

UNITED NATIONS ENVIRONMENTAL PROGRAMME



Climate Change Vulnerability Assessments in Selected Coastal Communities in Madagascar

Inception report

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1 Introduction

The Nairobi Convention has recently developed a Climate Change Vulnerability Assessments (CCVA) toolkit, which requires pilot testing for standardized application in the region i.e. in the Western Indian Ocean (WIO) countries. Social and economic data relevant to the CCVA of local communities dependent on major coastal ecosystems will be collected and analysed to identify specific adaptation technology needs, and national plans and with a focus on the needs of coastal communities, to map risks and possible responses to extreme climatic events, to identify potential networks for the sharing of information on successful adaptation, and contribute to management and policy option on climate change necessary for decision making. The 12-step framework developed by Thiault *et al* (2021) that guides practitioners to understand and conduct a vulnerability assessment will be used. This framework synthesizes the different approaches that have been used to evaluate vulnerability in SES (Social-Ecological Systems) and highlights current best practices: Objectives, System exploration, Review, Structure, Indicators, Data collection, Standardization, Integration, Uncertainty, Interpretation, communication and learning. The study will be conducted in Madagascar, Tanzania, Kenya and Mozambique.

2 Objectives

Apart from the impacts of climate change on natural ecosystems, the severity of the impacts of climate change depends also on factors such as the degree of socio-economic development, social inequalities, human adaptive capacities, health status and health services, demographic characteristics, economic livelihood alternatives. The purposes of this study are:

- To assess the vulnerability of communities who are highly dependent on coastal and marine resources to climate change. These assessments involve describing the intensity of threats and identifying potential impacts, relative to the capacity of the interacting human and ecological systems to cope with such threats. This will be conducted by gathering and analyzing of social and economic data relevant to the CCVA (Climate Change and Vulnerability Assessment) of local communities dependent on major coastal ecosystems i.e. mangroves, coral reefs and seagrass beds, and other marine resources, such as artisanal fisheries.
- To propose effective adaptation strategies in response to climate stresses and risks which will be translated into concrete and operational actions in order to anticipate the possible impacts of climate change.
- To identify specific adaptation technology needs, and national plans and with a focus on the needs of coastal communities
- To develop knowledge of risks and possible responses to extreme climatic events.
- To identify potential networks for the sharing of information on successful adaptation, and contribute to management and policy option on climate change necessary for decision making.

3 System exploration

3.1 Definition of coastal communities

Coastal communities are people living on the thin strip of land or on the water along the fluctuating line where the sea meets the land. Coastal communities have multiple sources of income but there are often serious threats to food security. The target communities in this research are local communities dependent on major coastal ecosystems i.e. mangroves, coral reefs and seagrass beds, and other marine resources, such as artisanal fisheries.

With over 5,500 km of coastline, Madagascar has a diversity of marine and coastal ecosystems that is unequalled in the Indian Ocean. These habitats provide valuable services to coastal communities; they are critically important source of food security and revenue for the country's population, over half of which lives within a buffer zone of 100 km of the coast (WRI 2003). However, Madagascar's fragile marine environment are facing unprecedented threats from climate change, habitat destruction and overfishing. While the current state of mangroves remains worrying because of anthropogenic pressures through land clearing for coastal development, conversion to agriculture and aquaculture, and overexploitation of wood products, this manifestation of climate change would exaggerate the level of vulnerability of mangrove ecosystems.

3.2 Social component of vulnerability

Vulnerability varies because of the capacity of groups and individuals to reduce and manage the impacts of climate change. Among the key factors determining vulnerability are gender, age, health, social status, ethnicity, and class (Adger *et al.*, 2009). These groups of individuals are coastal fishers and migrant fishers. Coastal fisheries encompass all fisheries within the exclusive economic zones (EEZ) that provide food, nutrition, and livelihoods, particularly to coastal communities. Migrant fishers move to distant fishing grounds for periods ranging from weeks to months. Migrant fishers operate within the socio-economic and ecological setting and are influenced by external factors and processes that result in changes at both the individual and community level. Population growth and migration caused by free access to these resources result in even more pressure on marine ecosystems (Kasprzyk *et al.*, 2018).

3.3 Study sites

This component of CCVA focuses on the social adaptive capacity and sensitivity dimensions applied to selected local communities in Madagascar covering the following sites:

- Mahajamba Bay (Boeny Region)
- Bay of Sahamalaza (Sofia Region)

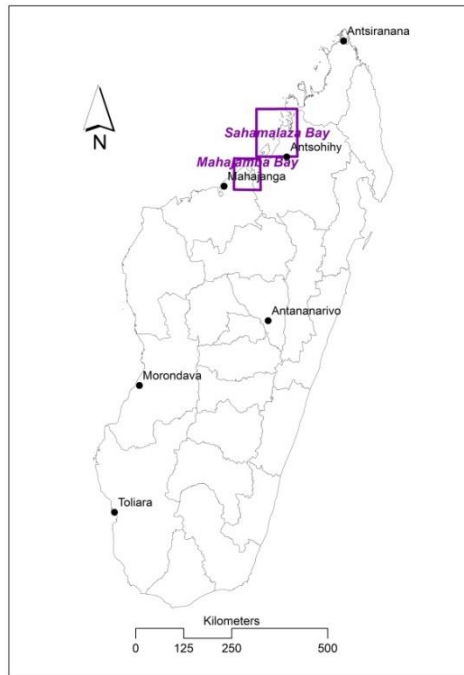


Figure 1: Location map of the sites

3.3.1 Mahajamba Bay

The bay of Mahajamba is located on the western facade of Madagascar, about 100 km northeast of Majunga (the nearest biggest town and a large port city). Administratively, it straddles the Boeny and Sofia regions. With its approximately 27,000 ha of mangrove, Mahajamba Bay is a mangrove ecosystem that is still relatively preserved compared to other mangrove forests in Madagascar. This ecosystem provides many important services to the indigenous population and is also a spawning area for many fishery resources including shrimp and crab. However, these areas are currently under pressure such as siltation. The mangrove forest is one of the main sources of timber wood and firewood.

3.3.2 Bay of Sahamalaza

Sahamalaza wetlands consist of several coastal and marine sites. There are forests that are home to around 220 species of plants, coral reefs that cover around 12,800 hectares and mangroves covering an area of some 10,000 hectares with eight species of mangroves. More than 40 endemic bird species have been recorded. Among the globally threatened waterbirds are the critically endangered Madagascan eagle (*Haliaeetus vociferoides*) and the Madagascan ibis (*Threskiornis bernieri*), the humblot heron (*Ardea humbloti*) and the white crab (*Ardeola idae*), all in danger. Coral reefs provide a wide variety of sub-habitats, including shallow reefs, seagrass beds and reef slopes within Ramanetaka Bay, as well as deep reefs on the outer slope, all cut by canals. Mangroves provide important ecosystem services to local communities by protecting the coast and enabling the renewal of fish stocks.

4 Preparation phase

4.1 Literature review

The review aims at mapping out previous effort as well as available data and knowledge.

