Climate risk assessment for fisheries and aquaculture-based adaptation in Myanmar: Technical report outlining the methodology and approach

WorldFish

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Table of Acronyms

AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
DoF	Department of Fisheries
DRR	Disaster Risk Reduction
FAO	Food and Agricultural Organisation
GEF	Global Environment Facility
GEF	Global Environment Facility
GIZ	Deutsche Gesellshaft für International Zusammenarbeit
HDI	Human Development Index
IHLCA	Integrated Household Living Conditions Assessment
IPCC	Intergovernmental Panel on Climate Change
LDCF	Least Developed Countries Fund
LoA	Letter of Agreement
MS-NPAN	Multi-Sectoral National Plan of Action on Nutrition
NAPA	National Adaptation Plan of Action
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Co-operation and Development
PRA	Participatory Rural Appraisal
SOBA	Ayeyarwady State of the Basin
ToR	Terms of reference
UNEP	United Nation Environment Program
UNFCCC	United Nation Framework Convention on Climate Change
UNU-EHS	United Nations University – institute for Environment and Human Security
VA	Vulnerability Assessment
WMO	World Meteorological Organisation
WWF	World Wildlife Fund

Executive summary

In 2012, the government of Myanmar developed a National Adaptation Plan of Action (NAPA) for climate change. The FishAdapt project aims to address the current barriers to delivering on the NAPA and more broadly as a contribution to addressing climate change impacts in the fisheries sector and its sub-sectors in Myanmar. The project's strategy is to assess and understand current vulnerabilities at different scales in a science-based, cross sector and participatory manner towards developing, planning and piloting new adaptation practices and technologies, and evidence-based policy recommendations.

WorldFish, contractually known as the service provider, was tasked through a letter of agreement (annexed) to *"identify national and regional sector priorities and gaps in support of VA methodology design under the FishAdapt project"*. The LoA was designed with a participatory and multi-sectoral approach in mind that incorporated stakeholder consultations at Union and State and Region (Ayeyarwady, Rakhine and Yangon) levels, in addition to expert consultations in Myanmar and Internationally, and a comprehensive desk-based assessment of global VA best practice for potential implementation in Myanmar.

Central to the findings of the consultations were the following three key issues; 1) non climate drivers (such as land use change and habitat degradation) were highlighted as key areas of concern with respect to vulnerability, 2) sector priorities have potential to impact (positively or negatively) on one another (such as water control infrastructure development e.g., irrigation and implications for river/habitat connectivity and fish migrations, and 3) responses/adaptation planning to climate and other non-climate hazards will almost always require an integrated multi-sector response (e.g., a small dam collapse required liaison between the irrigation department, the department for disaster risk reduction, the general administration division, the department for rural development and a number of others). Taken together these key findings alongside the overarching project goals and the barriers to delivering on the NAPA, justified the approach taken in the LoA and guided the design of the methodology itself.

Why a Risk Assessment approach to conducting the VA?

Building on these findings and a comprehensive review of the available methodologies and in consultation with the FAO and the Union and State/Region government sectors, the team propose, with some minor modifications, the AR5 IPCC 2014 Risk Assessment Approach to understanding exposure to hazards and vulnerability. The main reasons for adopting this approach can be summarised as follows:

- ✓ A step-wise, indicator-based approach with a reasonable degree of flexibility
- ✓ The approach assesses the vulnerability of the system (e.g. aquaculture) independently of its exposure to hazards thus allowing for an assessment of both climate and non-climate related drivers of vulnerability
- ✓ The risk assessment approach assesses what is termed 'contextual' vulnerability (i.e., a main focus of the approach is on the socio-economic conditions and institutional processes contributing to vulnerability) which allows for better inclusion of stakeholders

- ✓ Solutions proposed under this approach tend to focus on building adaptive capacity to climate and other hazards which can include technological but also institutional and inter-sectorial such as national/regional planning and policy measures.
- ✓ It follows latest state of climate science updates on understanding vulnerability from the IPCC 2014
- ✓ Provides opportunities to link with other related sectors such as Disaster Risk Reduction (DRR) by using the same concepts and terms
- ✓ Level of detail ('tiers') can incorporate different data scales presenting the opportunity to integrate the community consultations undertaken in 120 areas in the three states and regions and issues in data availability

Scope of the VA

The Risk Assessment will be conducted on three fisheries sub-sectors in Myanmar, namely inland fisheries, inshore fisheries, and aquaculture. These can potentially be refined into further sub-sectors (e.g. smallholder extensive aquaculture) if required dependent upon the objectives of any future assessments. A set of indicators have been selected for each of these sub-sectors to be further validated in consultation during implementation. Some indicators are applicable to all sub-sectors, others are specific to one sub-sector alone. The model we apply allows for a high degree of flexibility to include indicators specifically linked to one sub-sector and can easily be interchanged if another sub-sector or system becomes the scope of the analysis. The interchangeability of both the set of indicators and the weights would allow this method to be applied to sectors or systems outside the fisheries sector and to look at both climate- and non-climate-related drivers of vulnerability should this be desirable.

Scale

The scale chosen for this assessment will be the national level, through compilation of sub-national data. We propose to conduct the analysis at the state/region level in order to be able to pick up on regional differences vis-à-vis risk to a specific driver. This increases the data requirements, because data must be disaggregated at the state/region level, but also increases the level of detail and relevance to the regional situation. This could facilitate the design of adaptation plans relevant to the fisheries sector at sub-national level. Regarding data availability, some secondary data has already been collected and is publicly available, e.g. socio-economic data collected during the Integrated Household Living Conditions Assessment (IHLCA) in 2009-2010. Other secondary data exists but is not publicly available (e.g. fish production per state/region) and would need to be compiled at the state/region level. Data for some indicators doesn't exist and would either require primary data collection or to be based on expert opinion.

Timeframe

We propose that the Risk Assessment be conducted at 5-year intervals. Data for different indicators is being collected at different intervals. Some of the indicators are based on household census data, which are typically conducted every five years. Other indicators can be updated annually or biennially (e.g. fish production). Using a 5-year scale would allow the Government of Myanmar to update the national-level Risk Assessment every five years with the most recent data, without requiring additional data collection, providing a good reflection of the actual situation. Alternatively, the Government of Myanmar could set up a monitoring programme to collect data for the key indicators necessary to run the Risk Assessment annually in relation to the UNDP Human Development Index (HDI) and other assessments like the Ocean Health Index, which in effect measures the governance of ocean management at coastal national and sub-national levels.

Preface

FishAdapt is a project jointly funded by Global Environment Facility (GEF) and the Least Developed Countries Fund (LDCF) of the United Nations. This project was set up in order to address the challenges that the fisheries sector in Myanmar faces.[1]

In 2012, the government of Myanmar developed a National Adaptation Plan of Action (NAPA) for climate change. The FishAdapt project aims to address the current barriers to delivering on the NAPA and more broadly as a contribution to addressing climate change impacts on the fisheries sector in Myanmar. The main barriers that were identified were lack of resilient sector policies, lack of capacity and resources, and limited knowledge sharing and communication within the sector. The project's main objective is to assess and understand current vulnerabilities, pilot new adaptation practices and technologies, and information sharing.

The project is structured around four main components:

- "Component 1: Strengthen the National, Regional/State and Township level regulatory and policy frameworks to facilitate the adaptive capacities of the fisheries sector
- Component 2: Enhanced critical adaptation practices demonstrated by fishers and fishing communities in vulnerable coastal and inland water regions of Myanmar
- Component 3: Develop and apply adaptation models to strengthen the resilience of Myanmar's aquaculture sub-sector to the impacts of climate change
- Component 4. Knowledge management, monitoring and evaluation, training and scaling up adaptation practices, lessons learned development and dissemination"

Under component 1, a community level vulnerability assessment (VA) and set of adaptation plans will be conducted in 120 townships in the Ayeyarwady and Yangon Regions, and in Rakhine State. Additionally, a methodology (this report) will be developed by FAO in collaboration with WorldFish to conduct an assessment of the vulnerability of the fisheries sector at the regional and national level. A letter of agreement (LoA) Annex 1 describes in detail the terms of reference (ToR), summarised below, for this technical report.

Purpose for which the funds provided by FAO under this Agreement shall be used

The Services will contribute to the implementation of the project FishAdapt: Strengthening the adaptive capacity and resilience of fisheries and aquaculture-dependent livelihoods in Myanmar/ GCP/MYA/020/LDF with the objective to enable inland and inshore fishery as well as

[1] The fisheries and aquaculture sub-sectors are being stressed by several factors, of which climate change is clearly an important driver, although, increased pressure on the fisheries e.g., through Illegal, Unreported and Unregulated (IUU) fishing as well as a number of associated factors should not be underestimated.

aquaculture stakeholders to adapt to climate change by identifying, understanding and reducing vulnerabilities, piloting new practices and technologies, and sharing information.

Activities and Outputs

As part of the Letter of Agreement (LoA) between WorldFish and FAO, the following activities were carried out in preparation of the Climate Change Vulnerability Assessment methodology relevant to the fisheries and aquaculture sectors in Myanmar. A literature review of in-country and/or regional climate impact assessments focused on fisheries and aquaculture in order to gain a basic understanding of available methodologies. Multi-level stakeholder consultations were organised to gain an understanding of national/regional priorities, strategies, and policies related to fisheries and aquaculture relevant to climate change impacts. Information gathered through the literature review and the consultations is compiled and analysed to support development of a methodology relevant to Myanmar's fisheries and aquaculture context. Following the identification of potential methods and tools, data availability and data quality was assessed to determine data gaps and potential data collection. The methodology, relevant tools and data context are summarised in a final technical report, spelling out the process leading up to the development and selection of the methods and tools, applicability and relevance to the FishAdapt project.

Definitions (IPCC AR5, 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 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.

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 forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

Coping capacity: The ability of people, institutions, organizations, and systems, using available skills, values, beliefs, resources, and opportunities, to address, manage, and overcome adverse conditions in the short to medium term.

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

Fisheries sector: comprises three capture subsectors (offshore, inshore and inland) plus three aquaculture sub-sectors (marine, brackish and freshwater). There are further sub-divisions in terms of commercial and artisanal activities together with the intensity of aquaculture production.

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

Impacts: Effects on natural and human systems. In this report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.

Resilience: The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing 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, recognizing 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.

Transformation: A change in the fundamental attributes of natural and human systems. Within this summary, transformation could reflect strengthened, altered, or aligned paradigms, goals, or values towards promoting adaptation for sustainable development, including poverty reduction.

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.

Social-ecological system: complex 'systems of people and nature, emphasising that humans must be seen as a part of, not apart from, nature'. (Berkes and Folke 1998)

1. Background

The climate in Myanmar is already changing, based on actual field measurements (not predictive models) from 19 weather stations across the country, the average temperatures have increased by 0.25°C between 1981 and 2010. Inland areas have seen a faster increase than coastal areas and the daily maxima have increased more than daily average temperatures. Rainfall patterns are also changing, with coastal areas seeing an increase an annual rainfall spread out across the year, whereas in inland areas there has been more rain during the monsoon season. Summer monsoon has shortened by one week as suggested by a study by Lwin (2002).

Projections for the coming decades show that the increasing temperatures will increase even more, between 1.3°-2.7°C by 2050. There will also be an increase in extreme heat days, up to potentially 17 days per year. In the period 1981-2010 there was on average only one day of extreme heat per year. Furthermore, a projected increase in rainfall during monsoon and sea level rise are also expected to take place by the middle of the 21st century (WWF, 2017). WorldFish has documented fishpond surface temperatures of 36°C and 32°C at 2.5 m depth with concomitant reduced oxygen saturation resulting in fish mortalities in May 2019.

Germanwatch, in their annual Climate Risk Index (2019), have ranked Myanmar third in the list of countries most affected by natural disasters in the period 1998-2017. As part of the National Adaptation Programme of Action, an overview was presented of the regions and sectors deemed most vulnerable to the effects of climate change (figure 1).

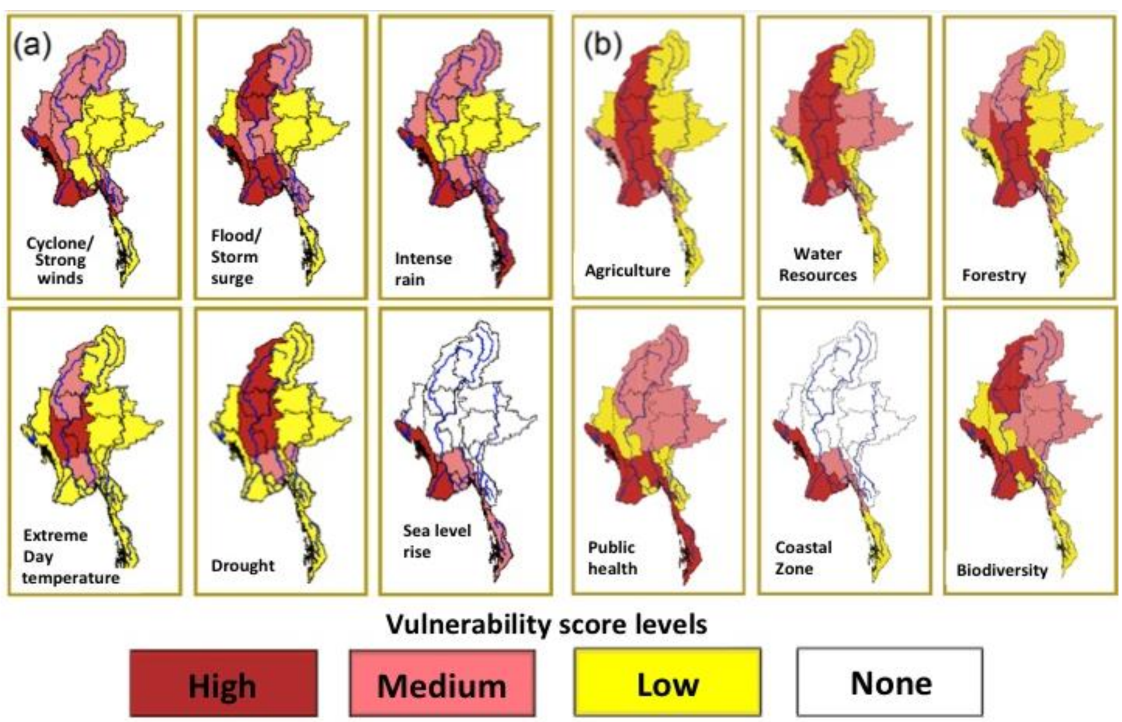

Figure 1: Map highlighting climate risk for specific hazards (a) and sectors (b), taken from the Myanmar National Adaptation Programme of Action

These vulnerability maps are based on expert opinion and previously conducted studies. The planned national vulnerability assessment will be helpful to provide a more detailed analysis of vulnerability in the specific regions and sectors more tailored to the FishAdapt project goals. There are many ways that Vulnerability Assessments can be used, especially when targeting climate change specifically. Overall, the main purpose of conducting a vulnerability assessment is to improve the targeting and effectiveness of adaptation measures by those operating in the fisheries sector.

