aquaculture NAP)
	Is climate change adaptation integrated into fisheries and aquaculture policies, strategies and plans? To what extent? (e.g. LOW: a brief mention of climate change, to HIGH: specification of climate change vulnerabilities and adaptation actions/climate change adaptation strategy/plan for fisheries and aquaculture)
	Are relevant Disaster Risk Management (DRM) plans and policies integrated in fisheries and aquaculture development or climate change adaptation plans?
NAP organisational readiness within the fisheries and aquaculture sector	Is there a formal climate change unit (task force, working group, etc.) in the fisheries and aquaculture institution?
	Does this fisheries/aquaculture climate change unit have a clear mandate for planning and coordinating climate change adaptation in the sector?
	Does the climate change unit have high-level legitimacy (e.g. endorsement by the minister of fisheries) for its actions?
	Is there a climate change focal point in the fisheries and aquaculture ministry/department (at national and provincial levels)? • Are the focal point's responsibilities regarding climate change and line of response well defined? • How connected to other sectors affecting fisheries and aquaculture (e.g. inland waters, energy, transport, and tourism) is the work of the focal point? • Does the focal point have regular interactions with the NAP body to facilitate cross-ministerial discussions?
	Is the current visibility of climate change in the organizational structure of fisheries and aquaculture institutions sufficient? How visible are the role and actions of the focal point?
	Does the visibility of climate change in the work of the fisheries and aquaculture ministry need strengthening? (e.g. increase the number of staff, promote their position, move to different line of authority within the ministry)
NAP technical readiness of the fisheries and aquaculture sector	Are data regularly collected on environmental, weather and climatic parameters and made available for use in planning/management by fisheries and aquaculture? • Is there a climate and environmental information system/seasonal forecasting system available to fishers, fish farmers and traders on a recurrent basis? • Is there a bio-climatic information system to inform recurrently on, for example, changes in species abundance and distributions available to fisheries and aquaculture stakeholders?
	Have the climate change impacts/risks for the fisheries and aquaculture systems, sectors, communities been assessed?
	Do vulnerability assessments exist for the fisheries and aquaculture systems, sectors, communities? • Are analytical tools such as vulnerability and risk assessment, scenario analysis, cost-benefit analysis used to understand the adaptation needs of the sector? • Do these analyses take into account sub-sectors (e.g. capture, culture, post-harvest/trade), actors (small-scale, large-scale) and geographic areas (provinces/districts, community, national) and ecosystems (freshwater, brackish, coastal, deep-sea)?
	Are the results of these analyses fed into or driven by planning and policy making?
	Have appropriate adaptation options been identified for the fisheries and aquaculture systems?

[7] Here, an impact (bio-physical or social/economic) results directly from changes in climate variables; whereas a risk takes into account the ability of a system to absorb or respond to a change and, hence, the consequences stemming from an impact.

FISHERIES AND AQUACULTURE INSTITUTIONS	
NAP financial, monitoring, communication readiness of the fisheries and aquaculture sector	Does a shared climate change financing framework for adaptation exist between fisheries/aquaculture and other sectors of the economy?
	Have the costs of climate change adaptation for the sector been assessed? • How do they compare to (i) the value of the sector; (ii) the development budget for the sector; and (iii) the sector allocations for adaptation?
	Is a budget for climate change vulnerability assessments and adaptation activities in fisheries and aquaculture clearly earmarked? • Can this budget for fisheries and aquaculture climate change adaptation activities, including skills development, be easily accessed?
	Is there a national climate change adaptation M&E system in place for the fisheries and aquaculture sector to monitor vulnerability reduction/adaptive capacity and effectiveness of adaptation actions? • Are climate change adaptation data regularly collected for M&E purposes?
	Is there a communication strategy and budget for the fisheries and aquaculture department's/Ministry's climate change adaptation work?

TABLE 3B.

Example questions for assessing fisheries and aquaculture individual capacity for climate change adaptation planning

FISHERIES AND AQUACULTURE TECHNICAL STAFF	
For climate change policy support	Are technical staff linked to policy making: • familiar with climate change adaptation policy and science? • provided with information on climate change implications for fisheries and aquaculture which are applicable to the policy level? • aware of the process and information requirements to formulate and implement their country's NAP? • aware of the national climate change focal points, departments and ministries? • highly knowledgeable and experienced in capture fisheries, aquaculture and post-harvest issues? • trained in policy influence, content design and implementation? • trained in media communication? • in possession of negotiating skills? • familiar with laws governing fisheries and aquaculture and the country's legal apparatus? • aware of national and sectoral budgeting processes? • familiar with climate change economics and finance? (e.g. cost-benefit analysis, investment appraisals for climate change options) • familiar with the EAF and EAA?
For climate change coordination	Are technical staff linked to coordination: • aware of relevant climate change strategies/plans/policies? • aware of the role and activities of the fisheries and aquaculture climate change focal point and fisheries and aquaculture climate change unit? • engaging with the focal point and fisheries and aquaculture climate change unit in their professional duties and activities? • provided with climate change information related to their management functions and planning? • informed on a regular basis of climate change activities in fisheries and aquaculture and nationally? • knowledgeable about non-fisheries or aquaculture issues affecting the sector (e.g. sharing of natural resources, vulnerability dynamics)? • aware of sectoral budgeting processes and procedures? • familiar with M&E procedures in their ministry/department and their links to climate change adaptation? • familiar with the EAF/EAA?

FISHERIES AND AQUACULTURE MANAGERIAL STAFF	
For implementation/operations of climate change adaptation actions	Are technical staff linked to implementation/operations: • aware of climate change fisheries and aquaculture focal points and climate change units? • informed of relevant climate change policies/strategies and how their operational work links to these? Depending on the context: • experienced in the application of vulnerability and climate risk assessment in fisheries and aquaculture social-ecological systems? • experienced in modelling methodologies and analysis of environmental and ecological data, or capable of outsourcing these skills to specialised institutes? • knowledgeable in fisheries and aquaculture climate proofing approaches and practices? • experienced in implementing livelihoods and economic analyses (e.g. cost-benefit analysis), in the context of climate adaptation projects, or capable of outsourcing these skills to specialised institutes? • experienced in surveying and mapping techniques, including Geographic Information System (GIS) skills, or capable of outsourcing these skills to specialised institutes? • equipped with the necessary computing software to carry out climate change analyses, or capable of outsourcing these analyses to specialised institutes? • conversant with DRM, community resilience, information and communication technologies? • familiar with participatory and stakeholder engagement techniques? • familiar with the EAF/EAA? • able to access necessary funds to implement assessments and adaptation activities in fisheries and aquaculture?
For climate change policy making	Do managerial staff linked to policy making have: - strategic leadership skills? - vision, creativity and inspiration? - advocacy skills? - knowledge of social responsibility (e.g. appreciation of sustainability, humanity and ethical considerations in fisheries and aquaculture development)? - knowledge/experience of international climate change frameworks? - sufficient budgets allocated for the climate change planning process within fisheries and aquaculture at national and sub-national levels?
For climate change programme management	Do staff linked to programme management have: - experience in project management (development, implementation oversight and management)? - time management skills? - knowledge of results-based management (planning for outcomes)? - experience in M&E of programmes or projects? - financial management skills, including budgeting, resource mobilisation and management? - skills in conflict management? - skills in human resources management? - knowledge of climate finance potentials and procedures?
For participatory and integrated processes	Do staff linked to participatory processes have skills in: - coordination? - communication? - team building? - public speaking? - listening and interpretation? - establishing relationships within fisheries and aquaculture and outside the sector? - cross-cultural understanding? - cross-sectoral cooperation? - gender mainstreaming? - consensus building? - participatory planning and decision-making? - communicating outward (face-to-face, via phone, email, text)?
Note: The capacity assessment assumes that staff have essential knowledge in fisheries management, including stock assessment, aquaculture development and post-harvest product handling; hence these aspects are not included here.	

Source: Adapted and developed from Mackay et al., *2015*

The above areas of assessment and example questions may be used to develop a NAP readiness organisational capacity assessment appropriate for different contexts. Different tools may be used to score and evaluate an organisation and its staff, such as through the use of:

- yes/no scores that state whether the capacity exists or not;
- stage scores that describe the current state of the capacity (e.g. nascent, growing or mature capacities); and
- level scores that describe the strength of capacity (e.g. none to full capacity).

Simple and easy-to-understand scoring techniques such as the above enable quantitative assessments of participants' perceptions and average scores for each component. They allow for the identification of areas of strength and weakness within an organisation and the prioritisation of actions. Actions undertaken following the results of this assessment will vary depending on country-specific needs, with support and endorsement of the national authorities, and stakeholders already engaged in climate change and the process to formulate and implement the country's NAP.

BOX 1.

Example of an institutional capacity assessment for a National Adaptation Plan

Kenya National Drought Management Authority capacity needs assessment for its National Adaptation Plan

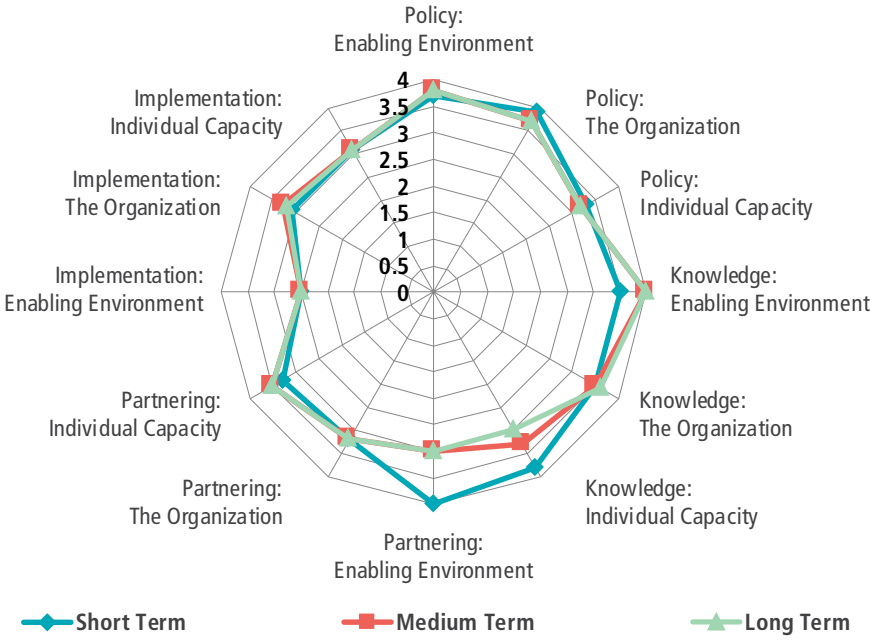
As part of the UNDP-FAO Integrating Agriculture in National Adaptation Plans (NAP-Ag) Programme, a comprehensive assessment was undertaken of the Kenya National Drought Management Authority (NDMA)'s capacity to support the planning and implementation of adaptation and priority adaptation actions relevant to the agriculture sectors. The NDMA's mission is to provide leadership and coordination of Kenya's effort in the management of drought risks and enhancing adaptation. Its role, functions, management structure and institutional arrangements for climate change were screened in order to refine the scope of the capacity assessment. It focused on NDMA's capacity for normative and policy function, knowledge, partnering and implementation capacity to support the short-, medium- and long-term adaptation actions outlined in the Kenya Climate Change Action Plan and NAP.

The assessment for each functional capacity addressed the enabling environment, the organisation and individual capacities. A score from 1 to 5 was assigned (1=None; 2=Low; 3=Moderate; 4=High; and 5=Full Capacity). A snapshot of the findings from the quantitative assessments are presented in the figure below. Responses were collected from key staff through a combined use of staff interviews and a participatory self-assessment questionnaire to enhance ownership of the findings.

It was concluded that NDMA has: (i) moderate-to-high levels of functional capacities, despite some specific limitations with respect to institutional arrangements to address the adaptation and Disaster Risk Reduction (DRR) priorities and implement NDMA's mandate; and (ii) gaps in the organisational and individual capacity to enhance the Authority's functions and effectiveness. The establishment of a Climate Change Unit within the Ministry of Devolution and Planning (MoDP) was one of the key recommendations from the study. The findings informed the compilation of a capacity development strategy and action plan for NDMA.

BOX 1. (CONTINUED)

Summary analysis of capacity needs assessment within the Kenya National Drought Management Authority



Source: FAO and UNDP, 2018.

Anticipated outcomes of Step A1:

- Establishment of an official focal point for climate change or task force in the fisheries and aquaculture in the ministry or other national institution, adequately staffed and with representation across the ministry's technical departments and at provincial levels, as appropriate, able to regularly partake in high-level inter-ministerial discussions on the NAP.
- A clear mandate for a fisheries climate change focal point or task force, with a clearly defined role (e.g. coordination, planning, representation), tasks, reporting lines and linkages with other institutions and sectors involved in the cross-sectoral NAP as well as other stakeholders in fisheries and aquaculture. It may be constituted of one or more people, as long as it has enough clout for taking forward the fisheries and aquaculture process to formulate and implement NAP forward. This cell should also have a budget and equipment to perform its tasks, coordinate activities, attend meetings as necessary and recruit the necessary expertise to help it progress through the steps (i.e. this guidance) and make sure fisheries and aquaculture concerns are adequately represented in the overall process to formulate and implement the NAP. It may however be required to look for complementary sources of funding (sources and cycles of funding should be clearly specified in the cell's 'terms of reference'). Responsibility for monitoring and evaluation of (i) how fisheries and aquaculture concerns are integrated in the process to formulate and implement NAP and climate change adaptation in general, and (ii) how the sector is adapting to the effects of climate change could also be included in the cell's mandate (monitoring and evaluation are further detailed in Element D).
- Capacity building training programme/strategy and budget to fill the identified gaps in individual skills for those involved in the climate change task force/cell and across the ministry/department (e.g. recruitment).

Step A2. Prior and current engagement of fisheries and aquaculture in climate change adaptation processes

Guiding question for Step A2:
To what extent have fisheries and aquaculture partaken in earlier climate adaptation planning and efforts so far, and how can this be capitalised upon?

The point here is to reflect on the extent to which fisheries and aquaculture were historically prepared, and are prepared today, to take part in national adaptation planning. Indirectly, this leads to identifying where engagement may have been missed in the past, and how these gaps can be filled to enhance the engagement of fisheries and aquaculture in adaptation planning processes today. In this reflection, one should consider answering the following questions:

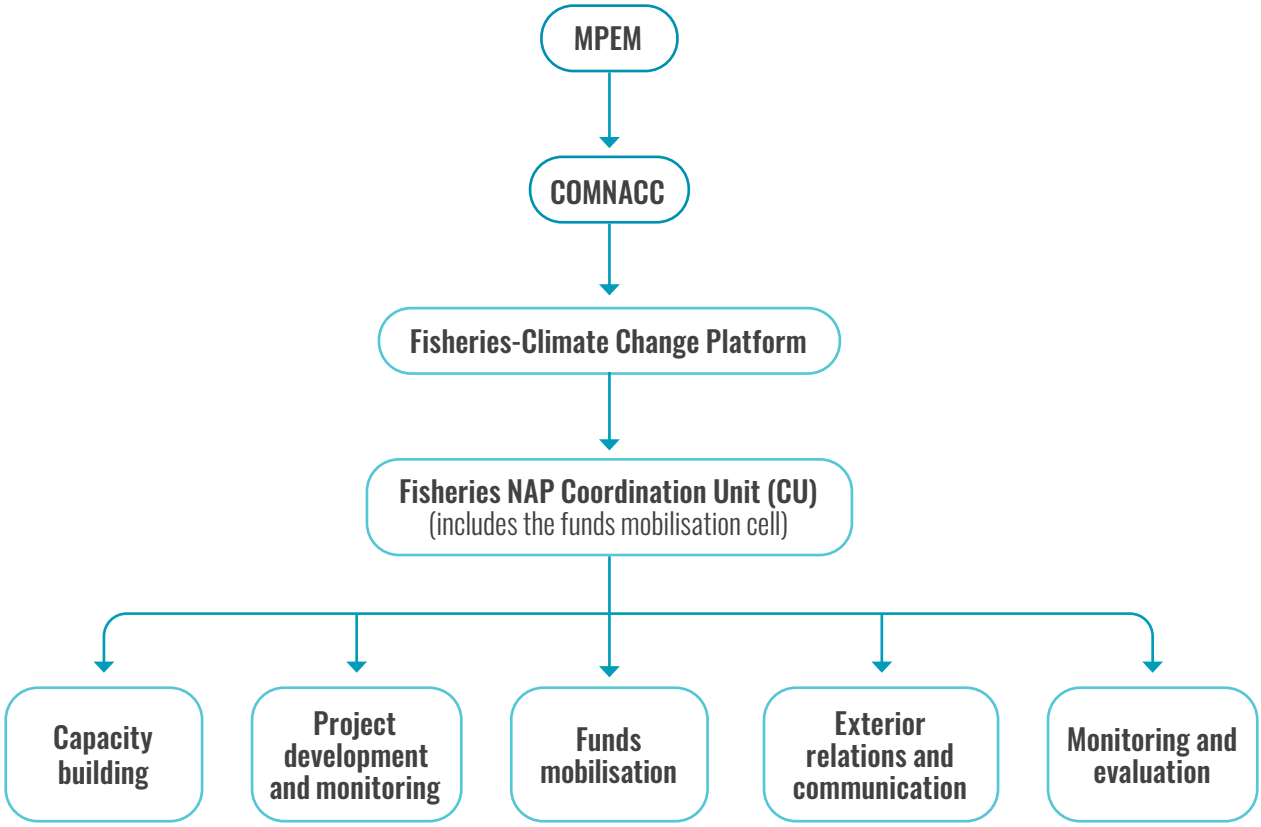
- Does the country have a National Adaptation Plan of Action (NAPA) or other national adaptation planning document/strategy? [8]
  - If so, does it include fisheries and aquaculture?
  - How was the sector included in its elaboration? If not included, what were the constraints to its inclusion?
  - Who were the key non-government fisheries and aquaculture stakeholders involved in this process (research institutions, private sector, NGOs)?
  - What has been achieved from the NAPA with regards to fisheries and aquaculture adaptation to climate change?
  - How is the fisheries and aquaculture sector's development impacted by the existing adaptation plan?
- Is the fisheries and aquaculture sector formally engaged in the process to formulate and implement the country's NAP?
  - If so, how and to what extent? (mechanisms of engagement, contributions so far, etc.).
  - Which other fisheries and aquaculture stakeholders are engaged (research, private sector, NGOs)?
  - If not, how to rectify this? This is where the role of the climate change unit/task force – as indicated in A1 above – will be important to help address this.
- Has the sector been taking part in any climate change discussions, plans or strategies?
  - If yes, what came out of this and how can it be taken further? If not, why? (keeping in mind the actions and decisions made under A1).
  - Are consultation mechanisms in place?
  - Is climate change adaptation in fisheries and aquaculture specifically mentioned in any of the country's strategic documentation?
- Do past and current fisheries and aquaculture development policies, strategies and plans make any considerations of climate change factors?
  - What are these considerations?
  - How do they affect the sector?
  - How do they affect the livelihoods of the communities?
  - How relevant are they?
  - Could they be lifted out for inclusion in the NAP as they are or after revision or validation?
  - If no, why is that and could it (or does it need to) be amended?

Identifying responses for the questions above can be among the tasks of the task force. It may involve filtering through the institutional memory of the ministry and national institutions via interviews of current and/or former officials, the revision of meeting minutes and reports, and enquiring directly to the authorities in charge of the country's NAP (Figure 3). If time is limited for the focal point carrying out these tasks, it may be considered to recruit external expertise or work with other institutions (e.g. universities).

[8] This could include climate change strategy, Nationally Determined Contributions (NDCs), climate change action plan or policy, etc., and may include both adaptation and mitigation priorities.

FIGURE 3.

Example of a Fisheries National Adaptation Plan unit to develop and implement a fisheries National Adaptation Plan in Senegal



Other key documents to review for Step A.2 are:

- National poverty reduction strategy papers, medium and long-term national development goals (e.g. Sustainable Development Goals);
- National development plans and/or economic strategies, sectoral policies (e.g. fisheries and/or aquaculture master plans, strategies and plans);
- Disaster preparedness and risk reduction policies and plans, multi and bilateral cooperation; and
- Development aid strategies and programs (e.g. with international banks, embassies, donors).

Additional guidance, which complements this Element, can be found in Step A2 of the NAP-Ag Guidelines (FAO, 2017a.)

Anticipated outcomes of Step A2:

- ❑ A clear understanding of where fisheries and aquaculture currently stand in the national processes of climate change adaptation.
- ❑ An identification of where engagement gaps lay and a strategy to improve the sector's involvement in NAP processes.

Element B: Preparatory elements

Fisheries and aquaculture technical assessment

Element B contains the core of this guidance, considering the multiple dimensions and sources of vulnerability in fisheries and aquaculture in order to devise suitable adaptation solutions. This element is more technical in nature. It includes a synthesis of existing information on climate change implications for fisheries and aquaculture (Step B1). This guides more in-depth analyses of the impacts (Step B2) and vulnerabilities specific to the sector (Step B3).

A repeated consolidation and synthesis of improved or updated knowledge on risks and opportunities for fisheries and aquaculture across the country allows for a national ranking of risks and helps determine early low- or no-regret options and longer-term adaptation interventions (Poulain *et al.*, 2018). This in turn provides the basis upon which the adaptation goals for the sector can be determined (Step B4). To attain these adaptation goals, a process for identifying and prioritising adaptation options appropriate to fisheries and aquaculture systems is presented in Step B5.

Undertaking these activities will provide the knowledge basis and agreed-upon adaptation priorities for use within the sector's development planning as well as for use by the sector in broader, cross-sectoral adaptation planning.

Importantly, decisions need to be made in spite of and taking into account uncertainties (Poulain *et al.*, 2018).

Anticipated outputs and outcomes of Element B:

- ❑ A synthesis of the state of current knowledge on climate change's threats, opportunities, vulnerabilities and adaptation options in fishing and aquaculture systems and communities, experienced at national and sub-national levels.
- ❑ More comprehensive vulnerability assessments of the sector (and specific systems and geographic areas/national and sub-national) allowing for detailed adaptation options to be identified.
- ❑ Agreed ranking of appropriate adaptation options per system and/or geographic area and/or group to be taken further in the fisheries and aquaculture climate change adaptation plan and general processes to formulate and implement a NAP.

	Steps	*Guiding question*
B1	*Stock-taking and analysis of available information in support of the inclusion of fisheries and aquaculture in the NAP*	What are the documented impacts of climate change on our aquatic systems, fisheries and aquaculture activities, and on the value chains they support?
B2	*Analysing future impacts of climate change on fisheries and aquaculture*	What will the impacts of climate change be on fisheries and aquaculture and who will be the social groups (communities, households, industries, etc.) impacted?
B3	*Assessing the contextual climate change vulnerability of fisheries and aquaculture systems and the people they support at appropriate levels*	What causes people to be vulnerable to the impacts of climate change in fisheries and aquaculture systems, and why?
B4	*Synthesis and ranking of fisheries and aquaculture climate change risks, impacts and vulnerabilities to determine adaptation goals*	Given what we now know of the causes of climate vulnerability among the people who depend on fisheries and aquaculture systems, what should our adaptation goals be?
B5	*Identifying, reviewing and appraising fisheries and aquaculture adaptation options*	Given the adaptation goals identified, which adaptation options will be most appropriate for fisheries and aquaculture systems/value chains, and people they support (in specific contexts, areas and for specific groups), and which adaptation options will need to be taken forward in the fisheries and aquaculture climate change adaptation plan and cross-sectoral NAP?

Step B1. Stock-taking and analysis of available information in support of the inclusion of fisheries and aquaculture in the National Adaptation Plans

Guiding question for Step B1:
What are the documented impacts of climate change on our aquatic systems, fisheries and aquaculture activities and the value chains they support?

Answering this involves a review of information that is already available on the state of fisheries and aquaculture in the face of climate change threats and opportunities. It does not involve new studies, which, depending on the information gaps identified here, will be carried out under subsequent steps of Element B. This first step intends to provide a broad-brush overview of the real and perceived impacts of climate change on fisheries and aquaculture systems and their potential to cope, adapt and bounce back. As such, it provides grounds for the more in-depth vulnerability assessments that will be carried out later under the steps included in Element B.

In simple terms, the guiding question involves considering:

- What are the physical and chemical changes likely to affect aquatic ecosystems, fish production systems (including value chains) and the people and communities involved in these?
- Why are these changes important? What will the impacts of these changes be on the socio-ecological system and the attainment of development goals linked to the sector? This is a step towards gauging the sensitivity of systems to these changes.
- What do we know about the socio-ecological systems' ability to cope and adapt to these changes, in a national context?
- What do we know about potential or real adaptation options that are relevant to these fisheries and aquaculture systems and these changes?

Sources of information could be global (Box 2) and include national studies or sub-national case studies (published research and grey literature) on climate change impacts, vulnerability and adaptation as well as project reports on initiatives concerning fisheries and aquaculture in the country. The questions above can serve as a way to organise the information for each system by splitting it according to the dominant fish production systems in a country, a region or a water basin; this could be complemented by interviews with key stakeholders.

BOX 2.

Recent global summaries of climate change implications for fisheries and aquaculture

Over the past decade or so, great progress has been made in documenting and researching the observed and predicted impacts of climate change on aquatic systems and species as well as other impacts affecting fisheries and aquaculture value chains and dependent communities. This has helped to provide options for adaptation and mitigation from within the sector. Global summaries provide good starting points to understanding local and regional impacts, the globally connected systems and how local physical changes may result in global impacts. Such reviews provide a means to learn how others around the globe are addressing similar issues and stimulate discussion for their adaptation to local situations.

A few resources providing global knowledge sharing on climate change, fisheries and aquaculture:

BOX 2. (CONTINUED)

Phillips, B.F. & Pérez-Ramírez, M., eds. 2018. *Climate Change Impacts on Fisheries and Aquaculture: A Global Analysis*. Hoboken (NJ), John Wiley & Sons Ltd.

Barange, M., Bahri, T., Beveridge, M., Cochrane, K., Funge-Smith, S., Poulain, F. 2018. Impacts of climate change on fisheries and aquaculture – Synthesis of current knowledge, adaptation and mitigation options. Editors: FAO Fisheries and Aquaculture Technical Paper. No. 627. Rome, FAO.

FAO. 2016e. Climate change implications for fisheries and aquaculture: Summary of the findings of the Intergovernmental Panel on Climate Change Fifth Assessment Report. Text by Seggel, A., De Young. C. and Soto, D. FAO Fisheries and Aquaculture Circular, No. 122. Rome, FAO.

It may be useful to structure the review of available information on climate change impacts on fisheries and aquaculture according to: (i) the key drivers of change that the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5) identified as having an impact on aquatic systems (Box 3); and (ii) to the various pathways that will lead to these drivers impacting fisheries and aquaculture socio-ecological systems (Figure 4). This will help identify the systems[9] most at risk and, within each system, which of the drivers are shown as most impactful.

BOX 3.