4.1.1 Definition of vulnerability

Vulnerability analysis for local communities first consists of analysing exposure factors, then factors of sensitivity to these hazards, then identifying the adaptive capacities of local communities, and finally measuring the vulnerability of systems to climate change. Vulnerability is the result of situations of exposure, sensitivity and adaptive capacities:

- The term exposure refers to "the rate and magnitude of climate change". In CCVA, social exposure is defined from the main climate risk factors to which households are exposed: increased storm intensity, altered rainfall patterns and sea level rise.
- Sensitivity is defined "to the degree to which a system is influenced, positively or negatively, by climate variability or climate change" (Adger et al., 2003, p. 28). In other words, sensitivity gathers the adverse effects and the magnitude that the risks from exposure have on local populations, their economic activities and natural resources.
- The words adaptive capacity depend on the relative level of economic resources, access to technologies, access to information on climate variability and change, the skills to use it, the means institutional and equitable distribution of resources (Smit et al., 2001).

4.1.2 Exposure in coastal areas of Madagascar

4.1.2.1 Exposure to sea level rise and intense cyclones

While the IPCC estimates an overall sea level rise of between 0.28m to 0.98m based on mitigation efforts from around the world by 2100, GIZ's analysis (2021) found a projection of 11cm, 22 cm and 43 cm in the coastal areas of Madagascar around 2030, 2050 and 2080 respectively. Intense cyclones bring heavy rains and cause coastal erosion (Asconit-Pareto, 2011)

4.1.2.2 Exposure to drought (Rainfall decrease)

The length of rainy season and seasonal distribution of rainfall has changed compared to data before 2010. If the rainy season started in November and ended in May, local observation reported by WWF (2013) highlighted that the range has reduced from January to March.

4.1.2.3 Exposure to wind

The wind is an important climatic parameter in fishing as it influences the fishing effort (eg: when to fish, the distance travelled, fishing time, etc.). According to WWF (2013), the period of the wind (called "Varatraza" in the North) has increased sharply based on local perception. This type of wind is however known for its high intensity which considerably influences the fishing periods offshore and at the reefs.

4.1.3 Sensitivity of coastal communities to climate variabilities

4.1.3.1 *Dependence of fishing on the wind speed and means of a canoe*

These activities gather the different kinds of fishing practiced on reef areas and the open sea (Octopus, crab and shrimp fishing) as well as the exploitation of timber wood collected from both mangrove and dry forest. In relation to the wind exposure particularly when fishing activities require a boat, the further away the fishing area is from the beach, the more the fishers are limited by the wind as their only mean of transportation is a simple canoe (difference between offshore and at reef fishing). When the wind blows strongly, sailing with a canoe is not safe. Subsistence fishing is done on foot or non-motorized dugout canoes and of which the catch will not be sold. The catch is only used to provide food for the fisherman and/or his dependants. Commercial fishing can be divided into traditional fishing on foot or canoe (The use of a dugout canoe equipped with an outboard motor is classified within this fishing category) and artisanal (small-scale) fishing which involves the use of a boat equipped with an engine of which the power is less than or equal to 50 Hp (Horse-Power). The wind has an impact on the frequency of resource extractions. One of the extracted resources is the mangrove crab *Scylla serrata*, also known as “**mud crab**” or “**mangrove crab**”. This is the largest and most prized species of crabs in the Portunidae family, especially for their meat.

4.1.3.2 *Competition between local fishers and migrants*

Fish extraction can also be competitive as there are migrants who come temporarily to practice fishing (WWF, 2013). In the North East of Madagascar people migrate in significant numbers to coastal villages of the Ambaro Bay to fish shrimp as —traditional fishers. There are numerous movements of artisanal fishers along the northern coast of Madagascar; for example: from Mahajanga North-Eastwards towards Mahajamba Bay. These artisanal fishers fish for shark, pelagic fish and free-dive for sea cucumbers or lobster. There are illegal dive teams harvesting sea cucumbers with scuba and motorised boats, who are originally from Antsiranana and Nosy Be (Helleville), but move itinerantly the length of the North West and West (though less so) coasts (Cripps, 2009).

4.1.3.3 *Dependence of agriculture on rainfall*

Agricultural activities, which mainly consist of food crops and on which farmers rely on food production, are the most vulnerable/sensitive to drought. For example, corns suffer the most from water deficiency because it is an excessively greedy plant in this component (WWF, 2013).

4.1.3.4 *Retreat of coastlines*

The absence of natural barriers such as mangrove forest, coral reefs against waves and cyclonic swells increases the probability of occurrence of coastal erosion. Both rainfall decrease and retreat of coastlines threaten Madagascar’s coastal communities and may cause saline intrusion in coastal waterways and groundwater reservoirs.

4.1.4 Adaptive capacity in coastal areas of Madagascar

Malagasy people use a set of activities to compensate for losses due to climate change on fishing. For example, agricultural and livestock activities reduce the average dependence of the population on natural resources. These are considered as alternative income resources. The total income generated by fishing and that of other activities will be compared. Other examples of adaptation measures can be the modification of techniques or cropping calendars, the adoption of new products or fishing techniques. The variety of responses can be explained mainly by the low level of education and the importance of the isolation of the villages.

4.2 Model structure

The main objective is to describe the links between exposure, sensitivity and adaptive capacity. Vulnerability assessments incorporate three nested layers that vary in the specificity of their definition: dimensions (generic), domains (moving from generic to specific), and indicators (context-specific). Domains can include multiple elements that are deemed locally relevant. For example, various elements of education such as quality of education; role of local knowledge/language in formal education; local beliefs/values toward formal and informal education; have been identified as being important for adaptive capacity.

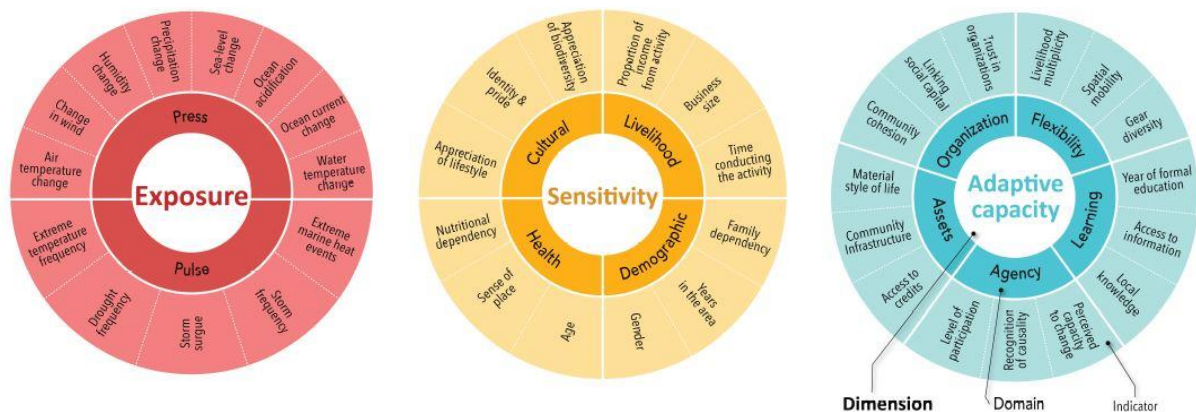


Figure 2: Conceptual diagram illustrating the three proposed nested layers for theoretically and contextually grounded vulnerability assessments

4.3 Indicators

Indicators are characteristics or processes that can be measured or estimated to track the state or trend of a particular domain. In 2009, WWF has developed a list of indicators based on the instructions of Marshall et al. to conduct a vulnerability analysis in coast areas of Madagascar (Clausen et al., 2010).