Fisheries in Myanmar a brief overview

Myanmar is a country located in Southeast Asia and has a surface area of 676,578km^2 (of which 23,070km^2 is water) making it the second largest in the region behind Indonesia. The coastline is 1,950km long with around 25 thousand fishing vessels registered. Fisheries and aquaculture are important sub-sectors in Myanmar. The total production of fish in 2018[2] was 5,877,000 MT, of which 54% was from marine fisheries, 21% from open fisheries, 19% from aquaculture, and 6% from leasable fisheries, (DoF 2019).

Aquaculture ponds covered a total area of 491,345 acres (198,840 ha) and had a production of 1.13 million MT. The main aquaculture producing regions are Ayeyarwady Region, Rakhine State, and Yangon Region. Rakhine state almost exclusively registered shrimp ponds, in Ayeyarwady and Yangon both fish and shrimp ponds were recorded.

There are 3,342 leasable fishing areas in the country, producing 341,000 MT. Open fisheries had a production of 1,253,000 MT bringing the total of freshwater fisheries production to 1,594,000 MT (please see earlier reference to the SOBA report 2018). In the WorldBank report on capture fisheries (Kelleher *et al.*, 2012), it was shown that over half of the total fish catch in developing countries comes from the small-scale fisheries sub-sector. Despite the fact that recent assessments have suggested inland capture fisheries generate around half the tonnage recorded in the annual statistics, there is evidence of a considerable 'hidden harvest' (unrecorded landings) which in the case of Myanmar's inland fisheries may be as high as 200,000MT per annum. If the latter is correct the total inland fisheries sub-sector landings could be around 1 million MT. This would rank Myanmar in 4th place globally behind China, India and Bangladesh (FAO 2018).

Fish is an important export product for Myanmar. In 2017-2018 fish exports totalled 568,227 tonnes for a total value of 712 million US$. The most important exported species are rohu, mud crab, ribbon fish, and hilsa. Fishmeal is also an important export product, coming fourth in terms of tonnage and export earnings. China and Thailand are the main destinations for Myanmar fish exports.

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[2] These figures are disputed by the State of the Basin Analysis (SOBA) report suggesting levels much lower than the DoF statistics with approximately 33% coming from each of the three major sub-sectors: marine capture; inland capture and aquaculture (SOBA Fisheries 2018).

Fish is not only important as an export product; it is also important as a source of food on the domestic market. It is the second most important food item, after rice. Estimates by the DoF for 2017-2018 show that fish supply is 66kg/capita. This was estimated by taking total fish production in the country and subtracting exports and non-food uses. Reports by Belton *et al.* (2016) and Young *et al*. (2018) estimated that fish consumption in 2010 was 18.9 and 20.8kg per capita respectively, based on household survey data. However, there can be a large disparity in availability across social classes and geographic locations. Poorer sections of the population have less access to fish than better-off households (Dubois *et al.*, 2019).

Fisheries is also an important contributor to livelihoods with according to McCartney et al (2015) fisheries provide 15 million people in Myanmar with an income. From a labour perspective DoF statistics for 2014-2015 show that around 3.2 million people are engaging in fisheries or aquaculture, either full-time or occasionally.

2. Literature review

In this section we present the findings of an in-depth literature review leading to the selection of a methodological approach and set of tools to conduct a national vulnerability assessment in support to the FAO project FISHADAPT "Strengthening the adaptive capacity and resilience of fisheries and aquaculture-dependent livelihoods in Myanmar"(GCP/MYA/020/LDF) in June 2019.

A number of publications provide an overview of vulnerability assessment concepts and methodologies in the context of fisheries (a key reference used was the "A*ssessing climate change vulnerability in fisheries and aquaculture: Available methodologies and their relevance for the sector*" published by the FAO in 2015 using 6 case studies in various contexts). This document aims to draw from and build on this earlier work to assist the decision-making process in line with the specific objectives of the FISHADAPT vulnerability assessment design.

The methodologies presented in this review were assessed using a list of selected criteria, which was compiled with inputs from various experts on Myanmar and on the fisheries sector. There are 43 criteria, grouped under 8 categories. Additionally, pros and cons of each method are listed to highlight the overall approach, what framework was used, and features that make them unique. (Annex 2: Table example for the methodological review).

1. Geographical location (where is it taking place)
2. Research questions and objectives
3. Ecosystem targeted
4. Sectors addressed (what is it looking at, which vulnerabilities are considered)
5. Themes addressed (what are the themes addressed in the methodology, are the focuses related to our VA)
6. Scale of the VA (what geographical scale is considered)
7. Scope of the VA (how broad is the assessment)
8. Credibility of the methodology (how rigorous and acknowledge are they)

+ Pros for this methodology
+ Cons for this methodology

The framework that was used also considered pros and cons as well as some "particularities" that could be interesting to consider in the FishAdapt context, or things that are unique among the reviewed methodologies. (Annex 3: Reviewed methodologies Framework and interesting particularities)

General background

Over the last few decades many factors have contributed to bringing climate change vulnerability and risk centre stage in the development sector. In addition to the well-documented and recognised challenges that are caused by climate variability, many anthropogenic stressors reinforced the need of a better understanding of the combined impacts on different systems. The 80s witnessed an unprecedented industrial expansion and associated pollution, land-use changes at larger scales and many other environmental stressors. These acted as catalysts on the already on-going climate change impacts and made longer-term risk assessments more and more relevant and revealed the need for a deeper understanding and definition of system vulnerability.

According to Sharma *et al.* (IHCAP, 2018), with this evolution, the timeframe of application of vulnerability shifted from "post-hazard" to "ante-hazard" in order to increase different systems' resilience by increasing their capacity to adapt and reducing their sensitivity.

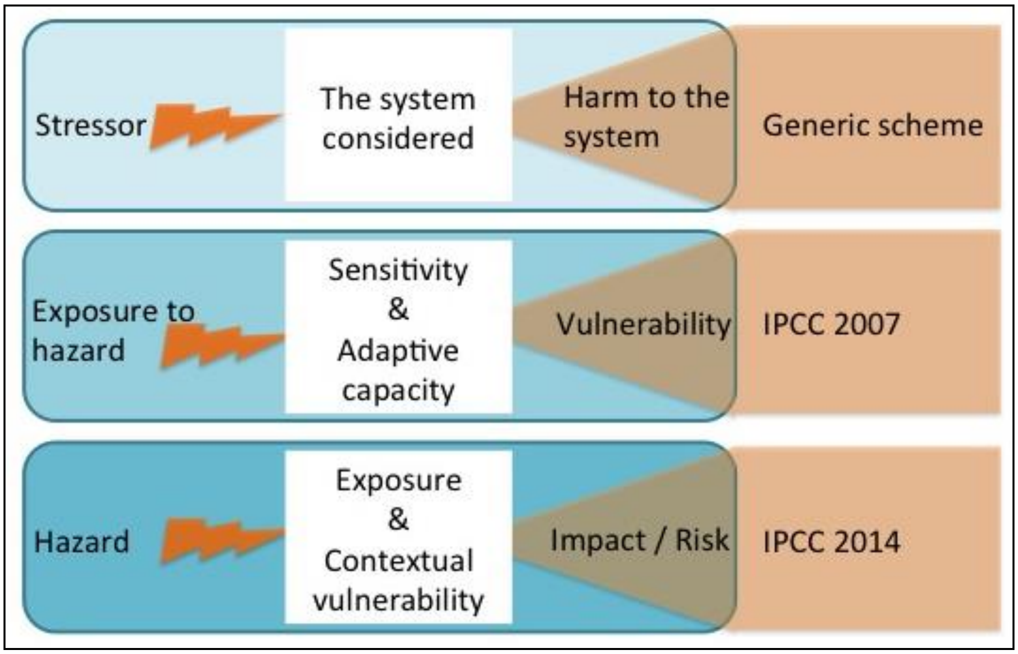

Figure 2: General evolution of the vulnerability approaches (based on ERAC 2014)

The definition of vulnerability most commonly used across methodologies is the IPCC AR4 (2007) definition, where vulnerability is defined as a combination of sensitivity, exposure, and adaptive capacity. The Intergovernmental Panel on Climate Change (IPCC) is an intergovernmental organisation open to all the member states of the United Nations. IPCC was founded in 1988 in a joint effort by United Nations Environment Program (UNEP) and the World Meteorological Organisation (WMO) and formalised through a UN resolution. IPCC currently counts more than 190 countries as members and is the leading international body for the assessment of climate change, including the physical science of climate; impacts, adaptation, and vulnerability; and mitigation of climate change. The IPCC assesses scientific articles in order to provide a comprehensive summary of the state of knowledge on drivers of climate change, its impacts and future risks, and how adaptation and mitigation can reduce those risks. Through its assessments, the IPCC evaluates scientific, technical, and socio-economic information, in an unbiased, methodical, clear, and objective manner, in order to understand the risks associated with human-induced global warming, to identify the potential impacts of this change, and to consider potential adaptation and mitigation strategies in order to highlight the areas where scientific consensus is reached and to indicate where further research is necessary.

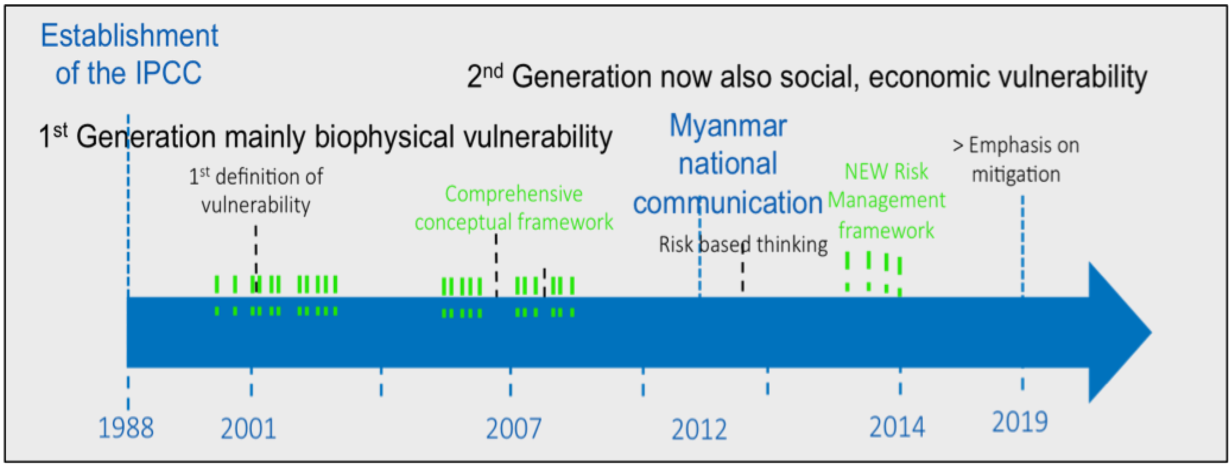

Figure 3: Evolution of the Vulnerability approach and the IPCC

General findings

As mentioned, the definition of vulnerability most commonly used across methodologies is the IPCC AR4 (2007) definition, where vulnerability is defined as a combination of sensitivity, exposure, and adaptive capacity. The factors contributing to vulnerability that were added most often were biophysical factors, political context, and adaptive capacity variables. The use of climate change scenarios, assessments of fisheries governance, or inter-sectoral approaches was less common although it is still incorporated to a certain degree in most methodologies. Issues related to water management as well as the government's position and vulnerability against impacts of climate change on fisheries are poorly addressed.

Vulnerability assessments of the fisheries and aquaculture sub-sectors have mainly targeted inland and coastal fisheries, or inland aquaculture. Coastal aquaculture is rarely addressed, and when it is, only in countries where it is already well-established. In terms of ecological zones, freshwater, brackish, and marine ecosystems are evenly represented, often assessed at the national scale using a series of community-based approaches. Assessments at the sub-national level are rare. It is important to note here that Myanmar is barely represented although it belongs to the top ten of freshwater-fish-producing countries. This is where the FishAdapt methodology could fill a clear gap in the knowledge base, by assessing the vulnerability of the fisheries and aquaculture sub-sectors at a sub-national level in Myanmar.

The different objectives and situations for which a vulnerability assessment is used is reflected in the diversity of approaches and methodologies. There is quite a range of diverse frameworks, despite most of them being (directly or indirectly) based on the IPCC framework (AR4, 2007 or AR5, 2014). The main differences are found in the way each of the individual components of vulnerability is assessed or what scale and themes are focussed on.

Under the IPCC 2007 framework, indicators of vulnerability are grouped under diverse categories such as socio-economic and livelihood vulnerability, technological vulnerability, biophysical vulnerability, institutional vulnerability, and adaptability vulnerability.
In 2014, the IPCC changed the understanding of vulnerability by moving to a risk-based conceptual framework for disaster risk management; vulnerability is presented in the overall risk management framework as one of three components (the other two are Exposure and Hazard) that give rise to risk. The Exposure component is separated from vulnerability in this new framework, and the vulnerability is composed of two components: Sensitivity and Adaptive Capacity.