Example of climate drivers of change on oceanic, coastal and freshwater systems

Oceanic systems:
- Physical drivers:
  - Temperature change
  - Thermal stratification
  - Sea level change, incl. extreme events
  - Ocean circulation
  - Surface winds
  - Storm systems and waves
- Chemical drivers:
  - Salinity and freshwater content
  - Oxygen concentration
  - Carbon uptake and acidification

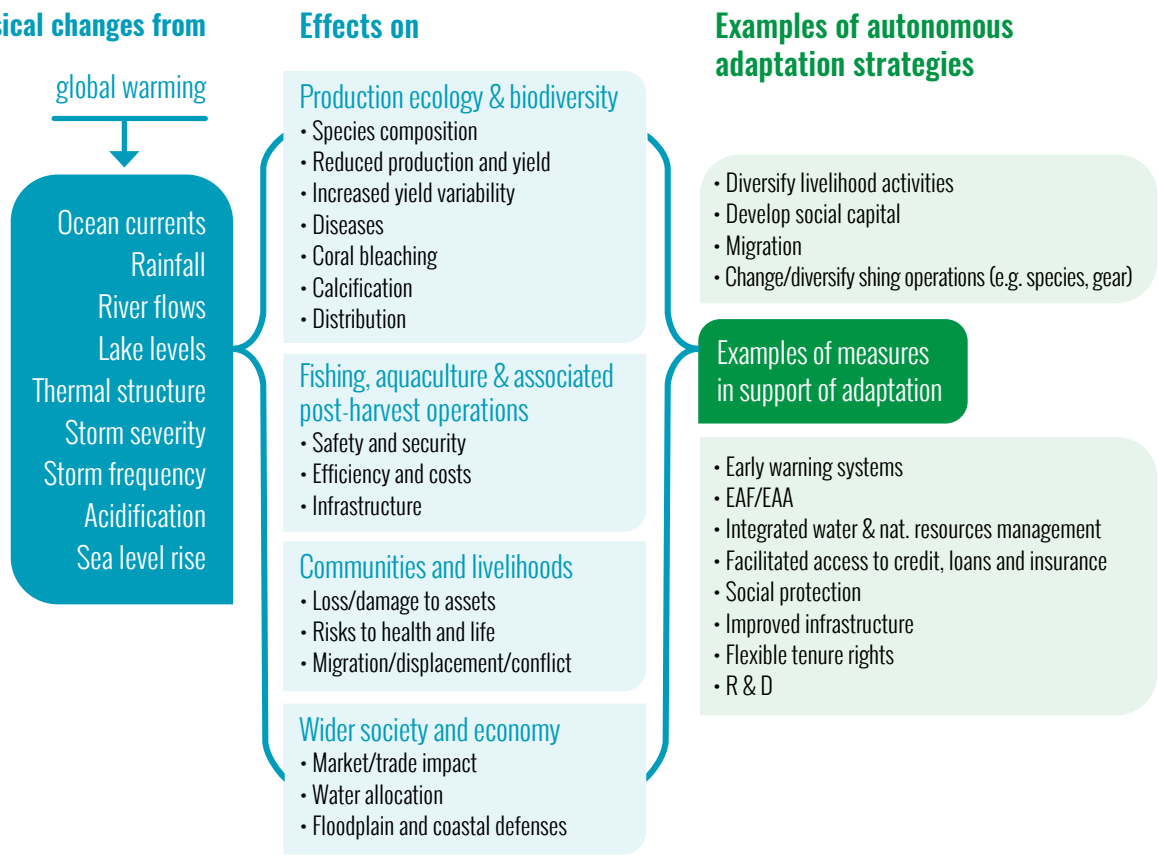
Coastal systems:
- Sea level rise
- Sea surface and air temperature
- Changes in pH values and oxygen levels
- Extreme events

Freshwater systems:
- Evaporation and precipitation
- Floods
- Droughts
- Chemical changes
- Temperature
- Storms
- Stratification

[9] These can be organised by different groupings (e.g. individual or groups of species, habitats, infrastructure, sub-sectors, farming systems, value chain actors and dependent communities).

FIGURE 4.

Schematic representation of potential impact pathways of climate change on fisheries and aquaculture system



Source: Adjusted from Badjeck et al., *2010*

This review would entail considering for each system: (i) their known exposure to these drivers; the time scales they span (year, decade, century); and (iii) the impact of these drivers on the system considered and the people they support. This could be done through:

1. A review of the results of existing climatic, oceanographic, etc. models predicting biophysical changes and system impacts (including the ecosystem) within the context of other drivers of change (e.g. pollution, irrigation, land and water use, other users of the aquatic system, and fishing)

2. An analysis of the impact pathways that lead from this exposure of the fisheries and aquaculture systems and the people within them, using Box 3 as a starting point and adding, as appropriate, other drivers of change (e.g. trade and globalisation, changes in markets, wars and migrations, national and international policies, and fisheries management measures).

It would also entail considering the sensitivity of these systems and associated people to the drivers listed in Box 3, by:

1. Describing the known biological and ecological state of the resources in the system: how sensitive are capture and farmed species to changes in temperatures, sea level, salinity, precipitatio, and the like (see drivers in Box 3)?

What are the consequences on ecosystem and human well-being as a result of these drivers?

2. Describing within each concerned aquatic system the known social and economic contributions of the fisheries and aquaculture activities to, for example, food/nutrition security, livelihoods, employment, export earnings, social stability and dependence of the relevant communities and social groups (local, regional, national) on the system: how sensitive are these categories to changes in the various drivers listed in Box 3 (direct physical risks to lives and infrastructure as well as indirect changes through production systems)? What are the consequences on human well-being and, ultimately, on development goals for the sector as a result of these drivers?

A broad evaluation of current knowledge on adaptive capacity and resilience to drivers listed in Box 3 (adapted from FAO, 2013a) should emerge from this review, including information on:

1. The various aquatic systems, using indicators on biodiversity within the ecosystem, genetic diversity of species, biomass, age and size structures, water quality, amount of habitat destruction/rebuilding and proximity to threshold limits.

2. Specific fisheries and aquaculture activities within each aquatic system, using indicators such as catches and harvests (quantities and composition), productivity, catch per unit effort, by-catches, losses (including post-harvest), target species, diversity of fishing gear and farming practices, feed ingredients, broodstock, and seed sources…

3. The human economic-social system associated with each type of fisheries and aquaculture activity, and focusing on aspects such as:

   - ☒ The ability of institutions, communities and individuals to learn, use and store knowledge and experiences related to climate change and impacts on fisheries and aquaculture at national and sub-national levels (collection, management and sharing of information).
   - ☒ The flexibility of decision-making and problem solving processes (consultative mechanisms, bottom-up processes).
   - ☒ The existence of power structures and institutions that are responsive, effective and consider the needs and risks of all stakeholders in fisheries and aquaculture and beyond (e.g. water, river basin authorities), including policies and legislation.
   - ☒ The existence of alternatives and access to support services (such as social protection, safety nets systems, alternative livelihoods, access to markets, public services).

f no formal information on these issues is available, opinions and perceptions would be useful. This, however, needs to be noted as an information gap.

Anticipated outcomes of Step B1:

- ❑ A 'baseline' of available knowledge and gaps on the challenges and opportunities that fisheries and aquaculture systems are facing with regards to climate change: What are the changes? Why are they important? What do we know of each system's ability to adapt?
- ❑ A highlighting of the particular importance of fisheries and aquaculture for food security, economic growth and livelihoods as well as factors that make the sector and communities who depend on it more sensitive and vulnerable to climate change (i.e. elements of the vulnerability context).
- ❑ A list of the known consequences of climate change on fisheries and aquaculture, and a justification of the specific needs for the sector to be included in the process to formulate and implement the NAP.
- ❑ A preliminary identification of possible adaptation options at this point (Box 4).

BOX 4.

Examples of initial scoping assessments

Examples of initial national/regional scoping fisheries and aquaculture vulnerability assessments and adaptation identification exercises include:

Africa
FAO. 2016f. Case studies on climate change and African coastal fisheries: a vulnerability analysis and recommendations for adaptation options.

Benguela Large Marine Ecosystem
De Young *et al.* 2012. Climate change implications for fisheries of the Benguela Current region – Making the best of change.

The Caribbean
McConney *et al.* 2015. Disaster risk management and climate change adaptation in the CARICOM and wider Caribbean region – Formulating a strategy, action plan and programme for fisheries and aquaculture.

Latin America:
Soto, D. & Quiñones, R. 2013. Priority adaptations to climate change for Pacific fisheries and aquaculture: reducing risks and capitalising on opportunities.

Lake Chad Basin
De Young *et al.* 2012. Climate change implications for fishing communities in the Lake Chad Basin.

Pacific Small Island Developing States (SIDS)
Johnson *et al.* 2013. Priority adaptations to climate change for Pacific fisheries and aquaculture: reducing risks and capitalising on opportunities.

Step B2. Analysing future impacts of climate change on fisheries and aquaculture

Guiding question for Step B2:
What will the impacts of climate change on fisheries and aquaculture be and how will social groups (communities, households, industries, etc.) be impacted?

Step B2 builds on the preliminary analysis and synthesis of current knowledge obtained under B1. It intends to look into future scenarios such as NAP for medium- to long-term adaptation planning and needs to account for forthcoming impacts of climate change.

Methodologically, it involves a top-down quantitative analysis of climate change impacts. Conceptually, this step is associated with the risk-hazard construct of vulnerability, which provides a perspective on the manner in which vulnerability in fisheries and aquaculture is an outcome of climate change. It further investigates the degree of exposure and sensitivity of fisheries and aquaculture systems to future climate change drivers (pre-identified in Step B1). As such, it enables to answer – within the confines of available information – the following questions:

- What will the main climate hazards on specific aquatic systems be?
- What will their impacts be on the fisheries and aquaculture activities these aquatic systems support?
- When and where will these impacts occur (within confidence ranges)?
- Who will be affected and how severely?

Downscaling and scenario-based approaches (e.g. projections) tend to be used for this purpose. The IPCC's different scenarios of future climate change are typically used as a basis for the analysis and complemented by risk assessments of climate change impacts specific to sub-sectors such as, for example, coastal tourism (e.g. Moreno and Becken, 2009). When data is fed into a GIS system, results can be conveyed through maps depicting vulnerability levels across geographic and time scales (e.g. Metzger and Schröter, 2006).

Indicator-based and modelling-based assessment methodologies could also be helpful here (Brugere and De Young, 2015). For example, indicators can link some of the biophysical and economic attributes of systems to vulnerability outcomes via a quantitative function (e.g. a variation in yield, resource quality, land value and/or economic returns). Typically, quantitative indicators tend to be chosen as proxies for the exposure, sensitivity and adaptive capacity components of the IPCC vulnerability model and are then compiled into a relative measure of vulnerability. Modelling methodologies have traditionally focused on biophysical systems, following a reductionist and dose-response logic to forecast or simulate the impacts of one or a mix of climate variables on a particular system. Economic simulations are now increasingly integrated in biophysical/bio-climatic modelling outcomes. An example of such an application is available in relation to the evaluation of the economic losses resulting from the impacts of climate change on Western African fisheries (Lam *et al.*, 2012).

The results of this analysis pave the way for step B3 (contextual vulnerability) – although B3 could be initiated before the results of B2 are available.

Anticipated outcomes of Step B2:

- ❑ A list of drivers of climate change and threats to particular fisheries and aquaculture systems.
- ❑ Insights into the anticipated severity of each of these drivers' impacts on the identified fisheries and aquaculture systems.
- ❑ A probability range of impacts occurring over space and time on different systems and the people they support.

Step B3. Assessing the contextual vulnerability to climate change of fisheries and aquaculture systems and the people they support at appropriate levels

Guiding question for Step B3

What causes people to be vulnerable to the impacts of climate change in fisheries and aquaculture systems, and why?

This step is about understanding how human systems are connected to the impact of climate change drivers on fisheries and aquaculture. Addressing this question will support the understanding of the context, reasons and root causes of what makes individuals (fishers, processors, traders, fish farmers, households) or social groups (youth, women farmers, urban/rural farmers and traders, communities, particular industries within the sector) vulnerable to the prevailing climate change drivers identified previously. By breaking this task down into the three following subtasks the enquiry remains focused and assists in progressing through Element B.

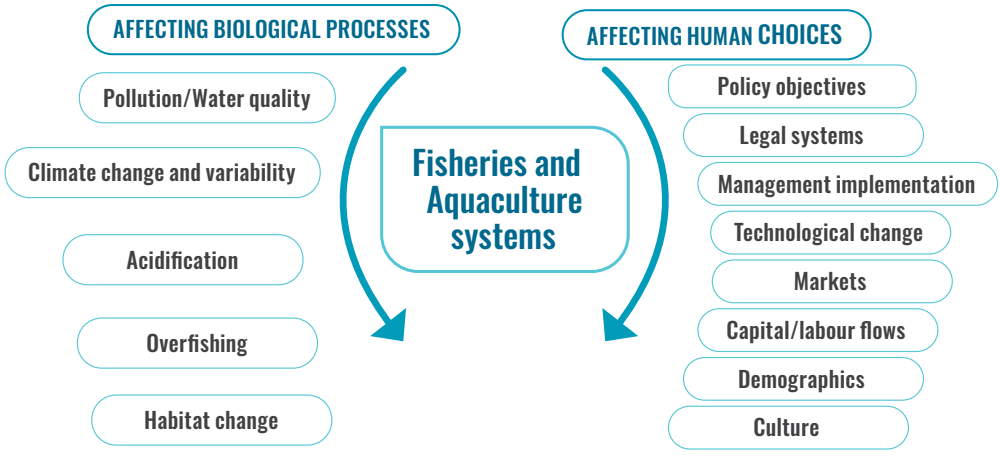
Characterising contextual vulnerability involves focusing on people's capacity, sensitivity and exposure to the drivers now and in the future. The following questions can be asked:

- How will climate drivers interact with other drivers (e.g. overfishing, poverty, inequalities, habit destruction)?
- How are individuals affected differently by climate change now and in the future?
- What is the capacity of different groups and institutions to respond to climate change now and in the future?
- What explains the different capacities to cope and adapt?
- What are the causes and consequences of different levels of susceptibility?
- What should be done to increase capacity in order to evolve and adapt to new or emerging climate impacts?

It is also paramount that gender dynamics be fully considered in these questions. Box 5 lists additional questions that must be asked to ensure that the perspectives and needs of both men and women are equally accounted for. Methodological approaches to address these questions are qualitative and participatory as well as bottom-up in nature (Brugere and De Young, 2015). Tools to collect data and information on contextual vulnerability include participatory rural appraisal (PRA) and rapid rural appraisals (RRA) with target groups, social mapping, expert judgement, key informant interviews and the Delphi technique. Analysed from a livelihood, institutional and/or gender perspective (Box 5), this information will broaden the study of vulnerability to encompass dimensions such as assets, access, capability, power and other constraints/ opportunities that underpin individuals' adaptive capacity to climate change.

FIGURE 5.

Multiple drivers of change



BOX 5.

Taking a gendered lens to climate change vulnerability assessment and adaptation planning

Climate change impacts and adaptation responses in the agriculture sectors impact different people in different ways depending on their cultural, economic, environmental and social contexts. The UNFCCC NAP Guidelines recognise the importance of a gender-responsive plan, noting the value of equal participation of men and women in decision-making, the need to avoid exacerbating gender inequalities and the likelihood that addressing gender leads to better adaptation and more resilient communities. The definition of a 'gender-responsive NAP' is clarified by three criteria as a programme that: (i) recognises the gender differences in adaptation needs, opportunities and capacities; (ii) ensures the equitable participation and influence of women and men in adaptation decision-making processes; and (iii) ensures gender equitable access to financial resources and other benefits resulting from adaptation (FAO and UNDP, 2018c.).

Nelson (2012) provides guiding questions to help researchers and practitioners understand the gender-differentiated impacts, vulnerabilities and adaptations in agriculture and food security for rural development, including:

- What role do men and women play with regards to food security of their family members?
- Who in the household is vulnerable and how? How is this vulnerability differentiated according to gender, age and other social indicators?
- What do men and women perceive is at risk due to changes in climate?
- What do men and women currently do to deal with the risks?
- What are men's and women's resources for coping with climate change?
- Who decides what adaptation strategy to implement? Who takes action and implements the strategy and is he/she involved in the decision-making?
- What are the implications of a given adaptation strategy on men's and women's use of time and labour and on their health?
- What information is needed to decide which strategy to implement? Is this information shared in the household?
- How might household and individual food security be affected by the adaptation strategy?

Although applied to a non-climate change context, Mills *et al.*'s 2011 study of vulnerability in Malian and Nigerian small-scale inland fishing communities illustrates the type of participatory methods that were used to identify key vulnerability factors affecting these fishers. Raemaekers and Sowman (2015) document their experience in applying a participatory rapid vulnerability assessment of small-scale fishing communities in the Benguela Current region.

Although the focus of contextual vulnerability is mostly on people, it is important to bear in mind that contextual vulnerability also applies to natural systems. For example, overfishing could be a contextual variable driving or increasing ecosystem vulnerability to a given climate driver.

Anticipated outcomes of Step B3:

- ❑ Understanding how and why climate drivers (identified in B2) affect different groups of people associated with fish production.
- ❑ Description of the capacity of these people to cope and adapt across different time (now / in the future) and organisational (individual / institutional) scales.

Step B4. Synthesis and ranking of fisheries and aquaculture climate change risks, impacts and vulnerabilities to determine adaptation goals

B4 is an intermediary step that allows combining and synthesizing the information that has been gathered and analysed, ranking climate change risks, impacts and causes of vulnerability, and determining adaptation goals accordingly.

The guiding question to answer here is:
Given what we now know of the causes of climate vulnerability among the people who depend on fisheries and aquaculture systems, what should our adaptation goals be?

Examples of such synthesising and combining include Chile (Government of Chile, 2014) and the Lower Mekong Basin (ICEM, 2013), where modelling efforts are combined with other information sources to provide an overall picture of vulnerability across the sectors and among fisheries and aquaculture production systems.

B4.1 Synthesising knowledge of fisheries and aquaculture climate change risks, impacts and causes of vulnerability

Steps B1, B2 and B3 have each provided various insights into the complex dimension of vulnerability. Combining and synthesising the findings from B1, B2 and B3 will help provide a holistic understanding of how and why climate change affects (and will continue to affect) fisheries and aquaculture systems and the people they support. Brugere (2015) illustrates the process of synthesising such information in the context of several regional capture fisheries. The identified and synthesised climate change risks, impacts and causes of vulnerability for specific, coupled fish production and human systems can then be taken a step further in order to be ranked.

In order to ensure that climate risks and impacts potentially affecting all segments of the fish production chain are considered in the synthesis it may be useful to adopt a value chain approach and disaggregate the contents of the synthesis accordingly. This would include input services to capture fisheries and aquaculture (nets, boats, fish seed and broodstock, fish feed, aquaculture equipment, etc.) as well as to post-harvest transformation.

This could be particularly useful to make sure that post-harvest activities, typically less visible in more generic analyses of the sector – despite the threat they face from climate change – receive the attention they deserve. They are also economically important and play a pivotal role in women's lives and empowerment (Box 6).

This synthesis may take into account geographic differences within a country, and/or aquatic systems and fish value chains depending on those prevailing or determined as most exposed and sensitive to climate change in Steps B1, B2 and B3.

BOX 6.

Women at centre stage of the fish processing technology

Given that as many as 90 percent of workers in processing activities can be female (FAO, 2014), including the postharvest sector in adaptation planning will help provide a gendered lens to adaptation planning in fisheries and aquaculture. Improvements in fish processing technologies can address increased efficiency and reduced losses in the face of increasing scarcity as well as gender inequalities by improving incomes. This can be done by increasing the value of the catch through improved product quality, an important contribution in a context of overfishing and climate change, where overall catches and stock health are likely to decline.

The Thiaroye fish smoking technology (also known as FTT-Thiaroye) improves economic productivity and food security by reducing postharvest losses in the fish value chain. Postharvest losses in quantity, quality, or marketability (Diei-Ouadi and Mgawe, 2011) lead to a reduction in real incomes and food available for a family. The FTT-Thiaroye was developed by FAO together with the National Training Centre for Fisheries and Aquaculture Technicians in Senegal (CNFTPA) in 2008. The technology addresses the deficiencies in smoking techniques by adding new components to the existing or improved kilns. The new smoking kiln reduces losses by consistently producing a larger quantity of safer products of superior and more uniform quality. Essentially, the FTT prevents fish quality losses that become apparent to value-chain actors at the commercialisation stage but that actually occur earlier, as a result of inadequate processing technologies in small-scale fisheries.

Another advantage of the FTT-Thiaroye system is its improved energy efficiency and other potential environmental protection features. The new kiln reduces charcoal consumption and optimises the use of biomass (plant and organic byproducts and cow dung) throughout the process. As agro-wastes are often easily available, they are not only an affordable alternative fuel, but because they are available within a reasonable distance, their use reduces the labour expended by women in obtaining wood or charcoal for fuel.

Source: World Bank, FAO and IFAD, 2015

B4.2 Ranking fisheries and aquaculture climate change risks, impacts and causes of vulnerability

Following on from B4.1, this sub-task will enable ranking climate change risks, impacts and causes of vulnerability identified and summarised for each segment of the concerned fish value chains, thus preparing the ground for the identification of where adaptation options are needed across different time and spatial scales (B5).

Common risk ranking criteria are indicated in Box 7. The ranking process should be broken down by aquatic system, fisheries and aquaculture activities and groups concerned, using information obtained from B1, B2 and B3, as well as information from Element A on institutional strengths and gaps. A consultative process should be adopted to carry out the ranking, ideally involving the different stakeholders involved in each fish production system and value chain, and ensuring equal gender representation (e.g. fishers/farmers, processors and/or input suppliers,

local authorities, environmental protection and water management authorities and non-governmental organisations (NGOs) as well as higher levels of government). Time scales should also be factored in the ranking of the risks.

This could be summarised and presented in a tabular format (Table 4), where each risk is ranked according to the criteria in Box 7 and evaluated across different time scales and in terms of 'most/less likely', 'more/less urgent', or 'higher/lower', thus enabling to narrow down areas, systems or groups where adaptation actions should be initiated now or later.

Whilst it may be difficult to resolve the steps outlined in Box 7 and fill all the cells of Table 4 because uncertainty is so high, one should remember that adaptation is adapting to 'possibles', rather than 'probables'. Thus, gaps or blanks in criteria in Box 7 and Table 4 should not unduly hold back moving ahead with adaptation actions.

Another approach, inspired by the 2012 Least Developed Countries Expert Group (LEG), could be to use stakeholder inputs to create a ranking matrix using scores (e.g. 1=low, to 3=high) for each criterion. A simple calculation of average and standard deviation for each criterion could provide a preliminary ranking, which, through several rounds of concertation and consensus building with the stakeholders could be further refined, agreed upon and finalised.

BOX 7.

Suggested criteria for ranking climate risks according to their impacts on fisheries and aquaculture and causes of vulnerability

Each criterion needs to be applied to specific aquatic systems, fisheries and aquaculture activities and the men and women they support that will have been identified in earlier steps.

A time scale should also be given to each criterion (now, and in x years' time).

- order of magnitude of each identified climate impact;
- probability, likelihood and level of confidence that current climate drivers will result in impact;
- timing of impact;
- persistence and reversibility of each impact;
- distributional consequences of each impact;
- importance (biophysical/ecological and social-economic) and sensitivity of the at-risk system;
- thresholds or triggers that could exacerbate the impact;
- assets (biophysical/ecological, social-economic and institutional) that could be built upon; and
- weaknesses (biophysical/ecological, social-economic and institutional) that will undermine coping with these impacts and potential evolution (adaptation).

Source: Developed from UNFCCC, 2012

TABLE 4.

Example risk criteria

IDENTIFIED IMPACTS TO FISHERIES AND AQUACULTURE SYSTEMS IN COUNTRY X					
Ranking criteria	**Sea level rise (or acidification) on aquaculture development**	**Temperature extremes on post-harvest processes**	**Increasing safety at sea risks during storms**	**Changes in water flows impacting species' productive cycles**	**Decreasing availability of fish for local consumption**
Order of magnitude of impact					
Probability, likelihood and level of confidence of impact					
Timing of these impacts					
Persistence and reversibility of impact					
Distributional consequences of impact					
Importance (biophysical/ ecological and socioeconomic) and sensitivity of the at-risk system					
Thresholds or triggers that could exacerbate the impact					
Assets (both biophysical/ ecological, social/economic and institutional) that could be built upon					
Weaknesses (both biophysical/ecological, social/economic and institutional) that will undermine coping with these impacts and potential evolution (adaptation)					
Average risk score					

B4.3 Determining fisheries and aquaculture adaptation goals

The ranking of risks then determines the adaptation goals towards which to work. The ranking process and decision over the goals of adaptation should be consultative and if possible participatory, involving stakeholders from fishing and farming communities (male and female producers), policy makers, researchers and NGOs in order to equitably reflect the range of concerns in the ranking. For example, trends in the decline of fish stocks offshore may be an over-riding concern for fish biologists while small-scale fishers' primary concern may have more to do with variations in catches as a result of increased seasonal variations. For example, whether adaptation measures should aim at conserving stocks in the face of climate change, or fishers' incomes – for example – should be decided consultatively.

As in the previous subtasks, full attention should be given to all segments of the fish value chain in determining adaptation goals, particularly the post-harvest sector because of the gender implications this can have on women's potential benefits from adaptation activities.

The adaptation goals chosen by Peru and Chile for their fisheries and aquaculture sectors are provided as examples in Box 8.

BOX 8.

Examples of fisheries and aquaculture climate change adaptation goals

These goals have been organised according to the three principal areas that can be targeted for successful climate change adaptation in the fisheries and aquaculture sector: institutions [I], livelihoods [L], and risk reduction and management for resilience [RRR] (Poulain ***et al.***, 2018; see Tables 6.1 and 6.2 in Element C).

Peru

Adaptation goal: reduce vulnerability of the fisheries and aquaculture sector to climate change.

Proposed adaptation objectives:

- Strengthen responsible fisheries contributing to the sustainable use of hydro-biological resources [I, RRR].
- Strengthen aquaculture activities to contribute to food security [L].
- Diversify and increase fisheries activities' value added [L].
- Improve climate change scenario modelling and prediction for the Peruvian seas [RRR].
- Strengthen the management of climate-driven ecological risks in the Peruvian seas [RRR].

Translated from www.produce.gob.pe/documentos/pesca/dgsp/publicaciones/diagostico-pesquero/Tomo-5.pdf

Chile

Main adaptation objective: strengthen the adaptation capacity of the fisheries and aquaculture sector to climate change challenges and opportunities, taking into account a precautionary and ecosystemic approach.

Specific adaptation objectives:

- Promote the implementation of the precautionary and ecosystemic approach to fisheries and aquaculture as a way of improving the resilience of marine ecosystems and coastal communities that use hydro-biological resources and depend on the sector in general [I].
- Develop research capacities necessary for improving knowledge of climate change scenarios and impacts on the conditions and delivery of ecosystem services that support fisheries and aquaculture activities [I].
- Disseminate information on climate change impacts in view of educating and building capacity on the topic of fisheries and aquaculture stakeholders [I, RRR].
- Improve the legal, political and administrative framework to address effectively and efficiently climate change challenges and opportunities [I].
- Develop direct measures of adaptation aimed at reducing the vulnerability and impact of climate change on fisheries and aquaculture activities [L].

Translated from http://portal.mma.gob.cl/wp-content/uploads/2016/12/Plan-Pesca-y-Acuicultura-CMS.pdf

Anticipated outcome of step B4:

- ❑ A list of agreed-upon and prioritised adaptation goals for each segment of concerned fish value chains and/or systems, according to the climate change risks, impacts and vulnerability experienced by the men and women they support.

Step B5. Identifying, reviewing and appraising fisheries and aquaculture adaptation options

This step enables the completion of the technical assessment of vulnerability in fisheries and aquaculture by considering adaptation options for aquatic systems, activities and people and their capacity to implement them. It is in the logical continuation of steps B1, B2 and B3 and the ranking of risks, impacts and vulnerabilities and identification of adaption goals to which they will have led (B4).

The guiding question to answer here is:
Given the adaptation goals identified, which adaptation options will be most appropriate for fisheries and aquaculture systems/value chains and for the men and women they support in specific contexts, areas and for specific groups? Which options will need to be taken forward in the fisheries and aquaculture climate change adaptation plan and cross-sectoral NAP?

Answering this question involves firstly identifying which adaptation options are appropriate and feasible (sub-step B5.1), and secondly, prioritising them (sub-step B5.2).

Conceptually, and owing to the limitations of evaluating with exactitude the costs and benefits of adaptation actions in the longer run, adaptation may be better viewed as "a sequence of decisions taken with progressively increasing information" (Colgan, 2016: 10), which should be iterative and flexible. This is important to keep in mind when considering possible adaptation options. Close M&E of the implementation of adaptation actions in the sector will enable to adjust them as and when required according to evolving external and internal circumstances. This is dealt with in greater detail under Element D.

Involvement of stakeholders in this step is an absolute pre-requisite. They should represent the range of male and female actors directly and indirectly affected by climate change, such as fishers, fish farmers, processors, gear suppliers but also those who can support adaptation, such as government authorities at various levels of administration, NGOs and financial and research institutions. Ideally, the same people should participate in all the steps outlined hereafter to ensure that the chosen adaptation options match needs and that their implementation receives necessary and long-lasting buy-in. This process should be professionally facilitated. If carried out thoroughly, it is likely to be relatively time-consuming, especially if it aims to elicit, tailor and target adaptation options according to climate-affected production/human systems, geographical areas or the level at which an intervention is targeted (e.g. community, local authority, national level). Stakeholder identification should already be known from the previous steps. It will be important to ensure that those most vulnerable to climate change impacts are adequately represented.

B5.1 Identification of fisheries and aquaculture adaptation options

This step takes the findings of B1 further and helps identify, according to the ranking of risks, impacts and vulnerabilities obtained under B4, the most appropriate adaptation options for the sector in specific contexts and areas for their integration into the fisheries and aquaculture climate change adaptation planning and cross-sectoral NAP (Element C).

