CLIMATE CHANGE VULNERABILITY ASSESSMENTS IN SELECTED COASTAL COMMUNITIES IN KENYA

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PILOT TEST OF THE CCVA TOOLKIT WITH DETAILED METHODOLOGY FOR MANAGERS/POLICY MAKERS IN KENYA

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Table of Contents

LIST OF ACRONYMS

ACI	-	Adaptive Capacity Index
AHP	-	Analytic Hierarchy Process method
BMU	-	Beach Management Unit
CCVA	-	Climate change vulnerability assessments
SCCVI	-	Social Climate Change Vulnerability Index
CP	-	Contracting Parties
FGDs	-	Focus Group Discussions
GEF	-	Global Environment Facility
KMFRI	-	Kenya Marine and Fisheries Research Institute
MSL	-	Material Style of Life
NC-SWIOFC PP	-	Nairobi Convention and the South West Indian Ocean Fisheries Commission for marine and coastal governance and fisheries management for sustainable blue growth
PCA Mix	-	Principal Component Analysis of a mixture of qualitative and quantitative variables
SAC	-	Social Adaptive Capacity
S.I	-	Sensitivity Index
SIDA	-	Swedish International Development Cooperation Agency
SI	-	Sampling interval
TORs	-	Terms of Reference
UNEP	-	United Nations Environment Programme
WIOSAP	-	Strategic Action Programme for the protection of the Western Indian Ocean from land-based sources and activities

GROSSARY OF COMMONLY USED TERMS

Aggregation: Combination of normalized indicators to the final index.

Climate change: Significant changes in global 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 periods.

Climate change vulnerability: The degree to which geophysical, biological and socio-economic systems are susceptible to and unable to cope with adverse impacts of climate change, including climate variability and extremes.

Household: Where one individual or a group of people live, cook and eat together at one place and share living space.

Indicators: Is a measurable variable used as a representation of an associated measurable or non-measurable variable.

Livelihood security: The adequate and sustainable access to income and other resources to enable households to meet basic needs.

Sensitivity: Is the responsiveness of a system to climatic influences, and the degree to which changes in climate might affect it in its current form.

Vulnerability: Is an integrated measure of the expected magnitude of adverse effects to a system caused by a given level of certain external stressors to generate risk.

Vulnerability index: Is a metric characterizing the vulnerability of a system, which is typically derived by combining, with or without weighting, several indicators assumed to represent vulnerability.

Weighting: The relative degree of indicator importance.

ABSTRACT

Piloting of climate change vulnerability assessments (CCVA) toolkit was carried out at Vanga, Gazi Bay, Mida Creek and Lamu Archipelago between November 2021 and March 2022. The target communities in these sites depend on the mangrove, seagrass and coral reef goods and services such as fisheries and coastal protection that support their livelihoods and wellbeing. The study aimed at establishing the relative social adaptive capacity, sensitivity scores among the coastal communities, and recommendations for adaptation options or mitigation. A cross sectional survey design was adopted with questions being asked once in the entire period of study. The study revealed that the communities that depend on mangrove, seagrass and coral reef systems in the four sites that were studied in Kenya have low adaptive capacity and high sensitivity, and are vulnerable to climate change. The main hindrances to adaptation to climate change were identified by the respondents to include poverty, lack of knowledge on adaptation methods, lack of information on weather, lack of access to water for irrigation and lack of improved seed. Data on material style of life revealed that there was variability within the broader variable grouping of types of housing material and sources of electricity to the households. It particularly showed that having electricity from generator suggested higher economic well-being than having electricity from a grid or solar, with the overall score indicating variability in material style of life among villages. The study further revealed that the elements of exposure include changes in precipitation that have been occasioned by frequent occurrence of droughts and floods, changes in both air and sea surface temperature that have been characterized by prevailing warmer conditions, changes in fish catch, increased disease, sea level rise, and increased occurrence of storms and extreme weather. Climate change is caused by a number of factors including deforestation, natural occurrence and industrial pollution. Based on the findings, it has been recommended that both National Government and County Governments in the coast of Kenya should mainstream climate change adaptation planning and implementation in climate policy and planning processes, promote protection and restoration of the coastal wetland and coral reefs, improve water resources management through appropriate rainwater harvesting and storage technologies to support water-efficient or climate smart irrigation as an adaptive strategy to improve production during periods when the rains fail, improve access to information on climate variability through early warning to inform fishers and coastal farmers on the timing of fishing activity and planting of crops, and provide basic social services, infrastructure, livelihood diversification and employment, strengthening of food production and supply systems to enhance the quality of life and livelihoods among coastal communities.

1.0 INTRODUCTION

A pilot test of Climate Change Vulnerability Assessments (CCVA) was conducted on the social and ecological systems at Vanga, Gazi Bay, Mida Creek and Lamu Archipelago in the coast of Kenya. The coast of Kenya is about 600 km long extending from Vanga in the south to Kiunga, Lamu in the north. The coastal ecosystems are endowed with diverse mangrove, seagrass and coral reef resources. Coastal communities in Kenya depend on the mangrove, seagrass and coral reef goods and services such as fisheries and coastal protection that support their livelihoods and wellbeing. The importance of fisheries as a source of livelihood is particularly more pronounced in Lamu, Kilifi, Kwale and Tana River Counties (Ochiewo et al. 2020). The study on climate change vulnerability assessments (CCVA) in selected coastal communities in Kenya was carried out based on the contract number 2500279467, that was signed on 1st November 2021 and amendment number 2500289149 of 25th January 2022 by the UNEP Nairobi Convention Secretariat and the Contractor.

Climate change can be defined as significant changes in global 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. Climate change is expected to considerably change ecosystems and their capacity to benefit human society. The intensity and magnitude of change will vary over space and time, leading to differential impacts on ecosystems and community livelihoods. The nature of climate change impacts and the responses of the social-ecological systems complicate the management intervention to address the impacts of climate change. Systems, where social, economic, ecological, cultural, political, technological, and other components are strongly interlinked are known as social-ecological systems. Therefore, informing the management on strategies that can help both the social and ecological systems adapt, recover, or minimize the impacts is critical to addressing climate change impacts on social-ecological and biophysical systems. Climate Change Vulnerability Assessment (CCVA) was therefore carried out to generate information that can inform climate change adaptation strategies.

Climate change vulnerability is the extent to which geophysical, biological and socio-economic systems are prone to and unable to cope with undesirable impacts of climate change, including climate variability and extremes (Füssel & Klein, 2006). Vulnerability is an integrated measure of the expected magnitude of adverse effects to a system caused by a given level of specific external stressors to generate risk (Oppenheimer et al., 2015). It reflects the potential for a system to experience damage in response to some external influence, pressure or hazard. The relevant system or process may be an individual or population; a single species or an entire ecosystem, a business enterprise or an entire regional economy. In this study, vulnerability was considered to be a function of exposure, sensitivity and adaptive capacity, however exposure was considered constant while sensitivity and adaptive capacity were allowed to vary.

1.1 Background

This study is part of two projects that are being implemented by the Nairobi Convention Secretariat namely: (1) Implementation of the Strategic Action Programme for the protection of the Western Indian Ocean from land-based sources and activities (WIOSAP) with funding from the Global Environment Facility (GEF), and (2) the Partnership project between the Nairobi Convention and the South West Indian Ocean Fisheries Commission (NC-SWIOFC PP) for marine and coastal governance and fisheries management for sustainable blue growth with funding from the Swedish International Development Cooperation Agency (SIDA).

The WIOSAP project on the one hand, is implementing interventions 'to reduce impacts from land-based sources and activities and sustainably manage critical coastal and marine ecosystems through the implementation of the agreed WIO-SAP priorities with the support of partnerships at national and regional level. It has presented an opportunity to the governments in the region and their conservation partners to jointly implement strategies of protecting coastal and marine ecosystems from land-based sources and activities to sustainably provide essential goods and services. On the other hand, the NC-SWIOFC partnership project seeks (i) to enhance the resilience of livelihoods based on WIO marine and coastal ecosystem and habitats, (ii) to promote sustainable management of coastal fisheries using the ecosystem approach to fisheries, and (iii) to enhance coordination between fisheries and environmental management

institutions. Component 1 of the project on environmental management will support regional and national capacity on adaptation to climate variability and change. It will address the capacity gap on options, approaches, and tools for the sustainable management of the use of coastal resources, particularly fisheries and assessment of risks and vulnerabilities affecting coastal fisheries communities.