The thematic scope of the different approaches is quite broad, some focus on specific sub-sectors (marine fisheries, inland fisheries, coastal fisheries), some focus on specific ecosystems (inland and brackish zones, marine areas) and this either in a very general way or applied to specific communities. Very few methodologies cover the sub-sectors of interest to the FishAdapt project (fisheries and aquaculture) at the desired scale (sub-national or national). In most cases it is one or the other, either the sub-sector, but at community level, or the sub-national scale but not focussed on fish-related sub-sectors. (Annex 4: short summary of the methodology review)

Schools of thought

There are three main schools of thought when it comes to understanding vulnerability of a system. These are: political ecology or economy approach, the risk-hazard approach, and the resilience approach. The **political ecology or economy** approach mainly centres around the political dimension of vulnerability, highlighting social inequalities and potential conflict areas within society. It is based mainly on socio-economic, cultural, and institutional factors and looks at social dynamics and differential impacts and adaptive capacities. The **resilience** approach considers human activities as only one of the driving factors and one of the affected species, the main focus is on the impact on the larger geographical space. The **risk-hazard** approach uses biophysical threats as the starting point of the analysis and aims to understand, at a broad scale: where the vulnerabilities lie, what the consequences are, and when those impacts might occur.

These schools of thought fit under two broad perspectives of looking at vulnerability: outcome vulnerability and contextual vulnerability. **Outcome vulnerability** mainly assesses the impacts of future climate change-related events as drivers of vulnerability. **Contextual vulnerability** looks at how the current system will be affected by (future) climate change events. Outcome vulnerability mainly tries to determine who or what will be affected and what the outcomes are, whereas contextual vulnerability is mainly concerned with the processes contributing to vulnerability.

Given the multi-scale approach of the VAs to be conducted under the FishAdapt project integrating the two approaches will likely deliver a ‘win win’ scenario with the benefits of both systems applied at the different scales; outcome focus and its strengths when applied in a community setting for adaptation planning such as in the 120 community assessments in the three target states and regions, and using the contextual approach at state/region and national scale in support of policy recommendations on systems, sectors and processes.

Outcome and contextual vulnerability approaches compared and contrasted.

Outcome and contextual vulnerabilities are considered as the two major approaches in the vulnerability understanding.

The two frameworks are illustrated below with the Figure 5, it shows that one is considering vulnerability as the result an exposure to "climate variability", while the other-one is considering the vulnerability as being a part of contextual conditions exposed to various changes (including climate change).

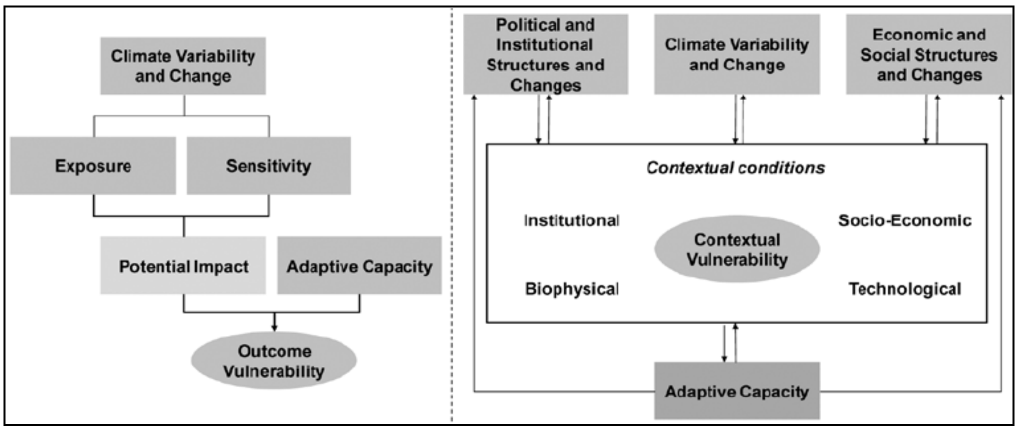

Figure 4: Outcome and Contextual vulnerability framework (Fellmann *et al.*, 2012)

Outcome vulnerability

> *"Outcome vulnerability (also known as the "end-point" interpretation) is a concept that considers vulnerability as the (potential) net impacts of climate change on a specific exposure unit (which can be biophysical or social) after feasible adaptations are taken into account"* (Fellmann *et al.*, 2012)

The focus of outcome vulnerability approaches typically lies on biophysical impacts of closed or well-defined systems. This information is then combined with socio-economic information on the capacity to adapt or cope with climate change impacts (Kelly and Adger, 2000; Füssel, 2007; O'Brien *et al.*, 2007). In determining adaptive capacity, emphasis is placed on biophysical factors. Socio-economic factors are treated as having no real impact in modifying the effects of climate change. Assessments that use this approach usually propose technological solutions for adaptation and mitigation of specific climate impacts (e.g. using a different aquaculture species), clearly lending itself to community scale assessments.

Contextual vulnerability

> *"Contextual vulnerability (also known as the "starting point" interpretation) is a concept that considers vulnerability as the present inability of a system to cope with changing climate conditions, whereby vulnerability is seen to be influenced by changing biophysical conditions as well as dynamic social, economic, political, institutional and technological structures and processes"* (Fellmann *et al*, 2012)

Contextual vulnerability approaches tend to define vulnerability as a characteristic of social and ecological systems that are defined by multiple factors (Adger, 2006; O'Brien *et al.*, 2007). Socio-economic conditions and institutional processes are seen as determining factors of vulnerability. Consequently, vulnerability is not treated as a result of biophysical factors alone but is a result of the interaction between biophysical changes happening within a specific socio-economic context, which influences the effects of climate change. It is said that under this approach adaptive capacity is determined by current vulnerability to climate change and climate change not only causes biophysical changes, but also alters the context in which it occurs. Solutions proposed under this framework tend to have as objective to increase adaptive capacity of human populations to deal with climate variations. This can include technological measures, but also institutional or inter-sectorial ones (e.g. land tenure, local policies).
As illustrated in the report "Vulnerability of coastal livelihoods to shrimp farming: Insights from Mozambique" published by the Royal Swedish Academy of Sciences in 2014, the contextual approach was selected in order to capture the strong inter-linkage between the social and the ecological context. The assessment focussed on the impacts of climate change, but only as one of the drivers of community vulnerability within an already vulnerable social and economic.

The IPCC 2007 framework in detail

Vulnerability definition IPCC 2007:

> *"The degree, to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity"*

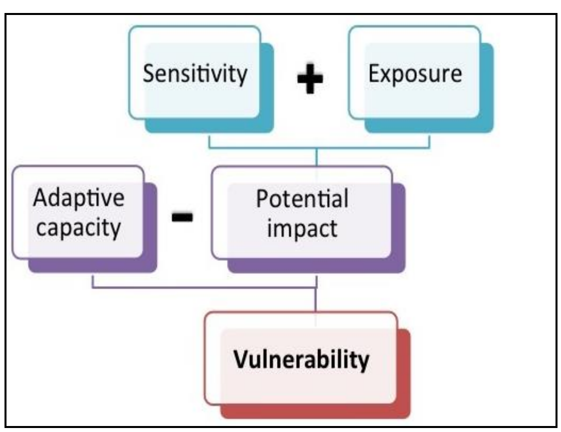

Figure 5: IPCC 2007 approach (Brugère *et al.*, FAO 2015; Sharma *et al.*, 2019)

The IPCC 2007 defines Vulnerability as a combination of Sensitivity (to a hazard or climate change impact) and Exposure (to the same event), which give rise to a potential impact, that is consequently compensated by the system's Adaptive Capacity (a high adaptive capacity reduces vulnerability).

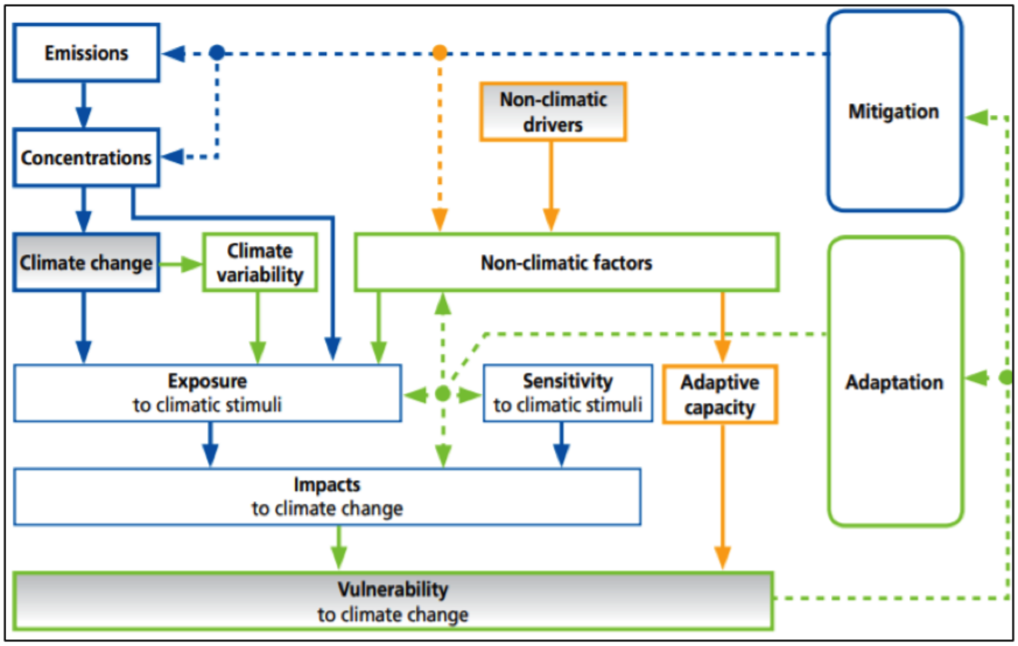

Figure 6 IPCC 2007 Framework example (Brugère. C et al, 2015)

Strengths and weaknesses

According to Brugère *et al*. (FAO 2015), this generic definition of vulnerability allows for some trans-disciplinary flexibility by including "non-climatic factors". Components of this definition of vulnerability can fit in to both the outcome vulnerability perspective (factors related to exposure to specific climate events) and to the contextual vulnerability perspective (sensitivity and adaptive capacity explain the system context). It is also a model that has benefited from years of evolution and its application has been extensively documented.

But, as Sharma *et al.* (2019) in their Environmental Research Communication paper suggest, this approach tends to consider vulnerability as an adverse impact following the system's exposure to a hazard or anticipated hazard, and the accuracy of the vulnerability assessment is limited by uncertainties in climate forecasting as well as masking the difference in vulnerabilities to a singular climate change impact at two different spatial contexts (since it focuses on "drivers of vulnerability" rather than "contextual and spatial" vulnerability).

The IPCC 2014 framework in detail

Vulnerability definition IPCC 2014:

> *"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"*

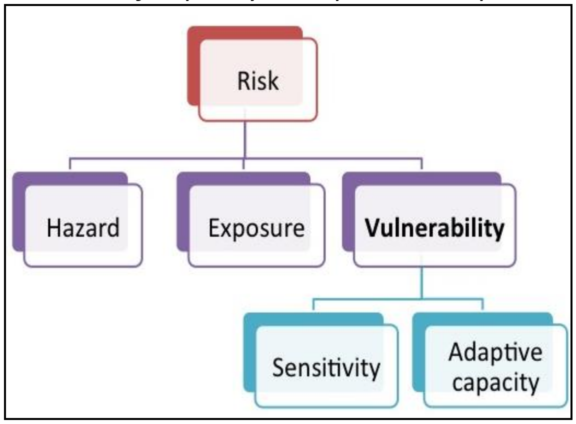

Figure 7: IPCC 2014 approach (Brugère *et al.*, FAO 2015; Sharma *et al.*, 2019)

The IPCC 2014 defines the vulnerability as a pre-existing state of a system and brings an important spatial component that is strongly linked to the contextual vulnerability perspective. Vulnerability is defined by only two components, the sensitivity of the system to adverse effects and the adaptive capacity of the system. Risk is defined as the interaction of vulnerability with exposure and hazard.

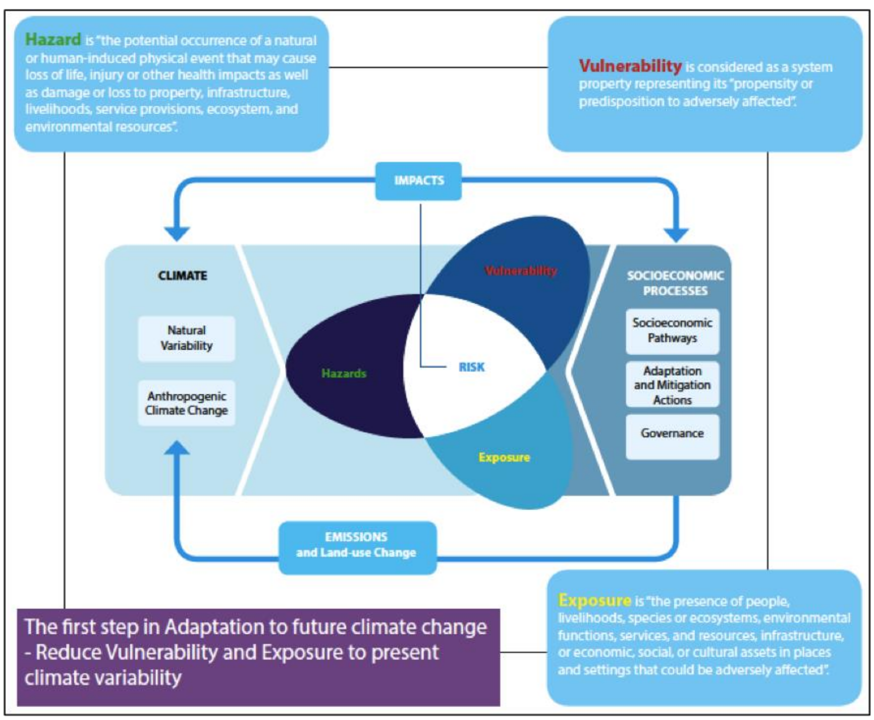

Figure 8: IPCC 2014 Framework example (IPCC, 2014)

Strengths and weaknesses

This new model presents several advantages over the 2007 model. An essential point in a vulnerability assessment is to determine potential hazards and their intensity, which relies on historical data or modelling scenarios, which carry a certain degree of uncertainty. The 2014 model avoids this uncertainty by assessing vulnerability independently of its exposure to hazards, using "hazard-relevant" indicators directly as a component of vulnerability (Sharma and Ravindranath, 2019). In addition, by focusing on contextual vulnerability, the 2014 model allows for better inclusion of stakeholders in the vulnerability and risk assessment process. However, this approach, by separating out exposure and hazard from vulnerability, requires a very careful selection of climate change-related indicators in order to determine the potential climate impact on the system. In addition to this, the use of this model is still recent and is not as thoroughly represented in the literature. A summary of those differences is proposed in the Table 1 below.