Adaptation actions can be categorised in groups or layers which are not mutually exclusive: according to their focus (e.g. ecosystem, sector), origin (planned or spontaneous), scale (e.g. national, community), timing (short-term, long-term), climate driver (e.g. sea level rise),), or level of risk (e.g. 'no regrets'). It is important here to recognise that all adaptation actions must be complementary and synergetic in order to yield benefits in the short- and long-term. Maladaptation can sometimes result from the – often involuntary – choice of incoherent or conflicting adaptation actions. How to avoid this is dealt with in greater detail further on (pp. 40-42).

Climate impact adaptation options for the fisheries and aquaculture production systems are part of the broader building of resilience that underpins reducing the existing vulnerability context that climate change magnifies, including (derived from FAO, 2016e):

- Adopting and adhering to good practices and principles such as those requested by the FAO Code of Conduct for Responsible Fisheries, the SSF Guidelines and EAF/EAA, (see, for example, FAO, 2003; FAO, 2009; FAO, 2010; FAO 2015), which imply a holistic, integrated and participatory way of managing fisheries and aquaculture systems, from precautionary and adaptive management frameworks to low-impact and efficient production systems, in order to improve human and ecological well-being.
- Increasing resilience of households and livelihoods through poverty reduction and social protection strategies, addressing human rights-based and gender-equitable development (Box 9).
- Implementing disaster risk reduction for fisheries, aquaculture, food and security and nutrition.
- Managing aquatic genetic resources.
- Investing in resilient fisheries and aquaculture development and investment, investment (IFAD, 2014), including diversified livelihoods.
- Investing in systems to assess risks, vulnerabilities and adaptation options.
- Ensuring enabling policies and institutions, such as
  - **a.** incorporating uncertainty into fisheries and aquaculture management;
  - **b.** designing flexible seasons responding to climatic conditions;
  - **c.** permitting flexible redistribution of fishing rights;
  - **d.** allowing for flexible temporal and spatial planning;
  - **e.** applying adaptive transboundary stock and natural resource management; and
  - **f.** implementing flexible co-management frameworks.

See Annex 2 for more examples on policy and institutional strategies to building flexible and adaptable institutions, to diversifying and creating flexible livelihoods and supporting risk reduction initiatives within fisheries and aquaculture.

Climate-resilient fisheries and aquaculture

The climate-smart approach to fisheries and aquaculture

The climate-smart approach to agriculture and allied sectors, including fisheries and aquaculture, is about making food production systems and their dependent communities more efficient and more resilient in the face of climate changes (FAO, 2013b). It requires taking into account a number of enabling and disabling technological, social, economic, institutional and environmental parameters occurring both within and outside the sector.

Climate-smart fisheries and aquaculture adaptation options can support the objectives of: (i) sustainably increasing output productivity/efficiency; (ii) reducing the vulnerability and increasing resilience of the fish production system(s) concerned and the people it supports; and (iii) reducing and removing greenhouse gas emissions from the sector. Objectives (i) and (ii) are intimately linked and are most relevant to adaptation and the process to formulate and implement NAP but even objective (iii), focusing on GHG mitigation, can co-benefit from adaptation actions and lead to increased resilience (e.g. through an ecosystem-based adaptation as described below).

BOX 9.

Applying a poverty lens to climate change adaptation in fisheries and aquaculture

To assist countries in applying a poverty lens to their climate change adaptation planning, the report, "Impacts of climate change on fisheries and aquaculture – Synthesis of current knowledge, adaptation and mitigation options" provides the following guidance:

- Climate change affects communities and livelihoods in fisheries and aquaculture, and efforts to adapt to and mitigate climate change must therefore be **human-centred**.
- Climate adaptation strategies must **emphasise the need for poverty eradication and food security**, in accordance with the Paris Agreement, the United Nations 2030 Agenda for Sustainable Development and other international instruments, such as the Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication.
- **Measures to eradicate poverty and provide food security** for people in fishing and aquaculture communities are also instrumental for climate change adaptation, and should be **integrated in the formulation and implementation** of national adaptation plans.
- Climate change adaptation for building resilience **must be multi-dimensional and multi-sectoral** to help people out of poverty and to prevent them from descending further into it.
- **Capacity at national, regional and local levels** of governance should be mobilized to facilitate adaptation to climate change for the poor and vulnerable.
- To address climate change vulnerability, management systems must **create opportunities for fishers, fish farmers and fish-workers** to remain flexible and to be able to sustainably use diverse livelihood opportunities.
- Climate change adaptation should **empower local stakeholders** to allow for meaningful participation of the poor and vulnerable, and safeguard their human rights.
- Climate change adaptation measures **must address issues of power imbalances and inequity disadvantaging the poor**, as they relate to, for example, gender, labour conditions, tenure rights, market access, migration patterns and stakeholder conflicts.
- The **impact of climate change and adaptation measures** for the poor and vulnerable **must be monitored** at different scales and dimensions, focusing both on achievements, best practices and on possible maladaptation.
- There is a need for the countries to **put a stronger emphasis on poverty and food security** in the context of fisheries and aquaculture within their NDCs.

Source: Kalikoski et al.*, 2018*

A climate-smart aquaculture development initiative is illustrated in Box 10.

BOX 10.

An example of climate-smart aquaculture: promoting mono-sex tilapia as a way of adapting to climate change in Viet Nam

Brackish water shrimp farming plays an important role in the socio-economic development of most coastal communities on the North Central Coast of Viet Nam. Farmers usually grow tiger shrimp, mud crabs, and seaweed in brackish water shrimp ponds near the coast. However, changes in temperatures and rainfall patterns and increases in extreme weather events are negatively impacting their operations, livelihoods and communities. Although shrimp give higher profits to farmers, growing shrimp during months when salinity drops below 5 parts per thousand (ppt) exposes farmers to high risks of crop failure, as shrimp do not grow well in these conditions and become more vulnerable to diseases. In addition, higher temperatures stimulate the growth of algae, which hinders the development of the cultured seaweed, fish, shrimp and crabs. From the observation that local tilapia could clean their ponds of algae, farmers started introducing the fish into their shrimp ponds. However, the local tilapia strain is small in size and was, therefore, only used by farmers for environmental and not economic purposes.

In response to these challenges, and within the action plan framework for adaptation and mitigation for climate change in the Ministry of Agriculture and Rural Development and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), a climate-smart aquaculture initiative – the ECO-SAMP project "Enhancing community resilience to climate change by promoting smart aquaculture management practices along the coastal areas of North Central Vietnam" – was launched in Hoang Phong commune, Thanh Hoa province in 2015 by WorldFish, the Vietnam Institute of Economics and Planning (VIFEP) and Thanh Hoa Agriculture Extension Center (TEC). Under this initiative, farmers replaced the local tilapia strain they were using with mono-sex tilapia in their ponds. Mono-sex tilapia can thrive in saline water (up to 15 ppt), whilst maintaining their algae cleaning function and feeding on waste from the shrimp. Farmers were then able to reduce the amount of feed given to the fish, and even save on labour for the regular clearing of algae. This approach to adaptation enabled building livelihoods while reducing risk and managing resilience. The initial evaluation of this climate-smart aquaculture trial suggests a triple win for local aquaculture farmers through: (i) sustainably improving aquaculture productivity and farming efficiency of the current production system; (ii) increasing adaptive capacity and resilience of coastal aquaculture to climate change; and (iii) contributing to climate change mitigation. Some constraints related to the wider adoption of the practice, e.g. lack of good quality tilapia seed and feed, low incentive to invest in the practice due to the uncertain market potential of tilapia and uncertainty of extreme climate events, would need to be alleviated prior to launching this practice across the region.

Ecosystem-based adaptation in fisheries and aquaculture

Because of the strong links of fisheries and aquaculture with ecosystems, considering ecosystem-based adaptation (EbA) can be another useful entry point to finding solutions to combat climate change effects and support the adaptation and building of resilience of the sector to climate change. It is also well aligned with the Code of Conduct for Responsible Fisheries (FAO, 1995) and the principles of the EAF/EAA.

EbA has been defined as an overall strategy that integrates the use of biodiversity and ecosystem services to help people adapt to the adverse impacts of climate change (CBD, 2009). It includes the sustainable management, conservation and restoration of ecosystems to provide services that help mitigate the negative effects of climate change and help people adapt to both current climate variability and climate change (IUCN, 2009). It focuses in particular on "adaptation activities that rely on goods and services provided by ecosystems, such as food and water production, and cultural services such as recreation. It also includes considerations of ecosystem integrity after the implementation of adaptation measures" (LEG, 2012). The approach has been shown to work effectively either alone or alongside other adaptation measures including building of hard infrastructures such as sea defenses (Colls *et al*., 2009).

In the context of fisheries and aquaculture, EbA implies the promotion of measures that reinforce the management, restoration and/or conservation of aquatic ecosystems and the maintenance of the ecosystem services they provide. This is founded on the principle that the health of these ecosystems strengthens their provisioning (food fish and aquatic commodities), regulating (buffers), supporting (aquatic biodiversity) and cultural (spiritual sanctuaries) services, and that these are essential to cope with the adverse effects of climate change. Examples of fisheries and aquaculture EbA include:

- *In the case of capture coastal fisheries*, EbA will typically involve the rehabilitation of aquatic habitats, such as mangroves and coral reefs, or the establishment of spatially and temporally flexible refugia for aquatic species (Box 11).
- *In the case of brackish* aquaculture (shrimp farming), EbA will typically involve mangrove restoration and integration in shrimp ponds (Box 12).
- *In the case of inland capture fisheries*, EBA will typically involve landscape management and river rehabilitation/restoration with the aim to restore ecosystem services, including flood prevention. This type of approach is gaining importance, notably in the USA (G. Marmulla, personal communication, 2017).

Examples provided in Boxes 11 and 12 recognise and strengthen the role of the concerned ecosystems in supporting fish production and buffering against the adverse impacts of climate change. In all cases, the objective of interventions is also to increase the resilience of the social-ecological systems to other non-climate drivers of change.

BOX 11.

Example of ecosystem-based adaptation to climate change in the Seychelles (coral restoration)

In 1998, the mass coral bleaching event, caused by the coupling of El Niño and the Indian Ocean Dipole, severely affected the reefs of the Seychelles Archipelago. The 1998 bleaching catastrophe decreased live coral cover by up to 97 percent in some areas and caused many reefs around the islands to collapse into rubble, which later became covered with algae. In the following decades, coral recovery has been extremely slow in the inner granitic islands of Seychelles.

To support recovery, the Reef Rescuer climate adaptation coral restoration project seeks to repair coral bleaching damage in selected sites around

Praslin and Cousin Island Special Reserve, a no-take marine reserve. Through this project, the first-ever large-scale active reef restoration project in the region is being piloted using coral gardening, a technique that involves collecting small pieces of healthy coral, raising them in underwater nurseries and transplanting them to degraded sites that have been affected by coral bleaching.

The long-term outcome of this mass transplantation is still being monitored but the project has already had positive results in terms of building the resilience of the ecosystem. Before-and-after comparisons in coral cover at the transplanted site showed that the restoration project resulted in an increase in coral cover from about 2 percent in 2012 to 16 percent by the end of 2014. Similarly, a five-fold increase in fish species richness, a three-fold increase in fish density and a two-fold increase in coral settlement and recruitment at the transplanted site has been documented. Researchers found that the coral transplants responded better to stressful conditions resulting from increased sea temperatures and a harmful algal bloom. The transplanted corals appear to recover faster and better than corals at other sites. The response of the transplanted reef to thermal stress bleaching is still being monitored. The preliminary analysis of the costs of reef restoration via coral gardening and the life cycle of coral reef restoration technology together with the ecological results so far support the application of large-scale, science-based coral reef restoration projects with long timescales to assist the recovery of damaged reefs. A proposal to scale up the coral farms to a mariculture venture so as to reduce costs through economies of scale has been accepted by the Seychelles government and funding is currently being sought.

Source: www.reefresilience.org/case-studies/seychelles-coral-restoration

BOX 12.

Example of ecosystem-based adaptation in Viet Nam aquaculture

Viet Nam has lost half of its mangroves over the past thirty years, primarily as a result of the expansion of rice production areas and more recently clearing for shrimp ponds. The profitability of shrimp exports in recent years has encouraged thousands of farmers in the deltas of Ca Mau province in Viet Nam to convert from rice farming to intensive shrimp aquaculture, the fastest-growing food source globally. Due to rapid expansion and insufficient environmental standards, the deltas of Ca Mau are now pockmarked with failed shrimp ponds, abandoned because of high costs and decreasing returns due to erosion, pollution and shrimp disease. The development of shrimp aquaculture in Viet Nam at the expense of the mangrove environment has serious consequences, as mangroves protect against tidal waves and storm surges; they are vital fish nursery-grounds; provide timber, honey, and other products; and raise land levels by trapping sediment. They also have high carbon content and the total carbon storage is very high relative to most forest types. Healthy mangroves thus make important contributions to both climate change adaptation and mitigation. The Mangroves and Markets (MAM) project aimed to reverse mangrove loss, reduce GHG emissions and promote mangrove restoration while supporting community resilience under climate change.

BOX 12 (CONTINUED)

The MAM project uses a shrimp farming model that integrates the farms into the mangrove ecosystems to reduce pollution and disease. These extensive, low-input shrimp farms require at least 50 percent mangrove cover and have much lower management costs than intensive farms. They are more sustainable for the small-scale shrimp farmers who make up the majority of shrimp producers. As traditional shrimp farms do not have the high yields of intensive aquaculture, access to stable and profitable markets is important for their long-term sustainability. Organic certification offers access to better export markets, providing shrimp farmers with a price premium and strengthening small-scale shrimp aquaculture. MAM selected global standard Naturland as the most suitable organic certification that requires mangrove conservation. With organic shrimp certification in place, MAM guided farmers in negotiating a favorable purchase agreement with Minh Phu, the world's second-largest seafood processor by shrimp export value. The farmers can sell their certified shrimp to Minh Phu Seafood Corporation with an additional income of VND3 000/kg. Furthermore, the project successfully supported Ca Mau in the establishment of the provincial decision on piloting a Payment for Ecosystem Services (PES) system. This system provides an incentive for mangrove conservation and restauration by paying farmers and additional VND500 000/ha of mangrove for ecosystem services.

Source: http://snv.org/projet/mangroves-and-markets

EbA is important in conservation, and the fisheries and aquaculture sector needs to be aware of it. One of the advantages of EbA is that in most cases, adaptation outside the sector is likely to benefit adaptation processes in fisheries and aquaculture. Steps to determine which EbA options would be most suitable for specific fisheries and aquaculture systems are suggested in Annex 2.

Avoiding maladaptation in fisheries and aquaculture

Not all climate adaptation measures are positive, because adaptation activities in fisheries and aquaculture or in other sectors can have unintended consequences on the resilience of fisheries and aquaculture or of other sectors (Shelton, 2014). It is particularly important to bear this in mind throughout the identification and review process, as well as when prioritising options (Step B5.2).

Maladaptation refers to "actions, or inactions that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in future" (Field *et al.*, 2014). When trade-offs start to arise, some social groups, sectors or ecosystems are left worse off either in the short- or long-term (UNFCCC, 2011a). In simpler terms, maladaptation activities are the wrong response to an event triggered directly or indirectly by climate change. (such as a reduction in catches or decline in fish production) These maladaptation practices are often adopted as a coping (i.e. short-term) mechanism, but can persist over time. For example, an adaptation measure that provides short-term benefits to fishers (e.g. a subsidy allowing the purchase of a deep-sea fishing vessel), but bears a long-term cost on the environment and/or livelihoods (e.g. contribution to the overexploitation of a specific species, and locking fishers in a particular type of fishery or unsustainable fishing practice) is effectively 'maladaptation' (Poulain *et al.*, 2018). Within fisheries and aquaculture, maladaptation often stems from a conflict or trade-off between autonomous adaptation by fishers, fish farmers or fish processors, and policy measures meant to support their adaptation.

Autonomous adaptation involves "actions by farmers, communities and others in response to the threats of climate change perceived by them, based on a set of available technology and management options. Autonomous adaptation is implemented by individuals only if considered cost-effective by those implementing it, i.e. when adaptation is in their own interest" (World Bank, 2010a: 13). In capture fisheries, fishers can select different fishing gear and target species, shift fishing grounds or migrate to other areas, scrutinise weather and sea forecasts, and diversify income streams, either within or outside fishing, provided the above are within their means and control capability. In aquaculture, fish farmers can, for example, decide to adopt new farming technologies, adjust management practices, improve infrastructure (e.g. stronger pond dikes), shift stocking dates, seek new farming sites or register for a training course.

Although the costs of autonomous adaptation have been shown to be lower in the context of aquaculture, positive returns from such measures are not guaranteed to farmers (Kam *et al.*, 2012). So, while it is important to acknowledge, inventory, promote and account these forms of adaption in the NAP, it is equally important to assess that they do not have long-term unintended consequences. All adaptation options must therefore be examined from the perspectives of all directly and indirectly affected stakeholders or social groups, upstream and downstream activities and ecosystems, as well as across several time and geographical scales.

Although maladaptation is of great concern, adaptation initiatives that account for many or all of the guiding principles listed in Box 13 will have a lower risk of maladaptation than initiatives that don't (Magnan, 2014).

BOX 13.

Principles to avoid maladaptation in fisheries and aquaculture

Avoid environmental maladaptation

1. Avoid degradation that causes negative effects in situ. An ideal initiative would have no collateral effect on assets' exposure to climate-related hazards, overexploitation of resources, habitat degradation or pollution of ecosystems.
2. Avoid displacing pressures onto other socio-ecological system environments. The aim of any adaptation is to reduce pressures on the environment, not to displace them.
3. Support the protective role of ecosystems against current and future climate-related hazards, so as to maintain natural buffer zones in the face of impacts of both sudden changes (storms, floods) and gradual changes (sea level rise).
4. Integrate uncertainties concerning climate change impacts and the reaction of ecosystems, so as to maintain enough flexibility to adjust activities in the event of unpredicted environmental changes and new scientific knowledge.

Avoid socio-cultural maladaptation

1. Start from local social characteristics and cultural values that could have an influence on risks and environmental dynamics.
2. Consider and develop local skills and knowledge pertinent to climate-related hazards and the environment.
3. Call on and develop new skills that the community is capable of acquiring.

Avoid economic maladaptation (i.e. creating poverty or investment irreversibility)

1. Promote the reduction of socio-economic inequalities and implement measures to reduce poverty and increase food security, as these measures can increase system resilience and sustainability of the extraction of natural resources.
2. Support the relative diversification of economic and/or subsistence activities.
3. Integrate any potential changes in economic and subsistence activities resulting from climate change, to avoid developing activities that require heavy investment (money, time and energy) but will quickly become obsolete in the face of climate change.

Source: Poulain et al., *2018.*

Choosing policy measures minimising the risk of maladaptation and in support of good adaptation is dealt with under Element C.

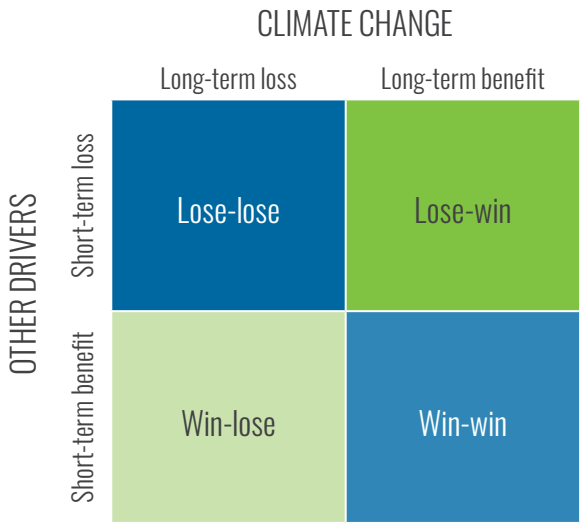
B5.2 Prioritisation of identified adaptation options

Aiming for no-regret, low-regret and win-win adaptation

'No-regret', 'low-regret', and 'win-win' adaptation options that provide both short- and long-term benefits are considered to be amongst the best options, and should be seen as a priority (Poulain *et al.* 2018). The framework presented in Figure 7 enables identifying the different categories of climate change adaptation options in the context of other drivers of change. 'Win-win' does not mean that there are no social and economic costs, but that it delivers immediate gains (a 'win' now) while insulating resources and communities from the effects of continued climate change impacts (a 'win' in the future) (Bell *et al.*, 2018). Inevitably, some adaptation options are likely to incur social and economic costs in the short-term before their benefits are felt in the long-term ('lose-win'). An example of this is investments linked to the climate-proofing of infrastructures (Poulain *et al.*, 2018).

FIGURE 6.

Possible outcomes of adaptation actions for addressing the effects of climate change in the long-term, in the context of other drivers of change, like population growth, in the short-term.



Source: Bell et al. *(2011b), adapted from Grafton (2010), cited in Poulain* et al. *(2018).*

Prioritisation process

The process of prioritising identified adaptation options can take several forms. The prioritisation process suggested here starts with a broad-brush evaluation of all pre-identified adaptation options. It then moves on to a pre-selection of the most appropriate adaptation options according to their suitability, impact, livelihood and ecosystem benefits, affordability and capacity to implement them. Thirdly, it concludes with a fine-grained analysis of each pre-selected option according to more specific criteria to determine which are to be chosen and retained for the fisheries and aquaculture climate change adaptation plan. These steps are outlined here and detailed in Annex 3 for further guidance.

Stakeholder consultation and inputs are essential in these three steps, as in any prioritisation exercise. The prioritisation process could be achieved during one or more workshop(s) with representatives of the aquatic ecosystem users and producers directly affected by climate change, local and/or national authorities depending on the scale of adaptation options and support stakeholders such as NGOs, academia and input providers. Regardless of the prioritisation approach chosen, stakeholders participating in these steps should be those who have been involved and consulted since the inception of the fisheries and aquaculture process to formulate and implement the NAP. If adaptation options considered have a strong local dimension, it will be necessary to bring the prioritisation process to that level, engaging with primary producers, traders and those directly and indirectly affected by climate change impacts at the foundation of particular fish value chains or aquatic systems.

Throughout the prioritisation process it is important to keep in mind the adaptation goals that have been chosen (B.4.2) and the extent to which potential adaptation options, whether taken individually or combined with others, contribute to achieving them, as well as their potential to decrease overall vulnerability of concerned ecological and human systems by reducing their exposure and sensitivity and increasing their adaptive capacity to climate change.

Sub-step 1: Broad-brush evaluation/scoping of all pre-identified possible adaptation options

SWOT (Strengths, Weaknesses, Opportunities, Threats), SCORE (Strengths, Challenges, Options, Responses, Effectiveness) and problem structuring methods are possible approaches (detailed in Annex 3) to achieve this. Which to choose, whether individually or in combination, is left to the users of this supplement.

Sub-step 2: Weighing and scoring the most appropriate adaptation options

The process of interpreting and weighing each option needs to be stakeholder driven and tied to the overriding aims of the adaptation that needs to be achieved in each individual aquatic system considered.

Two slightly different approaches in support of prioritisation and identification of the most promising adaptation options can be proposed to do this: one based on weighing importance criteria and scoring adaptation options against these, the other based on scoring only, as a follow-up to the SCORE approach outlined above. Both prioritisation approaches are detailed in Annex 3.

Sub-step 3: Fine-grained economic analysis and final decision of most appropriate options

The focus of this sub-step is on the economic, social and environmental feasibility, i.e. costs and benefits, of the adaptation options that have emerged as top candidates from the previous prioritizing steps for inclusion in the fisheries and aquaculture climate change adaptation plan.

There are several methods to evaluate the costs of adaptation options. Their choice will be guided by the goals of adaptation (B4.2) and number of possible adaptation options elicited earlier (B5.1 and B5.2), as well as available data. More information on which method to choose, their pros and cons, and how to implement them is available in Annex 3.

Organising and presenting information

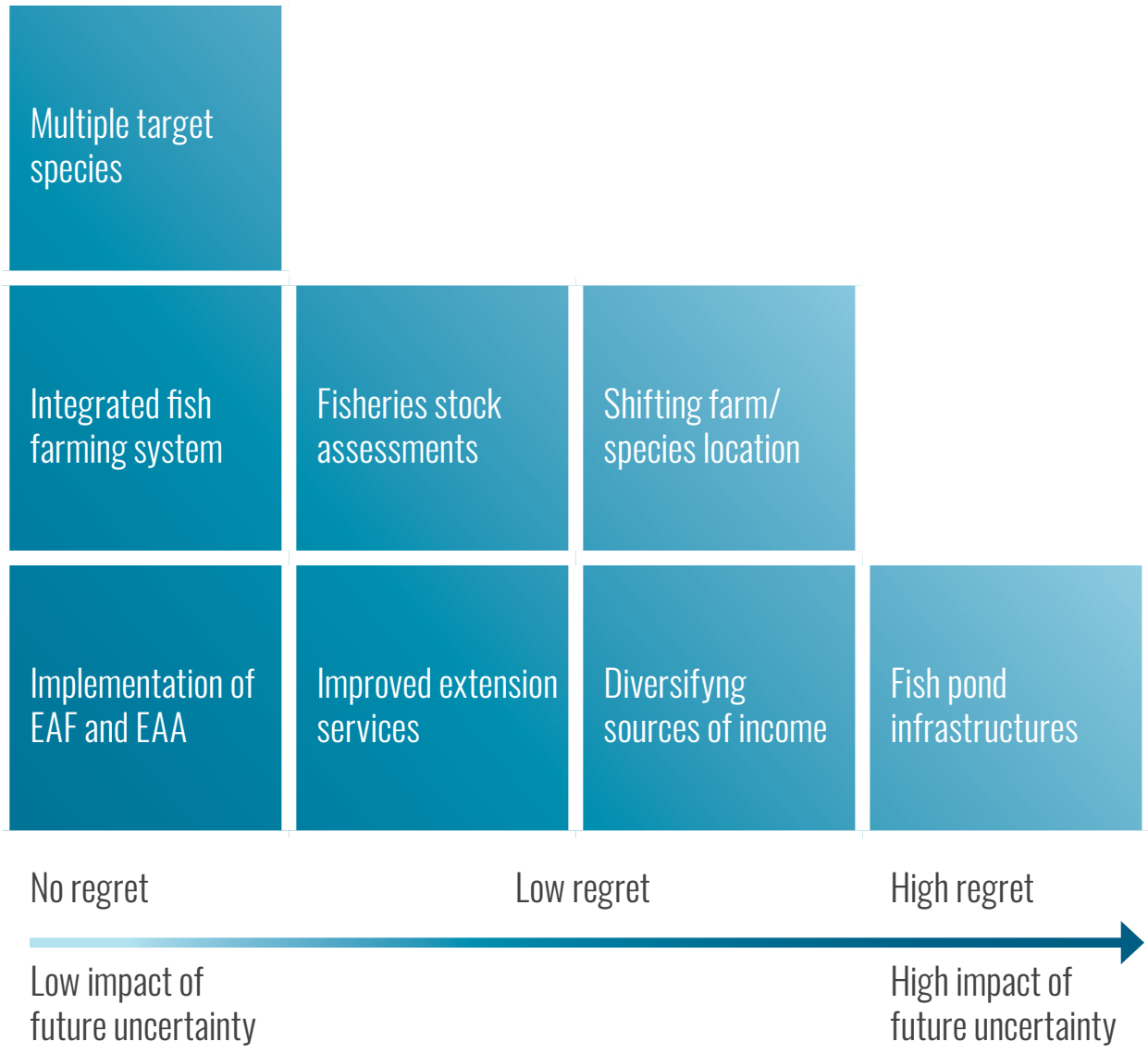
The results of the prioritisation process need to be presented in a way that is easily digestible and communicable. One way to do this is in tabular

format, allowing an overview of the ranking of options with other related information. Different formats of summary tables are proposed in Annex 3. Another way, closely aligned with the 'no-regret, low-regret and win-win' framework presented above, is based on the criteria used in the prioritisation process and brings out the trade-offs between different options. An example of what it could look like is presented in Figure 8, which uses a 'regret' scale that is closely linked to levels of uncertainty, which one must be aware of when making the final choice of options.

FIGURE 7.

Presenting adaptation options graphically using regret and uncertainty scales

Source: Adapted from World Bank, 2010.



Both no-regret and low-regret options can be win-win options when they enhance adaptive capacity (i.e., they reduce climate vulnerability and exploit positive opportunities), while also

contributing to the achievement of other social, environmental or economic outcomes. High-regret adaptation mainly involves decisions on large-scale planning (e.g. resettlement of a large population) and investments with high irreversibility (e.g. large infrastructure projects such as sea walls). Given the considerable consequences at stake in large-scale planning decisions, significant investment costs and the long-lasting nature of infrastructure, uncertainties in future climate projections must be carefully examined. The differentiation in no-regret, low-regret and high-regret adaptation is not universal, but depends on local circumstances and the time horizon. Being aware of the level of regret is important because different levels of regret have different implications in the realms of climate information, timing of investment, planning horizon, project design, project risk and economic evaluation (see World Bank 2010a: 9–11). It also means that uncertainty is factored into the ranking of adaptation options.