Dimension	Domain	Indicator	Questions
Sensitivity	Livelihood / Economic dependence	Income from fishing % of quantity of fish consumed by the household	Provides information on relationship between fishermen-collectors, fishermen-wholesalers and collectors-wholesaler. Study the techniques of conservation and treatment of products used by fishermen, and their influence on the value of the products. Study the income of fishermen, fishmongers and collectors according to the possible treatment of the products
		Mangrove exploitation	Provides information on why communities exploit mangrove forest: Charcoal. Firewood. Construction wood. Honey.
	Demographic	Years spent in the area/Time conducting the activity in the village	
		Family size	
		Proportion of gender	
		Mean proportion of active members in the family	Active members are people able to conduct activities that contribute to the income of the family
	Cultural	Percentage (%) of migrants in the community	
		Percentage (%) of perception of the highly ranked use and non-use value of mangroves and marine ecosystems	Provide a ranked opinion on: Extractive use. Non-extractive use. Ecological functions. Value for coastal and marine habitats. Value for marine, aquatic, terrestrial and bird species. Social and cultural value
		Level of understanding of human impacts to reefs	Measures whether communities are aware of their damaging activities and concerned about sustainability
	Health	Presence of a running water	Provides information on the hygiene and health of the population.
		Diversity of food	
		Age	
		Length of the lean season	Provides information on the period when the majority of the population reduces the number of meals or the amount of food consumed because of insufficient food.

Dimension	Domain	Indicator	Questions
Adaptation capacity	Learning	Presence of a primary school	Significantly influence the ability of the village to adapt and recover from a climate shock.
		Years of formal education	
		Access to information (radio, mobile...)	
	Assets	Existence of a marketplace	Measures the capacity of the population to eat in a variety of ways and the potential to carry out transactions on products.
		Point of sale of agricultural products	Indicates the capacity of farmers to use improved seeds and good quality products.
		Access to credits	
		Index of remoteness	Scoring villages according to their distance from basic services and infrastructure
	Flexibility (Livelihood multiplicity, spatial mobility, gear diversity)	Other activities: agriculture, fishing or livestock	Indicates the importance of natural resources for people livelihood and alternative livelihoods (ex: hunting, beekeeping, logging and seaweed farming)
		Use of chemical fertilizers	Provides information on the percentage of farmers using improved agricultural techniques and products.
		agricultural and fishing equipment	Provides information on the physical means to conduct activities: Canoe. Fishing net. Harpoon. Fishing rod
		Spatial and temporal change of the crop calendar	
		Business size /Frequency of fishing	Business size /Frequency of fishing
		Time spent in the sea	Time spent in the sea
		Fishing distance from the shore	Fishing distance from the shore
		Fishing output: target species	Provides information on the quantity/size of collected products: Shrimps. Crabs. Large fish. Small fish. Octopus. Squid. Shellfish. Sea cucumber
	Agency	Presence of a farmer / fishermen association	Characterizes the organization and social capital of the village
		Level of understanding and cooperation of Marine Protected Areas regulations	
	Organization	Percentage (%) of poor households	Provides information on the percentage of malnourished households throughout the year.

5 Data collection phase

The data collection methods that will be used are key informant surveys, participatory methods (focus group involving selected group of individuals and key stakeholders) and household surveys. Household survey is very suitable for understanding the adaptive capacity of the community and for sensitizing communities on future climate change (WWF, 2010).

5.1 Key informant interviews

Prior to data collection on the sites, interviews will be conducted with NGOs and government bodies. Key informant surveys will help get more details on the site. This includes governance, threats on the ecosystems and village selection. KIIs also help learn from experiences from others and ease the data collection process: accessibility to villages, contact of key informants on site (Cf. Appendix 1).

- BNCCC-REDD+ : Bureau national des Changements Climatiques, du Carbone et de la REDD+)
- Ministry of Environment and Sustainability
- Madagascar National Park (MNP): Works in Sahamalaza Bay
- Blue Ventures: Works in Mahajamba bay
- UNIMA/AQUALMA: Works in Mahajamba bay with Blue Ventures
- MIHARI Network: Provides Information on Locally-Managed Marine Areas in Madagascar
- INSTAT (Institut National de la Statistique) : Has statistical data especially infrastructure, health data, demographic data

5.2 Focus group

The Focus Group is a group interview technique that collects information on targeted subjects. By comparing individual opinions, this technique makes it possible to build collective representations. The sample for a focus group has individuals with characteristics of the overall population and can contribute to helping the research gain a greater understanding of the topic. The group must be rather homogeneous or in any case representative of the population studied (Association of fishermen, Migrant, Elders of the village...). The ambition of such a technique is to allow the protagonists to give their opinion without judgment while using the interaction of the group to advance the debate of ideas. It also leads to a stratified random sampling for household surveys. It is a method of sampling that involves the division of a population into smaller sub-groups known as strata. In stratified random sampling, or stratification, the strata are formed based on members' shared attributes or characteristics such as income, educational attainment or migrants. Within each stratum, households will be selected randomly based on the availability of households in the villages (Cf. Appendix 2).

5.3 Household surveys

Household surveys mainly consist of collecting information relating to household characteristics and socio-economic variables deemed to be decisive for the study using questionnaires (Cf. Appendix 3). A household is defined as a set of individuals who share the same roof generally composed by a head of household (male or female), the wife or wives (for male heads of household) and their children. The sample size will be 50 per village.

5.3.1 Mahajamba bay

Household surveys will be led at the villages of and around “Mahajamba Usine”, Tsinjomitondraka and Andranoboka. For the three villages, 150 households will be surveyed.