IPCC 2007 Framework	IPCC 2014 Framework
General structure and attributes	
Vulnerability consists of three elements: - Exposure (E) - Adaptive capacity (AC) - Sensitivity (S)	**Risk** is composed of three elements: - Hazard (H) - Exposure (E) - **Vulnerability** (Sensitivity (S), Adaptive capacity AC))
Vulnerability is assessed as the potential impact on a system (determined by Exposure and Sensitivity of the system), moderated by its Adaptive Capacity	Vulnerability is assessed independently of Exposure and Hazard and only represents internal characteristics of the system (composed of Sensitivity and Adaptive Capacity)
Outcome Vulnerability	Contextual Vulnerability
Exposure to climate events is seen as the main driver of vulnerability	Exposure is only interpreted as a spatial component, which together with occurrences of hazards (H), gives rise to Risk
Indicators for Exposure, Sensitivity, and Adaptive Capacity	Indicators only for S and AC, but *hazard-relevant* and can be hazard-specific
Outcome approach focuses on the driver of change as the main determinant of vulnerability. It does not sufficiently explain why different systems may or may not be vulnerable when facing the same event as opposed to the "contextual vulnerability approach". Because this approach assesses vulnerability after the occurrence of a hazard (through the Exposure indicators) measures reducing vulnerability are usually limited to addressing the impacts of a hazard.	Contextual approach focuses on the system's internal sensitivities and adaptive capacities to identify risks (including climate change-related ones), rather than depending directly on prior occurrences of climate change impacts and climate projections like the outcome perspective does. The sensitivity to change in particular and the adaptive capacity of the system are the focus, acknowledging that many socioeconomic factors (demographics, governance frameworks, etc.) determine how a system is exposed to climate-related drivers, what its sensitivity is.

IPCC 2007 Framework	IPCC 2014 Framework
	This approach allows reducing vulnerability of the system in anticipation of hazards by addressing inherent weaknesses in the system.
Aims for a general understanding of multiple-hazard situations.	Assessment has a higher context specificity and thereby increases the acceptability of assessment results by stakeholders
The IPCC 2007 framework gives a general understanding of vulnerability by merging Hazard probability, exposure, and sensitivity.	The risk assessment under the IPCC 2014 uses a combination of hazard occurrence probability, exposure, and vulnerability. Each of the components are independent which increases specificity and is thus potentially more useful for decision makers' in defining and prioritising adaptation measures.
PROS of the IPCC 2014 framework	
The climate change scenarios, no matter how precise they are, contain uncertainties. This introduces a bias at the earliest stage of the assessment when they are used to directly calculate climate change vulnerability like the IPCC 2007 does. Vulnerability is a result of past exposure to hazards.	The IPCC 2014 looks mainly at the internal system vulnerability (by looking at vulnerability as a combination of Sensitivity and adaptive capacity independently of hazards or exposure), which permits to consider more than only climate change-related threats. This is especially relevant in contexts where climate change is not the sole driver but exacerbates existing vulnerabilities.
LIMITS of the IPCC 2014 framework	
The IPCC 2007 is extensively documented, benefits from years of iteration and has been used in many similar situations.	There are still only a few examples that apply the IPCC 2014 framework, and even fewer in the fisheries sector.
The FishAdapt community level vulnerability assessment led by the FAO is based on the IPCC 2007 model	Depending on the degree of complexity of the community level vulnerability assessment, it should be relatively straightforward to combine the different scales.
Directly linked to specific hazards	By focusing on contextual vulnerability to drivers outside of only climate change-related ones, the selection of hazards and climate change-specific indicators will be critical.

Table 1: Comparison IPCC 2007 and IPCC 2014

Finally, the risk assessment model provides a useful decision-making tool to support decision making with respect to the scope, scale and level of detail of the VA termed the three-tier approach

Three-tier approach

This method is a useful tool to assist in selecting an approach (top-down/bottom-up/combination, primary data/secondary data, tools, scale, expected results of the VA) The four criteria that are identified as being essential to this approach are: skill, manpower, budget and time period, and the availability of local data at different scales, depending on the considered system's available resources. It proposes three tiers that each require four "essential inputs" to varying degrees and provide different levels of results. Tier 1 has the lowest requirements in terms of "essential inputs" and provides a preliminary idea about vulnerability. It is termed a top-down approach, meaning it relies on secondary data and does not involve any primary data collection. In terms of budget, time, and manpower the requirements are lower than for the other tiers. Tier 2 is a mixture between top-down and bottom-up approaches, still relying on secondary data, but also community involvement and primary data collection. Using a Tier 2 approach provides useful guidance and information for adaptation planning relevant to the community. Tier 3 is a bottom-up approach relying heavily on primary data collection in the specific communities/sectors/localities that will be assessed and makes use of GIS and climate models. This is the most scientifically rigorous method, but also has the highest requirements in terms of skills, budget, and time. This results in very system-specific information about the system's vulnerability to specific drivers, which can be used to draft detailed adaptation plans at a local level.

Characteristics	Tier 1	Tier 2	Tier 3
Approach to assessment	Top-down approach	Combination of top-down and bottom-up approaches	Largely bottom-up approach
Skill and expertise availability	Low	Medium	High
Financial resources availability	Low	Moderate	High
Choice of assessment indicators	Constrained; as depends on available secondary data	Less constrained; as primary data is also collected	Unconstrained; as necessary data is collected
Stakeholder consultation	Not consulted	Consulted	Consulted
Rigor of the assessment	Preliminary	Moderately rigorous	Highly rigorous and advanced

Table 2: Characteristics of each tier in the three-tier approach used in Climate Vulnerability and Risk Assessment: Framework, Methods and Guidelines (Sharma *et al.*, IHCAP 2018)

<table>
<tr><th colspan="2">Steps</th><th>Tier 1
(top-down approach)</th><th>Tier 2
(Mixed approach)</th><th>Tier 3
(Bottom-up approach)</th></tr>
<tr><td>1</td><td>Define objective and assessment unit</td><td colspan="3">Village, district, forest, cropping system, etc</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Select vulnerability indicators</td><td rowspan="2">Secondary data</td><td colspan="2">From literature, stakeholders and expert consultation</td></tr>
<tr><td></td><td>Remote sensing, spatial database</td></tr>
<tr><td rowspan="4">3</td><td rowspan="4">Indicator development</td><td rowspan="3">Indicator weight by consulting secondary stakeholders</td><td colspan="2">Generate indicator value</td></tr>
<tr><td colspan="2">Secondary data, field studies, PRA</td></tr>
<tr><td></td><td>Biophysical studies, PRA, remote sensing, spatial data and model</td></tr>
<tr><td>Calculate indicator value for the assessment units</td><td colspan="2">Develop indicators weight with stakeholder consultation, statistics</td></tr>
<tr><td>4</td><td>Aggregate indicator</td><td colspan="3">At the assessment level</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Analysis of the indicator</td><td rowspan="2">Segregate the aggregate value of indicator into different vulnerability classes</td><td colspan="2">Analyse the aggregated value of indicator at assessment unit level to evaluate vulnerability</td></tr>
<tr><td></td><td>Using GIS, stakeholder consultation to interpret and evaluate vulnerability</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Present the assessed vulnerability</td><td rowspan="2">Spatial profile or ranking</td><td colspan="2">Spatial profile, ranking, vulnerability index, major driver of vulnerability</td></tr>
<tr><td colspan="2">Spatial planning</td></tr>
</table>

Table 3 Methodological steps followed for three-tier approach (Sharma *et al.*, IHCAP 2018)

3. Approach and methodology

Given the outcomes of the literature review, the research team proposes to use a slightly modified IPCC 2014 Model for the national VA and the sections that follow provide a brief introduction to the approach and outline the steps required to conduct the risk assessment process. This section outlines the methods and approach for conducting the vulnerability assessment. The goal is to outline a methodology that can be specific enough to understand different vulnerability drivers across the different contexts encountered, but at the same time is applicable and replicable at larger scales.

Steps to conducting a Risk Assessments

Drawing on two very recent key reference works (GIZ, EURAC & UNU-EHS (2018)" and " IHCAP 2018) the risk assessment process is summarized in Table 4 below and comprises three main phases; 1) preparatory (a brief summary), 2) technical (described in detail) and 3) scaling (a brief summary), and 11 associated steps; 1.1) contextual analysis, 1.2) agenda setting, 1.3) action planning, 2.1) impact chains, 2.2) indicator mapping, 2.3) data collection, 2.4) normalising indicators, 2.5) weighting and aggregating indicators, 2.6) aggregating all risk components, 3.1) interpreting and communicating outcomes, and finally 3.2) identification of potential policy and adaptation measures.

PHASES & STEPS	TASKS
Preparation phase (I)	
Desktop-based; Correspondence and interviews with experts and relevant actors. workshops with experts for the thematic area(s)	
1.1 Contextual analysis	
	Situational analysis
	Identify development & adaptation priorities
1.2 Agenda setting	Objective & outcome setting
	Select tier level
	Decision on scope, system, scale and time frame
	Identify main adaptation / mitigation measures in place
	Decide on methods and tools to be used.
	Decide on methods and tools
	Identify resource needs
1.3 Action planning	Decide on who should be involved
	Outline roles and responsibilities
	Set deadlines
	Draft a detailed plan of action

Technical phase (2)		
Desktop-based; Correspondence and interviews with experts and relevant actors. Workshops with experts for the thematic area(s). Impact chain tool, primary and secondary data collection, data base development		
2.1 Impact chains	Identify main climate/hazard risks	
	Identify main drivers (climate and non-climate related)	
	Identify exposure elements	
2.2 Indicator mapping	Select hazard indicators	
	Select indicators for vulnerability and exposure	
	Validate indicators	
2.3 Data	Data acquisition	
	Data management	
2.4 Normalisation	Determine scale of measurement	
	Normalise indicators (standard score between 0 and 1)	
2.5 Weighting and composite indexes	Weight indicators	
	Aggregate indicators	
2.6 Aggregating all components	Determine a single composite index	

Scaling phase (3)		
Desktop-based; workshop with key actors for strategy development and planning. Dissemination events		
3.1 Interpretation and communication of the outcomes of the risk assessment	Plan the report	
	Present the results	
	Illustrate the findings	
	Consider a communication strategy	
3.2 Identification of policy and adaptation options	Outline recommendations for policy and adaptation planning	
	Planning and dissemination events	

Table 4: Example of the risk assessment steps (Based on "GIZ, EURAC & UNU-EHS (2018)" and "IHCAP 2018")

Preparation phase (I)

Contextual analysis and agenda setting

This phase covers the scoping and outlines in brief the essential steps needed for preparations for conducting a robust risk assessment. The work conducted under the LoA (this assignment) has generated some relevant data towards a number of these steps and is sometimes referred to.

This set of tasks are concerned with understanding what stage adaptation planning is at in Myanmar. It involves a review of relevant climate adaptation and related sector strategies and action plans such as the National Adaptation Plan of Action, the Agriculture Development Strategy and the Myanmar sustainable development plan 2018 to 2030 to provide just three examples. Understanding these strategic and sector plans helps to define the goals and objectives of the assessment.

It is intended to identify which sectors, partners and stakeholders should be involved and what resources are available and needed. This is especially relevant if a broad participatory approach is targeted as in the FishAdapt project. In addition, existing adaptation plans and mitigation measures both at an administrative and system scale should be understood.

It is also important to identify the development and adaptation priorities of the sectors, States and Regions and Republic of the Union of Myanmar. Part of this task is to ask *which plans and processes and what needs will the assessment feed in to or address? What do key stakeholders want to learn from the assessment and what outputs are expected?*

Who will be involved and what their roles and responsibilities are will also need to be determined. As will the types of methods and tools to be used and a detailed plan of action will need to be drafted.

Determine the scope of the Risk Assessment

The Risk Assessment scope should be determined. The assessment in Myanmar is expected to be conducted on three fisheries sub-sectors, namely inland fisheries, inshore fisheries, and aquaculture. These can potentially be refined into further sub-sectors. A set of indicators have been selected for each of these sub-sectors to be further validated in consultation during implementation.

A modification of the approach could allow for the use of several "vulnerability lenses" each linked to specific indicators which could allow a broad overview of the main drivers of vulnerability for different themes (e.g. food security, production, livelihoods). The adaptability of the indicators to different themes means the methodology is not country- or sector-specific.

Scale

Scale is another critical aspect to consider. The scale proposed for Myanmar will be the national level, through compilation of sub-national data. We propose to conduct the analysis at the state/region level in order to be able to pick up on regional differences vis-à-vis risk to a specific driver. This increases the data requirements, because data must be disaggregated at the state/region level, but also increases the level of detail and relevance to the regional situation.

Timeframe

Our proposition is to conduct a vulnerability and risk assessment that can be used to plan at 5-year intervals. Data for different indicators will be collected at different intervals i.e., seasonally, annualy, every few years etc. Using a 5-year scale would allow the Government of Myanmar to update the national-level Risk Assessment every five years with the most recent data, without requiring additional data collection, providing a good reflection of the actual situation.

Level of detail

Finally, it is important to decide upon the level of detail required. In the Myanmar context under the FishAdapt project, the 'tiers' (level of detail, refer to section 2 above) that seem most suitable are at least Tier 2 and potentially Tier 3. The main difference in the methodological steps is found in where Tier 3 adds the use high-level tools such as GIS.

Technical (phase (2)

This phase outlines the steps required to conduct an indicator-based risk assessment. It provides an explanation of the process, provides examples and supporting detail in the form of indicator tables in the annex. The section covers the impact chain tool, a central component of the assessment approach and a precursor for developing adaptation measures. Climate impacts and risks, hazards, vulnerability and exposure elements are all also covered here alongside the indicators for their measurement. These indicators and their selection are described in detail alongside the process of normalising and weighting them. Data acquisition and management is discussed along with some of the risks associated with data quality and availability and a section on mitigating these issues and an alternative complimentary approach is also proposed. Finally, how all the different elements fit together to derive an overall risk assessment value is explained.

Impact chains

Impact chains or causal chain analysis are tools used to map potential impacts to the system that is being assessed. The structure of impact chains is always similar: a climate signal or root cause leads to a physical impact and a series of intermediate impacts (based on the vulnerability of the system), which ultimately lead to a risk. Indicators for exposure, hazard, and vulnerability and their underlying factors make up the main components of an impact chain. On top of these indicators, intermediate impacts are added to the impact or causal chain (Figure 9). This allows the users to identify risks that arise due to the vulnerability of the system and the measures taken and not directly as a result of the climate signal. Constructing impact chains is an iterative process and includes inputs from local experts and stakeholders to gain a better understanding of the system under analysis.