Anticipated outcome of step B5:

- A list of agreed-upon and prioritised adaptation options for each segment of concerned fish value chains and/or systems, according to the climate change risks, impacts they face and vulnerability experienced by the men and women they support.

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Element C: Implementation strategies

Planning (integration in policies and strategies) and implementation

This element focuses on the consolidation of the fisheries and aquaculture adaptation options and the mechanisms that need to be established for their implementation. It also focuses on how the adaptation actions chosen for fisheries and aquaculture in the earlier steps can be mainstreamed in the country's NAP implementation so that they achieve the agreed-upon adaptation goals for the sector. Adaptation specific to fisheries and aquaculture can be standalone. However, given their close interactions with other sectors, it is important that their implementation be considered an integral part of the implementation of the country's NAP.

Anticipated outputs and outcomes of Element C:

- ❑ An agreed-upon fisheries and aquaculture climate change adaptation document (plan, strategy or brief) outlining the rationale and chosen fisheries and aquaculture climate change adaptation actions (e.g. key climate drivers, pathways, vulnerabilities) and their supporting policy measures, to be used for disseminating information.
- ❑ A financing strategy for the fisheries and aquaculture climate change adaptation plan.
- ❑ The necessary skills and competencies available and ready for implementing and mainstreaming the adaptation plan for fisheries and aquaculture.
- ❑ A clear roadmap for the fisheries and aquaculture climate change adaptation plan to be incorporated into the country's general NAP and other climate change documents (e.g. INDC), including a schedule of engagement and interaction points between the cell/task force overseeing the fisheries and aquaculture climate change adaptation plan and the institutions involved in the elaboration of the general country NAP and other multi-sectoral adaptation plans.
- ❑ Leverage for the fisheries and aquaculture sector to become a full player and component of the general NAP, and reciprocally of climate change considerations to be fully integrated in national and sub-national planning processes regarding fisheries and aquaculture development.

	Steps	*Guiding question*
C1	*Differentiating the policy mechanisms in support of institutional adaptation, livelihood adaptation, and risk reduction and management for resilience*	Which policy measures can best support the implementation of the adaptation options prioritised under Element B?
C2	*Consolidation of fisheries and aquaculture adaptation options and supporting policy measures*	What form should the information gathered, analysed and prioritised on climate change adaptation so far take to be useful for adaptation planning?
C3	*Mobilisation of funds and human power for implementation*	What needs to be in place, in terms of funds and human power, to support the implementation of the adaptation actions decided for the sector?
C4	*Feeding the fisheries and aquaculture adaptation plan contents into the general NAP and national fisheries and aquaculture development policies*	How to ensure the visibility and mainstreaming of fisheries and aquaculture adaptation actions in the country's NAP and in its (future) fisheries and aquaculture development policies?

Step C1. Differentiating the policy mechanisms in support of institutional adaptation, livelihood adaptation, and risk reduction and management for resilience

The guiding question here is:
Which policy measures can best support the implementation of the adaptation options prioritised under Element B?

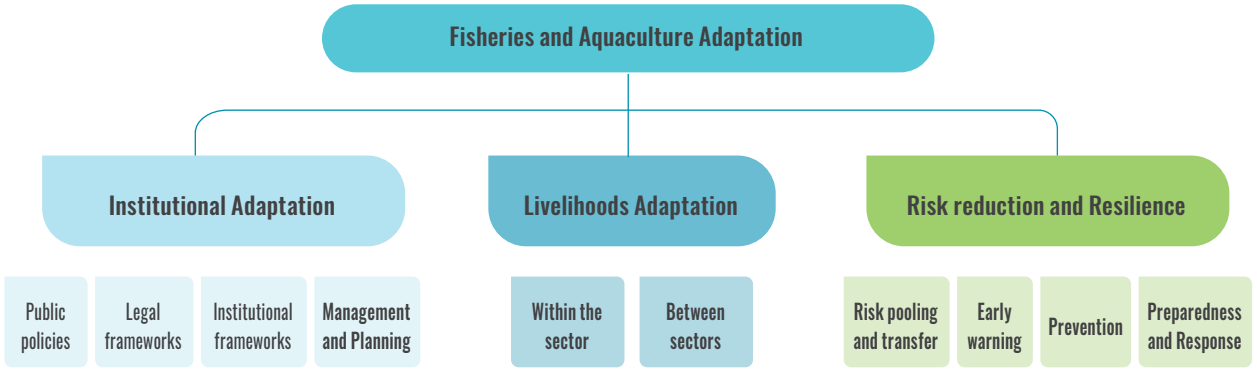
As inferred by Element A, policies and institutional support are necessary for building resilience within fisheries and aquaculture. Policies and measures in support of adaptation options can take many forms and act at several levels in support of the implementation of the adaptation options discussed and prioritised under Element B. Poulain *et al.* (2018) provide a useful categorisation of the different types of policy measures that can be used across the three principal areas that can be targeted for successful climate change adaptation in the fisheries and aquaculture sectors: institutions (I), livelihoods (L), and risk reduction and resilience (RRR) (Figure 9). These categories and corresponding measures are not mutually exclusive. On the contrary, used judiciously and complementarily, they will reinforce one another and considerably lower the risk of maladaptation (cf. Step B5.1).

The intention of Step C1 is to (i) cross-check that the adaptation options prioritised under Element B address as evenly as possible the three principal areas of institutions, livelihoods, and risk reduction and management for resilience, and (ii) determine the corresponding and most suitable policy measures or mechanisms needed for the effective implementation of the adaptation options.

Following Poulain *et al.* (2018), an overview of each of the principal areas is provided[10] before delving into the details of possible policy measures, listed in Tables 6.1 and 6.2.

FIGURE 8.

Three principal areas of policy measures in support of the implementation of adaptation to climate change in fisheries and aquaculture



Source: Poulain *et al.* (2018)

[10] The text that follows is extracted, with some minor changes, from Poulain *et al.*, 2018.

Limitations of institutions in the implementation of management tools

Current management tools should meet the objectives of sustainable fisheries and aquaculture development, whilst simultaneously enabling stakeholders to respond to the additional challenges of complexity and uncertainty posed by climate change. However, institutions in charge of the implementation of these tools are not always fully equipped to do so optimally. For example, weaknesses related to the limitation of stakeholder participation to a consultative role; the minimal or ignored stakeholder direct observations; the reliance on anecdotal instead of scientific information; the often conflicting and difficult-to-meet management objectives of ecological sustainability, economic viability and social stability; the significant difficulties with applying and operationalizing the precautionary approach; and the considerable influence of industrialised fishing interests on governments are hampering the capacity of institutions to support adaptation in the sector (Lane, 2010, cited in Poulain *et al*., 2018).

Critical adaptive properties of fisheries management and governance that enable climate change adaptation and resilience building include: flexibility; an explicit ecosystem level focus; a long-term focus; a learning orientation and adaptive approach; the capacity to cope with complexity and uncertainty; an integration of multiple sectors and scales; monitoring and review capability; and effective and inclusive stakeholder engagement and empowerment. Management approaches such as the EAF and EAA, adaptive management or co-management, comprise the key enablers and property of good adaptation to climate change and should therefore be applied (EAF: FAO, 2003; EAA: FAO, 2010; Ogier *et al*., 2016). Enhanced coordination between research and fisheries agencies is also paramount (Chang *et al*., 2013).

For fisheries and aquaculture, existing public policies and legal frameworks may require changing or updating, for example with a view to enhancing knowledge, transparency, incentives and adaptation. Fisheries and aquaculture management needs to account for other natural resource users (such as urban development, recreation, tourism, oil and gas extraction) – and vice versa – to holistically manage river basins, watersheds and the coastal zone. Transparency in resource allocation and transfer of resource access across different sectors will be required and will imply the development of cross-jurisdictional agreements. Preference should be given to a more devolved style of management that shares management responsibilities with resource users (Lane, 2010).

With regards to aquaculture specifically, changes may also involve drafting a legislative framework that ensures property rights and deals with planning and access, water and waste water, seed, feed, investment, food safety purposes and disease control (Miles, 2010). Self-regulation through voluntary codes of practice and standards should be encouraged, and environmental sustainability and social responsibility should be emphasised. In order to work effectively, the management system needs inter-institutional cooperation and coordination; skilled public and private personnel; and adequate financial resources to implement, monitor and enforce the legislation and the regulations that flow from there (Miles, 2010).

Building capacity to support livelihoods

Many of the individual or community-level responses or actions of the private sector need to be facilitated with government or institutional support. Governments can, for example, put in place incentives to facilitate fishers' mobility as fish stock distribution shifts with changing ocean conditions (including seasonal migration), provide tax breaks or guarantees to stimulate private investments in new technology (e.g. small-scale monitoring of climate drivers), or invest in the development of platforms for sharing knowledge about climate change impacts and adaptation strategies that have been successfully employed (Rathwell, Armitage and Berkes, 2015).

Small-scale fishers and fish farmers are often not as well-positioned to take advantage of opportunities and adapt to threats as larger-scale commercial actors. A strong focus should therefore be placed on building general adaptive capacity that supports poor and small-scale producers and value chain actors, in order to enable them to make the most of new opportunities and cope with the challenges related to climate change (FAO, 2017b). This broad-based

approach to building adaptive capacity can be designed to simultaneously produce benefits in terms of poverty reduction and food security, as well as climate adaptation.

Strategies for risk reduction and management for resilience

To reduce risk and build resilience of private operators (fishers, fish farmers, fish processors), government can act to pool and transfer risk, promote the use of early warning and information systems, improve risk prevention and preparedness, and enhance response to shocks from climate change impacts. In order to improve preparedness for and response to climate change impacts, adaptation and disaster response strategies can be aimed at minimizing the impact of weather-related hazards and extreme events on the fisheries and aquaculture sectors and dependent livelihoods through preparation and recovery (e.g. building back better,[11] dissemination of best practices, and capacity building) (Cattermoul, Brown and Poulain, eds., 2014). These measures can also help to address poverty and food security issues. In addition, early warning systems can be expanded beyond the traditional weather forecasting to include advance warning for other risks, such as temperature anomalies, algal blooms, market changes (in terms of access, volume and value) and price fluctuations. Advanced warnings of impending shocks can be used to make timely decisions in order to minimise the damage and loss to aquaculture and fisheries. Lastly, the overall resilience of the fisheries and aquaculture sectors to climate change impacts can be strengthened through adaptation focused on enhancing the sustainability of fisheries, avoiding overfishing, prevention of impacts, climate-resilient infrastructure (e.g. protecting harbours and fisheries landing sites, stronger farming structures, and more resilient designs such as deeper ponds), continued improvements to safety at sea and vessel stability, measures to improve food safety, climate-resilient structures, and widespread communication about climate drivers and what tools are available to combat likely impacts.

In light of the three principal areas of response, Table 6.1 and Table 6.2 expand on the measures and actions that can be promoted by the government and public institutions in the context of capture fisheries (marine and inland) and aquaculture, respectively, so as to create the enabling environment that fishers, fish farmers and fish processors need to adapt their activities to the challenges of climate change.

TABLE 6.1

Types and selected examples of policy measures in support of the implementation of adaptation options in capture fisheries

INSTITUTIONAL RESPONSE
Public policies
Public investments (e.g. research, capacity building, sharing best practices and trials, communication)
Formulation of climate change adaptation policies and plans that address fisheries
Provision of incentives for fish product value addition and market development
Removal of harmful incentives (e.g. for the expansion of fishing capacity)
Addressing poverty and food insecurity, which systemically limit adaptation effectiveness

[11] The use of the recovery, rehabilitation and reconstruction phases after a disaster to increase the resilience of nations and communities through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalisation of livelihoods, economies and the environment (www.unisdr.org).

Legal frameworks
Flexible access rights to fisheries resources in a changing climate
Dispute settlement arrangements
Adaptive legal rules
Regulatory tools (e.g. adaptive control of fishing pressure; move away from time-dependent effort control)
Institutional frameworks
Effective arrangements for stakeholder engagement
Awareness raising and capacity building to integrate climate change into research/management/policy/rules
Enhanced cooperation mechanisms including between countries to enhance the capacity of fleets to move between and across national boundaries in response to change in species distribution
Management and planning
Inclusion of climate change in management practices, e.g. ecosystem approach to fisheries, including adaptive fisheries management and co-management
Inclusion of climate change in integrated coastal zone management (ICZM)
Improved water management to sustain fishery services (particularly inland)
Use of 'adjustable' territorial use rights
Promotion of flexible seasonal rights
Temporal and spatial planning to permit stock recovery during periods when climate is favourable
Management of transboundary stock that takes into account changes in distribution
Reduction of non-fisheries non-climate stressors (e.g. habitat destruction, pollution) for enhanced resilience
Incorporation of traditional knowledge in management planning and advice for decision-making
LIVELIHOODS RESPONSE
Within sector
Promotion of diversification of markets/fish products, access to high value markets, support to diversification of citizens' demands and preferences
Promotion of improvements or change in post-harvest techniques/practices and storage with suitable incentives
Promotion of eco-labelling, reduction of post-harvest losses, value addition to improve product quality
Flexibility to enable seasonal migration (e.g. following stock migration)
Allow fishers to diversify patterns of fishing activities with respect to the species exploited, location of fishing grounds and gear used to enable greater flexibility
Promote private investment in adapting fishing operations, and private research and development and investments in technologies e.g. to predict migration routes and availability of commercial fish stocks
Promote adaptation-oriented microfinance
Between sector
Enable livelihood diversification (e.g. switching among rice farming, tree crop farming and fishing in response to seasonal and inter-annual variations in fish availability)
Exit strategies for fishers to leave fishing
RISK REDUCTION AND RESILIENCE RESPONSE
Risk pooling and transfer
Public and private insurance mechanisms (against fishing hazards, unemployment, death at sea, etc.)
Personal savings
Social protection and safety nets
Improve financial security
Early warning
Early warning communication and response systems (e.g. food safety, approaching storms)

Monitoring climate change trends, threats and opportunities (e.g. monitoring of new and more abundant species)
Extreme weather and flow forecasting
Risk prevention
Risk assessment to identify risk points
Safety at sea and vessel stability
Reinforced barriers to provide a natural first line of protection from storm surges and flooding
Climate resilient structures (e.g. protecting harbours and landing sites)
Address underlying poverty and food insecurity problems
Preparedness and response
Building back better and post-disaster recovery
Rehabilitate ecosystems
Compensation (e.g. gear replacement schemes)

TABLE 6.2

Types and selected examples of policy measures in support of the implementation of adaptation options in aquaculture

INSTITUTIONAL RESPONSE	SPATIAL SCALE
Public policies	
Mainstream aquaculture into national and regional adaptation and development plans	National/regional
More effective sharing of and access to water and coastal space with other users	National/watershed
Investments in research and development on aquaculture adaptation technologies; new species, breeding for species tolerant to specific or a combination of stressors (disease, temperature, salinity, acidification, etc.)	National, regional, international
Investments to facilitate the movement and marketing of farm products and supply inputs	National, regional, international
Appropriate incentives for sustainable and resilient aquaculture including taxes and subsidies	National, international
Attention to poverty and food insecurity within aquaculture systems	National, international
Legal frameworks	
Property rights, land tenure, access to water, use of exotic species	National
Standards and certification for production and for resistant facilities	National
Institutional frameworks	
Strengthening cross sectoral and inter-institutional cooperation and coordination	Zone/national/regional
Mainstream adaptation in food safety assurance and control	National
Management and planning	
Climate change mainstreamed into integrated coastal zone management (ICZM)	National/watershed/regional
Community-based adaptation	Site and community levels
Aquatic protected areas (marine and freshwater) and/or green infrastructure (see ecosystem approach to aquaculture (EAA) guidelines (FAO, 2010)	National/regional
Mainstream climate change in aquaculture area management under the EAA	Zone/watershed/national
Better management practices including adaptation and mitigation i.e. better feed and feed management, water quality maintenance, use of higher quality seed	Site level/zone/management area
Mainstream climate change into spatial planning and management for risk-based zoning and siting	Site level/zone/management area

Integrate climate change in carrying capacity considerations (production, environmental and social)	Site level/zone/management area
LIVELIHOODS RESPONSE	
Within sector	
Promote the development of new, more resilient farming systems and technologies	Site level/national
Genetic diversification and protection of biodiversity	National
Integrate climate change in microfinance	National
Promote aquaculture diversification	All
Promote more resistant strains	Site level
Promote more resistant and/or resilient hatcheries and hatchery- produced seeds	Zone/national
Promote value addition	National, regional, international
Promote better market access; new markets for new species and products	Zone, national, regional
Promote shift to non-carnivorous species	Site level
Invest in research and development regarding fish meal and oil replacement	Site level/national
Empower farmers' and women's organisations	Management area/national
Promote integrated farming systems and circular economy	Site level/management area
Between sector	
Promote diversification of income streams and livelihoods Site level/national	
RISK REDUCTION AND RESILIENCE RESPONSE	
Risk pooling and transfer	
Social safety nets	National
Social protection	National
Aquaculture insurance	National
Early warning	
Integrated monitoring (relevant aquaculture area), information analysis, communication and early warning of extreme events, disease outbreaks, etc.	Farm, watershed, zone
Development of national and local vulnerability maps and raising awareness of risks	Subnational/national
Synthesis and sharing of scientific and local knowledge, logistics to disseminate information	All
Reliable national risk communication system supporting early warnings	National
Meteorological infrastructure and system that effectively support crop and farm assets insurance (and particularly weather-indexed or parametric insurance)	National
Risk prevention	
Stronger farming structures (e.g. net pens) and more resilient designs (e.g. deeper ponds)	Site level/national
Enable adaptive movement between mariculture and inland aquaculture (recirculation aquaculture systems (RAS), aquaponics)	Site level/national
Better water management and biosecurity frameworks	Site level/zone/farm clusters
Preparedness and response	
Contingency for emergency management, early harvest and/or relocation	National
Rehabilitation and building back better plans	National/international
Relief programmes such as work-for-food and 'work in reconstruction and rehabilitation projects' that offer temporary jobs for farmers and farm workers whose livelihoods have been negatively impacted by climate change	International/national
Emergency assistance to avoid additional damage and loss from climate-related disasters – could include fish feed to avoid massive mortality of stock, etc.	National

Source: Adapted from Poulain et al., *2018 (adapted from FAO, 2017b)*

Planned institutional support for adaptation at national, sectoral and community levels

In the consideration of policy measures, it is also important to take into account the scales at which they apply.

For example, at national and regional scales, adaptation options for fisheries and aquaculture should (i) encompass capacity building at a high level within fisheries and aquaculture institutions to strengthen the linkages and visibility of fisheries and aquaculture with other areas of concern (e.g. disaster risk reduction and preparedness, transboundary natural resource management), (ii) improve political dialogue across ministries, and (iii) strategically plan for adaptation along the entire aquatic food supply chains, accounting for the trade-offs that may arise from interactions with other resource users.

At sectoral level, adaptation options concerning the fishing and/or aquaculture industries and local enterprises could include assessing and defining where strategic investments would be most appropriate (e.g. in hard engineering and infrastructures or marketing and related services). It could also include the promotion of research and development (R&D) to create innovative, resilient and more energy- and resource-efficient production systems.

For local enterprises, this would mean exploring the financial, infrastructural and technological implications of different climate change scenarios (e.g. incidence of floods, lower rainfall, variations in salinity every year, five years or decade) on the economic activity of local enterprises involved in fish capture, farming, or processing and distribution. Policies creating incentives for relocation, alternative development strategies, investments and diversification may need to be considered to promote adaptation at this level.

At community level, adaption options could include altering local/community-level institutional set-ups to emphasise learning; promoting the participation of fishing and fish farming communities in cross-sectoral negotiations and planning processes; and strengthening the social capital (e.g. community organisations). This would be a means to increase resilience and explore external partnerships for possible opportunities created by climate change.

The different approaches to adaptation outlined above are not mutually exclusive. They can be mixed, and can overlap, in order to address the climate risks, impacts and vulnerability of different aquatic systems, fish value chains or dependent communities.

Concretely, under Step C1, it is necessary to:

1. Organise all prioritised adaption options from Element B according to the three principal areas of interventions: I, L and RRR.
2. Match the organised adaptation options with policy measures corresponding to each of the three areas. Whilst the list of measures listed in Tables 6.1 and 6.2 is comprehensive, it is not exhaustive. Consequently, other measures may need to be considered to support the implementation of some of the adaptation options.
3. Recall the institutional and capacity gaps that emerged out of Element A, along with the strategy to fill them, so as to ensure that the strategy elaborated under Element A is suitable to enhance the capacity of institutions in implementing the prioritised adaptation options

Anticipated outcome of Step C1:

- A list of policy measures most suited to support the implementation of adoption options prioritised in Element B, and ready to be incorporated into a fisheries and aquaculture climate change adaptation document outlining the rationale and chosen fisheries and aquaculture climate change adaptation actions (see Step C2).

Step C2. Consolidation of fisheries and aquaculture adaptation options and supporting policy measures

The fisheries and aquaculture adaptation actions and products of the previous elements and step can now be consolidated and developed into a coherent set of projects or programmes, i.e. the fisheries and aquaculture adaptation plan.

The overarching question here is:
To be useful for adaptation planning, in what form should the information gathered thus far, analysed and prioritised on climate change adaptation be presented?

Turning adaptation actions into projects or programmes

The agreed ranking list of appropriate adaptation options per system and/or geographic area and/or group obtained from Step B5.2 and their matching policy measures (established under Step C1) should now each be developed into a detailed project, programme or strategy for its implementation. It would include timeframes, staff and budgetary information. It will be possible to extract much of this information from the steps undertaken in Element B. Each adaptation option is likely to require some form of training and/or capacity building either at individual (e.g. new fishing or farming techniques, new gear), community (e.g. social capital to manage shared resources) or institutional levels (e.g. increase of fisheries extension officers, increase in research capacity for monitoring stocks) and this should be clearly specified. The elaboration of these detailed sub-plans may be carried out by the cell/task force leading the process to formulate and implement the adaptation plan for the sector. As much as possible, it should seek support from relevant stakeholders (e.g. research institutions, NGOs, fishers or farmer associations, bilateral donors in the country) and external support (e.g. experts or consultants) as appropriate.

Presentation formats

The findings of the process so far may be presented in several forms, depending on the preferences and needs of the cell or those in charge of the process so far, as well as on what is deemed most practical and useful to communicate the findings and integrate them in the broader NAP (C3). Thus, it could take the form of:

- A relatively formal, stand-alone document (for example a 'Fisheries & Aquaculture National Adaptation Plan') containing the information collected and all the decisions regarding adaptation in the sector reached through the previous steps. This compendium document could then be used as a reference.
- A less formal and more synthetic strategy, in the form of a brief, slides or a web-based platform, pulling key messages and information together for easy use and sharing, across ministries and with all stakeholders involved in the NAP.

Regardless of the medium and terminology chosen to denominate and communicate the findings of the process so far, it is important to keep in mind that the fisheries and aquaculture climate change adaptation plan should not be an end in itself. It should enable the integration of the selected adaptation interventions (contained in the plan) into the broader process to formulate and implement the country's NAP and provide a basis for evaluation and reflection on performance (Element D).

Depending on the final format chosen to present the outcomes of the fisheries and aquaculture climate change adaptation plan process, the following components could be included (developed from LEG, 2012):

- How this plan fits into the national and cross-sectoral climate change plans/strategies.
- A summary of steps that were undertaken as part of the fisheries and aquaculture process to formulate and implement the NAP (i.e. the steps outlined above and/or any deviation or additional activity that may have been undertaken as part of the process).
- A discussion of key climate drivers, pathways and vulnerabilities in the context of the main development priorities for fisheries and aquaculture (i.e. results from B1, B2 and B3).
- A list of adaptation goals and corresponding prioritised adaptation actions, matched with

policy measures and with their respective implementation programmes, projects and other activities (i.e. results from B4, B5 and C1).

- A detailed outline of how funds and human power will be mobilised to implement the fisheries and aquaculture adaptation plan, and the role and responsibilities of those involved in overseeing and contributing to the implementation of the actions listed, and steering the engagement process with the broader NAP (i.e. result from Step C3 detailed below).
- A plan for M&E of (i) the effectiveness of the selected adaptation actions and progress of the sector in adapting to climate change; and (ii) the mainstreaming of fisheries and aquaculture in the country's NAP, which is further detailed under Element D. Here a timeline for reassessing adaptation decisions and actions as new information becomes available from ongoing assessments should also be included.

This should be submitted to the stakeholders who participated in the prioritisation process as well as to the wider public for consultation (e.g. through public meetings, an online consultation) and to non-participating stakeholders (e.g. members of universities, research institutes, NGOs and civil society organizations (CSOs)) for peer review. Feedback should be sought as much as possible and integrated in the contents. Ideally, formal endorsement should also be sought. The final version should be disseminated as widely as possible. The cell/task force overseeing the fisheries and aquaculture climate change adaptation plan process will be instrumental in this.

Anticipated outcome of Step C2:

- ❑ An agreed fisheries and aquaculture climate change adaptation document used for disseminating information on key climate drivers, pathways, vulnerabilities, prioritised adaptation options and their supporting policy measures.

Step C3. Mobilisation of funds and human power for implementation

Guiding question for Step C3:
What needs to be in place in terms of funds and human power to support the implementation of the adaptation actions decided for the sector?

Due consideration needs to be given to who the responsible authorities are, the timing, sequencing of activities and mobilisation of resources (UNFCCC, 2012). Thus, those in charge of the implementation of activities under the fisheries and aquaculture climate change adaptation plan should consider and decide on the following:

- Possible sources of funding and other forms of support for the implementation of fisheries and aquaculture adaptation activities decided during the previous steps through the country's NAP implementation programme as well as through sector-specific mechanisms.
- Options for mobilizing financial, technical and capacity building support under multilateral processes and other channels, including at the local, national and regional levels.
- Overall coordination of the implementation ofthe fisheries and aquaculture adaptation plan under the NAP umbrella.
- Ways and means to instigate and maximise synergies with adaptation plans or actions from other sectors, in particular those related to agriculture, freshwater resources, and coastal and marine management (e.g. irrigation, hydropower generation, maritime transport, coastal tourism).
- A sequence for implementation, taking into account currently available resources versus those required, ongoing and planned adaptation, relevant economic development initiatives and international commitments.

Decisions on these matters should be duly documented as part of the fisheries and aquaculture climate change adaptation plan resulting from Element C2 to ensure that they are adequately reflected in the broader NAP.

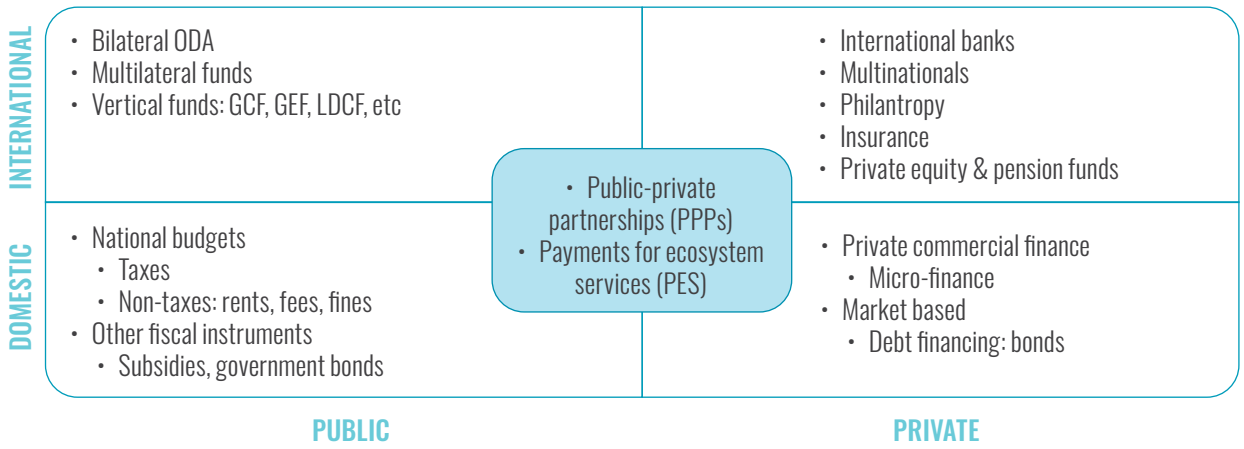
Mobilisation of funds

A wide range of financing sources and mechanisms can be used to support the implementation of NAP. Figure 9 summarises such options, including domestic public finance, international public finance and private finance. Further guidance on climate finance may be found in Price-Kelly (2016).

Box 14 illustrates how some countries have mobilised funds to increase the adaptive capacity of their fisheries and aquaculture sectors.