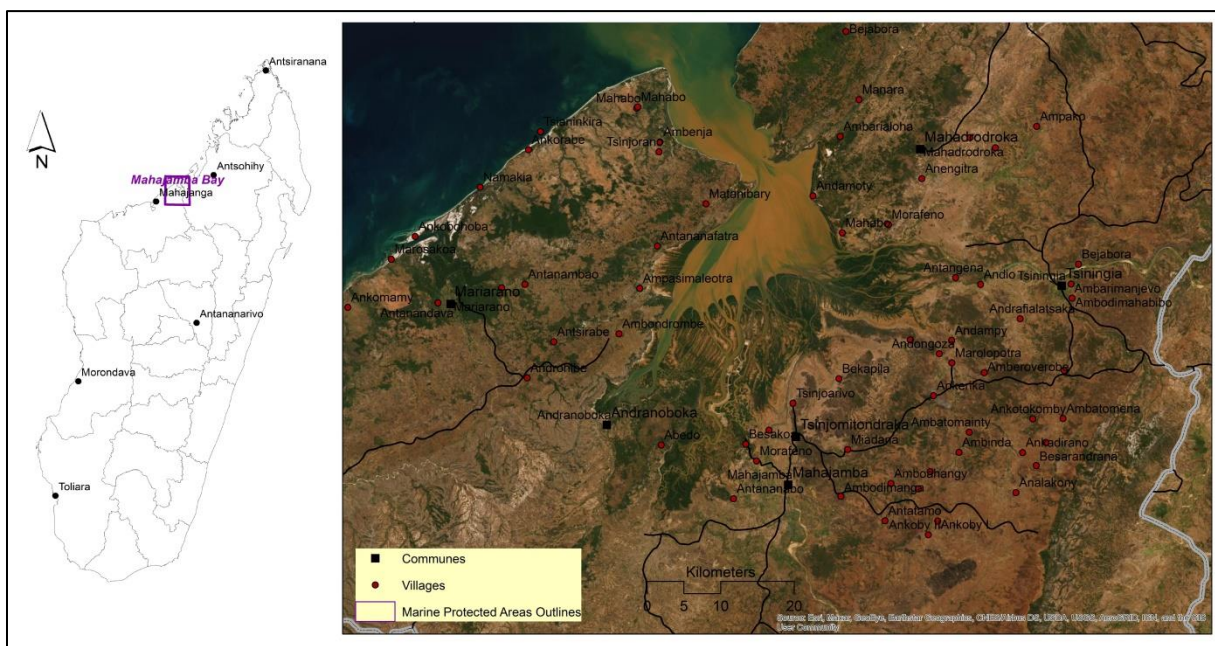


Figure 3: Location map of Sahamalaza bay

Table 1: Total number of households in the selected villages in Mahajamba

Principal villages	Population size	Estimated number of households*
Tsinjomitondraka	584	139
Mahajamba Usine	1412	336
Andranoboka	2021	481
Total	4017	956

Data source : (INSTAT, 2018)

5.3.2 Sahamalaza bay

Villages will be selected with key informants particularly with Madagascar National Park based on their proximity whether to mangrove, coral reef or seagrass beds ecosystems and the heterogeneity of the population: migrants, autochthones, fishers, farmers. However, prospective villages located to this are Andaveno I, Andaveno II and Analamena. The sample size will be 150 households.

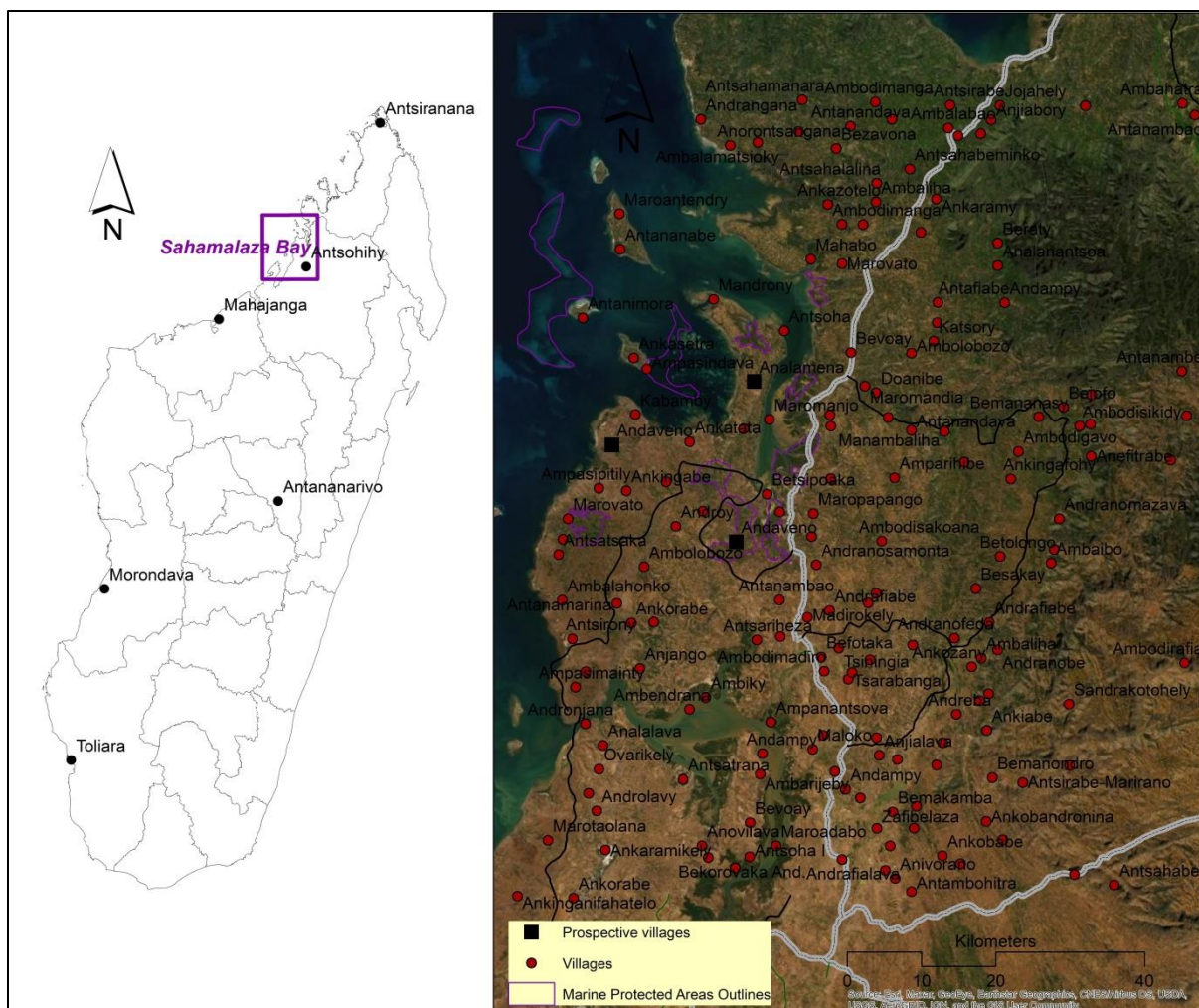


Figure 4: Location map of Sahamalaza bay

Table 2: Total number of households in the selected villages in Sahamalaza bay

Principal villages	Population size	Estimated number of households
Analamena	1423	339
Andaveno II	474	113
Andaveno II	1233	294
	2376	745

Data source : (INSTAT, 2018)

6 Data processing and analysis

6.1 Standardization

Generally, indicators generally must be standardized through transformation and rescaling so that indicators of different units such as number of person/job in households, contribution of an activity to livelihood and scales such as individual vs. community vs. country level can be integrated.

On one hand, data transformation deals with handling skewness and distribution. Common data transformation methods include **Min-Max normalization** and **Z score normalization** or, when the

distribution is skewed toward one side, root-, cube, and log-transformation. Min–max normalization performs a linear transformation on the original data. Min-max normalization method guarantees all features will have the exact same scale but does not handle outliers well but Z-score normalization handles outlier. Another method is the one that is called **Winsorization**. The distribution of many statistics can be heavily influenced by outliers. Winsorization transformation sets outliers to a specified percentile of the data by limiting extreme values in the statistical data to reduce the effect of possibly spurious outliers (Thiault et al., 2021). **Fuzzy logic** techniques can also be employed to standardize and synthesize indicators, especially in cases with complex response behaviour patterns. Fuzzy logic is a multi-value reasoning technique that is based on degrees of truth rather than the usual true or false (1 or 0) Boolean logic. It is therefore a gradient value of truth.

On the other hand, rescaling involves adjusting values measured on different scales to a notionally common scale. In machine learning, feature scaling is one of the most critical steps during the pre-processing of data before creating a machine learning model. In other cases, the indicator can be defined as a percentage. For example: contribution of fishing to household income, proportion of climate-sensitive species, and can be readily converted to a 0–100 scale (Thiault et al., 2021).