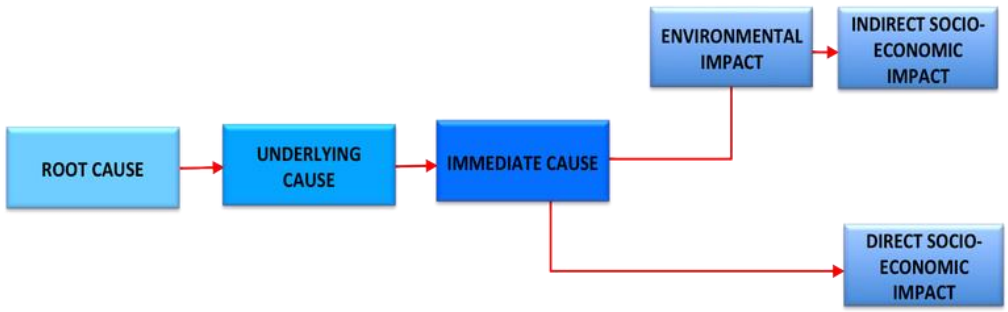

Figure 9: A causal chain is an ordered sequence of events linking the causes of a problem with its effects, in the context of this VA the root cause would be of climate change origin with the effects expressed in terms of direct and indirect socio-economic impacts or vulnerability Ref: (GEF International Waters Learning Exchange & Resource Network .

The Vulnerability Sourcebook (GIZ, 2017) identifies four steps in developing impact chains: “(1) identify potential climate impacts and risks, (2) determine hazard(s) and intermediate impacts, (3) determine the vulnerability of the social-ecological system, and (4) determine exposed elements of the social-ecological system”.

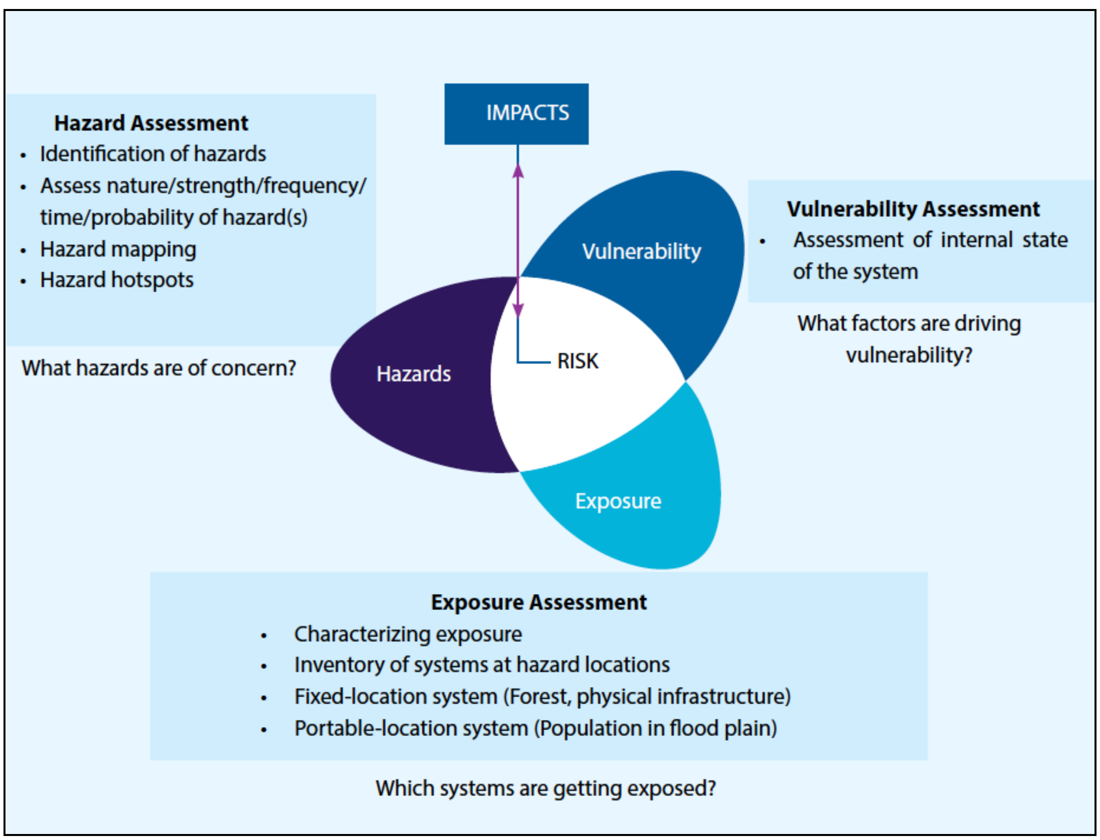

Figure 10: Details of the hazard, vulnerability, and exposure risk assessment steps (IPCC, 2014)

Hazard assessment

Determines what hazards will be of concern depending on the scale and scope of the desired risk assessment. The different locations, sectors, socio-economic and political context will have to be considered here.

Vulnerability assessment

This vulnerability assessment is focused on the factor driving vulnerability in different contexts.

Exposure assessment

Determine which systems are or will potentially be exposed to the vulnerabilities and climate change impacts identified.

In step 1, the risks and potential impacts are identified. A separate impact chain should be developed for each risk if more than one is identified. Then, in step 2, the appropriate climate signals and hazards causing those risks are identified, and intermediate impacts are determined. Next, vulnerability indicators (sensitivity and adaptive capacity) are identified and added to the impact chain. Finally, exposure variables are included to determine which areas, communities, sectors are most at risk to the particular risk in this impact chain. The visual representation of intermediate impacts allows adaptation planners to use impact chains to identify factors which could be targets for adaptation measures, using an ecosystem-based approach.

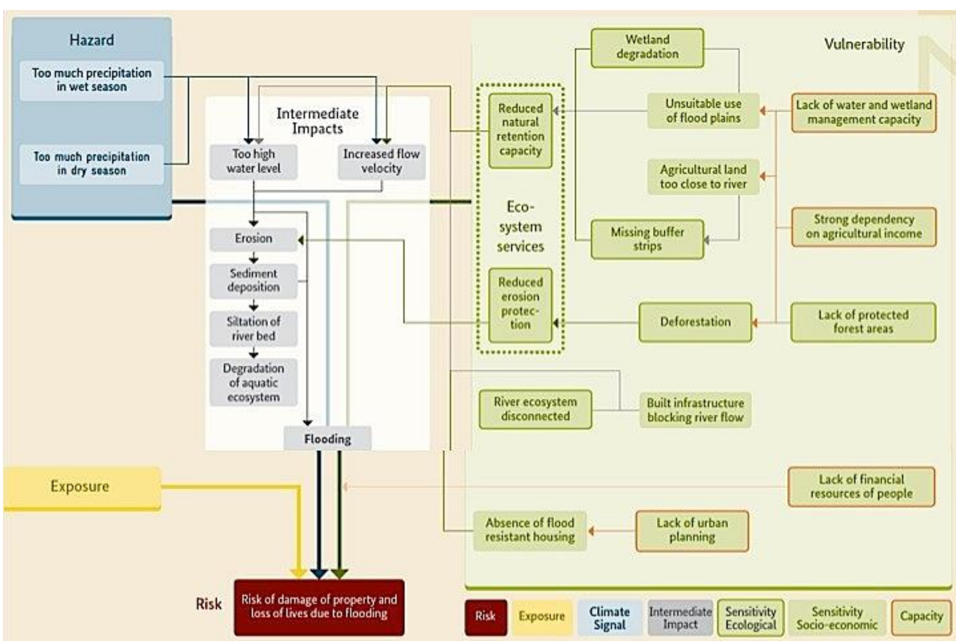

Figure 9: Example of an impact chain (taken from GIZ-EURAC&UNU, 2018)

Indicator selection

Vulnerability of a system is not a quantifiable, measurable value, but rather it is calculated by aggregating different indicators representing different factors, such as sensitivity and adaptive capacity (under the 2014 IPCC framework), that contribute to the system's vulnerability. Indicators should represent, unambiguously, either an increase or decrease in vulnerability of the system. Annual rainfall would not be a suitable indicator for example, because both low (risk of droughts) and high (risk of floods) values could contribute to an increase in vulnerability of the system. A suitable indicator related to rainfall could be *the number of days of rainfall above a certain threshold,* indicating extreme rainfall events that could lead to flooding. Indicators should be spatially relevant to the system that is being assessed. The most recent values should be used to explain the current situation to the highest degree possible. Indicators can be simple metrics or composite indicators combining multiple factors into a quantifiable value. After selection, indicators are assigned to the different elements of the Risk score: Sensitivity or Adaptive Capacity (combined into a Vulnerability Index), Exposure, or Hazard. The benefit of using the IPCC AR5 (2014) framework for vulnerability allows for the selection of 'hazard-relevant' indicators (Sharma & Ravindranath, 2019), i.e. indicators that can be linked directly to a specific hazard. One of the benefits of using an indicator-based model is that it can be updated every few years and it can be used to observe trends in vulnerability. Indicators can be scalar, ordinal (categorical), or binary. They can represent ecological, socio-economic, environmental, biophysical factors. The process of selection, weighting, and aggregation of indicators is based on the methods used by IHCAP (2018) and GIZ, EURAC, UNU (2018).

Composite indices

A composite indicator represents a vector of variables that is calculated by combination of different indicators to come up with a proxy for an unmeasurable variable. Similar to the Vulnerability Index, a composite indicator consists of different indicators that are normalised, weighted, and then aggregated. An example of a composite indicator is the Human Development Index (HDI[22]), which was developed by UNDP to characterise the development of a country. The index is a composite of life expectancy, mean years of schooling of adults above 25 years of age, expected years of schooling for children, and Gross National Income (PPP$) per capita and the final score is calculated by taking the geometric mean of these indicators.

Normalisation and weighting

After selecting indicators, in order to be able to aggregate them, they are normalised in order to end up with a set of dimensionless values between 0 and 1, where 0 indicates no vulnerability and 1 indicates maximum vulnerability. For normalising scalar indicator values, in case of a positive relationship between the indicator and vulnerability, the following equation should be used (1). In case of a negative relationship between the indicator value and vulnerability equation (2) should be used. Categorical and ordinal indicators are assigned to five classes and given a score between 0 and 1 to indicate its effect on vulnerability, ranging from *optimal* to *critical*, which are assigned values of 0 and 1 respectively. After normalisation, each indicator is assigned a specific weight, ranging from 0 to 1 or 0 to 100 (depending on what scale is easiest for the stakeholders to work with), to represent its importance in relation to vulnerability of the system. Each indicator could be weighted equally (1 or 100 divided by the total number of indicators) or unequally. In case of unequal weighting, the weighting scores can be determined using a statistical approach (such as Principal Component Analysis or Analytical Hierarchy Process), through stakeholder consultations, or through expert opinion. Examples of tools that could be used to define these weights are pairwise ranking, where each indicator is ranked against another one to come up with a ranking of all indicators, or budget allocation, where stakeholders are given a budget of 100 points that they have to divide it across all indicators. The chosen method will depend on the availability of manpower, budget, and timeframe of the assessment. In our case, we think weighting scores based on expert consultation will be the best way to proceed.

(1) $$x^p = \frac{x_i - x_{min}}{x_{max} - x_{min}}$$

(2) $$x^n = \frac{x_{max} - x_i}{x_{max} - x_{min}}$$

Where x^p, x^n are indicators with a positive or negative relationship to vulnerability respectively, x_i is the value for indicator i, x_{min} is the minimum value for that indicator, and x_{max} the maximum value for that indicator

Aggregating indicators

After weighting, all selected indicators are aggregated to determine a score for the vulnerability of the system. This score is calculated by multiplying the indicator value with its weight and then taking the arithmetic mean of all indicators, following equation (3). Higher scores for this index indicate a higher vulnerability of the system. This is then repeated for each of the states and regions that will be assessed during this project.

(3) $$VI = \frac{\sum(x_{ij} * w_{ij})}{K},$$

Where K: number of indicators, x_{ij} is the normalised indicator score for indicator I for region j, and w_{ij} is the weight for indicator i for region j

Risk Index score

The final score for Risk (Risk Index) is calculated by following the same steps as each of the separate risk components -exposure, hazard, and vulnerability. The Risk Index is calculated by assigning weights to each of the components (equal or unequal weights) and then calculating the arithmetic mean (i.e., sum of the components divided by the total number of components) of the product of the individual scores and their weights, using equation (4).

(4) $$Risk = \frac{(Hazard*w_H)+(Exposure*w_E)+(Vulnerability*w_V)}{w_{H+}w_E+w_V}$$, Where w_H, w_E, and w_V are the weights for Hazard, Exposure, Vulnerability respectively

Based on the scores calculated in step (4), classes could be created indicating high, medium, or low risk for example and represented visually, by using GIS maps. Each risk class receives a colour coding and then a map with the different scores for each of the states and regions can be produced to highlight what the most vulnerable areas are. This can be used to inform priority areas for adaptation planning, an example is provided in the text box below.

1. Heavy a-seasonal rainfall in upland Rakhine State where deforestation has taken place can lead to flash-foods and landslides with resultant heavy sediment loads in surface water. The latter are a hazard for fishponds reliant on surface water supplies. Fish kills are caused by high sediment loading. The adaptive planning response is multifold: reforestation; sediment check-dams; aquaculture planning changes for the location of ponds and/or water supply.
2. Increased cloud cover in the Sittwe area of northern Rakhine State makes the sun drying of small pelagic fish ineffective as humidity levels cause rancidity of fats and deteriorated overall quality. The fisheries industry needs to invest in solar-powered sun driers where humidity levels can be controlled

Set of indicators

The tables in Annex 5 represents the set of indicators that have been proposed for the VA. Indicators will be grouped into two categories: core indicators and supplementary indicators. Core indicators are those that either are a large factor contributing to vulnerability or are broadly applicable across systems. Supplementary indicators will be those that are relatively less important sources/drivers of vulnerability, but that are specific to a particular system or that add a level of detail. The indicators were chosen based on their relevance to the different systems and they represent either the sensitivity or adaptive capacity of the system. This set represents the ideal situation and highlights what indicators are critical in order to assess the vulnerability of the chosen systems, however this is not an exhaustive list and needs to be validated with relevant stakeholders. Indicators can be added or removed depending on the system that is being assessed. A short justification/rationale behind the selection of the indicators will be given in the following paragraphs. Examples of other studies using a range of similar indicators can be found in Allison *et al.* (2009) or Hughes *et al.* (2012), among others.