Implementation of these two projects will support regional collaboration for enhancing scientific research, data generation, assessment and analysis of impacts of climate change, which are essential in the context of the resilience of coastal communities as well as in assisting countries in identifying major technologies and innovative approaches at various adaptation scales. It is expected that countries will update their climate change adaptation policies to include coastal and marine systems necessary to enhance the resilience of their coastal communities. The two projects respond to Nairobi Convention's Contracting Parties Decision CP.9/1.3 on Work programme for 2018–2022 which requested the Secretariat to develop a regional integrated programme for the full implementation of the strategic action programmes developed under the WIO-LaB project and its extension beyond the lifespan of the Strategic Action Programme.

The WIOSAP and NC-SWIOFC partnership projects are implemented and executed through a "Partnerships Approach" with the Nairobi Convention Secretariat being the Executing Agency. The beneficiary countries are Comoros, Madagascar, Mauritius, Seychelles, Mozambique, Kenya, Tanzania, Somalia and South Africa. The objective of this assignment is to conduct climate change vulnerability assessment on coastal communities that highly depend on coastal and marine resources in Kenya, as part of the regional undertaking. This report however focuses on community demographics in the surveyed villages, including their dependence on coastal natural resources for their livelihoods, climate change impacts on their livelihoods, coping mechanisms and recommended adaptation measures to enhance community resilience.

2.0 SCOPE OF THE REPORT

This report covers the pilot test of the CCVA toolkit with detailed methodology for managers/policy makers. It includes a detailed methodology of how the piloting was done through application of socioeconomic surveys per target community at Gazi, Vanga, Mida Creek and Lamu. It contains:

- Results from the qualitative and quantitative data including the relative social adaptive capacity and sensitivity scores among communities
- Detailed recommendations for managers/policy makers for adaptation options and/or mitigation, including:
    - ✓ a detailed description of the relative scores of Social Adaptive Capacity (SAC) and sensitivity indicators,
    - ✓ the climate adaptation options that can address the identified SAC and sensitivity gaps.
    - ✓ Associated data, spreadsheets and summarized information that can be integrated with scores from other dimensions to develop an overall integrated CCVA.

3.0 METHODOLOGY

The study covered both sensitivity and vulnerability dimensions of climate change vulnerability assessment. Sensitivity dimension on the one hand covered the conditions that determine the degree to which a component is directly or indirectly altered in the short term by exposure to stressor. Adaptive capacity on the other hand refers to latent ability to implement effective responses to changes by minimizing, coping with, or recovering from the potential impacts of a stressor (Whitney et al. 2017, Cinner et al. 2018).The methodology followed the five (5) steps for CCVA that are detailed in the CCVA Toolkit for the Western Indian Ocean region, and entailed gathering data from primary and secondary sources to inform the review of the CCVA toolkit. The five steps that were domesticated in the present study were: (1) establish context, (2) compile relevant data, (3) evaluating vulnerability dimensions, (4) synthesizing dimensions into a composite index of vulnerability, and (5) operationalizing and mainstreaming vulnerability.

The context was covered by the objectives and scope of Vulnerability Assessment that were defined in the TORs for the study. The assessment target was well identified under sample size and sampling technique (sub-section 3.4 below) where the target population has been described. Conducting a desktop review to understand the impacts of climate change on a socio-ecological system has been elaborated in sub-section 3.2.Scope/boundary of the assessment has been defined to include coastal communities who occupy the selected project sites of Vanga, Gazi, Mida Creek and Lamu, formation of a team was undertaken as elaborated in sub-section 3.3. Justification and budget were prepared and authority was sought before commencement of the primary data collection. Compilation of relevant data and resources was done after the data collection. Secondary data was obtained through literature review while primary data was and information was collected through survey, key informant interviews and focus group discussions.Evaluating vulnerability dimensions was undertaken under data analysis as detailed in sub-section 3.8 below.

3.1 Study sites

The pilot study was conducted among different coastal communities who occupy the selected project sites of Vanga, Gazi, Mida Creek and Lamu, where they depend on the coastal and marine ecosystem goods and services for their livelihoods and income. These sites are endowed with mangroves, seagrass beds, coral reefs that support coastal fisheries (Figure 1). Vanga is a rural fishing village located in the southern-most part of the coast of Kenya at the border of Kenya and Tanzania. Gazi is a rural fishing village located at the mangrove fringed Gazi bay about 60 kilometres south of Mombasa town near seagrass beds and coral reef. Mida creek is a mangrove fringed Marine National Reserve in the northern coast of Kenya, where fishing is controlled. It was designated a UNESCO Biosphere Reserve in 1979 (Owuor et al. 2019). It is surrounded by seven villages that have been clustered into three main villages in this study namely Uyombo, Mida-Majaoni and Dabaso with the main economic activities being fishing, small scale agriculture, small-scale business activities and tourism related ventures. Lamu is an Archipelago with a number of small islands with the largest mangrove forest coverage in Kenya.

The villages that were covered during the pilot testing of the CCVA toolkit included Faza, Matondoni and Kiwayu which are typical fishing villages while, Ndau relies solely on mangrove harvesting.

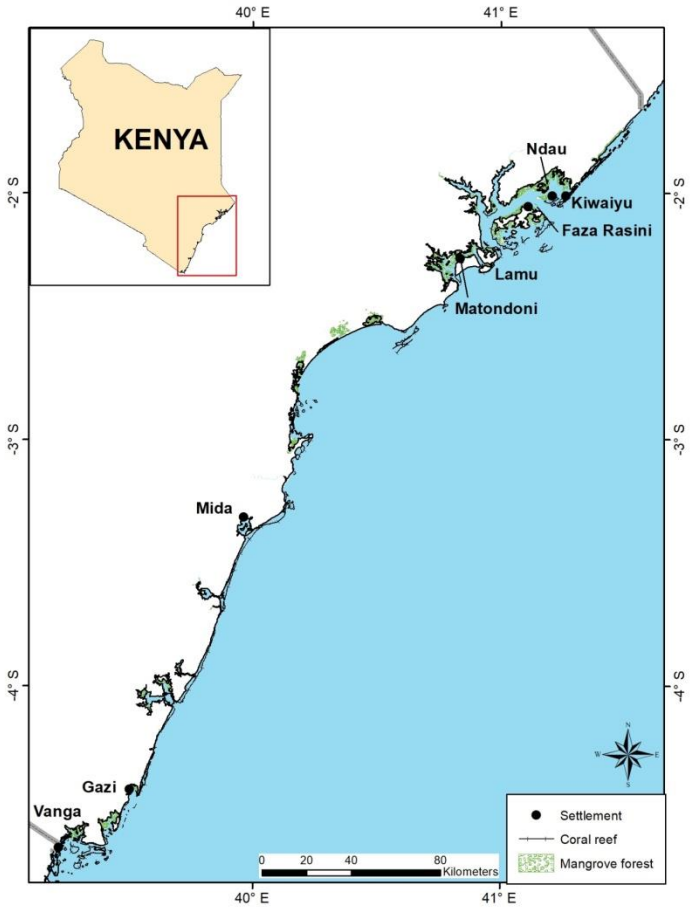


Fig. 1: The location of Vanga, Gazi, Mida Creek and Lamu Archipelago in the coast of Kenya

3.2Literature Review

Review of the existing literature material was carried out and it helped in gaining a deeper understanding of the factors that accelerate the impacts of climate change. A desk review of the Kenya National Population and Housing Census Report 2019 was conducted in order to identify the demographic characteristics in the study sites. Other literature included various scientific publications and technical reports on climate change vulnerability assessments.