6.2 Integration

It consists of combining indicators to provide a composite measure of vulnerability. Indicators do not have the same values, weights or importance. Therefore, weighting is applied as it is considered that some of the indicators have a stronger influence on the risk components compared to other indicators. The next step in the integration phase is aggregation. Aggregation is used to combine information from different indicators into a composite indicator as a single component. To aggregate individual indicators and obtain composite indicators, one method relies on empirical weights derived from statistical models, e.g., regressions, tree-based, or structural equation models, to explain vulnerability outcomes, i.e., a measured change in a component's attribute, as a function of indicators describing exposure, sensitivity, and adaptive capacity. To calculate the composite indicator (CI), the individual indicators are multiplied by their respective coefficients, added together, and then divided by the sum of all of their coefficients. Another method consists of measuring the structure (co-occurrence and correlation) between indicators through Principal Component Analysis (PCA) for example. Highly correlated indicators will tend to group together, and different principal components could be used to evaluate domains.

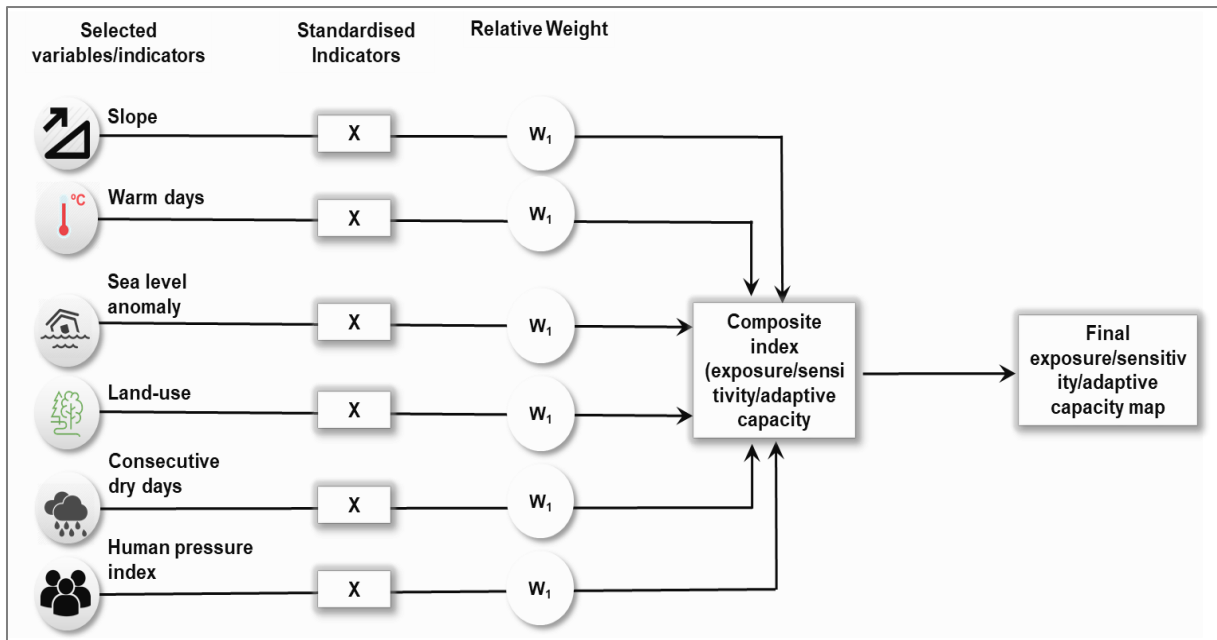


Figure 5: Illustration of analytical steps involved in evaluating any of the three vulnerability dimensions

7 Planning

Activities	Oct		Nov				Dec				Jan		
	1	2	3	4	5	6	7	8	9	10	11	12	13
a) Review the social aspects of the CCVA toolkit,													
b) Develop the sampling design and a generic survey template,													
c) Prepare a data template													
d) In consultation with the project manager have a full view of CCVA for the target communities reviewed													
Deliverable: 1. Inception report													
e) Test the socioeconomic surveys													
e1) Short KIIs in Antananarivo (Madagascar National Parks [Sahamalaza], Blue Ventures [Mahajamba])													
e2) Mahajamba data collection (KIIs and HH)													
e3) Sahamalaza data collection (KIIs and HH)													
f) In consultation with the project manager, analyse the collected qualitative and quantitative data													
g) In consultation with the project manager prepare and submit a report on the pilot test,													
h) Generate and produce key information awareness products and relevant manuscript targeting peer reviewed journals.													
Deliverables:													
2. Progress report (Information awareness products : graphics, brochures, video on adaptation, mitigation, and technological options available for the target communities); Excel database													
3. Working with the Focal Point of the Convention, ensure that management and policy options for adaptation, mitigation, and technological options available for possible adoption into national level processes													
i) Provide for assessments of risks and vulnerabilities (natural and human) and drivers affecting coastal fishery communities using the CCVA toolkit													
j) Review country specific adaptation technology needs,													
k) Provide for the definition and inclusion of coastal and marine adaptation options in climate change policies at national level.													
Deliverable: 4. Relevant manuscript targeting peer reviewed journals													

8 References

- Adger, W. N., 2003. « Social aspects of adaptive capacity », in Smith, J. B., R. J. T., Klein et S. Huq (dir.), *Climate Change, Adaptive Capacity and Development*, Imperia! College Press.
- ASCONIT-PARETO. 2011. Etude de vulnérabilité aux changements climatiques – Evaluation qualitative. Madagascar
- Clausen, A. Rakotondrazafy, H, Ralison, H. O., Andriamanalina, A., 2010. Les Mangroves de l’Ouest de Madagascar: Analyse de la vulnérabilité au changement climatique. Composante du Projet intitulé « Adaptation au Changement Climatique pour la Conservation à Madagascar », financé par la Fondation MacArthur et mis en oeuvre conjointement par WWF, Conservation International et Wildlife Conservation Society.
- Climate Crowd, 2021. "Mangrove Vulnerability to Climate Change: Insights from Climate Crowd Interviews" World Wildlife Fund, Washington, DC
- Cripps, G. 2009. Understanding migration amongst the traditional fishers of West Madagascar. Blue Ventures Conservation Report for ReCoMaP.
- GIZ. (2021). Climate Risk Profile : Madagascar.
- Kasprzyk Z., Levrel A., 2018. La chaîne de valeur et les opportunités de meilleure valorisation des principaux produits halieutiques de la baie de Mahajamba. Blue Ventures Conservation Report. Disponible au téléchargement sur blueventures.org/publications.
- Thiault, L., S. D. Jupiter, J. E. Johnson, J. E. Cinner, R. M. Jarvis, S. F. Heron, J. M. Maina, N. A. Marshall, P. A. Marshall, and J. Claudet. 2021. Harnessing the potential of vulnerability assessments for managing social-ecological systems. *Ecology and Society* 26 (2):1.
- World Resources Institute (WRI) 2003. *EarthTrends: coastal and marine ecosystems*, Madagascar. World Resources Institute, Washington D.C.
- WWF. 2013. Analyse de la vulnérabilité au changement climatique de la population locale et des ressources dont elle est tributaire au niveau des aires marines protégées d’Ambodivahibe et de Nosy Hara en vue de l’identification des stratégies d’adaptation appropriées.
- INSTAT Madagascar. 2018. Résultats globaux du recensement général de la population et de l’habitation de 2018 de madagascar (rgph-3)

3.3.1 What are the impacts of climate change on local community's health? Food and waterborne Diarrheal Disease, Air Pollution, Food security (Length of the lean season), mental health and stress-related disorders.