Sensitivity variables

A set of core indicators is presented in Annex 5: Indicators Table 1, a short overview of those selected and their relation to vulnerability are presented below. The main assumption behind dividing indicators between core and supplementary is because we believe the core indicators give a broad overview of factors contributing to the vulnerability of the system. Supplementary indicators can be added to further refine the system that is being assessed and to come up with more detailed adaptation plans.

Core indicators

Forests provide a wide range of ecosystem services ranging from habitat for plant and animal species, timber and non-timber resource provision, reduction of soil erosion, regulating the hydrological cycle, to carbon sequestration, evaporative cooling, and physical protection against weather events (Bonan, 2008). These ecosystem services can contribute to resilience against extreme climate events. Losing these services might have a knock-on effect on fisheries and aquaculture and those sub-sectors' vulnerability to climate change. Mangroves perform a similar function in coastal areas (Spalding et al, 2014): providing physical protection against waves and storms, but also reducing erosion, providing habitat to marine organisms, and providing timber and non-timber resources. Therefore, forest/mangrove cover is included as a core sensitivity indicator, because it is applicable to all three systems and can be linked with a broad range of climate effects. Wetlands provide a number of ecosystem services to communities in close proximity, such as flood control, water storage, aquifer recharge and ecological diversity, as well as resource provision. Together with mangroves and forests, wetlands are an important ecosystem linked to vulnerability of the fisheries and aquaculture sub-sectors' vulnerability. Percentage of wetland cover for states and regions is considered a core sensitivity indicator (Ringler & Cai, 2006). Access to irrigation facilities increases resilience to climate variability (Gbetigouo et al, 2010). This is useful for aquaculture farmers, as some fishponds are rainfed and would be vulnerable to changes in precipitation patterns.

Supplementary indicators

The list of supplementary indicators can be found in Annex 5: Indicators Table 2. A few examples are highlighted in this paragraph. A higher coral reef cover reduces the wave energy on coastal systems and can support a high biodiversity of marine life (Spalding et al, 2014). These characteristics, coupled with the extent of Myanmar's coastline, the large population that lives in coastal areas, and the importance of coastal fisheries in terms of food and nutrition, indicate that coral reef cover plays an important role in determining the vulnerability of the coastal fishery sub-sector to climate events. Its limited geographical scope however implies that it is not applicable as a core indicator but could be included as a supplementary indicator for assessing coastal provinces, where it is more likely to contribute to vulnerability of the fisheries sector.

Population density can be defined as a variable of sensitivity, higher population densities in risk areas increases vulnerability. Higher population density in rural areas increases sensitivity, as rural areas traditionally have less services available/easily accessible than urban areas (Gbetigouo et al, 2010). The sensitivity of a household is to a large degree determined by the physical conditions in which they live, having housing adapted to the environmental, climatic conditions of the area in which they live is crucial. This includes for example having a house on stilts in areas prone to flooding or making use of brick houses in areas where there are frequent storms (Kappes et al, 2012).

Adaptive capacity variables

Lemos *et al.* (2013) posit that adaptive capacity is made up of several determining factors: human capital, information and technology, material resources and infrastructure, organisation and social capital, political capital, wealth and financial capital, and institutions and entitlements. In the case of the fisheries and aquaculture sub-sectors in Myanmar, we believe the main determinants are human capital, institutions, and wealth and financial capital. These form the core indicators to determine risk to climate change in fisheries and aquaculture. The specific indicators are explained below.

Core indicators

Education level or literacy rate are used as indicators for adaptive capacity. The assumption is that a population with higher literacy rate or education level has an increased capability, increased access to information, and processes and adapts to new information better (Wall & Marzall, 2006; Gbetigouo et al, 2010). Studies by Lutz *et al*. (2014) and Muttarak & Lutz (2014) showed that higher education levels are related to lower disaster-related mortality. A composite index measuring a household's financial inclusion is an indicator for the household's wealth and assets. It is assumed that wealthier households have a broader range of options to adapt to or mitigate the impacts of climate change or other drivers. The index would include access to formal financial institutions (credit, loans, bank services), the level of debt of the HH, household assets, and share of income from fish(ing) in order to represent a household's financial capital. Health is also an important factor in determining whether a community is able to recover from shocks or extreme events. We propose to include a composite index including age, life expectancy, access to health services in order to have a robust indicator that can be comparable across regions and for which data requirements are not very high. These factors have been shown to reduce vulnerability (Muttarak & Lutz, 2014). Households who are engaged in a larger number of livelihood activities would have a higher adaptive capacity in case fisheries and aquaculture would be negatively impacted.

Supplementary indicators

Utilities infrastructure (electricity, communication networks, water) that is well-built and well-maintained can increase the capacity of communities to deal with shocks and stresses related to climate or to other drivers (Wall & Marzall, 2006). Communities where these facilities are lacking will have a harder time adapting to changing climate conditions. A study by Cinner *et al.* (2009) showed that as specific fishing gears tend to target a specific functional group of fish species, a varying effect of climate change will then consequently affect fisherfolk using specific gears differently. Therefore, we assume that fisherfolk with a higher legal gear diversity will be less vulnerable to fish species composition variations as a result of climate change.

Market access is an important factor in households' potential for livelihood diversification and acquiring goods and services (IHCAP, 2018). Households or communities with lower accessibility to markets will be more vulnerable to climate effects. Similarly, road access also plays an important role for communities to access goods and services. Better, all weather, road networks increase adaptive capacity.

Social capital is defined by the OECD as "networks together with shared norms, values and understandings that facilitate co-operation within or among groups" and in a more practical sense represent networks and connections, membership of formal groups, and relationships and trust (OECD, UNDP). Networks of reciprocity might play an important role in recovering from the adverse effects of natural disasters (Adger, 2003).

Potential for more in-depth assessment

The model allows for the scope of the assessment to be geared towards a specific 'lens' (e.g. nutrition focus) by adjusting the set of indicators and adapting their weight in order to have indicators relevant to the 'lens' (e.g. assigning higher weights to indicators more directly linked with the object of the focus). The adjustment of the weighting factors would be done based on expert opinion or stakeholder consultations to reflect the priorities of the involved stakeholders.

A potential application of this 'lens' approach to vulnerability is in determining vulnerability in relation to specific targets and outcomes of development strategies or plans (e.g. the Multi-Sectoral National Plan of Action on Nutrition MS-NPAN link). By applying a 'nutrition lens' to the risk assessment of the aquaculture sector, this could help identify drivers of risk which might jeopardise achieving the targets set out in the MS-NPAN. This is an iterative and participatory process and would include similar steps to the general model described earlier in this report. This would allow to build on the general conclusions reached by the overall risk assessment regarding system vulnerabilities and to assess specific topics.

Data collection and limitations

Data acquisition

Under this risk assessment, we will mainly use data from secondary sources, such as government departments, local or international NGOs, and development agencies. Data can include census data, household survey data, ecological and environmental data collected by international agencies or the Department of Meteorology and Hydrology. There are some limitations to using the government statistics as the way of collecting and formatting the information is not always the same across different administrative levels (township, district, state/region, etc.) or across different locations. Where possible, data should be cross-referenced from at least two independent sources. In some cases, data that was collected at the local level is not compiled at the state/region level or doesn't exist in a digital format. In which case time and effort will need to be put into compiling and digitising this information before it can be used effectively under the scope of this risk assessment. Another limitation might be the age of the data, as not all data is collected at the same intervals some information might be relatively outdated and not representative of the current situation. In some cases data may be up-to-date but not in the public domain.

Data management
As a solution to the current limitations of the quality and availability of data, we suggest setting up a multi-stakeholder committee including different ministries and potentially (I)NGOs. This committee would be tasked with collecting and archiving the data that currently exists in Myanmar. Depending on the available budget and timeframe, each state/region would have such a committee to compile data collected at the township and district levels into data at state/region level. The committee would also be responsible in managing this dataset in the future and continually updating the data repository when new data becomes available/is collected. Given the broad scope of the indicators proposed as part of this risk assessment, the data compiled by this committee could be useful for other purposes and not solely for conducting a risk assessment.

Alternatives to indicator-based frameworks
In the event that the data quality for the selected indicators is low or if the data is simply unavailable, using an indicator-based model would not be possible. Alternatives to using an indicator-based approach are using a model- or GIS-based approach (using a range of satellite, aircraft or drone imagery) or stakeholder-based approach. Model-based and GIS-based approaches use biophysical or socio-economic models to measure vulnerability but tend to focus on one specific factor or driver. Statistical and mapping tools are applied to visualise vulnerability. Stakeholder-based methodologies make use of participatory tools or expert opinion to determine vulnerability. It is usually applied at the community but can also be applied at the regional level. It is mainly used to assess vulnerability, determine existing resilience, and come up with adaptation measures. One example of a stakeholder-based methodology is the Climate Vulnerability and Capacity Analysis, developed by CARE International, the framework and steps of which will shortly be outlined in this section. The main issues that are explored during the information collection phase are climate context, livelihood context, climate impacts, current strategies of dealing with climate impacts, and strategies to increase resilience ('adaptive capacity'). Additionally, information about ecosystems and governance systems is also collected in this phase. The data sources for this information are both primary and secondary sources.

Climate context refers to the lived experiences of community members regarding climate risks. The perspectives of the community on how these risks affect them are included in this section. This can be combined with climate projections in order to complement the information gathered from community members and enables identification of the key points should be addressed to reduce vulnerability. Livelihood context refers to livelihood diversity, assets used, and opportunities to diversify livelihood strategies. Finally, the strategies that are currently being used by the community to adapt/respond to climate risks are explored and determined whether these strategies will still be viable options in view of the expected changes to the climate. General information about the governance systems that are in place and ecosystems is collected to the role they play in determining vulnerability or resilience. Although the conceptual framework that is used in this method is different than the IPCC 2014 model, the information that is collected using this approach can be applied to fit the different elements of the IPCC model. Information related to the climate context can be put under Exposure and

Hazard. Livelihood context data, environmental data, and information related to governance can be framed under vulnerability (sensitivity + adaptive capacity) to determine the risk of specific stakeholders to specific climate events.

The first step of analysis is to analyse the climate information to identify the climate risks the community currently faces and how these risks impact the ecosystem, their livelihoods and their capacity to adapt[3]. Next, the factors that increase or decrease their capacity to adapt to these risks are analysed. After a draft has been compiled highlighting the main risks and the overall vulnerability of the community, it is shared with relevant stakeholders to be validated before drafting specific adaptation plans. Although this approach is usually used at the local level to assess vulnerability of specific communities, in this community could be defined as the fisheries sector and representatives of this sector (and sub-sectors) at the state/region level could be chosen as stakeholders. The same tools and methods that are used at a smaller scale are still applicable at this level.

Tools that can be used for a stakeholder-based approach include focus group discussions or semi-structured interviews with key stakeholders (e.g. government officials, fishing communities, actors in the private sector related to fisheries or aquaculture). At the community level, participatory tools such as hazard maps, impact chains, or vulnerability matrices can be used to determine what the main factors are that contribute to vulnerability to climate events. Hazard maps highlight areas that are affected by or vulnerable to climate hazards. Vulnerability matrices are used to map the vulnerability of a sector or social group to specific climate events and to determine the degree to which those climate events would affect them.

Scaling phase (3)

The scaling phase is concerned with compiling, interpreting, illustrating and presenting/communicating the results of the risk assessment. This might include presenting the overall results or component data sets, illustrating/visualising the findings e.g., through GIS maps or vector diagrams, planning the report and identifying policy and adaptation options.

Interpretation and communication of the outcomes of the risk assessment

Plan the report

The first step might be to plan the format and structure and content of your report. The report would best follow a standard format, that is:

- a situation analysis
- a description of the objectives
- a methods and implementation section
- a presentation of the findings and,

[3] One difficulty may be that communities may not perceive climate change induced modifications in species diversity. For example, liver fluke (flatworm) populations may rise causing increased human health problems resulting in lost productivity and even death link

- a final section on conclusions and lessons learned.

A more detailed structure with sections and subsections under each of these headings will then need to be described.

Next the report needs to consider how to illustrate the findings the more visual the better. Maps, radar graphs, charts, tables, photographs are all excellent ways to communicate effectively to the reader.

Workshops presenting the high-level findings can also be an extremely valuable tool for communicating the results. A communications strategy including different products such as fact sheets, summary reports, blogs etc. can also be very useful.

There are many other resources available on how to present and communicate findings.

Identification of policy and adaptation options

The results generated from conducting the risk assessment such as risk maps and specific information on vulnerability, exposure and risk provide an opportunity to see how the underlying indicators contribute to risk and thus support the planning of adaptation measures as generated through the impact chain mapping discussed above.

Full adaptation plans and policy recommendations and events are key areas to ensure uptake and use of the results of the assessment. These are not discussed in detail here as a number of other resources are available and somewhat beyond the scope of this methodology.

Concluding remarks

This technical report outlines the proposed methodology and approach for conducting a climate risk assessment for fisheries and aquaculture-based adaptation in Myanmar. It is the product of a collaboration between FAO FishAdapt team and WorldFish Myanmar and consultations with government partners at Union and State and Region level. The proposed methodology selected is a slightly modified IPPCC 2014 risk assessment model considered most suitable to address the FishAdapt objectives and the needs and opportunities for climate adaptation response in Myanmar. It is the product of four months work between June and October 2019 and lays the groundwork for conducting a full climate risk assessment for fisheries and aquaculture in Myanmar.