3.3The research design

A cross sectional survey design was adopted with questions being asked once in the entire period of study. Cross sectional studies are suitable where the objective is to establish whether significant relationships exist among the study variables at some point in time (Mugenda and Mugenda 2003; 2008). The cross sectional survey made it possible to collect data in short duration of time. A number of limitations of cross sectional studies -including cohort differences, potential reporting biases associated with non-response and difficulty in making causal inference were identified. These limitations were addressed through an appropriate sampling technique and data collection procedure that was adopted by this study. Questionnaire survey method was used in this study because it has been successfully used in similar studies such as Odhiambo et al. (2020), Ochiewo et al. (2021), Thiault et al. (2021). It is also one of the most important research methods in the social sciences and is used extensively to collect information on numerous subjects of research (Nachmias and Nachmias 2004). The target population covered in this study included the communities that engaged in fishing, gleaning, fish trade, mangrove cutters and dealers at selected sites as elaborated in the TORs.

3.4 Sample size and sampling technique

In this study, a sample was selected from the households that were engaged in fishing, fish trade, gleaning, and mangrove cutting and trade. The sample size was calculated using the following standard formula for infinite population (Naing et al. 2006):

$$n = z^2p(1- p)/e^2$$

Where n is the sample size, z is the statistical certainty chosen at 95% confidence level (z = 1.96) for an error risk of 5%, p is estimated level/coverage to be investigated, chosen at p = 0.5, e is precision desired, expressed as a fraction of 1, usually e = 0.05 is chosen for the confidence interval. The output is corrected for finite population using the formula (Naing et.al. 2006):

$$n^1 = n/(1+n/N)$$

Where $n^1$is the sample size for finite population, N is the target population of fishing, fish trade, gleaning, and mangrove cutting and trade and n is the calculated sample size from infinite population. A sampling interval (SI) of two was calculated by dividing the total population by the sample size (n^1)

Based on the formula for estimation of sample size and considering that the target population consists of 10,877 households, the sample size was estimated to be 371 households (Table 1). The target population was first divided into strata based on main household occupations that are linked to marine resources namely households that depend on fishing, fish trade, and mangrove wood trade. Systematic random sampling was used to select the number of households that represent the target population from the identified strata. The respondents were systematically picked from the sample using the sampling interval to ensure that there were equal chances for each household in the target population to be included in the pilot (Kothari 2008). This sampling technique generated a representative sample that allows generalization to a larger population and the usage of inferential statistics.

Table 1: Distribution of sample size and response rate by study sites in the coast of Kenya

County	**Study Site**	**Name of village**	**Sample size**	**Response**	**Response rate (%)**
Kwale	Vanga	Vanga	51	50	98
	Gazi	Gazi	58	39	67
Kilifi	Mida Creek	Uyombo	50	50	100
		Mida-Majaoni	50	22	44
		Dabaso	50	24	48
Lamu	Lamu	Faza, Matondoni and Ndau-Kiwayu	112	77	68.8
Total			**371**	**262**	**70.6**

3.5 Response Rate

In this study, a total of 262 respondents answered the questionnaires against an estimated sample size of 371 respondents. This resulted in a response rate of 70.6 percent as shown in Table 1. The high response rate of 70.7 percent was realized because the research team followed up the target respondents, booked appointments with them in advance via phone calls and conducted guided administration of questionnaires. A high response rate enhances

validity of the results and the response rate in this study should be considered very good based on recommendations of Mugenda and Mugenda (2003, 2008), Babbie (2004) and Zikmund et al. (2010) that a response rate of 60 percent is good while 70 percent and above is very good for analysis. In addition, eighteen (18) key informant interviews and eighteen (18) focus group discussions were conducted in the study sites (Table 2).

Table 2: Distribution of Key Informant Interviews and Focus Group Discussions by Villages

Site	**Key Informant Interviews**	**Focus Group Discussions**
Vanga village	4	3
Gazi village	3	3
Uyombo village	3	3
Mida-Majaoni village	1	0
Dabaso village	4	3
Faza, Matondoni and Ndau-Kiwayu	3	6
Total	**18**	**18**

3.6 Data collection and procedures

The data collection team was constituted and trained by the consultant before embarking on the field data collection using the data collection instruments that were agreed on by consultants from the four (4) participating countries. The research team consisted of socioeconomics researchers and interns from the Kenya Marine and Fisheries Research Institute. Thereafter, the research team paid courtesy calls to the chiefs, fisheries officers, beach management unit Officials, village heads, Kenya Wildlife Service Officers and Kenya Forest Service Officers (where applicable) within the sites where the study was carried out. Field assistants who were residents of the study sites were recruited during these courtesy calls and were briefed on their roles during the data collection process.

Three data collection techniques were applied namely: household questionnaire survey to obtain both qualitative and quantitative information that -allow the determination of scores of

the indicators; key informant interviews to obtain qualitative information; and focus group discussions. A separate questionnaire was administered to different experts mainly scientists and marine resources managers in order to determine the weights of domains and indicators using the Analytic Hierarchy Process (AHP) method.

The household questionnaire was constructed taking into account objectives of the research (Kothari and Garg 2014). The questionnaire consisted of two parts with part 1 having both closed and open ended questions on demographic factors, and part 2 having both Likert scale type of questions and open ended questions on the main variables in the study. Each of the Likert scale questions in part 2 was assessed on a 5-point scale from 1 to 5 (Warmbrod 2014). Vulnerability of coastal communities to climate change was measured on ordinal scale making use of the Likert scale items in a questionnaire that covered social adaptive capacity and sensitivity dimensions.

Guided questionnaire administration was adopted in this study in order to capture a representative sample of the target population, avoid potential non-response bias and control for non-verbal behaviour (Nachmias and Nachmias 2004). The questionnaire was administered in Kiswahili which is the most widely spoken language. It was administered in the respondent's households or acceptable venues over a period of three months between November 2021 and January 2022. The researchers followed-up the target respondents, whose households were pre-selected through the sampling interval and appointments were booked with them in advance where necessary. To ensure accuracy in reporting, each respondent were informed that their personal details would remain anonymous and confidential. Anonymity and confidentiality are fundamental ethical considerations that this study was committed to observe. The overall purpose and objectives of the study was clearly explained to the respondents and informed consent was obtained with a clarification that the questionnaire was filled on voluntary grounds. Each questionnaire was administered in 1 hour but this can be reduced to 30 minutes when the new generic survey template that has been developed in used.

The focus group discussions (FGDs) approach proposed by Bunce *et al.* (2000) and de la Torre-Castro *et al.*(2007) was used in all sites that were covered by the study. FGDs are a commonly used qualitative approach to data collection. The importance of qualitative approaches in understanding social realities has been recognized by many social scientists. It addresses the limitations of adopting quantitative approaches to explain changes in social phenomena (Nyariki 2009). A set of open-ended questions were used to prompt participants into free discussions focusing on the issues under the study. The focal groups consisted of 5 to 12 people. Overall, each focus group discussion took about 90-100 minutes to complete.

3.7 Validity of the instrument

Content validity was assessed through a subjective assessment of the survey questionnaires' appropriateness and the extent to which the questionnaire captured the variables and indicators from the objectives of the study that need to be measured. Before the questionnaire was used to collect data, three experts evaluated it in terms of the percentage of questions that they considered relevant for them and the average score from the three experts was calculated. The first expert gave it 98%, the second expert gave 95% and the third expert gave 90%. This yielded an average congruency percentage of 94% which is greater than the lower limit of 90% hence the content validity of the questionnaire's was confirmed. Empirical validity was supported by comparisons with measurements made by other questionnaires. Construct validity was established by relating the survey questionnaire to a general theoretical framework around the analysis of sensitivity and social adaptive capacity.

3.8 Data analysis

A series of virtual meetings were held with the support of UNEP-Nairobi Convention to enable the consultants and the expert team from Macquarie University exchange ideas on data analysis. The data analysis included coding of responses based on a coding scheme that was agreed on by the national consultants from the four participating countries. These scores were further standardized and assigned values of between zero and one. The scores of indicators were combined using the weights obtained from the AHP questionnaire to obtain the combined

score (indicator) for different domains of both sensitivity and adaptive capacity as illustrated in Table 3. As shown in Table 3, weighting was first carried out for each indicator using AHP weights. Second level of weighting was conducted using AHP result for the domains.