FIGURE 9.

Options for financing the implementation of National Adaptation Plan



Source: Price-Kelly and Hammill, 2016; Price-Kelly, 2016.

BOX 14.

Mobilisation of funds for increasing the adaptive capacity of the fisheries and aquaculture sector

In 2016 and 2017, implementation of six national and regional projects began with the overall goal of increasing the adaptive capacity of the fisheries and aquaculture sector and enhancing its resilience. These projects are taking place in Bangladesh, the Benguela Current region (Angola, Namibia, South Africa), Chile, the Eastern Caribbean (Antigua and Barbuda, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago), Malawi, and Myanmar. FAO is supporting implementation of these projects, with support from the Global Environment Facility (GEF) Least Developed Countries Fund (LDCF) and Special Climate Change Fund (SCCF).

As further understanding of climate change implications is still needed at national and local levels, strengthening knowledge and awareness of climate change in riparian and coastal communities and the need to adapt the management and exploitation practices of fisheries and aquaculture is an important part of the projects. This awareness is expected to assist in the development of targeted adaptation actions, their integration into national policies and their effective implementation. The projects also seek to overcome barriers such as weaknesses in the national and local institutional framework and limited application of good management practices in the sector, which affect its general resilience. These practices include a strong fisheries and aquaculture management component, mainly based on EAF/EAA principles and tools.

Vulnerability assessments are key to a sound understanding of climate impacts and provide a pathway to the development of robust adaptation actions. Given the multitude of available approaches and methodologies for assessing vulnerability (Brugere and De Young, 2015), the initial phase of each project includes participatory and detailed vulnerability assessments at the regional, national, local and/or community levels to identify the areas and communities that are most at risk, with due consideration for gender and age groups. The next step is to identify suitable adaptation measures and provide a sound technical basis for informing policy changes. Project activities foreseen, specifically targeted to different stakeholder groups, include capacity strengthening to enable all stakeholders to assess the risks posed by climate change to their livelihoods and security and to ensure adaptation to address those risks.

Domestic public finance has received less attention than other forms of financing, in part because countries most vulnerable to climate change often lack the public resources needed to fully support adaptation. However, it potentially has a large role to play in the adaptation of fisheries and aquaculture. For example, appropriately taxed large revenue generation from offshore capture fisheries in countries with large Exclusive Economic Zones (EEZ), or exports of high-value aquaculture commodities, could support the creation of a national climate fund which could be tapped into by smaller producers for localised adaptation activities. Such a model is under development in the Seychelles. (A. Lesperance, personal communication, 2016).

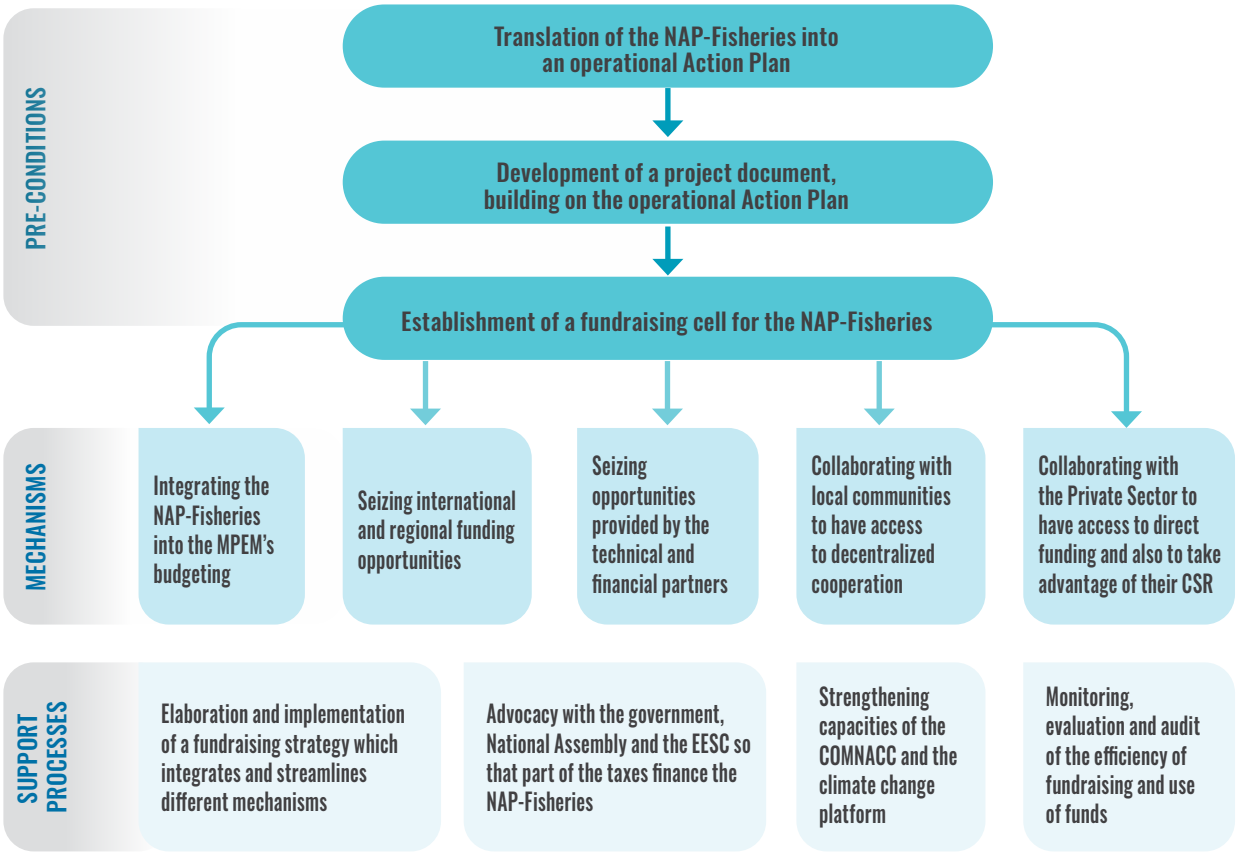
Both the public and the private sectors could be involved in financing the implementation of adaptation actions in fisheries and aquaculture. Their respective roles will need careful consideration to ensure their adequacy for the needs of the sector and its stakeholders. For example, insurance against destruction of aquaculture infrastructure or loss of fishing gear and income by extreme climatic events may not be suitable for standard private insurance providers and may require public support. This may vary depending on the nature of the activity (e.g. industrial versus artisanal fishers; small-scale, semi-intensive pond producers versus large and intensive producers). Similarly, lessons from the establishment of social protection programmes and public-private partnerships in natural resources-based initiatives can shed useful light on the nature of collaboration between private and public stakeholders to further resilience to climate change in fishing and aquaculture communities.

Implementing the fisheries and aquaculture adaptation actions included in the country's NAP will mean that either the sector will provide the funds necessary for the implementation of its own activities, or that it will need to lobby for an adequate proportion of the NAP implementation budget to be spent on fisheries and aquaculture-specific adaptation actions. IFAD (2014) provides specific guidance on the incorporation of climate change into fisheries and aquaculture investments. Figure 10 illustrates how Senegal went about securing funds for its Fisheries NAP.

Regardless of the modes of financing targeted, it is important that budgets for adaptation are clearly earmarked in national budgets, whether at the level of the country's ministry of fisheries or at the level of planning, and that the use of these budgets is clearly tracked (Price-Kelly and Hammill, 2016).

FIGURE 10.

Example of Senegal's Fisheries National Adaptation Plan financing strategy



Source: Government of Senegal, 2016.

Mobilisation of human power

Element A, Step A1 produced a "capacity building training programme/strategy and budget to fill the identified gaps in individual skills for those involved in the climate change task force/cell and across the ministry/department (e.g. recruitment)". It is now time to call upon the skills and capacities developed following the strategy or plan elaborated in Step A1 to take the adaptation plan for fisheries and aquaculture to implementation and integration in the broader NAP.

Two considerations are important to bear in mind here: 1. long-term investment in human power, to ensure that staff recruited stay in positions to enact the changes in planning required in the longer run, and 2. established connections across sectors, to ensure that staff and actors in other ministries and economic sectors are influencing the adaptation of fisheries and aquaculture at different levels act in synergy.

Anticipated outcomes of Step C3:

- A financing strategy for the fisheries and aquaculture climate change adaptation plan.
- The necessary skills and competencies available and ready for implementing and mainstreaming the adaptation plan for fisheries and aquaculture.

Step C4. Feeding the fisheries and aquaculture adaptation plan contents into the general National Adaptation Plans and national fisheries and aquaculture development policies

The guiding question here is:
How to ensure the visibility and mainstreaming of fisheries and aquaculture adaptation actions in the country's NAP and in its (future) fisheries and aquaculture development policies?

The country's fisheries and aquaculture adaptation plan may remain as a standalone document. However, as adaptation actions of one sector are rarely undertaken in isolation of other sectors, it may be necessary to envisage an integration of its contents into the country's NAP. Many adaptation actions in support of fisheries and aquaculture will not be within the line ministry's mandate or control. In addition, in their adapting to climate change, other sectors will have impacts on fisheries and aquaculture and vice versa. A NAP helps to ensure a better systems approach to adaptation planning, helping to minimise maladaptation and support synergistic efforts across sectors.

It will be the responsibility of the fisheries and aquaculture climate change cell or task force to champion the mainstreaming of the decisions on fisheries and aquaculture adaptation into the overall process to formulate and implement the country's NAP. Its role will be, in particular, to influence and lobby stakeholders from other sectors and ministries to ensure that the climate change adaptation needs for fisheries and aquaculture feature prominently in the overall NAP, as well as in the national development policies and strategies for the sector, and receive adequate budgetary allocations.

As was indicated in Figure 2, the contents of the fisheries and aquaculture climate change adaptation plan produced in C3 should be the entry point of the mainstreaming process. This should then be coordinated through the various stages of the process to formulate and implement the NAP and involve further specific fisheries and aquaculture consultations, as shown in Figure 2.

Depending on administrative structures, the fisheries and aquaculture adaptation plan may first be integrated into, say, an agriculture sector's adaption plan (e.g. Japan, 2015 in Annex 1). Doing so may support buy-in from other sectors and increase the leverage and attention that fisheries and aquaculture and allied sectors may gain in the wider process to formulate and implement the NAP. Mainstreaming the fisheries and aquaculture climate change adaptation plan contents through a top-down approach (i.e. strengthening the engagement and buy-in from fishing and aquaculture communities, stakeholders and other non-fisheries and non-aquaculture stakeholders and citizens at large) could, on the other hand, be done through a partnership with research institutions and NGOs. Engaging with non-fisheries and non-aquaculture stakeholders, as suggested here, is particularly important to increase the visibility of the sector from communities to institutions and ensure that fisheries and aquaculture have a place at the NAP table.

In this regard, it will be necessary to engage with those non-fisheries stakeholders leading the process to formulate and implement the NAP and multi-sector plans (e.g. agriculture, energy) as soon as the questions raised in A1 are answered, so that they are ready to integrate what comes out of the fisheries and aquaculture process. Chile's NAP (Government of Chile, 2014, in Annex 1), for example, required and supported the development of a sectoral NAP specific to fisheries and aquaculture (Figure 11). The elaboration process of the country's 'Adaptation plan to climate change for fisheries and aquaculture' (Government of Chile, 2015, in Annex 1) relied on a consultation of the sector's stakeholders and the wider public. Numerous workshops were held at local and regional levels to emphasise the sector's diversity at various levels of governance and geography. The plan builds on the findings of a vulnerability assessment of the sector, addressing both ecological and human dimensions. In the process of assessing and selecting adaptation projects, knowledge gaps were also identified that would need filling in order to strengthen adaptation outcomes (Alarcón *et al.*, 2013a, 2013b).

For further reading and examples of the types of outputs that can be reached, Annex 1 lists a number of countries' NAPs integrating fisheries and aquaculture concerns and actions, while being specific to the sector.

Reciprocally, the elaboration of the fisheries and aquaculture climate change adaptation plan will have brought out and created awareness about the current and future vulnerabilities of the sector to climate change as well as the strengths and weaknesses of the sector to evolve and adapt to changing economic, environmental and social conditions. This should be capitalised upon and integrated into the formulation or renewal of the fisheries and aquaculture policies and strategies a country may have and which may be weak in addressing climate change. Regular sharing and dissemination of information from Element B with fisheries and aquaculture officers in ministries and/or sub-national authorities and with those in charge of policy reviews and elaboration will be very important in this regard.

FIGURE 11.

Chile's National Adaptation Plan for its fisheries and aquaculture sector

Source: Chile, Subsecretaría de Pesca y Acuicultura and Departamento de Cambio Climático, 2015.
http://portal.mma.gob.cl/wp-content/uploads/2016/12/Plan-Pesca-y-Acuicultura-CMS.pdf

Sequencing of adaptation actions

No single adaptation option will fit all needs: target beneficiaries, systems and locations need to be taken into account, as well as the different time scales and degrees of complexity of the selected adaptation actions. Thus, it is better to avoid the rigidity of fixed adaptation options over time and leave the possibility to adjust their implementation by, for example, adopting a flexible sequencing strategy that allows alternating between adaptation options if necessary, actively timing decisions and using windows of opportunity to revise options depending on the speed of impacts of climate change (PROVIA/MEDIATION Adaptation Platform, 2016)[12]. This implies that the sequence of implementation of adaptation actions needs to be carefully thought through and discussed as part of the elaboration of a roadmap for implementation. A process of regular review enabling to go through the steps of B5 again to examine if new needs or questions have emerged and require the consideration of new adaptation options. This would in any case not preclude the establishment of a M&E system, as detailed in Step D2.

[12] http://www.mediation-project.eu/platform/home.html

Anticipated outcomes of Step C3:

- A clear roadmap for the fisheries and aquaculture climate change adaptation plan to be incorporated into the country's general NAP and other climate change documents (e.g. INDC), inclusive of a schedule of engagement and interaction points between the task force overseeing the fisheries and aquaculture climate change adaptation plan and the institutions involved in the elaboration of the general country NAP.

- Leverage for the fisheries and aquaculture sector to become a full player and component of the general NAP, and for climate change considerations to be fully integrated in national and sub-national planning processes regarding fisheries and aquaculture development.

Element D: Communicating, monitoring and reviewing

Communication, monitoring and evaluation and dissemination of fisheries and aquaculture adaptation

This element considers the mechanisms that need to be established to ensure that the adaptation actions chosen for fisheries and aquaculture in the earlier steps are mainstreamed in the country's NAP implementation and that they achieve the adaptation goals for the sector that were agreed upon. Adaptation specific to fisheries and aquaculture can be standalone. However, given their tight interactions with other sectors, it is important that their implementation be considered as an integral part of the implementation of the country's NAP.

Anticipated outputs and outcomes of Element D

- ❑ A strategy for communicating and disseminating information about the planned climate change adaptation actions and policies for the fisheries and aquaculture sector, and about the NAP process, to stakeholders within and outside the sector.
- ❑ A plan for monitoring and evaluating progress in the implementation of the fisheries and aquaculture climate change adaptation plan and how fisheries and aquaculture are being mainstreamed in the general process to formulate and implement the country's NAP.
- ❑ A specific plan for monitoring and evaluating how the fisheries and aquaculture activities targeted by the NAP are enabling greater adaptation outcomes for the systems and people of the fisheries and aquaculture sector.

	Steps	*Guiding question*
D1	*Dissemination and communication of information on climate change adaptation in fisheries and aquaculture*	How to communicate to different stakeholders information about climate change adaptation in fisheries and aquaculture, and the outcome of the NAP process for fisheries and aquaculture?
D2	*Monitoring and Evaluation (M&E)*	How to monitor and evaluate how fisheries and aquaculture and their dependent communities are adapting to climate change, and how to ensure that the interests of the sector are adequately represented in the country's NAP?

Step D1. Dissemination and communication of climate change adaptation information

The guiding question here is:
How to communicate to different stakeholders information about climate change adaptation in fisheries and aquaculture, and the outcome of the NAP process for fisheries and aquaculture?

Disseminating climate change adaptation information and communicating it effectively to a broad range of fisheries and aquaculture stakeholders affected by climate change is one of the keystones of effective adaptation. Communicating about climate change with policymakers is challenging because it is at the interface of scientific data (complex, uncertain, full of jargon), psychological phenomena (one's own mental models, values, behaviour), and policy-making (power, timing, agendas, ideology) (Scienseed, 2016). There is also a nuance between disseminating information, which is most common, and triggering change, which involves improving the understanding of adaptation challenges, raising awareness of adaptation pathways, encouraging dialogue, and influencing the behaviour of those who need to change their fishing and fish farming practices to adapt to climate change (Lumosi *et al.*, 2016).

To reach out to these different stakeholders and engage them requires framing messages according to their respective mental models. These need to be understood in advance (McNaught *et al.*, 2014; Climate Outreach and Adaptation Scotland, 2017; Scienseed, 2016):

- Understanding the values and motives of different groups of stakeholders, including sub-groups within them (e.g. experts upon which policymakers rely for specific advice, mid-level officers in public institutions, NGOs, private sector, fishers and fish farmers and their communities).
- Acknowledging their possibly diverging priorities.
- Framing messages so that they build a bridge between the values of each group of stakeholders and the benefits of adapting to climate change. This will involve overcoming the psychological distance of climate change: connecting the threats of climate change with people's lives and gaining traction with a positive message focused on the increased adaptive capacity beyond the sole discussion of the impacts of climate change. Messages should be distilled to the right level, according to the category of stakeholders, as part of dissemination, as this will add to their resonance at a personal level as part of learning and empowerment for action.
- Finding the appropriate communication channels and dissemination means, tailored to the needs and capacities of the target audiences, e.g. radio, video, games/role play, meetings in rural communities; leaflets, briefs (including policy briefs and visuals) in public institutions.
- Harnessing the power of social media and of virtually connected communities to spread messages, inform, generate acceptance and buy-in, and trigger change.

To this end, a climate change adaptation communication strategy with fisheries and aquaculture stakeholders should be produced, and included either in the country's fisheries and aquaculture NAP or as a standalone document or addendum to the country's general NAP. Relevant communication expertise should be called upon for this purpose. There is also a growing body of guidance on communicating climate change and climate change adaptation, some of which is cited above and listed in the references for further reading.

Anticipated outcomes of Step D1:

- ❑ A communication strategy for the fisheries and aquaculture climate change adaptation plan.

Step D2. Monitoring and Evaluation

Guiding question for Step D2:
How to monitor and evaluate how fisheries and aquaculture and their dependent communities are adapting to climate change, and whether the interests of the sector are adequately represented in the country's NAP?

Tracking change and progress through M&E is the core of Element D. It concerns, on the one hand, tracking and evaluating what progress the sector and its people are making in adapting to climate change and how they are benefiting from the adaptation actions that are being implemented (outcomes and impacts), and on the other hand, how effectively the fisheries and aquaculture adaptation actions are being implemented and mainstreamed in the country's NAP (process).

Theory of change in support of Monitoring and Evaluation

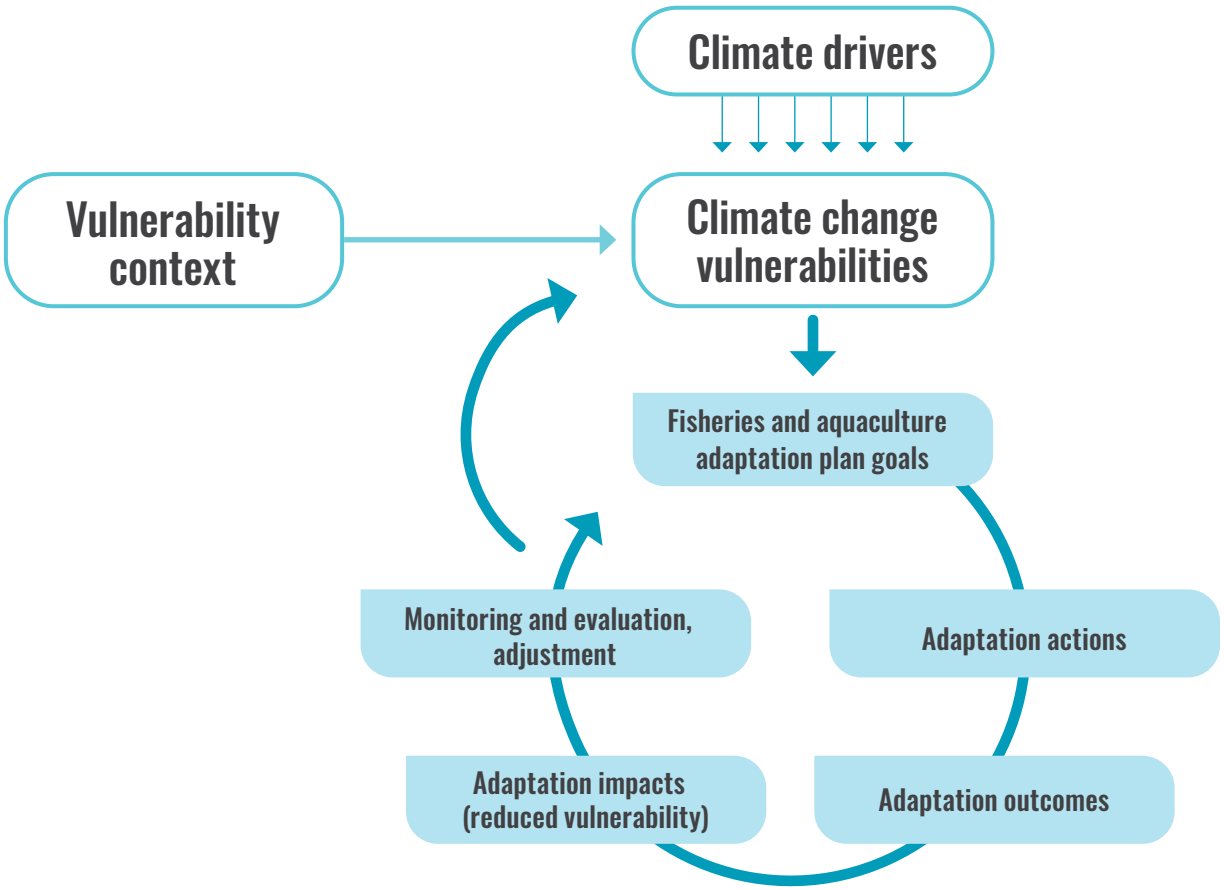
A M&E system based on a theory of change is likely to be particularly relevant to tracking the outcomes and impacts of adaption actions. Theories of change are increasingly recommended as the foundation to designing a M&E system (Spearman and McGray, 2011). Elaborating a theory of change requires reflecting on the pathway of chain of events through which adaptation actions will lead to the intended positive outcomes and impacts (i.e. achieving the agreed adaptation goals). Establishing this pathway involves specifying the assumptions which need to be satisfied or verified between each step of this chain for moving along this pathway towards the goal of adaptation. These assumptions may include process-response relationships or patterns of human behaviour and use (UNEP, 2012).

The implementation of the adaptation actions identified in the fisheries and aquaculture climate change adaptation plan may lead to unexpected developments – either positive or negative – that it will be necessary to either capitalise on or avert. Assessments of progress based on a theory of change, which may be elaborated either per aquatic system, geographic or administrative area or adaptation action (for example if it can be broken down in many sub-actions) as appropriate, will be essential to capture any deviation from the envisaged impact pathway. Regular evaluations will be necessary in this regard and their frequency should be clearly indicated in the M&E plan. They will be all the more necessary as climate change impacts will vary over time and uncertainty remains regarding how they will occur. The promoted adaptation actions may need to be adjusted to account for emerging or new climate change threats.

Developing a theory of change will stem directly from the impact and vulnerability analyses and ensuing adaptation goals for the sector (Figure 13). It will involve thinking about issues related to the measurement of adaptation itself in fisheries and aquaculture and of the effectiveness, relevance, efficiency, impacts and sustainability of adaptation measures encompassed in the fisheries and aquaculture climate change adaptation plan. Deciding on the type of indicators to choose should involve revisiting the criteria initially used to select the most appropriate adaptation options (Element B). Information on vulnerabilities gathered and analysed under B2 and B3 could be used as a starting point for the creation of baselines against impacts, while changes may be measured at a later date.

FIGURE 12.

Theory of change logic for climate change adaptation actions and Monitoring and Evaluation



Source: Authors

Measuring adaptation

Choosing indicators

The choice of indicators to measure the contribution of selected adaptation action to the capacity of the sector to cope with, and adapt to, climate change should be aligned with the adaptation goals agreed upon under Element B. However, both indicators and targets should be set within a framework that considers change over time, tracks climate data and deals with uncertainty and the dynamics of aquatic ecosystems and their changing environments, including human and institutional aspects. This is important for focusing on reducing long-term climate risks (Villanueva, 2011; Brooks *et al.*, 2011, cited in UNEP, 2012).

Box 15 outlines principles for choosing appropriate indicators to evaluate climate change adaptation. Although generic, they are highly relevant to the choice of indicators for adaptation in fisheries and aquaculture. Stakeholder consultation is once again paramount to ensure that what is monitored reflects stakeholders' concerns. Deciding on a set of indicators could therefore be done during a workshop gathering those directly and indirectly affected by the adaptation actions to be implemented. This workshop could, for example, be held back-to-back with the one(s) for the prioritisation of options (B5.2).

BOX 15.

Generic principles for choosing indicators of adaptation to climate change

There is no single set of universal or standard adaptation indicators. Individually, they may be indistinguishable from indicators used in other development programmes. Their one distinguishing characteristic is how a combination of indicators captures progress toward adaptation aims.

Given the local contextualisation of climate impacts, adaptation lends itself well for local stakeholder consultation and other participatory processes. A participatory approach helps to capture both the local context as well as the wider enabling environment that matter in the development and selection of indicators.

A good set of adaptation indicators should:

- be embedded in a theory of change that shows an understanding of, and appreciation for, the intervention's local context and wider enabling environment;
- include a balance of different types of indicators, but comprise a manageable number of indicators;
- be informed by participatory processes and be understood and agreed upon by key stakeholders;
- reflect gender considerations beyond gender disaggregation with a focus on how women are differently affected and cope, including their different access to resources, capacities and opportunities;
- be drawn from strong, sound data sources;
- provide data that can easily be converted into information and knowledge that suits the evaluation's use;
- follow established indicator criteria (e.g. SMART, ADAPT, CREAM, SPICED); and
- include indicators to track adaptive learning and, if applicable to the evaluation, feedback into policy.

Good indicators are not carved in stone and are never a substitute for thoughtful analysis and interpretation. Given the dynamism and uncertainty as to how climate change will exactly play out at the local level, there needs to be a certain flexibility and openness to changing indicators developed at the start of the project when the actual climate reality changes.

Source: Viggh et al., *2015*

There are numerous frameworks to design M&E systems (UNFCCC, AC-LEG, 2016).

However, we acknowledge that a specific M&E system may already exist within the ministry of fisheries and aquaculture or the authority in charge of the sector. In this case, it would be advised to first review this system and check its adequacy with measuring climate change adaptation outcomes and impacts. Tailoring it by adding or modifying existing indicators and integrating it into an existing M&E structure may be sufficient and more effective in this instance, as it will enable using arrangements already institutionalised to implement it.

In the next two sections, outcome and impact indicators are distinguished from process ones. Adaptation process indicators "track the development and implementation of measures in pursuance of adaptation (e.g. diversity of stakeholders attending adaptation meetings, number of sectoral plans that consider climate risk), whereas adaptation outcome indicators measure the change that has occurred as a result of adaptation measures, including percentage of people residing in flood-prone areas or number of households in need of food aid" (GIZ and IISD, 2014). As such, outcome and impact indicators are likely to be more environmental, technological/structural, economic and social, whereas process indicators are more likely to be related to governance and institutional (including legal) aspects in nature, although these categories are not hermetic (Box 16). In a theory of change, both types of indicators are likely to be present and distinguishing between them may become difficult at times because "what may appear to be an outcome in the short-term may actually be a step in a longer-term process" (ibid.).

BOX 16.

General characteristics of process and outcome/impact indicators of climate change adaptation

Process indicators

Many adaptation initiatives focus on the establishment of an adaptive process as their objective. Typically, in these initiatives, adaptation effectiveness means setting in motion an ongoing process of understanding and addressing risks and vulnerabilities, which fosters learning and improvement. This perspective aligns well with the uncertainties associated with climate change and recognises that an adaptation endpoint often cannot be determined at the outset. Success consists of establishing a process that enables decision makers to match their actions to the needs created by climatic circumstances, vulnerability drivers and stakeholders' priorities and risk tolerances. M&E in this context considers elements of procedure, including, for example:

- degree and quality of participant involvement in adaptation decisions;
- relevance and quality of informational inputs to adaptation decisions;
- thoroughness of accounting for climate risks and vulnerability in decision making;
- number and quality of laws or policies addressing climate change; and
- whether and how the adaptation process is sustained.