END OF REPORT

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6. Annexes:

ANNEX 1: WorldFish Terms of references for the FishAdapt project

منظمة الأغذية والزراعة للأمم المتحدة | 联合国粮食及农业组织 | Food and Agriculture Organization of the United Nations | Organisation des Nations Unies pour l'alimentation et l'agriculture | Продовольственная и сельскохозяйственная организация Объединенных Наций | Organización de las Naciones Unidas para la Alimentación y la Agricultura

Viale delle Terme di Caracalla, 00153 Rome, Italy Fax: +39 0657053152 Tel: +39 0657051 www.fao.org

FAO Budget Code:
GRMS Supplier Number:
PO Number :

Your Ref.:

LETTER OF AGREEMENT
Between
the Food and Agriculture Organization of the United Nations ("FAO")
and
The International Center for Living Aquatic Resources Management (ICLARM) also known as WorldFish
Department of Fisheries, West Gyogone,
Bayint Naung Road, Insein Township, Yangon

For provision of
"*Identifying national, regional and sectoral VA priorities and gaps in support of VA methodology design* under the FishAdapt Project"

1. Introduction

The Food and Agriculture Organization of the United Nations (hereinafter referred to as "FAO") and *The International Center for Living Aquatic Resources Management ICLARM* (hereinafter referred to as the "Service Provider") (together hereinafter referred to as the "Parties") have agreed that the Service Provider will provide certain services defined in **detail** in the attached Annex (the "Services") which forms an integral part of this Letter of Agreement (hereinafter the "Agreement") in support of the *FishAdapt: Strengthening the adaptive capacity and resilience of fisheries and aquaculture-dependent livelihoods in Myanmar/ GCP/MYA/020/LDF.* To enable the Service Provider to provide the Services, FAO will pay the Service Provider a total amount not exceeding USD 49,973 (Forty-Nine Thousand Nine Hundred Seventy-Three United States dollars), which represents FAO's maximum financial liability, into the Service Provider's account specified in paragraph 2 below.

2. Detailed Banking Instructions

Account Name:	ICLARM
Account Type:	USD
Account Number:	1013 8388
Bank Name:	Citibank N.A.
Bank Address:	Citi Private Bank
	153 East 53rd Street , 21st Floor
	New York, NY 10022
ABA Number:	021 000 089
Swift code:	CITIUS33
Attention to:	Ms. Susana Ruiz
Reference on transfer	Vulnerability study Myanmar
Reason for Payment	Grant

3. Designation of the FAO Responsible Officer.

Mr. Jose Parajua, Technical Adviser / Team Leader, FishAdapt Project, FAO Myanmar, Jose.Parajua@fao.org is designated the officer responsible for the management of this Agreement ("Responsible Officer") on behalf of FAO.

4. Entry into force and period of validity.

The Agreement will enter into force upon the date of signature by the Service Provider, by FAO or on *[15th May 2019,* **whichever of the three dates is the latest** and will terminate on 31 July 2019.

5. Purpose

a) The purpose for which the funds provided by FAO under this Agreement shall be used are the following:

(i) **Objective**. The Services will contribute to the implementation of the project **FishAdapt: Strengthening the adaptive capacity and resilience of fisheries and aquaculture-dependent livelihoods in Myanmar/ GCP/MYA/020/LDF** with the objective to *enable inland and coastal fishery as well as aquaculture stakeholders to adapt to climate change by identifiying, understanding and reducing vulnerabilities, piloting new practices and technologies, and sharing information.*

(ii) **Outputs**. The Service Provider will produce, achieve or deliver the following outputs:

1. Compendium and workshop documentation on available frameworks, approaches, methods and datasets on Vulnerability Assessment on Fisheries and Aquaculture. These will include a shortlist of frameworks, approaches and methods that will be presented to stakeholders for evaluation and confirmation of appropriateness to the Myanmar context.

2. A technical report containing: i) A list of vulnerability related questions, including those that will be addressed by the project through the VA work at national and sector level, as well as those for future work/support; and ii) Summary of identified themes, focus areas and sectors for VA, as well as linked methodologies.

3. A technical report containing: i) Shortlist of validated vulnerability related questions, themes, focus areas to be used in the FishAdapt VA and ii) Summary of data information needs and proposed data gathering framework/ methodology, including limitations, risks and assumptions.

4. Full document on the Vulnerability Assessment Methodology and Approach for the FishAdapt project.

(iii) **Activities**. The Service Provider will undertake the following activities across selected villages in Yangon and Ayeyarwaddy regions, and Rakhine State:

I. Review of in-country and/or in-region climate impact assessments conducted for Fisheries and Aquaculture, and other related sectors, including their methodologies and results (Baseline definition and setup)

II. Conduct of a series of multi-level stakeholder consultations to determine climate change vulnerability assessment and impact assessment priorities (based on their ex-post contextual vulnerability knowledge of the country and experiences from policy level and field level work) at national and regional levels, and from a sectoral perspective

III. Consolidation of priority/identified themes, focus areas and sectors for VA

IV. Identification of appropriate methods or tools and cross-checking of data availability and quality in line with guidance documents

V. Submission of proposed detailed VA methodologies, including implementation options/approaches

b) A detailed description of the Services including technical and operational requirements, budget, work plan and timeframe, performance indicators and means of verification, as well as inputs to be provided free-of-charge by the Service Provider and FAO, if any, are set out in detail in Annex I: Terms of Agreement.

6. General Conditions

a) Funds provided by FAO under this Agreement are to be used by the Service Provider exclusively for the provision of the Services in accordance with the budget set out in the Annex I: Terms of Agreement. Neither the Service Provider nor its personnel nor any other persons providing the Services on its behalf, will incur any additional commitment or expense on behalf of FAO.

b) The Service Provider will be responsible for all activities related to the provision of the Services and the acts or omissions of all employees, agents or other representatives, and authorized subcontractors providing the Services on its behalf. FAO will not be held responsible for any accident, illness, loss or damage which may occur during the provision of the Services or any claims, demands, suits, judgements, arising there from, including for any injury to the Service Provider's employees, or to third parties, or any loss of, damage to, or destruction of property of third parties, arising out of or connected to the Service Provider's work or performance under this Agreement.

c) The Service Provider shall not utilize funds received under this Agreement to subcontract services or procure items except as specifically provided for in the Annex I: Terms of Agreement or as specifically approved in writing by FAO. Any subcontracting arrangement shall in no way relieve the Service Provider of the responsibility for the provision/delivery of the Services required under this Agreement. Subcontracts or procurement of the items set forth in the Annex I: Terms of Agreement shall be procured in conformity with the Service Provider's own procurement rules and procedures. The Service Provider confirms that its procurement rules and procedures, and their implementation, ensure that the procurement process is transparent and consistent with generally-accepted principles governing public sector procurement to obtain best value for money. The Service Provider will ensure that its agreements with any subcontractor include the

ANNEX 2: Table example for the methodological review

<table>
<tr><td>Reference and link</td><td>Reference:
Link: http://www.fao.org/gef/projects/detail/fr/c/1056959/</td></tr>
<tr><td>Geographical location</td><td>Myanmar</td></tr>
<tr><td>Research questions and objectives</td><td>Objectives:
Strengthening the adaptive capacity and resilience of fisheries and aquaculture-dependent livelihoods in Myanmar
Identifying, understanding and reducing vulnerabilities, piloting new practices and technologies, and sharing information
Sub-objectives:
Strengthen the National, Regional/ State and Township level regulatory and policy frameworks to facilitate the adaptive capacities of the fisheries and aquaculture sector
Enhance critical adaptation practices demonstrated by fishers and fishing communities in vulnerable coastal and inland water regions of Myanmar
Develop and apply adaptation models to strengthen the resilience of Myanmar’s aquaculture sector to the impacts of climate change.
Knowledge management, monitoring and evaluation, training and scaling up adaptation practices, lessons learned development and dissemination.</td></tr>
<tr><td>Sectors and themes addressed</td><td>Ecosystem:
Inland freshwater (stream, river, lac, oxbow)
Coastal (salted water)
Brackish water

Sectors:
Capture inland fisheries
Capture coastal fisheries
Inland aquaculture
Coastal aquaculture
(Other sectors in relation with the previous ones can be included, but will be of secondary importance)

Themes:
Disaster risk reduction
Vulnerability:
Climate change related vulnerabilities and impacts (past, present, and future)
Socio-economical vulnerability
Biophysical vulnerability
Adaptation capacities
Information sharing capacities</td></tr>
</table>

	Institutional vulnerabilities: Policy adaptation Political changes and supports Sector strategies Water management Fisheries governances …
Scale of the VA	Potentially international (replicable methodology) National Myanmar Regional/State level (Ayeyarwady, Rakhine, Yangon)
Scoop of the VA	Policy level assessment, Collaborative approach Sectorial/Inter-sectorial perspective(s) Ecosystem perspective
Credibility of the methodology	High (globally acknowledged, tested and used Internationally or in a Myanmar VA like context, recent…) General approach (IPCC related, school of thought…TBC)

ANNEX 3: Reviewed methodologies Framework and interesting particularities

Specificity	1	2	3	4	5	6	7
The use of detailed indices for the different components of vulnerability assessed		X	X	X		X	X
Strong link between the vulnerability assessment, providing recommendations and the policies and strategy plans already in-place			X	X		X	
Use of a short-term and long-term wins/losses recommendation model, including short-term losses for long-term wins with a sectorial approach			X				
Inclusion of broader sectors and the potential impact of climate change on fisheries like agricultural systems, government revenue (what is capital in Myanmar), tourism…		X	X		X	X	X
Link between biophysical and socio-economic vulnerability, by considering the socio-economical "exposure" as the resulting biophysical vulnerability				X			
Inclusion of the governance diversity in the assessment, in addition to the ecosystem and sectorial diversity				X		X	
Capacity to produce two scales of analysis using both quantitative (higher level like national) and qualitative (lower level at community level for example) data				X	X		X
Use of a Rapid Participatory Assessment at the lower level in support of a final higher-level assessment, to be used as an orientation tool for the thematic included in the larger assessment				X		X	
TOTAL		**2**	**4**	**6**	**2**	**5**	**3**
Framework: Based on IPCC 2007		X	X		X	X	X
Framework: Based on IPCC 2007 extended				X			
Framework: Based on IPCC 2014						X	
Framework: ICEM CAM method					X		X
Framework: PRA Vulnerability assessment (very local scale)	X						

ANNEX 4: Short summary of the reviewed methodologies

N°	Name of the study	Inst.	Date	Pros	Cons	score	Rank
1	PARTICIPATORY RURAL APPRAISAL-VULNERABILITY STUDY OF AYEYARWADY DELTA FISHING COMMUNITIES AND SOCIAL PROTECTION OPPORTUNITIES	FAO WF	2019	In Myanmar. Participatory approach. Focused on broad vulnerabilities (five capitals), but at community level	Scale very local, at the community level, even individual. Focused in the Ayeyarwady Delta only. Limited focus on the Aquaculture sector. CC vulnerability not central to the assessment. Policy assessment limited to the direct impact on the households, no higher-level policy assessment.	25	3
2	VULNERABILITY OF NATIONAL ECONOMIES TO THE IMPACTS OF CLIMATE CHANGE ON FISHERIES	Fish and fisheries journals	2009	National scale (1/to match with the policy level elaboration, 2/level where most of the data was available like in Myanmar). Potential CC impact based on a broad range of indices. Assessment of the vulnerability by explaining every component and indicators (based on the IPCC) in detail	No regional/state scale, only national. No data for Myanmar. Lack of regional data for CC scenarios use and link with the local subsistence fishing activities, agriculture, climate exposure indices... No ecosystem approach, no specific vulnerability indicators to specific ecosystems to link to the CC impacts on the sectors.	26	2
3	VULNERABILITY OF TROPICAL PACIFIC FISHERIES AND	SPC	2011	CC impacts on the sectors related to the Myanmar VA. Relation of CC impacts with economic	No regional/state scale, only national Needs of CC projections with data to support it. Focused on the CC impact on	24	6

N°	Name of the study	Inst.	Date	Pros	Cons	score	Rank
	AQUACULTURE TO CLIMATE CHANGE, SUMMARY FOR PACIFIC ISLAND COUNTRIES AND TERRITORIES			development, government revenue, food security, livelihoods. CC impact on the government revenue, linked to potential policy vulnerability. Indirect CC effect taken into account. VA at national scale	fish habitat and fish productivity more than on communities. Limited place for recommendations of practical adaptations.		
4	SOCIAL-ECOLOGICAL VULNERABILITY OF CORAL REEF FISHERIES TO CLIMATIC SHOCKS	FAO	2013	Link between ecological and social vulnerability to express socio-economical vulnerability integrating adaptive capacity. Detailed sets of indicators for each component of the IPCC vulnerability (adaptive capacity among other things)	Focused on coral reef ecosystems. No links to sectors other than capture fisheries Limited place to CC policy assessment	21	7
5	RAPID CLIMATE CHANGE ASSESSMENTS FOR WETLAND BIODIVERSITY IN THE LOWER MEKONG BASIN, CLIMATE	ICEM	2012	Very complete and handy in the two methodological steps allowing good flexibility. Interesting double scale (Geo-spatial more regional, community level)	Needs a minimum of CC modelling with data to support it. Mainly looks at the bio-physical impact of CC. It gives a global overview more than a sectorial approach with a socio-economic analysis	25	3

N°	Name of the study	Inst.	Date	Pros	Cons	score	Rank
	CHANGE VULNERABILITY ASSESSMENTS FOR MEKONG WETLANDS						
6	SOCIAL–ECOLOGICAL VULNERABILITY OF FISHERIES DEPENDENT COMMUNITIES IN THE BENGUELA CURRENT REGION	FAO	2015	Context of the VA and its objectives and scale are in line with the VA in Myanmar. Participatory and inclusive approach. Rapid vulnerability assessment easier to conduct with available data. Assessment of the coping mechanisms that exist at the community level. Inclusion of sectors other than fisheries that are potentially impacted by CC and might exacerbate the CC outcomes on the fisheries sector Include perception of the local stakeholder in the assessment Very interesting and complete review of the	At the community level, not higher level. Limited to coastal areas. Difficult to understand the inter-sectorial impact in relation to climate change. Limited resources for the VA led to a limited assessment in terms of time and scope.	25	3

N°	Name of the study	Inst.	Date	Pros	Cons	score	Rank
				existing methodologies. Pros and cons of the different approaches			
7	USAID MEKONG ARCC CLIMATE CHANGE IMPACT AND ADAPTATION STUDY: FISHERIES REPORT	USAID ICEM	2013	Detailed direct CC impacts on capture fisheries and aquaculture, depending on eco-zones and ecosystems. Similar geographical and ecological zone. Species-specific assessment relating to potential CC impacts. Focused on the fisheries sector, but links to the potential impacts coming from other systems CC adaptations in other ARCC studies (Agriculture, Livestock, Natural systems, Socio-economic)	Doesn't include Myanmar but does include neighbouring countries. Methodology needs extensive information on major species and their sensibility to potential CC impact, CAM database might not be relevant to Myanmar. Focused on the inland systems, limited consideration of costal systems. Limited policy assessment. Few links to broader themes concerning the major CC impact on targeted species	29	1