Further, the combined scores for different domains were aggregated using the weights for domains, and determined using the discussion guide implemented for the separate AHP questionnaire to obtain the two indices per community, (1) the sensitivity index and (2) the adaptive capacity index. The final score of social climate change vulnerability index was determined by subtracting the adaptive capacity index from the sensitivity index as illustrated in Table 3. Finally, the Social climate change vulnerability of studied communities was compared using the calculated indexes.Data on the material style of life was analyzed using principal component analysis of a set of data consisting of a mixture of qualitative and quantitative variables (PCA Mix).

Table 3: Determination of social climate change vulnerability index

Indictor							Domain				Dimension			SCCVI
(i) 1.1.1	Scoring	1.1.1 scored	Standardization	1.1.1 standardized	Weighting[1]	1.1.1 weighted	Summation	1.1	Weghting[2]	1.1 weighted	Summation	1. Sensitivity index	Subtraction	Social Climate Change Vulnerability index
(i) 1.1.2		1.1.2 scored		1.1.2 standardized		1.1.2 weighted								
(i) 1.1.3		1.1.3 scored		1.1.3 standardized		1.1.3 weighted								
(i) 1.2.1		1.2.1 scored		1.2.1 standardized		1.2.1 weighted		1.2		1.2 weighted				
(i) 1.2.2		1.2.2 scored		1.2.2 standardized		1.2.2 weighted								
(i) 1.2.3		1.2.3 scored		1.2.3 standardized		1.2.3 weighted								
(i) 2.1.1		2.1.1 scored		2.1.1 standardized		2.1.1 weighted		2.1		2.1 weighted		2. Adaptive capacity index		
(i) 2.1.2		2.1.2 scored		2.1.2 standardized		2.1.2 weighted								
(i) 2.1.3		2.1.3 scored		2.1.3 standardized		2.1.3 weighted								
(i) 2.2.1		2.2.1 scored		2.2.1 standardized		2.2.1 weighted		2.2		2.2 weighted				
(i) 2.2.2		2.2.2 scored		2.2.2 standardized		2.2.2 weighted								
(i) 2.2.3		2.2.3 scored		2.2.3 standardized		2.2.3 weighted								

4.0 RESULTS

4.1Results from quantitative data

4.1.1 Key Indicators of Sensitivity and Adaptive Capacity

a) Key indicators of sensitivity

The results (Table 4) revealed that among the critical indicators that were used, the most critical indicators based on proportional contribution to the sensitivity dimension were percentage of income from the main activity, appreciation of biodiversity, nutritional dependency, identity and pride, and percentage of catch sold.

- *Percentage of income from the main activity*

  The coastal and marine fisheries are a major source of livelihood and income to many coastal dwellers in Kenya. Artisanal fishing from the coastal ecosystems is estimated to account for over 90% of the entire marine fish landed in Kenya (Ochiewo, 2004). It constitutes the main source of income for the fisher households providing about 80% of the total income to 70% of Kenya's coastal communities (Malleret-King et al., 2003). The artisanal fishing is carried out within the mangrove, seagrass and coral reef areas and is already characterized by over-fishing and the subsequent depletion of fish stock in these coastal ecosystems.

- *Appreciation of biodiversity*

  A number of coastal communities in Kenya have appreciated the importance of biodiversity conservation and are applying indigenous knowledge to identify sites of biodiversity significance. Some sites within the coastal environment that contain high biodiversity are already locally protected through "co-management area" approach, where the local communities exercise "no-take policy". Such sites are only available for ecotourism.

- *Nutritional dependency and food security*

  The coastal dwellers depend on fisheries products for their protein requirements and food security. Consequently, most of the fish landed from the coastal and marine waters is consumed within the coast with only a small percentage being either exported or sold

to distant markets within Kenya. The poor rural households consume most of the less costly fish such as anchovies, sardines and the sun-dried fish with the bulk of their income being spent on the purchase of staple foods such as rice and maize meal. The more costly high value fish is consumed mainly by those who can afford. During periods of severe drought, many children from rural poor households suffer from malnutrition.

- *Identity and pride*

  About 31 percent of the respondents were willing to participate in the protection of coastal and marine ecosystems and climate change adaptation actions while 69 percent of the respondents were not willing to participate. This indicates that probably most people are increasingly getting less concerned with how to eke a living irrespective of the consequences and are increasingly getting less concerned with sustainability of the resources that support their livelihoods. It may also suggest that people could be losing their sense of identity and pride with respect to their coastal and marine resources.

- *Percentage of catch from fishing sold*

  The study further established that on average; about 87 percent of the catch from fishing is sold to provide income to the households. About 90% of the capture fisheries production is by small scale artisanal and subsistence fishers who operate within the mangrove, seagrass, coral reefs and related shallow nearshore areas. There has been a general increase in the number of small scale fishers in the coastal waters with about 13,426 small-scale fishers operating in 2016, having increased from 12,748 in 2014 (Government of Kenya, 2016). Over 80 percent of the catch is sold leaving less than 20 percent to be retained for own consumption. The market is well developed with fishmongers and other fish traders found in all fish landing stations along the coast. The fishmongers often sell to the local communities while the other traders transport fish to the urban centres where they have established fish or seafood shops. Some large companies that target particular products such as octopus and lobsters are also present through their agents who are strategically located in the fish landing stations.

b) Key indicators of adaptive capacity based on the study

The results (Table 4) further revealed that among the critical indicators that were used, the most critical indicators that based on proportional contribution to the adaptive capacity dimension were access to information, linking social capital, level of participation, community cohesion and access to credit.

- *Access to information*

  As indicated in Table 8below, access to information on climate change, adaptation measures and early warning increases the adaptive capacity of a community. The study has established that 63 percent of the respondents had access to basic climate change information thus signifying progress towards realizing high adaptive capacity. If greater access to information on climate change, adaptation measures and early warning could be realized, it would increase the likelihood of timely and appropriate adaptation. Efforts have been made towards building capacity to integrate climate information into County Integrated Development Plans (CIDPs) and apply it to realize resilience but the counties have so far not been able to achieve this due to high turn-over. Since lack of informed, skilled and trained personnel to spearhead climate change adaptation reduces adaptive capacity, it is important to build the necessary skills and improve knowledge retention at both National and County Government as well as in the collaborating development partners in order to provide continuous capacity building through partnerships.

- *Linking social capital*

  Communities along the coast of Kenya have social networks that enable them to solve their problems. This study has revealed that about 85 percent of the respondents often go to someone else for help. The social networks include strong links with relatives, friends and people with whom they relate in their occupations. It became clear that fishermen particularly fishing crew often go credit advances from the owners of fishing gears and boats for whom they work. The gear-boat owners often double up as fish traders so that they are able to purchase the catch a relatively lower and sell at a profit. While this arrangement may suggest that the coastal communities including fishermen

have a high adaptive capacity, the arrangement between the crew and the gear-vessel owners is quite exploitative to the crew (Ochiewo et al., 2010) who often become vulnerable during extreme events.

- *Level of participation*

  The communities confirmed that they are often involved in decisions about marine resource use particularly by attending meetings about marine resources and management of marine resources. The fishers are particularly involved in marine resources management through their Beach Management Unit (BMU); a co-management body, which has been established through the Fisheries Management and Development Act, 2016. There are over 100 BMUs spread along the entire coast of Kenya that are empowering communities to participate in fisheries management decisions. The communities are also involved in decisions about mangrove forest management through Community Forest Associations (CFAs) that have been established under the Forest Act, 2015.

- *Community cohesion*

  The study established that there are conflicts over marine resources in their neighborhood. The existence of conflicts indicates low community cohesion among the competing users of the resources and relatively low adaptive capacity.

- *Access to credit*

  Access to credit shows high adaptive capacity. The study has however revealed that 60 percent of the respondents did not have access to credit. This reveals that there is low adaptive capacity among the communities that reside in the study sites. Availability of credit enables a person or household to expand their businesses or acquire more expensive assets that they could otherwise not afford.