4. Adaptive capacity

4.1 Flexibility

4.1.1 Business size /Frequency of fishing in the community (Difference from a reference time) [Livelihood multiplicity]

4.1.2 Time spent in the sea (Difference from a reference time) [Spatial mobility]

4.1.3 Fishing distance from the shore (Difference from a reference time) [Spatial mobility]

4.1.4 Gear diversity

4.1.5 What are the main sources of income? (1) Fishing (2) Commerce (3) Agriculture (4)Workers (For another households) (5) Other

4.2 Organization

4.2.1 Are there migrant fishers in the site? Have they settled permanently or temporarily? What period of the year do they fish and where?

4.2.2 How many different ethnic groups are there in the site?

4.2.3 Are there conflicts/problems about marine resources here? If conflict happens, (b) who is involved? (c) What is the conflict about? (d) What is the intensity? (e) What is the frequency? (f) How is the conflict resolved? [Community cohesion]

4.3 Assets

4.3.1 When were there interventions by government, NGOs, projects or individuals from outside the village (e.g. nurseries, environmental awareness, infrastructure, school, running water, hospital)? [Community infrastructures]

4.3.2 Do the sites have access to credit? What is the percentage of households that have access to credit? [Access to credits]

4.4 Learning

4.4.1 How do communities have access to information: Radio, Mobile... [Access to information]

4.5 Governance (will be added to Organization)

4.5.1 How is the site managed? Community based? Government based? NGOs?

4.5.2 What types of activities have you [the interviewee] been involved in?

4.5.3 What tools have you used? How effective were these tools in reaching and motivating Fishers?

4.5.4 Who have your efforts been focused on?

4.5.5 Who have you collaborated with?

4.5.6 What are the sources of weather and climate information in the site?

4.5.7 Do people break rules?

- Places where people are not supposed to fish
- Certain fishing gears that people are not supposed to use
- Certain times that people are not supposed to fish
- Certain species or types of fish
- that people are not supposed to catch

5. Fieldwork: Village selection

Based on these data, to which villages would you think we should conduct household surveys to get representative data of the site?

Do you have any contacts or key informants that we should talk to in the site/selected villages?

Appendix 2: Participatory methods (Focus Group)

1) Objectives

- Familiarize with the situation in the village.
- Guide household's surveys.
- Determine the historical elements (from 1990) and current situation related to climate variabilities that have influenced or changed the way communities operate.

2) Participants

- Elders of the village (male / female) and at least one middle-aged person (or two) motivated to talk about the history of the village.
- Member of fishermen's association
- Non-member of the association

3) Methods: PESTEL (Political, Economic, Social, Technological, Legal and Environmental factors)

Political

- When were there interventions by government, NGOs, projects or individuals from outside the village in relation to the climate or not (e.g. nurseries, environmental awareness, infrastructure, school)?
- How have fishing activities developed since 1990?

Economic

- Presence of running water
- Total number and list of infrastructures
- Presence of a primary school
- Existence of a marketplace
- Index of remoteness

Social

- Percentage (%) of household's members in the association
- Percentage (%) of household's members of a community association
- Percentage (%) of migrants in the community
- Percentage of villagers having access to information (radio, mobile...)
- Proportion of men and women fishing
- Main challenges facing coastal communities
- List of other villages operating the same fishing ground
- Local solutions

Technological

- List and percentage of users of agricultural and fishing equipment: Canoe. Fishing net. Harpoon. Fishing rod
- Percentage (%) of farmers using chemical fertilizers

- Spatial and temporal change of the crop calendar

Environmental

- What were the main events or changes that affected the village, especially in relation to climate variabilities: temperature, wind, rainfall, sea level rise, cyclones (from 1990)
 - Threats to mangroves and fishing resources: human activities, pollution, the effect of climate change
 - Has the quantity of fish decreased compared to last year?
 - Percentage habitats targeted by the community and difference between men and women
1. fringing reef
 2. Lagoon
 3. Outside the reef
 4. Mangrove
 5. Pelagic fishing in the open sea

Legal (knowledge, compliance and law enforcement)

- Are there any regulations relating to the following activities: fishing, use of mangroves, aquaculture, hotel facilities
- What measures have improved coastal management in the area and especially the coral reefs and mangroves?
- Application of the specifications by the communities

Appendix 3: Households survey

Study site: _____ County/District: _____
 Village: _____ Date: _____
 Survey no.: _____ Name of interviewer: _____
 Latitude/longitude: _____

PART 1: SENSITY DIMENSION

Demographic Characteristics (*Please tick one*)

- 1) Age (in years):
- 2) Sex:
 [1] Female [2] Male [3] Other
- 3) Formal education:
 [1] Class 8 or less [2] Secondary school - level certificate [3] A-level certificate
 [4] Tertiary [5] University and above
- 4) What is your religion?
 [1] Muslim [2] Christian [3] Hindu
 [4] Traditional [5] Other (specify)
- 5) Marital status: [1] Single [2] Married [3] Married before [4] Other
- 6) Where are you originally from? (*Tick only one option below*)
 [1] This village [2] Another village in this county [3] Coastal area other than this location [4] This country (not coastal area) [5] Another country
- 7) How many years have you lived in this village?
- 8) How many people are currently in your household, including yourself? (*Please write down the number of people below each category*)

Adult male	Adult female	Male children	Female children

- 9) What is your employment status? [1] Unemployed [2] Employed
- 10) If employed, what form of employment are you engaged in?
- 11) If unemployed, is anyone from your household engaged in formal employment?
 [1] No [2] Yes
- 12) Please give details of employment for any members of your household who are employed (specify type of occupation)

- 13) If unemployed, how do you earn income or obtain food and other necessities?

- 14) How much income do you earn per week/month/year? KShs.

- 15) If fisher, what marine resources do you depend on? KShs.

PART 2: SOCIAL ADAPTIVE CAPACITY DIMENSION

FLEXIBILITY

Livelihood multiplicity

16) Traditional uses of marine resources

- i. What goods did you obtain from the marine resources in the past?
- ii. Have these goods changed over time? [1] No [2] Yes
- iii. If yes, how?
- iv. How else did you benefit from the marine resources in the past? (*probe for ecological services*)
- v. Has the benefits changed over time? [1] No [2] Yes
- vi. If yes, how?
 - a) How do you use marine resources now?
 - i. What goods do you obtain from the marine resources now?
 - ii. How else do you benefit from the marine resources now? (*probe for ecological services*)

17) What economic activities do you engage in to obtain food or income to your house?

What do other people in your house do that brings in food or money to your house?