Outcome/impact indicators

Several adaptation initiatives focus more on identifying the substantive outcomes than identifying the procedural outcomes. For these, adaptation success typically means building specific capacities, reducing a particular vulnerability or managing specific risks. Outcomes may connect to procedural effectiveness, but the emphasis is on evidence of change, rather than on the processes through which change occurs. Examples include:

- change in degree of exposure to climate risks and threats;
- evidence of changed quality of climate-sensitive natural resource base;
- utility and quality of early warning systems;
- change in stakeholder response to climate risk, or utilization of adaptation options; and
- evidence of community, sectoral or institutional understanding and capability to deal with or avoid climate-induced losses.

Source: Spearman and McGray, 2011

D.21 Monitoring and evaluating the outcomes and impacts of fisheries and aquaculture adaptation actions

The suite of indicators chosen should be aligned with the adaptation goals determined in B.4 and reflect the levels (inputs, results, outcomes, impacts) of the adaptation theory of change. In the context of fisheries and aquaculture, indicators of climate change adaptation are most likely to fall in the following domains (after FAO, 2017c):

- Natural resources and aquatic ecosystems – to track the influence of fisheries and aquaculture adaptation actions on the quantity and quality of marine and freshwater resources. Indicators could be chosen around main sub-categories, such as:
  - **(1)** availability of, and access to, quality water resources for capture fisheries and aquaculture value chains;
  - **(2)** availability of, and access to, suitable land (e.g. for land-based aquaculture, resettlement of fishing communities);
  - **(3)** status and functioning of aquatic ecosystems (habitats, species, ecosystem services);
  - **(4)** availability of, and access to, renewable/clean energy resources for fishing, fish farming and post-harvest activities; and
  - **(5)** status of diversity of aquatic genetic resources.

- Biophysical and production systems – to track the influence of fisheries and aquaculture adaptation actions on the productivity of fisheries and aquaculture systems themselves. Indicators could be chosen around main sub-categories, such as:
  - **(1)** capture fisheries and aquaculture production and productivity;
  - **(2)** sustainable and adaptable management of fisheries and aquaculture within the EAF/EAA;
  - **(3)** sustainable land use management in support of, for example, aquaculture and inland capture fisheries;
  - **(4)** reduced exposure of aquatic resources and production systems to climate extremes; and
  - **(5)** reduced impact of climate-related risks on fish-based livelihoods and infrastructure.

- Socio-economics – to track the influence of fisheries and aquaculture adaptation actions on the resilience of target groups affected by climate change. Socio-economic indicators will seek to facilitate the understanding of the relationship between climate change adaptation activities and social and economic wellbeing, based on sub-categories (gender equality considerations need to be prominent in each sub-category), such as:
  - **(1)** food security and nutrition (see Box 17 for an example);
  - **(2)** poverty and inequalities;
  - **(3)** access to basic services (education, health, water, sanitation, infrastructure, etc.);
  - **(4)** strength of social capital and networks in fisheries/aquaculture communities and sectors;
  - **(5)** value addition to fish products (value chains), income and livelihoods;
  - **(6)** access to credit and finance for adaptation investments in the agriculture sectors, including fisheries and aquaculture; and
  - **(7)** access to social protection.

- Institutional structures and capacity – to track the influence of fisheries and aquaculture adaptation actions in enhancing the capacity and coordination of relevant stakeholders at all levels. Indicators could be chosen around main sub-categories, such as:
  - **(1)** existence and functioning of early warning and environmental monitoring systems and other information services for adaptation within fisheries and aquaculture sector and dependent communities;
  - **(2)** institutional coordination for climate change adaptation within fisheries and aquaculture and among sectors;
  - **(3)** institutional capacity of fisheries and aquaculture agencies as well as professional groups (e.g. cooperatives) to respond to climate variability and change;
  - **(4)** initiatives for fisheries and aquaculture stakeholder awareness, lessons learning and knowledge management; and
  - **(5)** stakeholder engagement for broad uptake of fisheries and aquaculture climate change adaptation actions.

- Governance and Policy – to track the influence of fisheries and aquaculture adaptation actions

in informing policy-making and supporting the inclusion of climate change and adaptation concerns in national and/or sub-national fisheries and aquaculture development policies, strategies, plans and legal frameworks. Indicators could be chosen around main sub-categories, such as:

(1) availability and use of climate information services in fisheries management and aquaculture development planning;

(2) integration of climate change adaptation priorities into fisheries and aquaculture sector policies/strategies /plans and vice versa;

(3) budgeting for climate change adaptation in fisheries and aquaculture; and

(4) achievement of targets relevant to fisheries and aquaculture adaptation in national and international commitments.

These indicator categories leave enough flexibility to the fisheries and aquaculture climate change cell or task force, ideally in collaboration with a range of stakeholders, to select specific indicators and adapt targets and scores according to the intended outcomes and impacts of the actions selected for the fisheries and aquaculture climate change adaptation plan.

BOX 17.

Example of food security adaptation indicators

Philippines National Climate Change Action Plan
Action plan and indicators for priority area: Food Security

OUTCOMES	IMMEDIATE OUTCOME	OUTPUT AREA	INDICATORS
Ultimate Outcome Enhanced adaptive capacity of communities and resilience of natural ecosystems to climate change *Intermediate Outcome* Ensured food availability, stability, access and safety amidst increasing climate change and disaster risks	1. Enhanced resilience of agriculture and fisheries production and distribution systems from climate change	1.1. Enhanced knowledge on the vulnerability of agriculture and fisheries to the impacts of climate change	Provincial level agriculture and fishery sector vulnerability and risk assessment conducted nationwide
			National and provincial agriculture and fisheries climate information and database established
			Number of researches conducted on agriculture and fisheries adaptation measures and technologies developed
			Number of appropriate climate change adaptation technologies identified and implemented
		1.2. Climate-sensitive agriculture and fisheries policies, plans and programme formulated	Climate change responsive agriculture and fisheries policies, plans and budgets developed and implemented
			Number of climate change responsive agriculture-fisheries policies formulated and implemented
			Climate change actions-DRR Performance Monitoring Indicators developed and implemented
			Number and type of risk transfer (e.g. weather-based/ index insurance) and social protection mechanisms developed for agriculture and fisheries

OUTCOMES	IMMEDIATE OUTCOME	OUTPUT AREA	INDICATORS
Ultimate Outcome Enhanced adaptive capacity of communities and resilience of natural ecosystems to climate change	2. Enhanced resilience of agriculture and fishing communities from climate change	2.1. Enhanced capacity for CCA and DRR of government, farming and fishing communities and industry	Number of farmers and fisher communities trained on adaptation best practices and DRR
			Number and type of formal curricula and non-formal training programmes developed and implemented for agriculture and fisheries
		Intermediate Outcome Ensured food availability, stability, access and safety amidst increasing climate change and disaster risks	Number of farming and fishing communities with weather-based insurance
			Increase in the number of small farmers and fishers who are creditworthy

Source: Government of Philippines, 2011

Other priority areas and indicators are available for water sufficiency, environmental and ecological stability, human security, climate-friendly industries and services, sustainable energy, and knowledge and capacity development.

D2.2 Monitoring and evaluating the inclusion of fisheries and aquaculture in the National Adaptation Plan process

M&E under the NAP can focus on different aspects, namely: i. monitoring the adaptation planning process, ii. tracking the inclusion of fisheries and aquaculture into the process to formulate and implement the country's NAP; iii. monitoring mainstreaming of adaptation into fisheries and aquaculture policies, programmes and plans; and iv. tracking implementation and results of the adaptation actions. For the four main areas, it may be useful to follow the Progress, Effectiveness and Gaps (PEG) M&E Tool established by the LEG (2013) to monitor and evaluate progress, effectiveness and gaps in the formulation and implementation of the NAP. This tool enables the M&E of the ten essential functions of the process to formulate and implement a country's NAP (AC-LEG, 2016). Table 7 suggests a correspondence between these ten essential functions and some indicators that could be derived to track the inclusion and visibility of fisheries and aquaculture in the broader NAP. Tracking the impact of the fisheries and aquaculture adaptation actions would instead require understanding the global policy context with regards to reporting in adaptation M&E, including the Paris Agreement Article 14 on Global Stocktake and Article 13 on Transparency Framework. It should also build on concrete and ongoing national efforts to track adaptation outcomes and impacts of programmes, plans and policies at local and national levels. Extensive literature is available on the subject (see FAO and UNDP, 2018b) while the tools and resources to support the steps in Element D can be found in FAO, 2017a.

Moreover, there is a range of impact evaluation (IE) methods that enable programme managers and policymakers to plan interventions in a rational and evidence-based manner. IE methods are well established, data-driven and provide estimates that are widely accepted as reliable (Duflo *et al.*, 2007 and Gayer and Greenstone, 2009). With experimental and quasi-experimental techniques, programme managers and policymakers are better able to make choices that are oriented to adapting agriculture to a changing climate. Longer-term adaptation actions such as investments in large-scale infrastructure like irrigation canal networks may not lend themselves to IE easily since the time frames involved are very long (for more information on this topic see FAO and UNDP, 2018d).

TABLE 7

Examples of process indicators to track the mainstreaming of fisheries and aquaculture concerns to formulate and implement National Adaptation Plans

10 ESSENTIAL FUNCTIONS OF THE PROCESS TO FORMULATE AND IMPLEMENT NATIONAL ADAPTATION PLAN (AC-LEG, 2016)	EXAMPLES OF PROCESS INDICATORS TO TRACK THE REPRESENTATION OF FISHERIES AND AQUACULTURE CONCERNS IN THE BROADER NATIONAL ADAPTATION PLAN
1. (Government to) Provide national leadership and coordination of adaptation efforts at all levels and act as the main interface with regional and international mechanisms.	Evidence of effective representation and participation of fisheries and aquaculture in national adaptation efforts through appointed focal points and cell/task force. Evidence of the cell/task force's effectiveness and capacity to bring multiple stakeholders together and to coordinate fisheries and aquaculture adaptation across levels (community, local, national).
2. (The NAP process to) Collect, compile, process and disseminate data, information and knowledge on climate change and relevant development aspects in support of adaptation planning and implementation.	Depth of information and robustness of data on climate risks and impacts on fisheries and aquaculture systems and communities as well as general sectoral development information.
3. Identify and address gaps and needs related to capacity for the successful design and implementation of adaptation.	Extent to which gaps and capacity development needs in the fisheries and aquaculture sector at all levels are identified and catered for in capacity building plans.
4. Assess climate-development linkages and needs, and support the integration of climate change adaptation into national and subnational development and sectoral planning (through policies, projects and programmes).	Adequacy with which the adaptation needs of the fisheries and aquaculture sector are reflected in the broader NAP and in national/subnational level planning and policies and in fisheries and aquaculture planning.
5. Analyse climate data, assess vulnerabilities to climate change and identify adaptation options at sector, subnational, national and other appropriate levels.	Extent to which the exposure, sensitivity and contextual vulnerability of fisheries and aquaculture systems and communities are assessed and adaptation options investigated.
6. Appraise adaptation options to support decision making on adaptation investment plans and development planning.	Quality and extent to which fisheries- and aquaculture specific adaptation actions and investments are developed and tested.
7. Promote and facilitate the prioritisation of climate change adaptation in national planning.	Place of fisheries- and aquaculture-specific adaptation actions in the entire NAP portfolio of adaptation actions, including fisheries and aquaculture development planning.
8. Facilitate the implementation of adaptation at all levels through appropriate policies, projects and programmes taking into account opportunities for synergy.	Degree of climate change adaptation in fisheries and aquaculture supported through policies, strategies and projects. Existence and relevance of public-private partnerships for the fisheries and aquaculture sector.
9. (The NAP process to) Facilitate monitoring as well as review and update adaptation plans over time, to ensure progress and effectiveness of adaptation efforts and to demonstrate how gaps are being addressed.	Number of fisheries- and aquaculture related indicators in the cross-sectoral climate change adaptation M&E system.
10. Coordinate reporting and outreach on the NAP process to stakeholders nationally, internationally and formally on progress to the UNFCCC.	Extent to which awareness about the importance of adaptation in the fisheries and aquaculture sector has grown among stakeholders at national and international levels.

Sources: Developed from Climate Investment Funds, 2016; AC-LEG, 2016; FAO, 2017c.

NB: Fisheries and aquaculture adaptation actions referred to in this table are those emanating from the fisheries and aquaculture climate change adaptation plan process described in this supplement and are, therefore, assumed to be inclusive of the concerns and representative of the views of the stakeholders consulted throughout this process.

Anticipated outcomes of Step D2:

- ❑ A monitoring and evaluation strategy for the fisheries and aquaculture climate change adaptation plan.

Glossary

Definitions retrieved from the IPCC AR5 glossary (IPCC, 2014)

Adaptation – the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate change and its effects.

Adaptive capacity – the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Adaptive management – A process of iteratively planning, implementing and modifying strategies for managing resources in the face of uncertainty and change. Adaptive management involves adjusting approaches in response to observations of their effect and changes in the system brought on by resulting feedback effects and other variables.

Autonomous adaptation – Adaptation in response to experienced climate and its effects, without planning explicitly or consciously focused on addressing climate change. Also referred to as spontaneous adaptation.

Biomass – The total mass of living organisms in a given area or volume; dead plant material can be included as dead biomass.

Capacity building – The practice of enhancing the strengths and attributes of, and resources available to, an individual, community, society or organisation to respond to change.

Carbon dioxide (CO_2) – A naturally occurring gas, also a by-product of burning fossil fuels from fossil carbon deposits, such as oil, gas and coal, of burning biomass, of land use changes, and of industrial processes (e.g. cement production). It is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1.

Climate change – Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate variability – Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). See also Climate change.

Climatic driver (Climate driver) – A changing aspect of the climate system that influences a component of a human or natural system.

Community-based adaptation – Local, community-driven adaptation. Community-based adaptation focuses attention on empowering and promoting the adaptive capacity of communities. It is an approach that takes context, culture, knowledge, agency and preferences of communities as strengths.

Contextual vulnerability (Starting-point vulnerability) – A present inability to cope with external pressures or changes, such as changing climate conditions. Contextual vulnerability is a characteristic of social and ecological systems generated by multiple factors and processes.

Convection – Vertical motion driven by buoyancy forces arising from static instability, usually caused by near-surface cooling or increases in salinity in the case of the ocean and near-surface warming or cloud-top radiative cooling

in the case of the atmosphere. In the atmosphere, convection gives rise to cumulus clouds and precipitation and is effective at both scavenging and vertically transporting chemical species. In the ocean, convection can carry surface waters to deep within the ocean.

Coral bleaching – Loss of coral pigmentation through the loss of intracellular symbiotic algae (known as zooxanthellae) and/or loss of their pigments.

Dead zones – Extremely hypoxic (i.e. low-oxygen) areas in oceans and lakes, caused by excessive nutrient input from human activities coupled with other factors that deplete the oxygen required to support many marine organisms in bottom and near-bottom water.

Disaster management – Social processes for designing, implementing, and evaluating strategies, policies, and measures that promote and improve disaster preparedness, response, and recovery practices at different organisational and societal levels.

Ecosystem approach – A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. An ecosystem approach is based on the application of scientific methodologies focused on levels of biological organisation, which encompass the essential structure, processes, functions, and interactions of organisms and their environment. It recognises that humans, with their cultural diversity, are an integral component of many ecosystems. The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. Priority targets are conservation of biodiversity and of the ecosystem structure and functioning, in order to maintain ecosystem services.

Ecosystem-based adaptation – The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. Ecosystem-based adaptation uses the range of opportunities for the sustainable management, conservation and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change. Ecosystem-based adaptation is most appropriately integrated into broader adaptation and development strategies.

El Niño-Southern Oscillation (ENSO) – The term El Niño was initially used to describe a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with a basin-wide warming of the tropical Pacific Ocean east of the dateline. This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation. This coupled atmosphere-ocean phenomenon, with preferred time scales of two to about seven years, is known as the El Niño-Southern Oscillation. It is often measured by the surface pressure anomaly difference between Tahiti and Darwin or the sea surface temperatures in the central and eastern equatorial Pacific. During an ENSO event, the prevailing trade winds weaken, reducing upwelling and altering ocean currents such that the sea surface temperatures warm, further weakening the trade winds. This event has a great impact on the wind, sea surface temperature, and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world, through global teleconnections. The cold phase of ENSO is called La Niña.

Eutrophication – Over-enrichment of water by nutrients such as nitrogen and phosphorus. It is one of the leading causes of water quality impairment. The two most acute symptoms of eutrophication are hypoxia (or oxygen depletion) and harmful algal blooms. See also Dead zones.

Extreme weather event – An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as, or rarer than, the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme

climate event, especially if it yields an average or total that is itself extreme (e.g. drought or heavy rainfall over a season).

Food security – A state that prevails when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development, and an active and healthy life.

Flood – The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods.

Greenhouse gas (GHG) – Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and clouds. This property causes the greenhouse effect. Water vapor (H2O), carbon dioxide (CO_2), nitrous oxide (N2O), methane (CH4), and ozone (O3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO_2, N2O, and CH4, the Kyoto Protocol deals with the greenhouse gases sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Hypoxic events – Events that lead to deficiencies of oxygen in water bodies. See also Dead zones and Eutrophication.

Ocean acidification – Ocean acidification refers to a reduction in the pH of the ocean over an extended period, typically decades or longer, which is caused primarily by uptake of carbon dioxide from the atmosphere, but can also be caused by other chemical additions or subtractions from the ocean.

Outcome vulnerability (End-point vulnerability) – Vulnerability as the end point of a sequence of analyses beginning with projections of future emission trends, moving on to the development of climate scenarios, and concluding with biophysical impact studies and the identification of adaptive options. Any residual consequences that remain after adaptation has taken place define the levels of vulnerability.

Oxygen Minimum Zone (OMZ) – The midwater layer (200 to 1000 m) in the open ocean in which oxygen saturation is the lowest in the ocean. The degree of oxygen depletion depends on the largely bacterial consumption of organic matter, and the distribution of the OMZs is influenced by large-scale ocean circulation. In coastal oceans, OMZs extend to the shelves and may also affect benthic ecosystems.

Resilience – The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation

Risk – The potential for consequences where something of value is at stake and where the outcome is uncertain, recognising the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard.

Salt-water intrusion/encroachment – Displacement of fresh surface water or groundwater by the advance of salt water due to its greater density. This usually occurs in coastal and estuarine areas due to decreasing land-based influence (e.g. from reduced runoff or groundwater recharge, or from excessive water withdrawals from aquifers) or increasing marine influence (e.g. relative sea level rise).

Sea level change – Sea level can change, both globally and locally due to (1) changes in the shape of the ocean basins; (2) a change in ocean volume as a result of a change in the mass of water in the ocean; and (3) changes in ocean volume as a result of changes in ocean water density. Global mean sea level change resulting from change in the mass of the ocean is called barystatic. The amount of barystatic sea level change due to the addition or removal of a mass of water is called its sea level

equivalent. Sea level changes, both globally and locally, resulting from changes in water density are called steric. Density changes induced by temperature changes only are called thermosteric, while density changes induced by salinity changes are called halosteric. Barystatic and steric sea level changes do not include the effect of changes in the shape of ocean basins induced by the change in the ocean mass and its distribution.

Sea Surface Temperature (SST) – The sea surface temperature is the subsurface bulk temperature in the top few meters of the ocean, measured by ships, buoys, and drifters. From ships, measurements of water samples in buckets were mostly switched in the 1940s to samples from engine intake water. Satellite measurements of skin temperature (uppermost layer; a fraction of a millimetre thick) in the infrared or the top centimetre or so in the microwave are also used, but must be adjusted to be compatible with the bulk temperature.

Sensitivity – The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea level rise).

Storm surge – The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place.

Thermal expansion – In connection with sea level, this refers to the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence an increase in sea level.

Thermocline – The layer of maximum vertical temperature gradient in the ocean, lying between the surface ocean and the abyssal ocean. In subtropical regions, its source waters are typically surface waters at higher latitudes that have subducted and moved equatorward. At high latitudes, it is sometimes absent, replaced by a halocline, which is a layer of maximum vertical salinity gradient.

Upwelling region – A region of an ocean where cold, typically nutrient-rich waters well up from the deep ocean.

Vulnerability – The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

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Annexes

1. Examples of National Adaptation Plans including fisheries and aquaculture adaptation plans
2. Steps to determine ecosystem-based adaptation options for fisheries and aquaculture systems
3. Sub-steps and methodologies to prioritise adaptation options

Annex 1. Examples of National Adaptation Plans including fisheries and aquaculture adaptation plans

Australia

DAFF. 2010. *National Climate Change and Fisheries Action Plan 2009-2012*. Department of Agriculture, Fisheries and Forestry on behalf of the Natural Resource Management Ministerial Council. Commonwealth of Australia.

Burkina Faso

Government of Burkina Faso. 2016. *Burkina Faso National Climate Change Adaptation Plan (NAP)*. Ministry of Environment and Fishery Resources. (also available at www4.unfccc.int/nap/Documents/Parties/PNA_Version_version%20finale[Transmission].pdf).

Chile

Government of Chile. 2014. *Plan Nacional de Adaptación al Cambio Climático - Elaborado en el marco del Plan de Acción Nacional de Cambio Climático.* Gobierno de Chile. (also available at https://mma.gob.cl/wp-content/uploads/2016/02/Plan-Nacional-Adaptacion-Cambio-Climatico-version-final.pdf)

Government of Chile. 2015. *Plan de adaptación al cambio climático pesca y acuicultura. Subsecretaría de Pesca y Acuicultura (Ministerio de Economía, Fomento y Turismo) y Ministerio del Medio Ambiente (División de Calidad del Aire y Cambio Climático).* Gobierno de Chile. (also available at https://mma.gob.cl/wp-content/uploads/2016/12/Plan-Pesca-y-Acuicultura-CMS.pdf).

Denmark

Government of Denmark. 2008. *Danish strategy for adaptation to a changing climate*. The Danish Government. (also available at https://www.klimatilpasning.dk/media/5322/klimatilpasningsstrategi_uk_web.pdf).

European Union

EC. 2014. *Common Fisheries Policy of the European Commission*. (also available at https://ec.europa.eu/fisheries/cfp/).

France

Government of France. 2011. *French National Climate Change Impact Adaptation Plan 2011 – 2015*. Ministry of Ecology, Sustainable Development, Transport and Housing. (also available at https://climate-adapt.eea.europa.eu/metadata/publications/national-adaptation-plan-france-2011-2015).

Indonesia

Government of Indonesia. 2014. *National Action Plan for Climate Change Adaptation (RAN API).* Ministry of National Development Planning (BAPPENAS). (also available at https://www.acccrn.net/sites/default/files/publication/attach/ran-api_english_translation.pdf).

Japan

Government of Japan. 2015. *Climate Change Adaptation Plan of Ministry of Agriculture, Forestry and Fisheries*. (also available at https://www.maff.go.jp/e/policies/env/attach/pdf/index-9.pdf).

Kenya

Government of Kenya. 2016. *Kenya National Adaptation Plan 2015-2030: Enhanced climate resilience towards the attainment of Vision 2030 and beyond*. (also available at https://www4.unfccc.int/sites/NAPC/Documents%20NAP/Kenya_NAP_Final.pdf).

Peru

Government of Peru. 2016. *Documento síntesis del Diagnóstico de Vulnerabilidad Actual y Líneas de acción preliminar a la Estrategia de Adaptación*. Direccion General de Sostenibilidad Pesquera, ministerio de la Producción. (also available at https://www.produce.gob.pe/documentos/pesca/dgsp/publicaciones/diagostico-pesquero/Tomo-5.pdf).

Philippines

Government of Philippines. 2010. *National Framework Strategy on Climate Change 2010-2022*. Climate Change Commission. Manila. (also available at http://www.neda.gov.ph/wp-content/uploads/2013/10/nfscc_sgd.pdf).

Government of Philippines. 2011. *National Climate Change Action Plan 2011-2028.* Climate Change Commission. Manila.(also available at http://extwprlegs1.fao.org/docs/pdf/phi152934.pdf).

Senegal

Government of Senegal. 2016. *Plan d'adaptation de la Pêche et de l'Aquaculture. Plan national d'adaptation du secteur de la pêche face aux changements climatiques horizon 2035.* Ministère de la Pêche et de l'Economie Maritime, Sénégal. (also available at https://chm.cbd.int/api/v2013/documents/A0E18B74-831F-6EEB-3AAA-1A7C07F3F3AC/attachments/Plan%20National%20Adaptation%20Principal_2016.pdf).

South Africa

DAFF. 2015. *Climate change sector plan for agriculture, forestry and fisheries.* Department of Agriculture, Forestry and Fisheries, South Africa. (also available at https://www.greenagri.org.za/assets/documents-/SmartAgri/2017-uploads-of-SmartAgri/FurtherReading/DRAFT-CLIMATE-CHANGE-SECTOR-PLAN-FOR-AGRICULTURE-2015.pdf).

Sri Lanka

Government of Sri Lanka. 2016. *National Adaptation Plan for Climate Change Impacts in Sri Lanka 2016 – 2025.* (also available at https://www4.unfccc.int/sites/NAPC/Documents%20NAP/National%20Reports/National%20Adaptation%20Plan%20of%20Sri%20Lanka.pdf).

Annex 2. Steps to determine ecosystem-based adaptation options for fisheries and aquaculture systems

In order to determine which EBA options may a priori be suitable given the contextual information elicited so far and the adaptation goals agreed upon, the following sequential steps have been established (adapted from UNEP, 2012):

1. Identify the range of potentially appropriate measures to simultaneously treat identified problem(s) in each aquatic system and to achieve your context-specific adaptation goals.

   - Consider priority ecosystem services in your system to inform the selection of the range of potentially applicable treatment alternatives.
   - Review measures aligned to ecosystem services.
   - Carry out a pre-selection of measures that are deemed potentially appropriate to treat the identified problem(s) and meet the specified adaptation goals in each system. Note that this is not the prioritisation process per se (this is dealt with in section B5.2), but, if the list of potential adaptation options is long, it may help narrowing it down at this stage.

2. Consider making a checklist allowing you to assess if you have internal capacity to specify your adaptation options, or if you require external advice from relevant expert(s). For example, in the case of mangrove planting, it would involve considering whether:

   - you know the most appropriate species for your area of consideration;
   - you are aware of the optimal energy setting, density of planting, ongoing care requirements of the plants and areas to be replanted; and
   - you have enough local knowledge and/or stakeholder capacity to inform these questions.

If you can answer YES to these considerations, then it is likely that you have the capacity to make an informed decision with respect to discrete options to be employed in your context. If you answer NO to any of the above considerations, it is likely that you will require the input of an external expert to assist in translating generic measures into operational actions in your area of concern.

Annex 3. Sub-steps and methodologies to prioritise adaptation options

This Annex details the prioritisation process and organisation and presentation of information outlined in section B5.2.

Note: all the citations made in this Annex are listed in the references section of the main document.

Prioritisation process

Sub-step 1: Broad-brush evaluation of all pre-identified possible adaptation options
Several approaches can be considered to do this. Here we outline the SWOT, SCORE and problem structuring methods (PSM). Which to choose – whether individually or in combination – is left to the users of these guidelines.

A SWOT analysis identifies, for each adaptation option, its strengths, weaknesses, opportunities and threats for the prevalent fisheries and aquaculture activities concerned in each system to adapt to these drivers. Whilst strengths and weaknesses concern the adaptation option itself, opportunities and threats would relate to the positive and negative factors affecting the feasibility and implementation of the adaptation option. If chosen, it is important that this analysis be as specific as possible, for example, sub-divided according to the scale of each adaptation option and its spatial and temporal context. This exercise is based on known information and experiences, not the generation of new information. What is unknown (information/knowledge gaps) should be clearly marked as weakness, or as a threat, depending on the circumstances.