Table 4: Key indicators and their proportional contribution to the dimensions

Dimension	Domain	Indicator	Sum of weighted score	Proportional contribution to the dimension
Sensitivity	**Livelihood**	Employment status	8.738	2.0
		Percentage of catch from fishing sold	38.822	8.8
		Percentage of income from main activity	82.254	18.6
		Time conducting the activity	21.433	4.9
	Demographic	Sex	12.399	2.8
		Years living in the village	25.716	5.8
		Percentage of children in the household	25.195	5.7
		Family dependency	22.065	5.0
	Cultural	Appreciation of biodiversity	69.132	15.7
		Identity and pride	49.153	11.1
	Health	Age	8.743	2.0
		Nutritional dependency	61.982	14.0
		Sense of place	15.624	3.5
				100.0
Adaptive Capacity	**Learning**	Level of education	8.400	1.4
		Knowledge of rules	12.453	2.1
		Access to information	148.800	24.5
	Assets	Access to credit	45.397	7.5
	Flexibility	Livelihood multiplicity	9.966	1.6
		Adapt to live without fishing	23.640	3.9
		Gear	1.092	0.2
		Spatial mobility	21.378	3.5
	Agency	Perceived capacity to change	35.528	5.9
		Recognition of causality	20.641	3.4
		Level of participation	94.179	15.5
	Organization	Trust in organization	19.718	3.3
		Community cohesion	48.777	8.0
		Linking social capital	116.145	19.2
				100.0

4.1.2 The relative social adaptive capacity and sensitivity scores among communities

The relative social adaptive capacity and sensitivity scores among communities were computed in Annex 1. The sensitivity to environmental change caused by climate change that consists of summation of the weighted scores of livelihood domain, demographic domain, cultural domain and health domain is presented in Table 5 below. The social adaptive capacity that consists of the weighted scores of learning domain, assets domain, flexibility domain, agency domain and organization domain is also presented in Table 5. The Social Climate Change Vulnerability Index (SCCVI) which has been obtained by subtracting Adaptive Capacity Index (ACI) from Sensitivity Index (S.I) is presented in the last part of Table 5.

Table 5: Sensitivity Index, Adaptive Capacity Index and Social Climate Change Vulnerability Index

Dimension	**Domain**	Aggregated domains	Domain Weights	Aggregated weighted domains	Percentage contribution of each domain
Sensitivity	Livelihood	151.247	0.47	71.086	59
	Demographic	85.376	0.08	6.830	6
	Cultural	118.285	0.13	15.377	13
	Health	86.348	0.32	27.631	23
Sensitivity Index				**120.925**	**100**
Adaptive Capacity	Learning	169.653	0.34	57.682	49
	Assets	45.397	0.14	6.356	5
	Flexibility	56.076	0.31	17.383	15
	Agency	150.348	0.09	13.531	12
	Organization	184.640	0.12	22.157	19
Adaptive Capacity Index				**117.109**	**100**
Social Climate Change Vulnerability Index (Adaptive Capacity Index less Sensitivity Index)				**3.816**	

Based on the simple addition and subtraction of composite indicators where the overall vulnerability can be computed by simply subtracting estimates of adaptive capacity from the sum of exposure and sensitivity (equation 1):-

Vulnerability = (Exposure + Sensitivity) – Adaptive Capacity ……(1), the results (Table 5) show that overall, the mangrove, seagrass and coral reef systems in the four sites (eight villages) that were studied in Kenya have low adaptive capacity and high sensitivity, hence vulnerable. This study focused on sensitivity and adaptive capacity dimensions without factoring in exposure dimension hence, if the exposure dimension is factored in then the summation of exposure and sensitivity could be much higher than adaptive capacity. It is therefore concluded that the systems are more susceptible to climate change impacts and therefore have an overall high vulnerability. In the next study, it would be useful to factor in all the three dimensions of vulnerability namely exposure, sensitivity and adaptive capacity, using the same methodology.

4.2.3 Material Style of Life

Material style of life (MSL), as shown by household assets and facilities, are an indicator of relative wealth or social status among the coastal communities in Kenya. As part of CCVA study that was conducted in the coast of Kenya at Vanga, Gazi, Mida Creek and Lamu, 20 household assets or facilities were considered to be indicative of differential social status and were recorded for each household included in the CCVA survey. The items that were covered in the study sites are listed in Table 6. In order to generate MSL composite based on the indicator variables and to provide a clear picture of the distribution of material wealth among the coastal villages that were investigated, the 20 material style of life variables listed in Table 6 were analyzed using the principal component analysis of mixed variables. An examination of the eigenvalues based on eigenvalue rule of cumulative eigenvalue >1, indicated that ten principal components accounted for 65 percent of the variations.

Table 6: Material style of life variables

S. No.	Item	S. No.	Item
1	Cooking pots	11	Electric refrigerators freezers
2	Radios/cassette/CD	12	Livestock
3	DVD/VCD players	13	Televisions
4	Mattresses	14	Satellite dishes
5	Mobile phone (not smart phone)	15	Private toilet
6	Smart phone portables	16	Out-door well

7	Flushing toilet	17	Roof material
8	Indoor piped water (tap)	18	Wall material
9	Washing machine	19	Floor material
10	Computers	20	Electricity

A comparison of mean MSL scores across the different variables indicates variability among MSL indicators in their relative contribution to the overall MSL scores. Particularly livestock (cattle, goats, donkey and chicken), radios/cassettes and computers) contributed less to the MSL while advanced assets (DVD/VCD players, electric refrigerators and freezers, mobile phones, private toilet, smart phone, televisions) and mattresses were the main contributors to MSL as indicted by R^2 (Figure 2).