Livelihood activity	Tick livelihoods of the respondent	Number of people in the household involved in activity		Rank the economic activities in order of importance
		Women	Men	
Fishing				
Gleaning				
Medium scale fish trade/fish dealer				
Fish mongers (<i>mama karanga</i>)				
Mangrove cutting or trade				
Agent (middleman)				
Aquaculture/Mariculture				
Hunting				
Farming (cash crops)				
Farming (peasant/subsistence, livestock)				
Salaried employment (e.g. teacher, nurse)				

Tourism and handicrafts				
Small business(not marine related)				
Other:				
Other:				

18) Is fishing your primary livelihood? [1] No [2] Yes

19) If yes, how much do you agree with this statement? (*Please circle one option*):
 “I could easily stop fishing, and make my living on land”

Strongly disagree	Somewhat disagree	Neither	Somewhat agree	Strongly agree

20) Cultural/heritage impacts

- a) What areas of the marine environment/resources are of special interest to communities for cultural or religious purposes?
- b) Has this changed over time? [1] No [2] Yes
- c) If yes, how? _____

Fishing and Marine Resources Management/Gear diversity

21) Do you own a boat? (Tick as appropriate)

- [1] No boat
- [2] Boat without a motor (e.g., canoe)
- [3] Boat with a motorized engine (engine has __hp)
- [4] Other(specify)___

22) Which fishing gears does your household use? (*Tick appropriately*)

Gear	Tick gear used	Gear	Tick gear used
Hand line (inshore/reef)		Purse seine net	
Hand line (offshore/blue water)		Hand spear	
Multiple hooks (more than 20)		Spear-gun	
Trolling line		Fish trap	
Mesh gillnet, above 5cm(2inches)		Explosives/Poison	
Mesh gillnet, below 5cm(2inches)		Gleaning	
Mosquito nets		Other(specify):	
Small/beach seine net (nets dragged along substrate)		Other(specify):	

23) Which fishing gear is the most important to your household? _____

24) Where is your fishing ground?

25) Catch, fishing effort and catch value:

Parameter	Details
Quantity of fish & other seafood landed (Kgs/ Bundles/pieces)	
Number of fishing crew	
Number of hours (fishing and travelling)	
Total value of catch (local currency)	

26) Typically, what percentage of your catch from fishing or gleaning do you sell, retain for own consumption or give away?

Retain for own consumption ____% sell ____% give away ____% don't know ____%

27) If you were to get 50% less catch all year what would you do? (*Tick multiple boxes if necessary*)

Keep fishing at same amount	Fish more often	Change fishing grounds	Change fishing gears	Fish less & switch to other livelihood	Stop fishing entirely
Other(specify):					

28) In general, how often do you and your household eat locally caught fish or other sea food that was caught by you or someone in your community? (*Please circle one option*)

More than once per day	Once per day	More than once per week	Once per week	More than once per month

29) Over the past 5 years, has the number of fish caught around your area changed? If so, how has it changed? (*Tick one option*)

- [1] Significant decrease [2] Decrease [3] No change
 [4] Increase [5] Significant increase

30) What can be done to increase availability of fish in the sea around here? _____

ORGANIZATION

31) In general, how much do you trust the following people? (*Tick one option for each group*).

	Not at all	Distrust more people than trust	About half-half	Trust more people than distrust	Trust all
People in your village					
Village leaders					
Marine resource management group					
NGOs					
Government					

32) I am interested in learning about some of the rules and traditions about fishing here. **(A)** Are there places where people are not supposed to fish, nor use certain gears, etc.?

(B) Who created the rules? **(C)** Do people still fish there? If so, how many people? (*Interviewer: please **fill out first row** before moving to next row, i.e. ask A-C for places where people are not supposed to fish followed by A-C for fishing gears that people are not supposed to use*).

Rule	Description of rules, e.g. what gears are not used etc.	Who created the rules? (<i>tick multiple boxes if necessary</i>)	Do people still fish there? If so, how many? (<i>tick one box</i>)
Places where people are not supposed to fish		<input type="checkbox"/> Fishers/local users <input type="checkbox"/> NGO <input type="checkbox"/> Government <input type="checkbox"/> Other: _____ <input type="checkbox"/> Don't know	<input type="checkbox"/> No one <input type="checkbox"/> A few <input type="checkbox"/> About half <input type="checkbox"/> Most <input type="checkbox"/> Everyone <input type="checkbox"/> Don't know

Certain fishing gears that people are not supposed to use		<input type="checkbox"/> Fishers/local users <input type="checkbox"/> NGO <input type="checkbox"/> Government <input type="checkbox"/> Other: _____ <input type="checkbox"/> Don't know	<input type="checkbox"/> No one <input type="checkbox"/> A few <input type="checkbox"/> About half <input type="checkbox"/> Most <input type="checkbox"/> Everyone <input type="checkbox"/> Don't know
Certain times that people are not supposed to fish		<input type="checkbox"/> Fishers/local users <input type="checkbox"/> NGO <input type="checkbox"/> Government <input type="checkbox"/> Other: _____ <input type="checkbox"/> Don't know	<input type="checkbox"/> No one <input type="checkbox"/> A few <input type="checkbox"/> About half <input type="checkbox"/> Most <input type="checkbox"/> Everyone <input type="checkbox"/> Don't know
Certain species or types of fish that people are not supposed to catch		<input type="checkbox"/> Fishers/local users <input type="checkbox"/> NGO <input type="checkbox"/> Government <input type="checkbox"/> Other: _____ <input type="checkbox"/> Don't know	<input type="checkbox"/> No one <input type="checkbox"/> A few <input type="checkbox"/> About half <input type="checkbox"/> Most <input type="checkbox"/> Everyone <input type="checkbox"/> Don't know
Other, please describe:		<input type="checkbox"/> Fishers/local users <input type="checkbox"/> NGO <input type="checkbox"/> Government <input type="checkbox"/> Other: _____ <input type="checkbox"/> Don't know	<input type="checkbox"/> No one <input type="checkbox"/> A few <input type="checkbox"/> About half <input type="checkbox"/> Most <input type="checkbox"/> Everyone <input type="checkbox"/> Don't know

Social Capital

33) Social networks

- a) Are there times when you go to someone else for help? [1] No [2] Yes
b) If the answer to question a) is yes, who do you run to for help in times of need?

—

—

- c) Why do you run to this person(s) and not any other person(s)?

- d) Who are the key decision makers in the community?

- e) How are decisions made in the community?

Learning

34) Local perception of marine resources management and management success

- a. In your opinion, are the marine resources managed well?

b. What aspects of management do you consider successful in your area?

f) Is there effective enforcement of rules and regulations governing marine resources? [1] No [2] Yes

If _____ yes, _____ explain:

c. Are the local communities involved in marine resources management?

[1] No [2] Yes

If _____ yes, _____ how?

d. What is your opinion regarding marine resources conservation?

35) Level of understanding of human impacts on marine resources

a. Are there any activities that damage marine resources in the area?

b. Are you concerned about sustainability of the marine resources?

36) Distance from village to the sea; importance of markets; slope

37) Distance from village to nearest market

38) How is cultural knowledge passed down by the community from one generation to another? _____

39) Is there any cultural memory, traditions, and assets that relate to coastal and marine resources that have been handed over to you? _____

Food Security and Wellbeing

40) Were there any moments in the last month when your home did not have enough to eat?

[1] No [2] Yes [3] I don't know

41) Was this unusual?

[1] No [2] Yes [3] I don't know

42) In the past year, have there been times when you feared that your food would not last until you were able to get more?