A related approach is the SCORE. Like in the SWOT, inner and external influences are considered, but it goes a step further by adding both a temporal and strategic dimension to the analysis through consideration of the present potential (strengths and challenges) and future sustainability (options, responses and effectiveness criteria) of an adaptation option. It is also more suited than a SWOT to identify potential gaps in resources where investments will be needed. Each possible adaptation option would need to be considered in turn, according to the five SCORE criteria.[13]

- **Strengths** / skills / support:
  - What do we think are the strengths of this option?
  - What skills and support (including resources) do we have to implement it? Which ones can we call on from others?
- **Challenges** / constraints / capabilities needed:
  - What issues are we facing with the implementation of the adaptation itself and in relation to other, external, factors?
  - What is likely to hold this option back, prevent any needed change?
  - How will we resolve or work around these constraints?
  - What new capabilities and support would we need? What would be needed to acquire them?
- **Opportunities** and risks:
  - What risks are likely to emerge and opportunities to be generated and seized in relation to the implementation of this adaptation option?
  - Given the strengths and challenges identified, is this adaptation option suitable over time?
- **Responses** / returns / rewards:
  - What are the probable or emergent consequences of action or inaction?
  - What responses can we expect from stakeholders (direct and indirect, at various scales) to the adaptation option?
  - What benefits are expected (weighed against risks)?
- **Effectiveness** / impact:
  - How can we optimise the use of resources to implement this adaptation option?
  - What benefits will it yield? To whom, what?
  - How predictable and reliable in yielding positive impacts will it be over time?
  - Will it create positive synergies with other forms of adaptation and development, and

[13] Adapted from Moore *et al.*, 2014 and http://weblog.tetradian.com/2013/06/29/checking-the-score/

across wider social-ecological systems? Are there possible negative cross-scale impacts that we should be aware of?

The criteria of the SCORE approach are usually scored based on the merit they present in terms of strengths and opportunities to overcome challenges, allowing for the most suitable options to stand out. This scoring system is detailed under sub-step 2; Selection of appropriate actions. Barbados has used the SCORE approach successfully in its scoping of options to green its economy, including its fisheries sector (Moore *et al*., 2014).

For each pre-selected adaptation option, both the SWOT and the SCORE processes should enable to highlight, to slightly different degrees:

- the knowledge, capacity (individual and institutional) and financial gaps and constraints;
- which additional stakeholders to engage with. (e.g. lack of engagement and consultation with irrigation and hydropower development authorities can have large implications for the type of adaptation options that freshwater aquaculture systems can adopt, tourism for coastal fisheries and aquaculture systems, transport and communications for oceanic fisheries systems);
- the potential barriers to planning, design and implementation of adaptation actions; and
- the most possible adaptation options, both now and in the future.

Another type of approach to help initiate the prioritisation of adaptation options is PSM. Climate change adaptation has been described as an unstructured or 'wicked problem' (Incropera, 2015) because it requires considering multiple actors and multiple perspectives, reconciling incommensurable and/or conflicting interests, and accounting for important intangibles and key uncertainties – all of which raise complex governance questions (Termeer *et al*., 2013). PSM can be more or less formal, ranging from brain storming, cognitive mapping and multi-criteria analysis to more advanced options such as strategic choice approach and strategic options development and analysis, developed specifically for problem structuring. Carried out in a group/workshop setting, these methods enable the joint exploration of a situation or issue and potential avenues to improve or solve it. PSM (Yearworth, 2015):

- are not mathematical, but structured and rigorous and based on qualitative, diagrammatic modeling;
- allow for a range of distinctive views to be expressed/explored/accommodated and allow for multiple and conflicting objectives;
- encourage active participation of stakeholders in the qualitative/visual modelling process, through facilitated workshops and cognitive accessibility;
- can facilitate the negotiation of a joint agenda and ownership of the implications of action;
- allow significant uncertainty to be expected and tolerated;
- operate iteratively; and
- aim for exploration, learning and commitment from stakeholders.

As such, these methods constitute a form of collaborative strategy, founded on stakeholder interactions, through which adaption options for specific climate change threats can be discussed for evaluation and prioritisation, whilst the inherent uncertainty and multiple benefits and constraints of each option are taken into account. Although diverging perspectives on the problems themselves and contextual external factors can strain collaboration (Head *et al*., 2016), these methods can work across scales and help with "reframing problems, and building bridges, in multi-level regional arrangements, as well as linking science, policy and community arenas in policy, planning and practice" (ibid., p. 91), which is what one needs for climate adaptation to be effective over the long term.

There are a large number of PSM applications in participatory forestry planning (Khadka *et al*., 2013), but less so in the context of fisheries. The visual and oral techniques upon which PSM rely (e.g. maps), which are aligned with participatory techniques and with the principles of participation, make them particularly amenable to low literacy contexts or engagement with groups of stakeholders of mixed status and abilities. While using PSM, power influences among the stakeholders involved should be kept in check as this may undermine collaborative efforts, particularly if adaptation options under consideration cut across institutional and geographical scales (Yearworth, 2015).

PSM can be used to consider the multiple facets of potential adaptation options for their prioritisation and to review, check and validate the characteristics of the climate impacts elicited during the previous steps of Element B according to the stakeholders' ultimate choice for integration in the NAP. This takes into account who the stakeholders and affected parties are,what their values are, as well as levels of uncertainty, key issues, influences from the external environments, constraints and opportunities for action and goals of adaptation. This validation process is likely to be useful and pave the way for the implementation of multi-criteria decision making analyses (MCSA) (Belton and Stewart, 2010) that can be used to help evaluate the most appropriate adaptation options amongst the list of prioritised ones (see sub-step 3; Fine-grained analysis).

Sub-step 2: Weighing and scoring the most appropriate adaptation options

The process of interpreting and weighing each option needs to be stakeholder-driven and tied to the overriding aims of the adaptation that needs to be achieved in each individual aquatic system considered. Stakeholder consensus is required to agree on what constitutes the most appropriate options for each system (UNEP, 2012). Thus, those options with the highest scores should be taken through to the next stage of prioritisation. Where the threshold lies (between those options that make it sub-step 3 and those that do not) should also be discussed and agreed upon among the stakeholders participating in the prioritisation exercise.

As in the previous step, it is essential that primary stakeholders – local men and women depending directly and indirectly on fisheries and aquaculture – be widely consulted in this process because they are at the frontline of climate change and will be the first involved and affected by the adaption options chosen.

All potential planned and autonomous adaptation options, for each individual aquatic system and fisheries and aquaculture activities, will have been elicited during the previous step. The idea here is to arrive at an evaluated and ranked list of the potential of each adaptation option, based on either assigned weights or scores, to decrease vulnerability to climate change, before a fine-grained analysis of the economic feasibility of each option is carried out (cf. sub-step 3 further).

Here we propose two slightly different approaches in support of prioritisation and identification of the most promising adaptation options: one based on weighing importance criteria and scoring adaptation options against these; the other based on scoring only, as a follow-up to the SCORE approach outlined above. Both approaches should be carried out during a workshop given the importance of stakeholder participation in this process.

Weighing and scoring

Weighing importance starts with the choice of criteria to which weights will be assigned for evaluating the pre-identified adaptation options. This should be done by the stakeholders participating in the exercise and, consequently, be context-specific. In Box A3.1, we suggest a number of such criteria. Although they are categorised in two broad groups of 'impact' and 'viability', the chosen criteria need to be aligned with the chosen goals of adaptation determined earlier as far as possible.

When criteria are chosen, it is important to bear in mind that they need the following characteristics (USAID, 2013; DCLG, 2009):

- Completeness: Have all important criteria been included?
- Redundancy: Are some criteria not necessary or redundant?
- Operationality: Are the criteria measurable or defined?
- Mutually independent: Is the performance of one option against a criterion independent of the performance of the same option against a second criterion?
- Double counting: Are two criteria counting the same issue?
- Size: Are there too many criteria?
- Impacts occurring over time: Are time-differentiated impacts adequately dealt with through the criteria?

Once the criteria for characterising adaptation actions have been agreed upon, giving a weight to each can be done by asking stakeholders to individually allocate a fixed number of points (e.g. 100) across all chosen criteria to reflect their importance, in general terms (not in relation to each potential adaptation option). The averages of allocated points constitute the weight, i.e. assigned importance. Standard deviations should

be considered as well, and openly discussed, to ensure that there is an overall consensus among stakeholders on the weights finally assigned.

Alternatively, the allocation of the number of points can be done jointly by all stakeholders, in a facilitated plenary session.

BOX A3.1 EXAMPLES OF GENERIC CRITERIA OF IMPORTANCE AGAINST WHICH POSSIBLE ADAPTATION OPTIONS IN FISHERIES AND AQUACULTURE CAN BE EVALUATED

IMPACT

- **Timing/urgency** for the adaptation action (which actions are required when, consequences of delays on vulnerability, addressing of short-, medium- and/or long-term impacts, possible sequential implementation).
- **Co-benefits/equity** generated by the adaptation action in terms of e.g. emission reductions as well as productivity and income increases (including who benefits and who loses, with gender, race and intergenerational equity considerations fully taken into account).
- **Side effects**, either positive or negative (impacts on the delivery of ecosystem services, including biophysical processes and livelihoods; secondary and cross-sectoral impacts and trade-offs).
- **Additional contribution and synergies** (potential to address other issues than climate resilience and fisheries and aquaculture sustainability, e.g. poverty reduction, wellbeing, strategic relevance to wider and long-term development goals).

VIABILITY

- **Efficacy** of the adaptation option (effective reduction of risks, taking into account uncertainty and different climate scenarios, fast and slow onset changes, prevention of irreversible damage).
- **Flexibility and/or robustness** of the adaptation action (possibility for adaptation action to evolve/remain fixed over time, if the system changes following adaptation, if impacts that are not initially anticipated occur and/or if external circumstances affect implementation).
- **Social and political acceptance/legitimacy**.
- **Barriers and capacity for implementation** (dependence on other sectors to adapt and improve too, such as water management, tourism, legislation).

NB: Economic dimensions are addressed more specifically further, under sub-step 3.

Source: Developed from LEG, 2012; Hahn and Fröde, 2011; World Bank, 2010a, 2009.

To evaluate each adaptation against each weighted criteria, stakeholders are then given a matrix and asked to assign a value from 1 (not at all) to 10 (completely) that reflects the extent to which they believe each criteria is effectively addressed by each adaptation option. For example, "will adaptation option 1 enable a timely response to the identified threat x?", "will adaptation option 1 have the capacity to generate co-benefits"? The scores (averaged if each participant has scored individually, or taken as such if this was done in plenary) of each adaptation option by criteria are then weighed by the criteria weights previously calculated. If deemed appropriate, the over-arching 'impact' and 'viability' criteria can be assigned an overall weight of 50 percent each, but this can be discussed depending on the stakeholders' perceptions and the number of categories. The results are then multiplied by 100 to normalise the weighted scores to a maximum value of adaptation options that can then be ranked by decreasing order of priority.

A number of Latin American countries used this approach to decide on their response strategies to climate change in the agriculture sector (World Bank, 2009).

Scoring (SCORE approach follow-up)
If the SCORE approach has been used earlier, each adaptation option evaluated could now be scored. Scoring can however also be carried out independently from this approach, for example to broadly assess adaptation options in terms of their achievability. It enables to measure each option in terms of the performance gap it represents (i.e. what is required to be filled for an adaptation action to fully achieve its objectives) and in terms of the importance of its combined effectiveness and potential to generate and seize opportunities. In this case, expert opinion may be used as an alternative to stakeholder consultation. This approach is outlined here. Barbados has used it successfully in the scoping of options to green its economy, including its fisheries sector, which was the subject of a specific scoring exercise (Moore *et al.*, 2014).

Each of the challenges identified during the SCORE exercise, ensuring that they cover not only resources limitations but also what needs to change (e.g. capabilities, services), are first attributed a score based on a one (very low) to ten (very high) point scale in relation to their frequency of occurrence or likelihood of impact. A number of other criteria could be used, as outlined earlier. The combination (i.e. multiplication) of these two scores (or more if more criteria are used) provides an overall value of the degree of acuteness of the challenge. Thus, a challenge with a value close to one would mean that it is perceived as not being acute to implement the adaptation action, one with a score close to ten,[14] as extremely acute.

The second element of the gap analysis is to assign a score to where the adaptation option currently stands, i.e. its strengths in addressing each challenge, with one suggesting that it does not currently have what is required to do so, and ten suggesting that it completely does. Subtracting the challenge scores from the strength scores for each challenge gives an idea of the potential of the adaptation action in overcoming each listed challenge: the larger the negative value, the larger the amplitude of the performance gap and efforts/investments that need to be deployed to fill it.

As for challenges, each opportunity that the adaptation option presents can be scored on a ten-point scale according to its likelihood of occurrence and likelihood of effectiveness. The scores of occurrence and effectiveness are then multiplied to obtain a quantified indicator importance (or attractiveness) for each opportunity and the possibility to rank them (the higher the number, out of 100, the higher the importance).

Sub-step 3: Fine-grained (economic) analysis and final decision of most appropriate options
The focus of this sub-step is on the economic, social and environmental feasibility of the adaptation options, i.e. costs and benefits, and on the adaptation options that have emerged as top candidates from the previous prioritising steps for inclusion in the fisheries and aquaculture climate change adaptation plan.

Estimating the costs and benefits of adaptation of each option is an integral but potentially complicated part of the prioritisation process, which is why it is dealt with separately here. It is important because it will ensure the visibility of fisheries and aquaculture adaptation options in the general NAP, where these options will be standing alongside those made for other sectors. However, it is also important to bear in mind that given the mostly small-scale nature of fisheries and aquaculture, the valuation of their benefits in terms of contribution to livelihoods and food security will be difficult to fully capture in economic analyses and, as a result, adaptation options may appear more costly (at least in the short-term) compared to those for other sectors.

While the previous prioritisation sub-steps 1 and 2 may have been carried out consultatively, for example within the confines of a stakeholder workshop, this fine-grained economic analysis itself is likely to require more time and expertise.

This expertise may be either in the cell overseeing the fisheries and aquaculture process to formulate

[14] After dividing the overall score by ten to normalise the scores and make them comparable with those of the next steps.

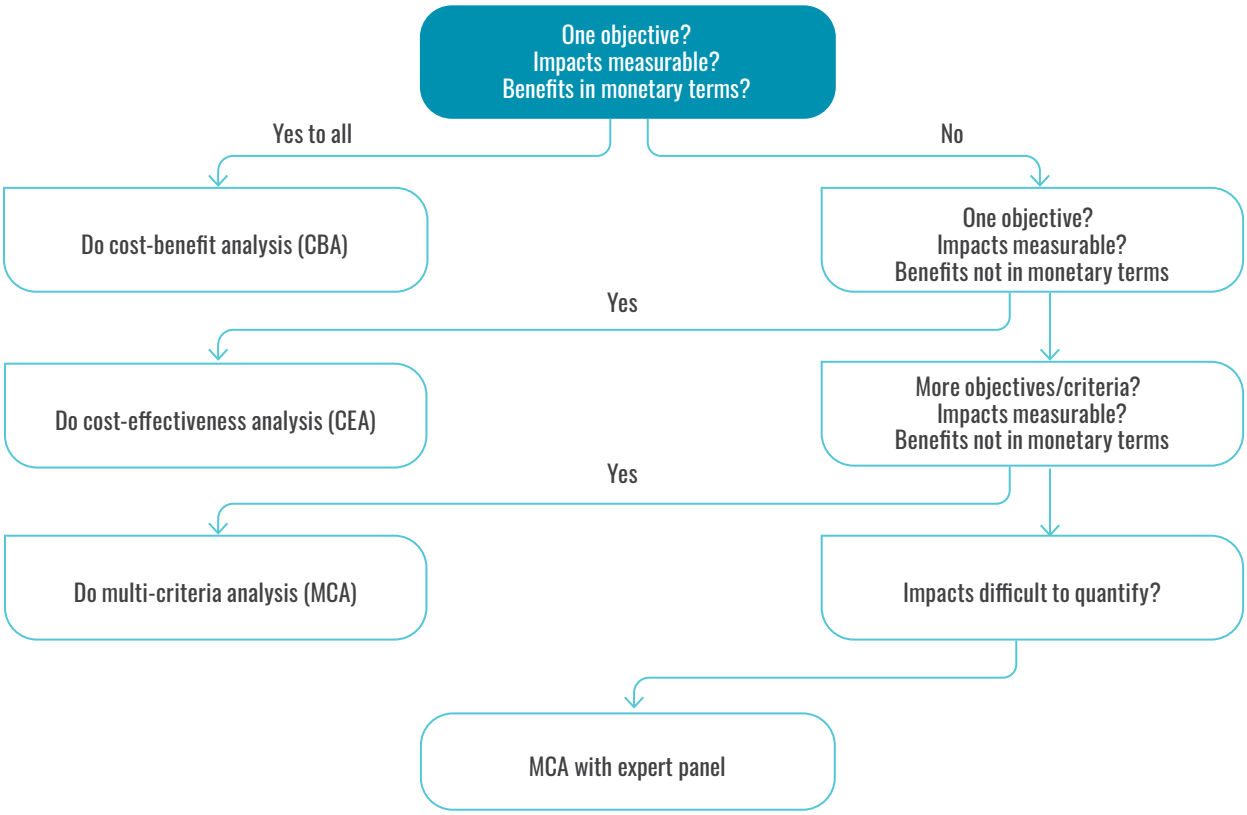
and implement NAP or outsourced. Although likely to be more appropriately expert-driven, consultation with stakeholders involved in the earlier steps of the prioritisation and/or the overall process to formulate and implement the fisheries and aquaculture climate change adaptation plan will be necessary to seek their views and endorsement of the findings of this analysis.

There are several methods to evaluate the costs of adaptation options. Their choice will be guided by the goals of adaptation (see section B4.2) and number of possible adaptation options elicited earlier (see sections B5.1 and B5.2), as well as data available.

Figure A3.1 provides a simplified decision tree guiding towards the choice of the most appropriate method.

Estimating the costs and benefits of adaptation needs to account for issues of uncertainty, equity (distributional impacts) and valuation (baselines, types of valuation, discount rates and time horizons), which are particularly acute in the context of climate adaptation. Some of the methods highlighted in Figure A3.1 are more or less adapted to handle these issues, which, as a consequence, make them more or less suited to the final appraisal of adaptation options (UNFCCC, 2011b; World Bank, 2010b). An overview of these methods can be found in Watkiss and Hunt (2013 – open access).

FIGURE A3.1 A (SIMPLIFIED) DECISION TREE OF POSSIBLE APPROACHES FOR ASSESSING THE COSTS AND BENEFITS OF ADAPTATION OPTIONS



Source: UNFCCC, 2011b

Because of the constraints in economic valuation of the benefits of fisheries and aquaculture, MCA or MCDA is likely to be the method of choice because it enables to overcome issues of quantification and valuation in monetary terms. Applied at this stage of the process, a MCA would follow on from the scoring and weighing of options carried out previously (these earlier steps are effectively the first step of a MCA), using as criteria those listed in Box A3.1 and the estimated costs and benefits – net or incremental – associated with each adaptation option, which may or may not be expressed in monetary terms.

The MCA will involve scoring the performance of each adaptation option against each of the selected criteria, standardising the scores obtained for the various criteria and assigning a weight to each criteria to reflect priorities. This will allow taking into account all the criteria both economic and non-economic in the prioritisation process. As always, it is important to be very clear about the intended outcomes of each adaptation option and how it meets the stated adaptation goals. If this is not clear for all options, step B4.2 (and those that follow) should be revisited as it will make the valuation (assigning numerical values and/or ranks) more difficult.

The mixed quantitative-qualitative nature of MCA makes it more suited for stakeholder interactions, for example in the context of a workshop during which the weighing and scoring is carried out, than other approaches such as CBA. Another advantage of MCA is that it enables conducting sensitivity analyses with different scores or weights: What would happen if…? How would the options then compare? Iteratively adjusting scores or weights allows to consider the range of possibilities and thus more explicitly account for different degrees of uncertainty in the decision-making process over the final choice of adaptation options.

MCA was the method of choice for LDCs for ranking adaptation options in the preparation of their National Adaptation Programmes of Action (NAPAs) (UNFCCC, 2011b), for example Rwanda in 20067 and Ethiopia in 2007.

Paterson *et al.* (2010) have piloted the use of MCA to bring stakeholders together in the evaluation of the effectiveness of the implementation of the EAF to the management of the South African sardine fishery. Although not in a fisheries context, De Bruin *et al.* (2009) have piloted it in the evaluation of a range of possible climate adaptation actions in the Netherlands.

Organising and presenting information

Summary tables can take many shapes. Ultimately, they will reflect the characteristics that will have emerged as important during the prioritisation process. Table A3.1, which reflects adaptation options chosen for capture fisheries in the U.K., emphasises the actors responsible for implementation and the different timeframes for action. It also illustrates the range of adaptation actions that have been considered throughout the entire capture fisheries sector, and how onerous each action will be (Garrett *et al.*, 2015).

TABLE A3.1 ADAPTATION ACTIONS CHOSEN FOR DOMESTIC CAPTURE FISHERIES IN THE UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND

Timescale for implementation		System	Adaptation action	Stakeholder	Resources needed			
					Minor	Moderate	Significant	Major
	Underway	Fishery	Development of training and education modules for fishers	Fishing into the Future (with Seafish)				
		Operations	Enhance operational safety (raised decks)	Industry				
			Enhance operational safety (training, personal floatation devices)	The Fishing Industry Safety Group, Seafish-approved training providers				
		Processing	Develop markets for available domestic seafood	Seafood Scotland				
	Immediate (< 2 yrs)	Ports	Ensure berth allocations for vulnerable vessels	Port/harbour authorities				
		Processing	Develop markets for available domestic seafood	Industry trade organisations				
	Short-term (2-5 yrs)	Fishery	Develop close science-industry collaboration and engaged research	Industry trade associations/ scientists				
		Fishery	Ensure quota swaps/ transfers	Industry				
		Operations	Keep a watching brief on climate change and potential responses	Industry trade associations				
		Ports	Improve port risk management	Port/harbour authorities				
		Processing	Establish specific seafood marketing organisations for rest of the United Kingdom of Great Britain and Northern Ireland	Industry trade organisations (e.g. Fishmongers Hall)				
	Medium-term (5-15 yrs)	Fishery	Developing a more robust, strategic fisheries knowledge base	Scientists/industry/Government				
		Fishery	Review of domestic quota allocation	European Union/United Kingdom of Great Britain and Northern Ireland Government/Fisheries scientists/industry				
		Operations	Review of fishing seasons in response to disruptions	Industry/Government				
	Long-term (> 15 yrs)	Fishery	Review 'Relative stability' (Governance) arrangements	European Union/United Kingdom of Great Britain and Northern Ireland Government /Fisheries scientists/industry				
		Operations	Assess vulnerability of fleets across the European Union	European Union research				
		Processing	Re-locate processing sites inland	Processors and planning inspectorate				

Source: Garrett et al., 2015

References

AC-LEG. 2016. An input to the discussions by the Adaptation Committee and the Least Developed Countries Expert Group at their meetings on their work in addressing the mandates contained in decision 1/CP.21, paragraphs 41 and 45. Desk Review by the Secretariat. Adaptation Committee Least Developed Countries Expert Group, 5 October 2016. AC-LEG/2016/2. (also available at https://unfccc.int/files/adaptation/groups_committees/adaptation_committee/application/pdf/ac-leg2_mandates.pdf)

Alarcón, C., Cubillos, L., Norambuena, R., Quiñones, R. & Gonzalez, E. 2013a. Desarrollo de un enfoque regional y propuestas de proyectos pilotos de adaptación al cambio climatico del sector pesca y acuicultura. Subsecretaría de Pesca y Acuicultura, Programa COPAS Sur-Austral, Valparaiso. (also available at http://www.subpesca.cl/portal/618/articles-81741_documento.pdf).

Alarcón, C., Cubillos, L., Norambuena, R., Montecinos, A., Neira, S., Quinones, R. & Gonzales, E. 2013b. Portafolio de propuestas para el plan nacional de adaptación al cambio climático del sector pesca y acuicultura. Subsecretarıa del Medio Ambiente - Ministerio del Medio Ambiente. (also available at http://portal.mma.gob.cl/ wp-content/doc/portafolio-propuestas-plan-nacional-adaptacion-CC-sector-pesca.pdf).

Badjeck, M.-C., Allison, E.H., Halls, A.S. & Dulvy, N.K. 2010. Impacts of climate variability and change on fishery-based livelihoods. *Marine Policy*, 34(3): 375-383. (also available at https://doi.org/10.1016/j.marpol.2009.08.007).

Barange, M., Bahri, T., Beveridge, M., Cochrane, K., Funge-Smith, S. & Poulain, F. eds. 2018. Impacts of climate change on fisheries and aquaculture - Synthesis of current knowledge, adaptation and mitigation options. Fisheries and Aquaculture Technical Paper. No. 627. Rome, FAO.

Barsley, W., De Young, C. & Brugere, C. 2013. Vulnerability assessment methodologies: an annotated bibliography for climate change and the fisheries and aquaculture sector. *FAO Fisheries and Aquaculture Circular*, No. 1083. FAO, Rome. (also available at www.fao.org/3/a-i3315e.pdf).

Belton, V. & Stewart, T. 2010. Problem structuring and multiple criteria decision analysis. In: M. Ehrgott, J. Rui Figueira & S. Greco, eds. *Trends in Multiple Criteria Decision Analysis*. Springer, pp. 209-239.

Brugere, C. 2015. Climate change vulnerability in fisheries and aquaculture: A synthesis of six regional studies. FAO Fisheries and Aquaculture Circular, No. 1104. FAO, Rome. Also available at http://www.fao.org/3/a-i4398e.pdf).

Brugere, C. & De Young, C. 2015. Assessing climate change vulnerability in fisheries and aquaculture: Available methodologies and their relevance for the sector. FAO Fisheries and Aquaculture Technical Paper No. 597. Rome, FAO. (also available at www.fao.org/3/a-i5109e.pdf).

Cattermoul, B., Brown, D. & Poulain, F., eds. 2014. *Fisheries and aquaculture emergency response guidance.*Rome, FAO. 167 pp. (also available at http://www.fao.org/3/a-i3432e.pdf).

CBD. 2009. Secretariat of the Convention on Biological Diversity (2009). Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. Montreal, Technical Series No. 41, 126 pages. (also available at www.cbd.int/doc/publications/cbd-ts-41-en.pdf).

Chang, Y., Lee, M.-A., Lee, K.-T., & Shao, K.-T. 2013. Adaptation of fisheries and mariculture management to extreme oceanic environmental changes and climate variability in Taiwan. ***Marine Policy***, 38: 476–482. (also available at http://doi.org/10.1016/j.marpol.2012.08.002).

Climate Investment Funds. 2016. PPCR Monitoring and Reporting Toolkit. Pilot Programme for Climate Resilience. (also available at https://www.climateinvestmentfunds.org/knowledge-documents/ppcr-monitoring-and-reporting-toolkit).

Climate Outreach and Adaptation Scotland. 2014. Communicating climate change adaptation. A practical guide to values-based communication. Adaptation Scotland/Government of Scotland, Edinburgh. (also available at http://climateoutreach.org/ resources/communicating-climate-change-adaptation-a-practical-guide-to-values-based-communication/)

Cochrane, K.; De Young, C.; Soto, D.; Bahri, T. eds. 2009. Climate change implications for fisheries and aquaculture: overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper. No. 530. Rome, FAO. 2009. 212p. (also available at www.fao.org/docrep/012/i0994e/i0994e00.htm).

Colgan, C.S. 2016. The economics of adaptation to climate change in coasts and oceans: Literature review, Policy implications and research agenda. *Journal of Ocean and Coastal Economics*, 3(2): Article 1. DOI: (also available at http://dx.doi.org/10.15351/2373-8456.1067).

Colls, A., Ash, N. & Ikkala, N. 2009. Ecosystem-based Adaptation: a natural response to climate change. Gland, Switzerland: IUCN. 16pp. (also available at https://www.iucn.org/content/ecosystem-based-adaptation-a-natural-response-climate-change).

DAFF. 2010. National Climate Change and Fisheries Action Plan 2009-2012. Department of Agriculture, Fisheries and Forestry on behalf of the Natural Resource Management Ministerial Council. Commonwealth of Australia.

DAFF. 2015. Climate change sector plan for agriculture, forestry and fisheries. Department of Agriculture, Forestry and Fisheries, South Africa. (also available at https://www.greenagri.org.za/assets/documents-/SmartAgri/2017-uploads-of-SmartAgri/FurtherReading/DRAFT-CLIMATE-CHANGE-SECTOR-PLAN-FOR-AGRICULTURE-2015.pdf).

Daw, T., Adger, W.N., Brown, K. & Badjeck, M.C. 2009. Climate change and capture fisheries: potential impacts, adaptation and mitigation. In K. Cochrane, C. De Young, D. Soto & T. Bahri, eds. Climate change implications for fisheries and aquaculture: overview of current scientific knowledge, pp. 107–150. FAO Fisheries and Aquaculture Technical Paper No. 530. Rome, FAO. 212 pp. (also available at http://www.fao.org/3/i0994e/i0994e00.htm)

DCLG. 2009. Multi-criteria analysis: a manual. Department for Communities and Local Government, London. (also available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/191506/Mult-crisis_analysis_a_manual.pdf).