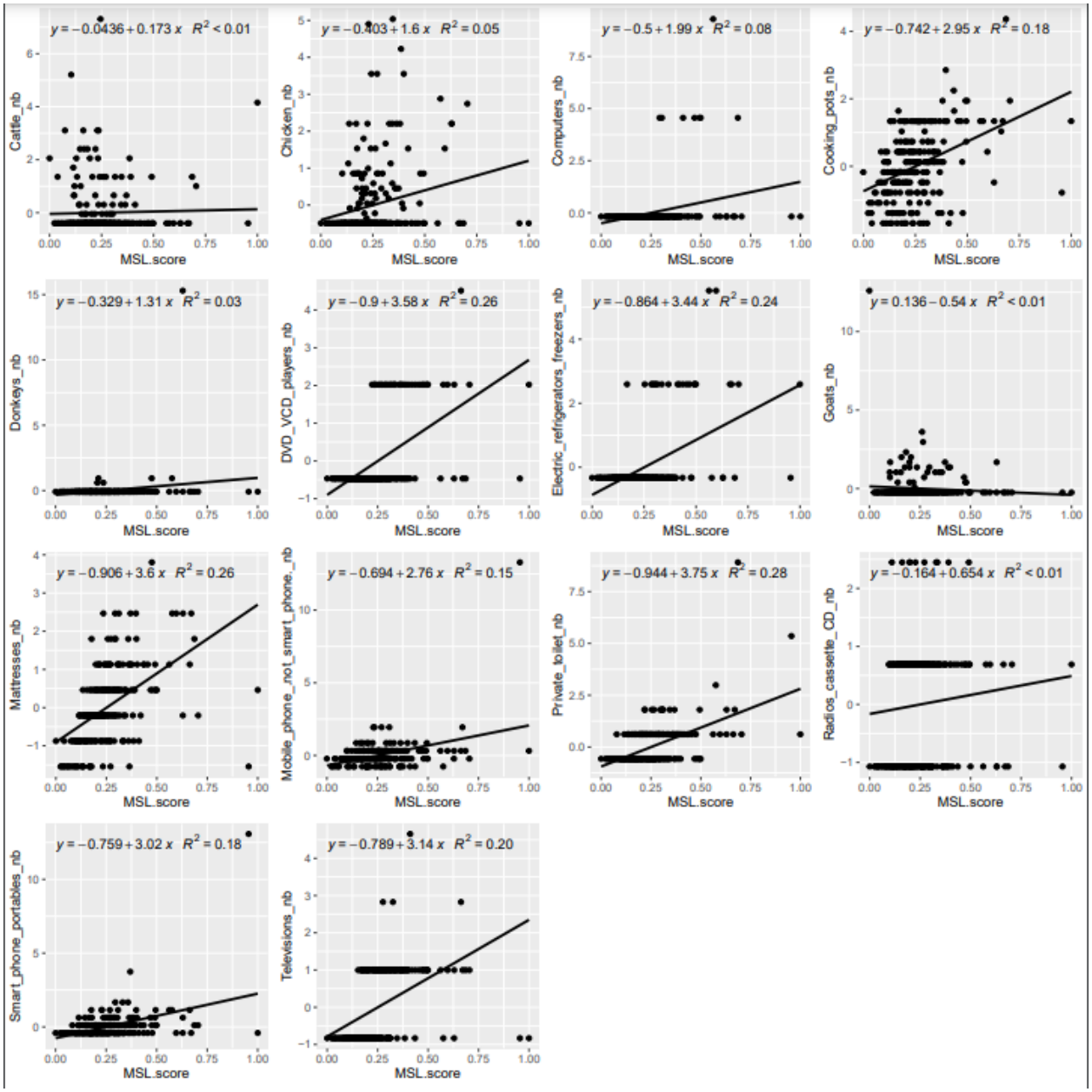


Fig. 2: Variability among MSL indicators in their relative contribution to the overall MSL scores

There was also variability within the broader variable grouping of types of housing material and sources of electricity to the households. For example, electricity from generator suggested higher economic well-being than from a grid or solar. Further, houses with floor made of tile and wall made of bricks implied higher economic well-being (Figure 3).

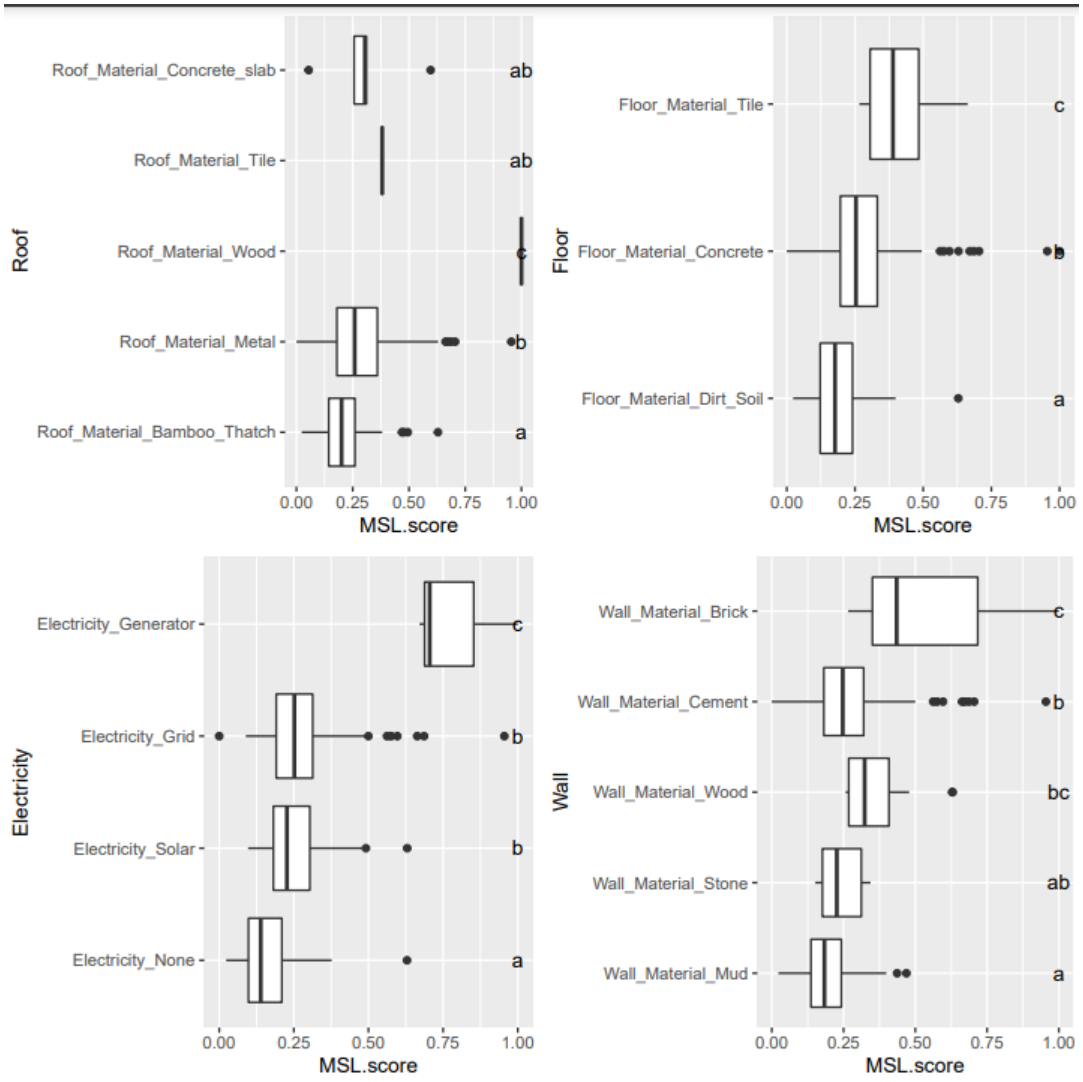


Fig. 3: Variability within the broader variable grouping of housing material and electricity

The overall score indicate variability in MSL among villages, with Dabaso, being the wealthiest, and Mida-Majaoni and Vanga, the lowest (Figure 4). Dabaso village has diverse livelihood options with many households deriving income from small-scale fishing and tourism related activities such as employment in the eco-friendly restaurant and mangrove board-walk that have been established in the village as part of sustainable utilization of mangrove ecosystem. This eco-friendly restaurant is attracting a large number of tourists almost throughout the year. Community members have also obtained employment in the tourist hotels and tour boat operations, while other members derive their livelihoods from small scale businesses and farming.

Vanga village on the other hand relies on small-scale fishing, agriculture and small-scale businesses. The agriculture practiced at Vanga has traditionally relied on the natural flow of River Umba, but recently, River Umba changed its course when it was diverted during the construction of the Vanga - Lungalunga road. This has affected the farmers who live on the lower part of the river and relied on River Umba flood plain to grow rice and other crops such as maize. The diversion of River Umba has left them with no water to irrigate their crops thus disrupting their livelihood and income. It would be interesting to follow up the social and economic changes that would occur in the area which is now traversed by the river.