[1] No [2] Yes [3] I don't know

43) In general, how many times do you eat in the day?

[1] Once [2] 2 times [3] 3 times [4] Over 3 times

44) Since yesterday, can you tell me about the meals you have prepared for your family?

ASSETS AND ACCESS TO CREDIT

Material Style of Life

45) Material style of life and owned assets. *Please tick all the household items or facilities present in the household. Also record the number of each asset owned by the household.*

Cooking pots [1] No [2] Yes How many:	Radios/cassette/CD [1] No [2] Yes How many:	DVD/VCD players [1] No [2] Yes How many:	
Mattresses [1] No [2] Yes How many:	Mobile phone (not smart phone) [1] No [2] Yes How many:	Smart phone sortables [1] No [2] Yes How many:	
Flushing toilet [1] No [2] Yes How many:		Indoor piped water (tap) [1] No [2] Yes How many:	
Washing machine [1] No [2] Yes How many:	Computers [1] No [2] Yes How many:	Electric refrigerators or freezers [1] No [2] Yes How many:	
Cattle/Goats/Pigs /Sheep(livestock) [1] No [2] Yes How many:	Televisions [1] No [2] Yes How many:	Satellite dishes [1] No [2] Yes How many:	
Private toilet [1] No [2] Yes How many:	Other1 [1] No [2] Yes How many:	Other2 [1] No [2] Yes How many:	
Roof Material <input type="checkbox"/> Bamboo/Thatch <input type="checkbox"/> Wood <input type="checkbox"/> Metal <input type="checkbox"/> Tile <input type="checkbox"/> Other:_____	Wall Material <input type="checkbox"/> Bamboo/Thatch <input type="checkbox"/> Wood <input type="checkbox"/> Metal <input type="checkbox"/> Cement <input type="checkbox"/> Other:___	Floor Material <input type="checkbox"/> Dirt/Soil <input type="checkbox"/> Wood <input type="checkbox"/> Concrete <input type="checkbox"/> Tile <input type="checkbox"/> Other:_____	Electricity <input type="checkbox"/> Solar <input type="checkbox"/> Generat or <input type="checkbox"/> Grid <input type="checkbox"/> None <input type="checkbox"/> Other:___

46) Community infrastructure

a) How are the communities governed?

b) How do the communities relate with higher levels of government?

47) It would be great to know more about how you feel about your life here. All things considered, has your satisfaction with your life as a whole changed over the last three years? [1] No [2] Yes.

If so, how has it changed? (Please tick **one** option)

Much worse	Worse	No change	Better	Much better

48) If there was a change, what are the three main causes of this change?

1. _____
2. _____
3. _____

49) Supposing that for some reason you were moving away from your current village, how would you feel about leaving?

Very sad	Sad	Neither happy nor sad	Happy	Very happy

50) Do you have access to savings to respond to extreme climatic events? [1] No [2] Yes

51) Do you have access to credit facilities? [1] No [2] Yes; Explain _____

52) For people dependent on marine resources, do you have access to markets?
[1] No [2] Yes

53) Do both men and women have equal access to resources? [1] No [2] Yes

54) Are there any barriers restricting access to the coastal and marine resources? Explain

55) Is government investing in longer term adaptation options? [1] No [2] Yes,
If yes, how? _____

AGENCY

Recognition of causality

56) Does fisheries and mangrove management affect this community? [1] No [2] Yes

57) Does fisheries and mangrove management affect you? [1] No [2] Yes

58) If yes, what are the positive impacts of fisheries and mangrove management for you?

59) What are the negative impacts of fisheries management on you? _____

60) In general, do you think management has affected fish stocks? If yes, how has the fish stock been affected? (Please tick **one** option)

Much worse	Worse	No change	Better	Much better

61) In general, do you think management has affected the quality (e.g., size) of fish and other sea food landed?

(Please tick **one** option)

A lot less	Somewhat less	No change	Somewhat more	A lot more

62) In general, do you think management has made it easier or harder to catch fish and other sea food (in terms of time, effort, or travel distance)? (Please tick **one** option)

Much harder	Hard	Neither	Easier	Much easier

63) In general, do you think management has affected the reliability of what you can catch?

If yes, how has it changed the reliability? (Please tick **one** option)

A lot less reliable	Less reliable	No change	More reliable	A lot more reliable

Level of participation

64) Currently, are you involved in the following aspects of marine resources management?

a) decisions about marine resource use (attending meetings about marine resources)

Not at all	Seldom	Never	Often	Very often

b) management of marine resources

Not involved	Involved a little	Never	Involved	Highly involved (in leadership)

65) How much do you agree or disagree with this statement: (Please tick **one** option)

“People like me have influence on the management of marine resources.”

Strongly disagree	Disagree	Neither	Agree	Strongly agree

66) In general, do you think the way that decisions are made about marine resource use and management are fair? (Please circle **one** option)

Very unfair	Unfair	Neither	Fair	Very fair	Don't know

Why? _____

67) Is there any conflict over marine resources here? If yes, how often does this conflict occur? (*Please circle **one** option*)

No conflict	Daily	Weekly	Monthly	More than once per year	Less than once per year	Don't know

CLIMATE CHANGE

68) Have you heard of climate change or global warming?

[1] No [2] Yes

69) Can you tell me what it is? *Please check all the answers the respondent provides. Do not prompt the respondent*

- Drought – not enough rain
- Floods – too enough rain
- Sea level rise
- Warmer conditions
- Other
- More storms & extreme weather
- Increased disease
- Impact on fish catch

70) Are you worried about this affecting your family?

[1] Not worried [2] A little worried [3] Not sure [4] Worried [5] Very worried

71) What traditional knowledge or practices relevant to addressing climate are available in the communities?

72) What adaptation options are available to you and the local communities? _____

73) Do you and other members of the community have access to relevant information, such as forecasts or early warning?

SUPPLEMENTARY QUESTIONS - Adaptation to Covid-19

74) How has COVID-19 impacted how you and your family obtain food and income compared to how you normally would at this time of year?

75) Have you and your family made any changes to cope with these impacts? [1] No [2] Yes

76) If the answer to question 74 is yes, please explain

77) Has COVID-19 changed the quantity of fish or other sea food that much you have been catching compared to how you would normally catch at this time of year?

[1] No [2] Yes

If yes, how?

Much worse	Worse	No change	Better	Much better

78) Has COVID-19 impacted the fish market? [1] No [2] Yes

Please

explain

79) Are people in the community able to access markets? [1] No [2] Yes

Please explain

80) Have you and your family made any changes to cope with these impacts? Please tell me about them.

81) Has COVID-19 changed the price of fish now compared to this time of year normally?

How?

Has COVID-19 affected the types and variety of food you and your family are eating now, compared to normally at this time of year? [1] No [2] Yes

If yes, how?

82) Are there foods you normally eat at this time of year that you are not able to eat at the moment? [1] No [2] Yes

If yes, why?

83) Have you and your family made any changes to cope with these impacts? Please tell me about them.

84) What impacts has COVID-19 had on livelihoods in the community?

85) Has the number of people who are engaged in fishing changed? [1] No [2] Yes

If yes, how?

86) Has the intensity of fishing changed? [1] No [2] Yes

If yes, how?

87) How has the community responded to COVID-19? _____