De Bruin, K., Dellink, R.B., Ruijs, A., Bolwidt, L., van Buuren, A., Graveland, J., de Groot, R.S., *et al***.** 2009. Adapting to climate change in The Netherlands: an inventory of climate adaptation options and ranking of alternatives. Climatic Change, 95: 23-45. DOI 10.1007/s10584-009-9576-4. (also available at https://link.springer.com/article/10.1007/s10584-009-9576-4).

De Silva, S.S. & Soto, D. 2009. Climate change and aquaculture: potential impacts, adaptation and mitigation. In K. Cochrane, C. De Young, D. Soto & T. Bahri, eds. Climate change implications for fisheries and aquaculture: overview of current scientific knowledge, pp. 151–212. FAO Fisheries and Aquaculture Technical Paper No. 530. Rome, FAO. (also available at http://www.fao.org/3/i0994e/i0994e00.htm).

De Young, C., Hjort, A., Sheridan, S. & Davies, S. 2012. Climate change implications for fisheries of the Benguela Current region – Making the best of change. FAO/Benguela Current Commission Workshop, 1–3 November 2011, Windhoek, Namibia. FAO Fisheries and Aquaculture Proceedings. No. 27. Rome, FAO. 2012. 125 pp. (also available at http://www.fao.org/3/i3053e/i3053e.pdf).

De Young, C., Sheridan, S., Davies, S., & Hjort, A. 2012. Climate Change implications for fishing communities in the Lake Chad Basin. FAO/Lake Chad Basin Commission Workshop, 18–20 November 2011, N'djamena, Chad. FAO Fisheries and Aquaculture Proceedings. No. 25. Rome, FAO. 2012. 84 pp. (also available at http://www.fao.org/3/i3037e/i3037e.pdf).

Diei-Ouadi, Y. & Mgawe, Y.I. 2011. Post-harvest fish loss assessment in small-scale fisheries: A guide for the extension officer. FAO Fisheries and Aquaculture Technical Paper. No. 559. Rome, FAO. 2011. 93 p. (also available at http://www.fao.org/3/i2241e/i2241e00.htm)

Duflo, E., Glennerster, R., & Kremer, M. 2007. Using Randomization in Development Economics Research: A Toolkit. Handbook of development economics 4: 3895-3962.

EC. 2014. Common Fisheries Policy of the European Commission.

FAO. 1995. Code of Conduct for Responsible Fisheries. FAO, Rome. (also available at www.fao.org/fishery/code/en).

FAO. 2003. Fisheries management. 4. The ecosystem approach to fisheries. *FAO Technical Guidelines for Responsible Fisheries*, No. 4, Suppl. 2. FAO, Rome. (also available at www.fao.org/3/a-y4470e.pdf).

FAO. 2007. Building adaptive capacity to climate change. Policies to sustain livelihoods and fisheries. New Directions in Fisheries – A Series of Policy Briefs on Development Issues. No. 08. Rome. 16 pp. (also available at http://www.fao.org/3/a-a1115e.pdf).

FAO. 2009. Climate change implications for fisheries and aquaculture. FAO Fisheries and Aquaculture Technical Paper. No. 530. FAO, Rome. (also available at http://www.fao.org/3/i0994e/i0994e00.htm).

FAO. 2010. Aquaculture development. 4. Ecosystem approach to aquaculture. *FAO Technical Guidelines for Responsible Fisheries*, No. 5, Suppl. 4. FAO, Rome. (also available at www.fao.org/docrep/013/i1750e/i1750e00.htm).

FAO. 2013a. Report of the FAO/PaCFA Expert Workshop on Assessing Climate Change Vulnerability in Fisheries and Aquaculture: Available Methodologies and their Relevance for the Sector, Windhoek, Namibia, 8–10 April 2013. FAO Fisheries and Aquaculture Report No. 1047. (also available at www.fao.org/3/a-i3357e.pdf).

FAO. 2013b. Climate-Smart Agriculture Sourcebook. FAO, Rome. (also available at http://www.fao.org/3/i3325e/i3325e.pdf).

FAO. 2015. Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication. FAO, Rome. (also available at http://www.fao.org/3/a-i4356en.pdf).

FAO. 2016a. The Agriculture Sectors in the Intended Nationally Determined Contributions: Analysis. FAO, Rome. (also available at www.fao.org/3/a-i5687e.pdf).

FAO. 2016b. The State of Fisheries and Aquaculture: Contributing to food security and nutrition for all. FAO, Rome. (also available at www.fao.org/3/a-i5555e.pdf).

FAO. 2016c. The State of Food and Agriculture: Climate Change, Agriculture and Food Security. FAO, Rome. (also available at www.fao.org/3/a-i6030e.pdf)

FAO. 2016d. Climate change implications for fisheries and aquaculture: Summary of the findings of the Intergovernmental Panel on Climate Change Fifth Assessment Report. Text by Seggel, A., De Young, C. & Soto, D. FAO Fisheries and Aquaculture Circular, No. 122. FAO, Rome. (also available at www.fao.org/3/a-i5707e.pdf).

FAO. 2016e. Climate change and food security: Risks and responses. FAO, Rome. (also available at www.fao. org/3/a-i5188e.pdf)

FAO. 2016f. Case studies on climate change and African coastal fisheries: a vulnerability analysis and recommendations for adaptation options. Edited by Anderson, J. & Timothy, A. FAO Fisheries and Aquaculture Circular No. 1113. FAO, Rome. (also available at www.fao.org/3/a-i5612e.pdf).

FAO. 2017a. Addressing Agriculture, Forestry and Fisheries in National Adaptation Plans – Supplementary Guidelines. Text by Garcia, C., Karttunen, K., Meybeck, A. & Wolf, J. FAO, Rome. (also available at www.fao.org/3/a-i6714e.pdf).

FAO. 2017b. Adaptation strategies of the aquaculture sector to the impacts of climate change. Text by Bueno, P.B. & Soto, D. FAO Fisheries and Aquaculture Circular No. 1142. FAO, Rome. (also available at http://www.fao.org/3/a-i6943e.pdf).

FAO. 2017c. Tracking adaptation in agricultural sectors. FAO, Rome.(also available at www.fao.org/3/a-i8145e.pdf).

FAO. 2018. *The State of World Fisheries and Aquaculture 2018 – Meeting the sustainable development goals*. FAO, Rome. (also available at http://www.fao.org/3/I9540EN/i9540en.pdf).

FAO. 2019a. Addressing forestry and agroforestry in National Adaptation Plans: Supplementary guidelines, by A. Meybeck, V. Gitz and J. Wolf. *[in press at the time of writing, final citation is to be checked].*

FAO. 2019b. *FAO yearbook of fisheries and aquaculture statistics 2017.* FAO, Rome. (also available at www.fao.org/3/ca5495t/ca5495t.pdf).

FAO. 2019c. Assessing the role of agriculture and land use in the NDCs: A methodology. FAO, Rome. (also available at http://www.fao.org/3/CA5543EN/CA5543EN.pdf).

FAO. 2020. *The State of World Fisheries and Aquaculture 2020 – Sustainability in action*. FAO. Rome. (also available at https://doi.org/10.4060/ca9229en).

FAO and UNDP. 2018. Institutional capacity assessment approach for national adaptation planning in the agriculture sectors. Briefing note. FAO, Rome. (also available at www.fao.org/3/I8900EN/i8900en.pdf).

FAO and UNDP. 2018a. Cost-benefit analysis for climate change adaptation policies and investments in the agriculture sectors. Briefing note. FAO, Rome. (also available at http://www.fao.org/3/I8905EN/i8905en.pdf)

FAO and UNDP. 2018b. Advancing on monitoring and evaluation for adaptation in the agriculture sectors. FAO, Rome. (also available at http://www.fao.org/3/I9000EN/i9000en.pdf).

FAO and UNDP. 2018c. Promoting gender-responsive adaptation in the agriculture sectors: Entry points within National Adaptation Plans. FAO, Rome. (also available at www.fao.org/3/I8906EN/i8906en.pdf).

FAO and UNDP. 2018d. Using impact evaluation to improve policymaking for climate change adaptation in the agriculture sectors. FAO, Rome. (also available at www.fao.org/3/I8904EN/i8904en.pdf)

Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach *et al.* (Eds.) 2014. Climate Change 2014: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press. DOI: 10.1017/CBO9781107415379.

Garrett, A., Buckley, P., Brown, S. & Townhill, B. 2015. Climate change adaptation in UK seafood: Understanding and responding to climate change in the UK wild capture seafood industry. A joint Seafish/MCCIP summary. Seafish, Edinburgh. doi:10.14465/2015.sarps.001-016. (also available at https://www.seafish.org/media/1476670/climate_change_annex_lr2.pdf).

GIZ and IISD. 2014. Monitoring and evaluating adaptation at aggregated levels: A comparative analysis of ten Systems. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn. (also available at https://gc21.giz.de/ibt/var/app/wp342deP/1443/wp-content/uploads/filebase/me/me-guides-manuals-reports/GIZ_2014-Comparative_analysis_of_national_adaptation_M&E.pdf).

Government of Burkina Faso. 2015. *Burkina Faso National Climate Change Adaptation Plan (NAP).* Ministry of Environment and Fishery Resources. (also available at https://www4.unfccc.int/sites/NAPC/Country%20Documents/Parties/PNA_Version_version%20finale[Transmission].pdf).

Government of Denmark. 2008. Danish strategy for adaptation to a changing climate. The Danish Government. (also available at https://www.klimatilpasning.dk/media/5322/klimatilpasningsstrategi_uk_web.pdf).

Government of Ethiopia. 2007. Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. The Federal Democratic Republic of Ethiopia Ministry of Water Resources National Meteorological Services Agency. (also available at https://unfccc.int/resource/docs/napa/eth01.pdf).

Government of Japan. 2015. Climate Change Adaptation Plan of Ministry of Agriculture, Forestry and Fisheries. (also available at https://www.maff.go.jp/e/policies/env/attach/pdf/index-9.pdf).

Government of Peru. 2016. Documento síntesis del Diagnóstico de Vulnerabilidad Actual y Líneas de acción preliminar a la Estrategia de Adaptación. Direccion General de Sostenibilidad Pesquera, ministerio de la Producción. (also available at https://www.produce.gob.pe/documentos/pesca/dgsp/publicaciones/diagostico-pesquero/Tomo-5.pdf).

Government of Rwanda. 2006. National Adaptation Programmes of Action to Climate Change: NAPA-Rwanda. Ministry of Lands, Environment, Forestry, Water and Mines, Rwanda. (also available at www.unfccc.int/resource/docs/napa/rwa01e.pdf**).**

Government of Sri Lanka. 2016. National Adaptation Plan for Climate Change Impacts in Sri Lanka 2016 – 2025. (also available at https://www4.unfccc.int/sites/NAPC/Documents%20NAP/National%20Reports/National%20Adaptation%20Plan%20of%20Sri%20Lanka.pdf).

Government of French Republic. 2011. French National Climate Change Impact Adaptation Plan 2011 – 2015. Ministry of Ecology, Sustainable Development, Transport and Housing.

Government of Philippines. 2010. National Framework Strategy on Climate Change 2010-2022. Climate Change Commission. Manila. (also available at http://www.neda.gov.ph/wp-content/uploads/2013/10/nfscc_sgd.pdf).

Government of Philippines. 2011. National Climate Change Action Plan 2011-2028. Climate Change Commission. Manila. (also available at http://extwprlegs1.fao.org/docs/pdf/phi152934.pdf).

Government of the Republic of Chile. 2014. Plan Nacional de Adaptación al Cambio Climático - Elaborado en el marco del Plan de Acción Nacional de Cambio Climático. Gobierno de Chile. (also available at https://mma.gob.cl/wp-content/uploads/2016/02/Plan-Nacional-Adaptacion-Cambio-Climatico-version-final.pdf).

Government of the Republic of Chile. 2015. Plan de adaptación al cambio climático pesca y acuicultura. Subsecretaría de Pesca y Acuicultura (Ministerio de Economía, Fomento y Turismo) y Ministerio del Medio Ambiente (División de Calidad del Aire y Cambio Climático). Gobierno de Chile. (also available at https://mma.gob.cl/wp-content/uploads/2016/12/Plan-Pesca-y-Acuicultura-CMS.pdf).

Government of the Republic of Indonesia. 2014.National Action Plan for Climate Change Adaptation (RAN API). Ministry of National Development Planning (BAPPENAS). (also available at https://www.acccrn.net/sites/default/files/publication/attach/ran-api_english_translation.pdf).

Government of the Republic of Senegal. 2016. Plan d'adaptation de la Pêche et de l'Aquaculture. Plan national d'adaptation du secteur de la pêche face aux changements climatiques horizon 2035. Ministère de la Pêche et de l'Economie Maritime, Senegal. (also available at https://chm.cbd.int/api/v2013/documents/A0E18B74-831F-6EEB-3AAA-1A7C07F3F3AC/attachments/Plan%20National%20Adaptation%20Principal_2016.pdf).

Hahn, M. & Fröde, A. 2011. Climate proofing for development. Adapting to climate change, reducing risk. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn. (also available at https://www.adaptationcommunity.net/?wpfb_dl=34).

Head, B.W., Ross, H. & Bellamy, J. 2016. Managing wicked natural resource problems: The collaborative challenge at regional scales in Australia. *Landscape and Urban Planning*, 154: 81-92.

ICEM (International Centre for Environmental Management). 2013. USAID Mekong ARCC climate change impact and adaptation on fisheries. Prepared for the United States Agency for International Development. (also available at https://www.usaid.gov/asia-regional/documents/usaid-mekong-climate-change-study-main-report-2013).

IFAD. 2014. Guidelines for Integrating Climate Change Adaptation into Fisheries and Aquaculture Projects.International Fund for Agricultural Development, Rome. (also available at https://www.uncclearn.org/sites/default/files/inventory/ifad701.pdf)

Incropera, F.P. 2015. *Climate Change: A Wicked Problem*. New York, Cambridge University Press.

IPCC. 2014. Climate change 2014: Impacts, adaptation, and vulnerability. Intergovernmental Panel on Climate Change, Working Group II. (also available at https://www.ipcc.ch/report/ar5/wg2/).

IUCN. 2009. Ecosystem-based Adaptation: A natural response to climate change. International Union for Conservation of Nature and Natural Resources, Gland. (also available at https://portals.iucn.org/library/sites/library/files/documents/2009-049.pdf)

Johnson, J., Bell, J. & De Young, C. 2013. Priority adaptations to climate change for Pacific fisheries and aquaculture: reducing risks and capitalizing on opportunities. FAO/Secretariat of the Pacific Community Workshop, 5–8 June 2012, Noumea, New Caledonia. FAO Fisheries and Aquaculture Proceedings No. 28. Rome, FAO. 109 pp. (also available at http://www.fao.org/3/i3159e/i3159e.pdf).

Kam, S.P., Badjeck, M.-C., Teh, L. & Tran, N. 2012. Autonomous adaptation to climate change by shrimp and catfish farmers in Vietnam's Mekong River delta. WorldFish Working Paper 2012-24.

Karim, M. Castine, S. Brooks, A. Beare, D., Beveridge, M. & Phillips, M. 2014. Asset or liability? Aquaculture in a natural disaster prone area. *Ocean & Coastal Management*, 96: 188–197. (also available at https://doi.org/10.1016/j.ocecoaman.2014.04.021).

Kersting, D.K. 2016 Cambio climático en el medio marino español: impactos, vulnerabilidad y adaptación. Oficina Española de Cambio Climático, Ministerio de Agricultura, Alimentación y Medio Ambiente. Madrid, 166 pp. (also available at https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/kersting_2016_cambio_climatico_medio_marino_tcm30-70535.pdf).

Khadka, C., Hujala, T., Worlfslehner, B. & Vacik, H. 2013. Problem structuring in participatory forest planning. *Forest Policy and Economics*. 26: 1–11.

Lam, V.W.Y., Cheung, W.W.L., Swartz, W. & Sumaila, U.R. 2012. Climate change impacts on fisheries in West Africa: implications for economic, food and nutritional security. *African Journal of Marine Science*, 34(1): 103–117.

Lane, D.E. 2010. Is the current fisheries management toolbox sufficient to address climate change? In OECD. *The economics of adapting fisheries to climate change*, pp. 177–215. Paris, OECD Publishing. (also available at http://dx.doi.org/10.1787/9789264090415-9-en).

LEG (Least Developed Countries Expert Group). 2012. National Adaptation Plans. Technical guidelines for the national adaptation plan process. UNFCCC Secretariat. Bonn. Germany. December 2012. (also available at https://www4.unfccc.int/sites/NAPC/Guidelines/Pages/Technical-guidelines.aspx).

LEG (Least Developed Countries Expert Group). 2013. Development of a tool for monitoring, reviewing and assessing progress, effectiveness and gaps under the NAP process in LDCs: the PEG M&E Tool. By P. Latasi. UNFCCC Adaptation Committee workshop on the M&E of adaptation 9–11 September 2013, Nadi, Fiji. (slides). (also available at https://unfccc.int/sites/default/files/peg_tool_latasi.pdf).

Lumosi, C. & McGahey, D. 2016. Communicating climate change for adaptation: Challenges, successes and future priorities. Information Brief. Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA). International Development Research Centre, Ottawa. (also available at https://www.weadapt.org/knowledge-base/assar/communicating-climate-change-for-adaptation).

Mackay, A., Gallo, I., Husch, J. & Raksakulthai, V. 2015. Skills Assessment for National Adaptation Planning. How countries can identify the gap. United Nations Institute for Training and Research (UNITAR), Geneva. (also available at https://www.uncclearn.org/sites/default/files/inventory/nap16062015.pdf)

Magnan, A. 2014. Avoiding maladaptation to climate change: towards guiding principles. *S.A.P.I.EN.S: Surveys and Perspectives Integrating Environment and Society*, 7: art: 1 [online].[Cited 22 April 2018]. (also available at http://journals.openedition.org/sapiens/1680).

McConney, P., Charlery, J., Pena, M., Phillips, T., Van Anrooy, R., Poulain, F. & Bahri, T. 2015. Disaster risk management and climate change adaptation in the CARICOM and wider Caribbean region – Formulating a strategy, action plan and programme for fisheries and aquaculture. Regional workshop 10–12 December 2012, Kingston, Jamaica. FAO Fisheries and Aquaculture Proceedings. No. 35. FAO, Rome. 123 pp. (also available at http://www.fao.org/3/a-i4369e.pdf).

McNaught, R., Warrick, O. & Cooper, A. 2014. Communicating climate change for adaptation in rural communities: a Pacific study. *Regional Environmental Change*, 14:1491–1503.

Metzger, M.J. & Schröter, D. 2006. Towards a spatially explicit and quantitative vulnerability assessment of environmental change in Europe. *Regional Environmental Change*, 6(4): 201–216.

Miles, E. 2010. Fisheries management and governance challenges in a changing climate? In OECD. *The economics of adapting fisheries to climate change*, pp. 159–175. Paris, OECD Publishing. (also available at http://dx.doi.org/10.1787/9789264090415-8-en).

Mills, D., Béné, C., Ovie, S., Tafida, A., Sinaba, F., Kodio, A., Russell, A. *et al.* 2011. Vulnerability in African small-scale fishing communities. *Journal of International Development*, 23: 308–313.

Moreno, A. & Becken, S. 2009. A climate change vulnerability assessment methodology for coastal tourism. *Journal of Sustainable Tourism*, 17(4): 473–488.

Moore, W., Alleyne, F., Alleyne, Y., Blackman, K., Blenman, C., Carter, S., Cashman, A. *et al.* 2014. Barbados' Green Economy Scoping Study. Government of Barbados, University of West Indies - Cave Hill Campus, United Nations Environment Programme (UNEP). (also available at https://wedocs.unep.org/bitstream/handle/20.500.11822/8907/-Barbados'%20Green%20Economy%20Scoping%20Study-2014Barbados%20GESS%20study.pdf?sequence=3&amp%3BisAllowed=).

Nelson, S. 2012. Training Guide: Gender and climate research in agriculture and food security for rural development. Second edition. FAO and GCIAR CCAFS. 139 pp. (also available at http://www.fao.org/3/i3385e/i3385e.pdf).

Ogier, E.M., Davidson, J., Fidelman, P., Haward, M., Hobday, A.J., Holbrook, N., Hoshino, E. & Pecl, G.T. 2016. Fisheries management approaches as platforms for climate change adaptation: Comparing theory and practice in Australian fisheries. Marine Policy, 71: 82–93. (also available at https://doi.org/10.1016/j.marpol.2016.05.014).

Paterson, B., Isaacs, M., Hara, M., Jarre, A. & Moloney, C.L. 2010. Transdisciplinary co-operation for an ecosystem approach to fisheries. A case study from the South African sardine fishery. *Marine Policy*, 34: 782–794. (also available at https://doi.org/10.1016/j.marpol.2010.01.019)

Phillips, B.F. & Pérez-Ramírez, M., eds. 2018. *Climate Change Impacts on Fisheries and Aquaculture: A Global Analysis*. Hoboken (NJ), John Wiley & Sons Ltd.

Porter, J.R., Xie, L., Challinor, A.J., Cochrane, K., Howden, S.M., Iqbal, M,M., Lobell, D.B. *et al.* 2014: Food security and food production systems. In C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee *et al.*, eds. *Climate Change 2014: Impacts, Adaptation, and Vulnerability*, pp. 485–533. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK, Cambridge University Press.

Poulain, F., Himes-Cornell, A. & Shelton, C. 2018. Methods and tools for climate change adaptation in fisheries and aquaculture. In M. Barange, T. Bahri, M. Beveridge, K. Cochrane, S. Funge-Smith, F. Poulain, eds. Impacts of climate change on fisheries and aquaculture - Synthesis of current knowledge, adaptation and mitigation options. Fisheries and Aquaculture Technical Paper.Chapter 25, pp. 535-566. No. 627. Rome, FAO.

Price-Kelly, H. 2016. Financing National Adaptation Plans (NAP): Options for implementation. Targeted Topics Forum Report 2. International Institute for Sustainable Development, Winnipeg. (also available at http://napglobalnetwork.org/wp-content/uploads/2016/05/TTF2-Report.pdf)

Price-Kelly, H. & Hammill, A. 2016. sNAPhot: Domestic public finance for implementation of NAP. Overview Brief II. NAP Global Network Secretariat, International Institute for Sustainable Development, Winnipeg. (also available at http://napglobalnetwork.org/wp-content/uploads/2016/05/TTF2-Report.pdf)

Raemaekers, S. & Sowman, M. 2015. Community-level socio-ecological vulnerability assessments in the Benguela Current Large Marine Ecosystem. FAO Fisheries and Aquaculture Circular No. 1110. Rome, FAO. 120 pp. (also available at www.fao.org/3/a-i5026e.pdf).

Rathwell, K., Armitage, D. & Berkes, F. 2015. Bridging knowledge systems to enhance governance of environmental commons: A typology of settings. International Journal of the Commons, 9(2): 851–880. (also available at http://doi.org/10.18352/ijc.584).

Scienseed. 2016. Communicating climate change and biodiversity to policy makers. A guide by Scienseed SL for the Bern Convention (Council of Europe). (also available at https://rm.coe.int/168064e897)

Shelton, C. 2014. Climate change adaptation in fisheries and aquaculture – compilation of initial examples. FAO Fisheries and Aquaculture Circular No. 1088. Rome, FAO. 34 pp. (also available at http://www.fao.org/3/a-i3569e.pdf).

Soto, D. & Quiñones, R. 2013. Cambio climático, pesca y acuicultura en américa latina: Potenciales impactos y desafíos para la adaptación. Taller FAO/Centro de Investigación Oceanográfica en el Pacífico Sur Oriental (COPAS), Universidad de Concepción, Concepción, Chile. FAO Actas de Pesca y Acuicultura. No. 29. Roma, FAO. 335 pp. (also available at www.fao.org/docrep/018/i3356s/i3356s.pdf)

Spearman, M. & McGray, H. 2011. Making adaptation count. Concepts and options for monitoring and evaluation of climate change adaptation. GIZ and World Resources Institute (WRI), Washington D.C. (also available at www.wri.org/publication/making-adaptation-count)

Termeer, C., Dewulf, A. & Breeman, G. 2013. Governance of wicked climate adaptation problems. In J. Knieling & W.L. Filho, eds. *Climate Change Governance*. Climate Change Management, DOI: 10.1007/978-3-642-29831-8_3, Springer-Verlag, Berlin. (also available at https://link.springer.com/chapter/10.1007/978-3-642-29831-8_3).

Trinh, T., Tran, N. & Cao, Q. 2016. Climate-smart aquaculture: Evidences and potentials for northern coastal area of Vietnam. Working Paper No. 169. CCAFS Working Paper No. 169. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen. (also available at https://cgspace.cgiar.org/rest/bitstreams/78305/retrieve).

UNEP. 2012. Ecosystem-based adaptation guidance. Moving from principles to practice. Working Document: April 2012. UNEP, Geneva.

UNFCCC. 2011a. Ecosystem-based approaches to adaptation: compilation of information. Note by the secretariat. Subsidiary Body for Scientific and Technological Advice, Thirty-fifth session, Durban, 28 November to 3 December 2011, FCCC/SBSTA/2011/INF.8. (also available at https://unfccc.int/resource/docs/2011/sbsta/eng/inf08.pdf)

UNFCCC. 2011b. Assessing the costs and benefits of adaptation options: An overview of approaches. UNFCCC Secretariat, Bonn. (also available at https://unfccc.int/resource/docs/publications/pub_nwp_costs_benefits_adaptation.pdf)

UNFCCC. 2012. The national adaptation plan process: A brief overview. UNFCCC Secretariat, Bonn. (also available at https://unfccc.int/files/adaptation/application/pdf/nap_overview.pdf).

UNFCCC. 2018. Progress, experience, best practices, lessons learned, gaps, needs and support provided and received in the process to formulate and implement national adaptation plans. Synthesis report by the secretariat. FCCC/SBI/2018/INF.1

USAID. 2013. Analysing climate change adaptation options using multi-criteria analysis. African and Latin American Resilience to Climate Change (ARCC). US Agency for International Development, Washington, D.C. (also available at https://www.climatelinks.org/sites/default/files/asset/document/Multi-Criteria%2520Analysis_CLEARED_0.pdf).

Vadacchino, L., C. De Young & D. Brown. 2011. The fisheries and aquaculture sector in national adaptation programs of action: importance, vulnerabilities and priorities. FAO Fisheries and Aquaculture Circular. No. 1064. Rome, FAO. (also available at http://www.fao.org/3/i2173e/i2173e.pdf).

Viggh, A., Leagnavar, P. & Bours, D. 2015. Good practice study on principles for indicator development, selection, and use in climate change adaptation monitoring and evaluation. Climate-Eval. GEF Independent Office of Evaluation, GEF, Geneva. (also available at https://www.eartheval.org/sites/ceval/files/studies/Good-Practice-Study.pdf).

Watkiss, P. & Hunt, A. 2013. Method overview: Decision support methods for adaptation. Briefing Note 1. Summary of Methods and Case Study Examples from the MEDIATION Project. Funded by the EC's 7FWP.

World Bank. 2009. Building Response Strategies to Climate Change in Agricultural Systems in Latin America. The World Bank, Washington D.C. (also available at https://openknowledge.worldbank.org/handle/10986/12473).

World Bank. 2010a. Mainstreaming adaptation to climate change in agriculture and natural resources management projects. Guidance Note 6. The World Bank, Washington D.C. (also available at https://www.preventionweb.net/publications/view/17066).

World Bank. 2010b. Economic evaluation of climate change adaptation projects. Approaches for the agricultural sector and beyond. World Bank, Washington, D.C. (also available at http://documents.worldbank.org/curated/en/354331468176979682/pdf/554700WP0D1CC010Box349454B01PUBLIC1.pdf).

World Bank, FAO & IFAD. 2015. Gender in Climate-Smart Agriculture. Module 18 for the Gender in Agriculture Sourcebook. Rome. (also available at http://www.fao.org/3/a-i5546e.pdf).

Yearworth, M. 2015. Sustainability as a "super wicked" problem; opportunities and limits for engineerin methodology. In Proceedings of the 7th International Conference on Sustainable Development on Building and Environment (SuDBE). SuDBE. University of Bristol, UK. (also available at www.bristol.ac.uk/engineering/people/mike-yearworth/pub/34804388).

ADDRESSING FISHERIES AND AQUACULTURE IN NATIONAL ADAPTATION PLANS

[*Supplement to the UNFCCC NAP Technical Guidelines*]

*The **Addressing fisheries and aquaculture in National Adaptation Plans – Supplementary guidelines** provide specific guidance for national adaptation planning in the agricultural sectors. They are intended to be used by national planners and decision–makers working on climate change issues in developing countries and authorities and experts within the fisheries and aquaculture sectors who are contributing to climate change adaptation and NAP formulation and implementation.*

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