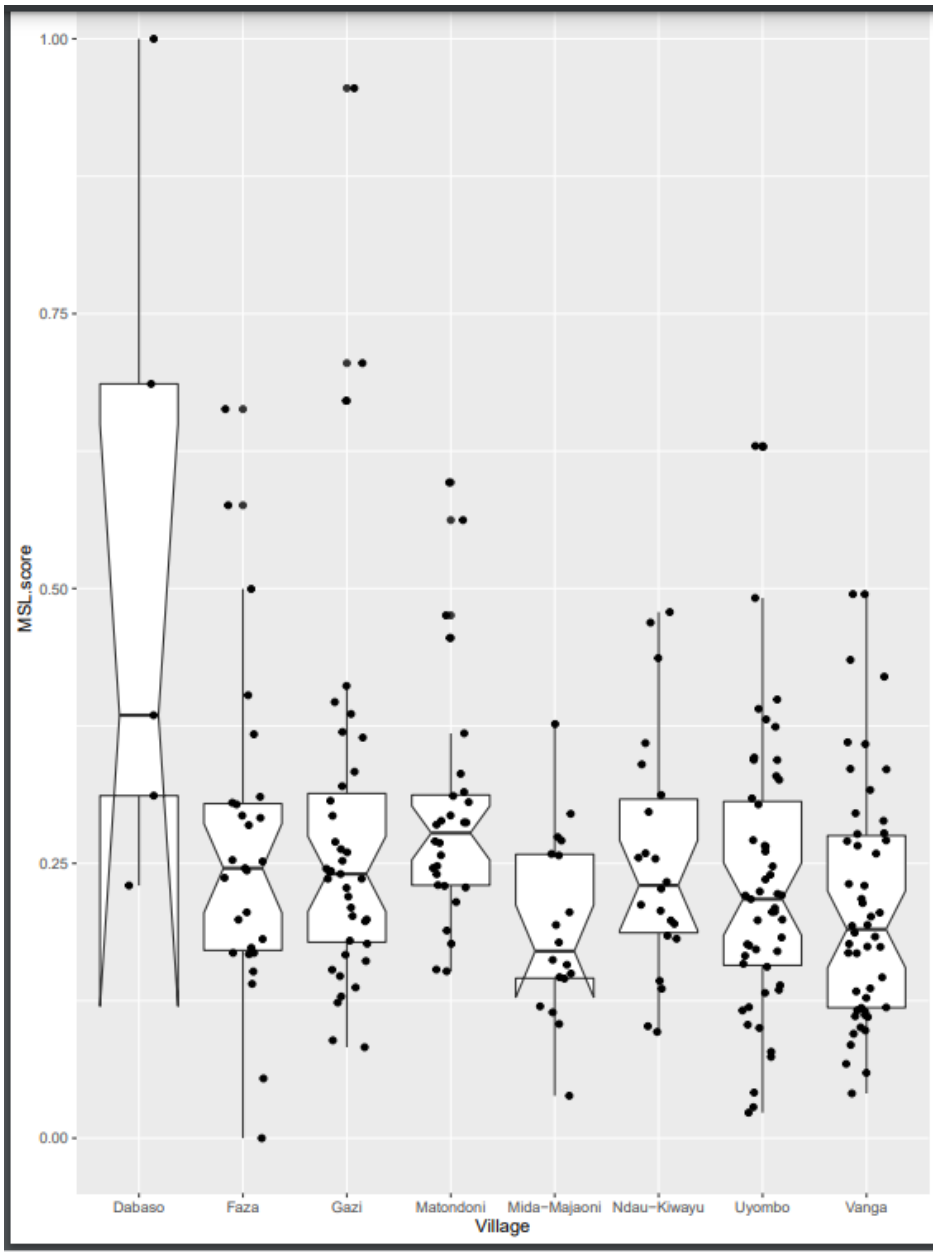


Fig. 4: Variability in MSL among villages
d

4.2 Qualitative results

The descriptive statistics confirmed the existence of high sensitivity in the four ecological systems of Vanga, Gazi, Mida Creek and Lamu, and low adaptive capacity of the communities that depend on these ecological systems. The high sensitivity was attributed to changes in the weather patterns and other climate change factors as elaborated in the sub-sections below.

4.2.1 Awareness on weather patterns

Results in Table 7 show that about 84 percent of the respondents from all the eight villages that were covered in the four ecological systems had observed changing weather pattern. This shows a high level of awareness among the local communities on changing weather patterns. The main reasons for change in weather pattern were identified to include deforestation, natural occurrence, and change in seasons, reduced and unpredictable rainfall, and increased industrial pollution. Further, the main elements of climate change were identified in order of prominence include increased frequency of climate change hazards such as droughts and inadequate rainfall resulting on crop failure and loss of livestock, temperature increase resulting in warmer conditions, negative impact on fish catch, sea level rise and increased frequency of floods that affect livelihoods and human welfare (Figure 5). Kenya coast is highly vulnerable to climate change, and increased climate change impacts result in mounting challenges to sustainable development. Local communities in the villages have recognized the importance of mainstreaming climate change adaptation strategies into development activities to build resilience.

Table 7: Perceptions on changes in weather

Is weather pattern changing	**Frequency**	**Percent**
Yes	201	84
No	39	16
Total	**240**	**100**

The respondents further identified various elements of exposure to include changes in precipitation that have been occasioned by frequent occurrence of droughts and floods, changes in both air and sea surface temperature that have been characterized by prevailing warmer conditions, changes in fish catch, increased disease, sea level rise, and increased occurrence of storms and extreme weather (Figure 1). The identified elements of exposure point towards the greatest risks posed by climate change impacts. This finding is consistent with the position of IPCC that climate change including increases in frequency and intensity of extreme climatic events, have reduced food and water security, hindering efforts to meet Sustainable Development Goals.

The IPCC has further reported that climate change has adversely affected people's health through natural and human systems, including socio-economic social conditions and disruptions. There is increased occurrence of climate-related food-borne and water-borne diseases, and increased incidence of vector-borne diseases from range expansion and/or increased reproduction of disease vectors. Further, there is concern that animal and human diseases are emerging in new areas. Although diarrheal diseases have decreased globally, higher temperatures, increased rain and flooding have increased the occurrence of diarrheal diseases, including cholera and other gastrointestinal infections (IPCC, 2022).

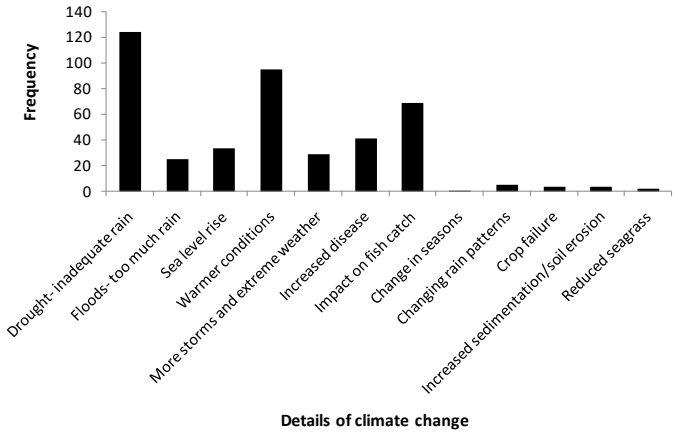


Figure 5: Elements of exposure to impacts of climate change

A summary of the direct Climate Change impacts reported by the various communities in the different sites is presented in Table 8. Results from Vanga and Gazi have been put together because they emerged to be similar.

Table 8. A summary of the direct Climate Change impacts reported by the various communities

Vanga and Gazi	**Mida Creek**	**Lamu**
Crop failure due to prolonged droughts	Crop failure due to prolonged drought	Crop failure due to increased frequency of droughts
Reduction in fish catch due to increased sea-surface temperature	Reduced fish catch	Inadequate rainfall

and fishing pressure		
“Ice-ice” disease in seaweed due to increased sea-surface temperature	Increased air temperature	Increased air temperature
Sea level rise affecting mangroves and property	Sea level rise resulting in coastal erosion	Sea level rise
Loss of livestock due to drought	Loss of pasture due to drought	Loss of pasture due to drought
Ocean acidification	Decreased rainfall	Increased outbreak of pest infestation particularly the army worms
Mangrove mortality due to excessive siltation	Increased poverty	
Shortage of potable water during droughts	Shortage of potable water	
Floods disrupt fish transport as access roads often get degraded thus limiting fish dealers from reaching the fish landing sites leading to high fish spoilage during the rainy season	Increased pest infestation	

4.2.2 Causes of climate change

Climate change is caused by a number of factors. The key causes of climate change that were identified by the respondents include deforestation, natural occurrence and industrial pollution. Deforestation is accelerated by the rapid population growth, increased demand for wood for construction and fuel, and increased urbanization in the coast. Coastal forests in Kenya are mainly threatened by increased human population with the associated inefficient farming systems, encroachment by human settlement, grazing, charcoal burning and bush-fires, among others (Samoilys 2013). Agricultural expansion was identified to be the biggest threat facing the Coastal Forests of East Africa (Burgess & Clarke 2000). As population increases, both subsistence agriculture and commercial farming expand thus impacting negatively on the coastal forests. In the lower Tana, a site which not covered by this study, the forests are threatened with agricultural clearing and extraction of forest products.