ANNEX 5: Indicators

Table 1: core indicators

Indicator	What is represented?	System	Category of variable
Socio-economic			
Composite index of economic dependence on fisheries	Percentage of the workforce engaged in fisheries, percentage of gdp or per capita income from fish	Inland fisheries, inshore fisheries (S)	Socio-economic
Ratio of (marine) caught fish in per capita fish consumption	Reliance on wild fish for nutrition (ratio fish caught/fish bought)	Inland fisheries, inshore fisheries (S)	Socio-economic
Total fish catch/ size distribution	Scale of fisheries sector in Myanmar/ sensitivity of fish stocks to changing conditions	Inland fisheries, inshore fisheries (S)	Socio-economic
Composite index to represent the health status of the (active) population	Health indicators (age, life expectancy, disease indicators)	All systems (AC)	Socio-economic
Financial inclusion (composite index)	Opportunities to recover from adverse fishing events. Access to credit, possibility for insurance, access to formal financial institutions	All systems (AC)	Socio-economic
Education level	Potential for other job opportunities, capacity to take up new knowledge to enhance adaptive capacity	All systems (AC)	Socio-economic
Livelihood diversity	Ratio of income from fish to other activities or total number of livelihood activities	All systems (AC)	Socio-economic
Biophysical			
Percentage of wetland cover	Wetland degradation increases sensitivity to floods and impacts fish stocks	Inland fisheries, aquaculture (S)	Biophysical
Rate of deforestation/ forest cover	Sensitivity to erosion, flooding increases with decreasing forest cover	All systems (S)	Biophysical
Irrigation water availability	Dependence of aquaculture ponds on irrigation facilities	Aquaculture (S)	Biophysical
Institutional & ecological			
Planned mangrove reforestation activities	Mangroves provide a range of ecosystem services, among which flood and erosion protection, habitat for fish and aquatic species, and resources	Inshore fisheries (S)	Institutional

Table 2: supplementary indicators

Indicator	What is represented?	System	Category of variable
Dietary diversity of fishing households	Higher adaptive capacity to a reduction in fish availability	All systems (AC)	Socio-economic
Affordability of nutritious diets	Proxy for nutrition insecurity	All systems (S)	Socio-economic
Basic food basket price	Sensitivity to changes in fish prices	All systems (S, AC)	Socio-economic
Crop diversity/use of climate-resistant varieties	Higher adaptive capacity to crop area loss/failed harvests/etc.	All systems (AC)	Socio-economic
Area cover of leasable fisheries	Smaller areas are more sensitive to biophysical changes	Inland fisheries (S)	Biophysical
Coverage of no-fish zones	Higher percentage of no-fish zones would indicate a higher potential for system to recover to natural state	Inland fisheries, inshore fisheries (S)	Biophysical
Gear diversity in leasable fisheries	Adaptive capacity to species composition changes	Inland fisheries (AC)	Socio-economic
Spatial distribution of main fishing spp.	Lower sensitivity if important fish species are spread out over a larger area	Inland fisheries, inshore fisheries (S)	Ecological
Species diversity	Higher species richness has a larger potential to settle in an alternative equilibrium	All systems (AC)	Ecological
Human Pressure Index	Index representing the current anthropogenic pressure on an ecosystem	All systems (S)	Ecological
Coral reef cover in EEZ/ distance of coral reefs to coast	Higher cover of coral reef mitigates effects of cyclones/tsunamis, the farther away the lower the effect	All systems (S)	Biophysical
Biodiversity loss/ ecosystem 'health'	Less diverse systems are more at risk to changes in biodiversity	All systems (S)	Biophysical
Average size of ponds	Smaller ponds are more sensitive to flooding, temperature changes, etc.	Aquaculture (S)	Biophysical
Groundwater level	Higher groundwater levels reduce sensitivity of aquaculture systems as pumping water for ponds is easier	Aquaculture (S)	Biophysical

Indicator	What is represented?	System	Category of variable
Extent of flood-controlled areas	Presence of flood-controlled areas reduce sensitivity to flood events	All systems (S)	Biophysical
Presence of integrated water management plans	Institutional capacity to mitigate/deal with adverse effects to sectors related to water	Inland fisheries, aquaculture (AC)	Institutional
Early Warning Systems	Do EWS exist and are they used? (Y/N)	All systems (S)	Institutional
DRR plans in place	Institutional capacity to deal with (natural) disasters	All systems (S)	Institutional
Population density	Areas with higher pop. Density are more vulnerable	All systems (S)	Socio-economic
Suitable housing	House on stilts, brick house, Having a house adapted to the climate in which one lives decreases sensitivity	All systems (S)	Socio-economic
Access to drinking water/sanitation	Access to drinking water is an important health factor	All systems (AC)	Socio-economic
Electrification	KWh usage per state/region, degree of electrification (%)	All systems (AC)	Socio-economic
Road access/ road density	Higher adaptive capacity	All systems (AC)	Socio-economic
Market access	Percentage of HHs with market access, average distance to market. Better access to goods and services increases adaptive capacity	All systems (AC)	Socio-economic
Membership of community groups (charity organisation, religious, social,)	Social capital under the livelihood capital approach	All systems (AC)	Socio-economic
Fuel cost/ household assets (motorised)	HH expenditure on fuel, presence of motorised assets (water pump, combine harvester, boat, motorcycle)	All systems (AC)	Socio-economic

ANNEX 6: Consultation workshops report

The purpose of the consultation workshops was to inform the government departments of the purpose of conducting a climate change vulnerability assessment of the fisheries sector in the chosen regions. Secondly, we wanted to gauge the stakeholders' opinion on the feasibility and relevance of the proposed methods and tools. Lastly, we wanted to understand the government priorities in the strategic development plans of the fisheries sectors. The WorldFish team presented a number of different methodologies and tools to the stakeholders to gauge their opinion on the feasibility and relevance of the proposed methods. In the presentation the key concepts and definitions related to a Vulnerability Assessment (VA) were explained, so all stakeholders have the same understanding of the different terms. Then the evolution of the different VA frameworks was given and explained why the WF team has chosen the IPCC 2014 approach. After the presentations, group discussions were held to assess the priorities and sector development strategies of the different departments and to discuss what the main hazards are to the region and the respective sectors.

Questions asked to the stakeholders

- *What are the department's* **priorities** (at least top 5) *in the 5-year development plan and* **how** *they are* **decided?**
- *What are the* **planned activities/projects/programmes as part of the development plan**?
- *What are the* **targets and expected outcomes** *are under the 5-year plan?*
- *How might the department's development activities **impact** the **fisheries and the aquaculture sector** by your and was this impact considered when drafting the 5-year plan?*
- *Are these 5-year strategic plans fitted to the ADS or other national-level development plans (e.g. MS-NPAN)?*
- *What are the main risks and threats in your state/region and/or for your sector?*
- *Is climate change and the potential impact thereof included in the plans? If yes, in what ways? If no, Why not?*
- *Are there any plans known to your department to carry out a climate change vulnerability assessment at union or regional level?*

VA consultation workshop Ayeyarwady Region (9/09/2019, Pathein)

Departments present: GAD, DRD, Forestry Department, Department of Environmental Conservation, DoF, DoA, IWUMD, DALMS

The government departments presented their priority activities and the main hazards to their sector. Afterwards they were split into two groups to have a discussion among departments regarding the priorities and hazards. The main issues that came out of this consultation were the lack of qualified staff, conflicts between farmers and fisherfolk, lack of technology, and lack of funding. Participants mentioned that leasable fisheries area are not large enough for community fisher groups and there are conflicts between lease owners and paddy farmers regarding the demarcation of their lands. Water control infrastructure can't be maintained properly due to a lack of staff and funds. Other departments have also mentioned they can't perform all of their assignments to the highest capacity because they lack staff, funding, and appropriate technologies.

The priorities are to improve people's livelihoods, to develop fisheries and small-scale aquaculture, integration of agriculture and fish food production systems, maintenance of water control infrastructure, and capacity building. Increasing job opportunities and household income will improve the socio-economic status of the communities and has the potential to contribute to human capacity development. This can be done by enabling and supporting community-led fisheries activities, which creates local job opportunities. In conjunction, development of small-scale, homestead aquaculture can provide households with an extra source of income. Another focal point is the integration of fisheries and agriculture at the local level, but potentially of high enough quality to be sold in the global markets. Maintenance of dams and irrigation infrastructure is also a priority for the future. Building human capacity and trust between local communities and the government is very important. The participants believe if there is development at the local level, this will ultimately contribute to development of the country as a whole.

In the group session the first group was made up of the GAD, DRD, Forestry Department, and Environmental Conservation department. They indicated their main priorities are construction and maintenance of infrastructure, livelihoods and income generation, human capacity building, forest restoration, and decrease or halt deforestation. The main barriers to these objectives are lack of skilled staff and funds, lack of job opportunities, weak technical skills, no time for successful collaboration between government departments.
The second group consisted of DoF, DoA, IWUMD, and DALMS. Their priorities are sustainable development of the fisheries sector, development of community-based fisheries management schemes, strengthening research and development, construction of water control infrastructure to withstand natural disasters, and human capacity development. Lack of staff, low development, weak cooperation, and deforestation are the main barriers to these activities.

VA consultation workshop Yangon Region (11/09/2019, Yangon)

Departments present: DDM, IWUMD, DoF, GAD, DoA

The main priorities for IWUMD are the construction and maintenance of water control infrastructure (e.g., dams, sluices, dykes). Dams are being monitored 24 hours a day. General Administration Department are contacted by IWUMD whenever events occur that have a significant impact on the WCI and might lead to flooding for example.
Department of Disaster Management are tasked with emergency relief after natural disasters. The most common hazards are fire, drought, landslides, cyclones and storms, heavy rainfall. The main threats they are expecting to face in the coming years are increasing sea level rise,

temperature rise, drinking water shortage. The DDM has constructed cyclone shelters in the eleven costal states and regions in Myanmar and is planning to construct more. They also organise awareness raising campaigns and organise trainings on how to behave in case of earthquakes and floods. The main barriers preventing them to carry out their activities effectively are a lack of funding, qualified staff, and access to technology.

The Department of Fisheries stated the main problems they face in their sector are increasing temperatures, water scarcity, and water quality deterioration. They plan to shift to species with a shorter growing period and to introduce small indigenous species for commercial-scale aquaculture. They are also looking at implementing rice-fish integrated farming, similar to the models used in China and Indonesia.

Increased number of days with heavy rainfall and floods are the main hazards for the Department of Agriculture. In order to mitigate or cope with the effects of those hazards, DoA are planning to establish climate-smart agriculture methods, apply flood management, and to implement sustainable practices in order to restore the natural ecosystems. They will collaborate with (inter)national institutions on habitat, environmental, and genetic management to improve ecosystem health and resilience. The department also plans to share weather information in a timely manner to allow fisherfolk, farmers, and livestock herder to react appropriately to (extreme) weather events.

<u>VA consultation workshop Rakhine State (27/09/2019, Sittwe)</u>

Departments present: IWUMD, DRD, DoA, DoF, GAD, DALMS

The departments gave a presentation highlighting the department's 5-year development strategy and their focus as well as highlighting which hazards occur most frequently or have the highest impact on the department's activity. The Irrigation and Water Utilization Management Department stated that the main priorities for the next 5 years are the renovation and maintenance of large dams and construction of new smaller dams. The main hazards that they face in Rakhine state are floods due to dam collapses, dyke or sluice breaks, droughts, earthquakes, and extraordinary high tides. The Department of Rural Development plans to provide potable water to all townships in Rakhine by 2030, and to plant trees along mountain springs to provide shade and reduce evaporation. They highlighted saline water intrusion, floods, and storms as main hazards for their sector. Most of these hazards have an impact on drinking water supply. The Department of Fisheries has a mangrove reforestation programme, plans to implement a mud crab conservation zone and to focus on promoting small-scale aquaculture, and to restock fish in natural water bodies. Cyclones and pollution were mentioned as main threats for the fisheries sector. The main priorities for Department of Agriculture are increasing water availability for farmers and introducing new climate-resistant rice varieties and crops. The DoA conducts monthly surveys to monitor the development of the introduced crops and their suitability to the climatic conditions. Water shortages and landslides were mentioned by the Department of Agriculture as main hazards for their sector. Food security was mentioned as top priority for GAD, in collaboration with the MoALI departments. The General Administration Department stressed the importance of conserving and restoring marine natural resources and to prevent or mitigate habitat degradation.

After the sector presentations a plenary session was held where the attendees were asked to rank to top 3 hazards for Rakhine state in general and for their sector in specific. The hazards that were highlighted for Rakhine state were temperature increase, followed by droughts, floods and cyclones. All these hazards are climate-related. When asked about what hazards would impact their sectors respectively, the main hazards that were brought up were droughts and floods, followed by deforestation and habitat loss. Although the main hazards at sector level are climate-related (drought and flood), non-climate-related drivers (deforestation and habitat loss) were also mentioned by multiple departments as important risks for their sector. The impact of habitat loss that was put forward was the decline of species and their socio-economic impact on people's livelihood and nutrition. One of the key aspects that was highlighted regarding reacting to natural disasters was the coordination and collaboration between government departments. After a natural disaster event happens the emergency response is coordinated through a Disaster Risk Committee, which is organised at the regional level and coordinated by GAD. All department heads are members of this committee and they are tasked with setting up the initial response. After the damage has been assessed the Department of Restoration assists with planning and coordination the restoration efforts.

Conclusion

There is quite some overlap in departmental strategies between different departments. The most common one is the focus on capacity development, both in terms of staff and basic infrastructure. Another key point is the development of the small-scale agriculture and fisheries sector and supporting smallholder operations. The main risks to these sectors can be climate-related (e.g., natural disasters, extreme weather events) or non-climate-related (e.g., lack of qualified staff, underfunding, deforestation). There is a relatively high degree of cooperation between departments for day-to-day activities, as well as during emergency situations.