Extraction of forest products has been accelerated by high level of illegal logging in some coastal forests and conversion of some sections of forests for other economic activities and resettlement of people. The mangroves are considered threatened due to encroachment and over-harvesting (KMFRI, 2002). Inland erosion from farming and grazing is a common threat to the mangroves in Kenya and the entire East Africa since the soil which is washed downstream covers mangrove roots thus suffocating the mangroves (UNEP-WCMC, 2003). In some sites such as Manda Island in Lamu, mangroves are considered a major source of fire wood and building poles (de Jong & Butynski, 2009).

Industrial pollution on the other hand is hastened by increased industrialization particularly in Mombasa and increased urbanization. These factors contribute to increased vulnerability of coastal communities as they lead to increase in both direct and indirect effects of climate change. In fact this finding confirms the position of IPCC (2022) that degradation and destruction of ecosystems by humans increases the vulnerability of people. Unsustainable land-use and land cover change, unsustainable use of natural resources, deforestation, loss of biodiversity, pollution, and their interactions, adversely affect the capacities of ecosystems, societies, communities and individuals to adapt to climate change. Loss of ecosystems and their services adversely impacts on people, especially Indigenous Peoples and local communities who are directly dependent on ecosystems to meet their basic needs.

Natural occurrences have been associated with changes in wind speed, air and sea-surface temperatures and seasons. The natural occurrences have been attributed to the Indian Ocean Dipole (IOD) that has caused significant fluctuations in rainfall and temperature. The IOD is an irregular oscillation of sea surface temperatures and related atmospheric circulation in the Indian Ocean; resulting in irregular occurrence of events that vary in strength and duration, and often coincide with El Nino and La Nina events. The respondents have also attributed the natural occurrences to break-down of social values and norms that have annoyed the supernatural power (God), resulting in the occurrence of extreme events such as frequent droughts and floods that punish people.

4.2.3 Main sources of information on climate change

Sources of information are essential for climate change adaptation and mitigation. Information and skills is one of the determinants of adaptive capacity. The respondents identified the main sources of information on climate change to include radio due to the presence of various local radio stations, television, friends and family, personal observation/ experience, and internet (Figure 6). It is however surprising that the traditional sources of information such as government agency, environmental groups and schools/colleges and universities were identified by only a few respondents. Overall, there was widespread awareness on climate variability and change issues among the respondents. Greater access to information increases likelihood of timely and appropriate adaptation (Smit et al. 2001). Since lack of informed, skilled and trained personnel reduces adaptive capacity, the communities that depend on the ecological systems that were covered by this study performed better.

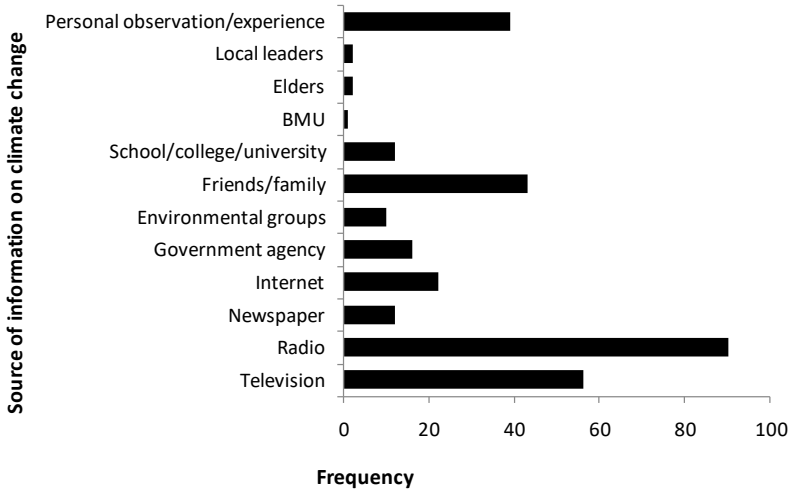


Figure 6: Source of information on climate change identified by the respondents

4.2.4 Importance of climate change to local communities

Over 80 percent of the respondents stated that climate change is a major issue to them because it highly impacts on their occupational activities. This confirms the earlier position that communities have understood the direct and indirect effects of climate change on their livelihoods and income. In fact, 63 percent of the respondents were either worried or very worried about future effects of the extreme events (drought and floods) on their families.

These two extreme weather events have been occurring more frequently in the recent past with devasting impacts on livelihoods, income and increased transmission risk for mosquito-borne infectious diseases such as malaria and dengue fever. In the future, coastal communities are worried that climate change is likely to have significant impact on the coastal and marine ecosystems. However, 27 percent of the respondents were not worried about the future effects of extreme events.

4.2.5 Most affected areas

When the aspects that are mostly threatened by climate change were ranked, results (Figure 7) indicated that food supply comes first followed by human health, quality of biodiversity and its sustainability, and business. From this ranking, it is evident that people are heavily concerned about the impacts of climate change on their livelihoods (food and business) and health.

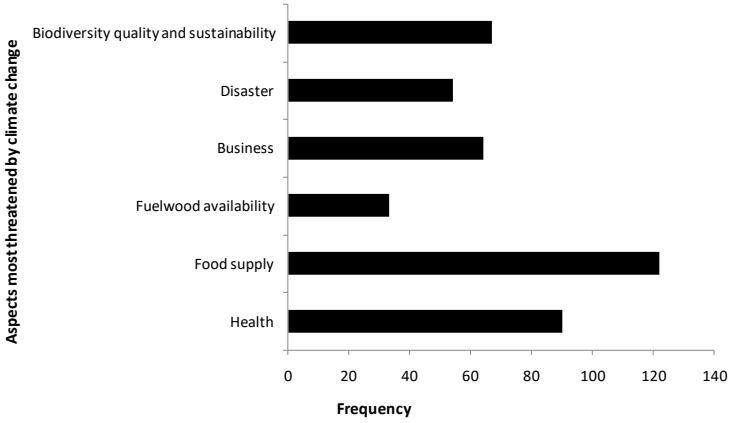


Figure 7: Areas that are most threatened by climate change

4.2.6 Hindrances to adaptation to climate change

Hindrances or barriers to effective adaptation to climate change can manifest in a range of ways. A barrier could hamper effective adaptation by leading to a poor appreciation by households or individuals of the need to adapt, inappropriate incentives for adaptation, or insufficient capabilities of households or individuals to adapt effectively. The hindrances can be in the form of inadequate resources, knowledge and skills. In this study, the main hindrances to adaptation to climate change were identified by the respondents to include poverty, lack of knowledge on adaptation methods, lack of information on weather, lack of access to water for

irrigation and lack of improved seed (Figure 8). Adaptation was looked at in terms of the action by households, firms, community based and non-governmental organizations and government (both national and county levels of government) to respond to the impacts of climate change that cannot be avoided through climate change mitigation efforts. These hindrances lower the adaptive capacity particularly of households and communities. Adaptive capacity is the ability to adjust to new ways of doing things in the face of climate change.

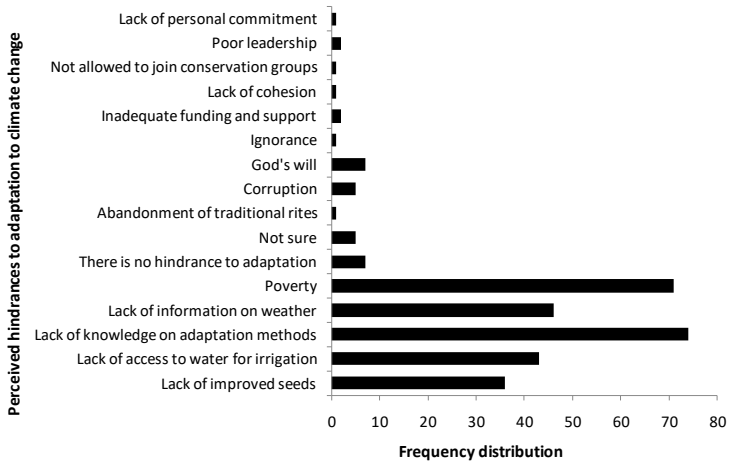
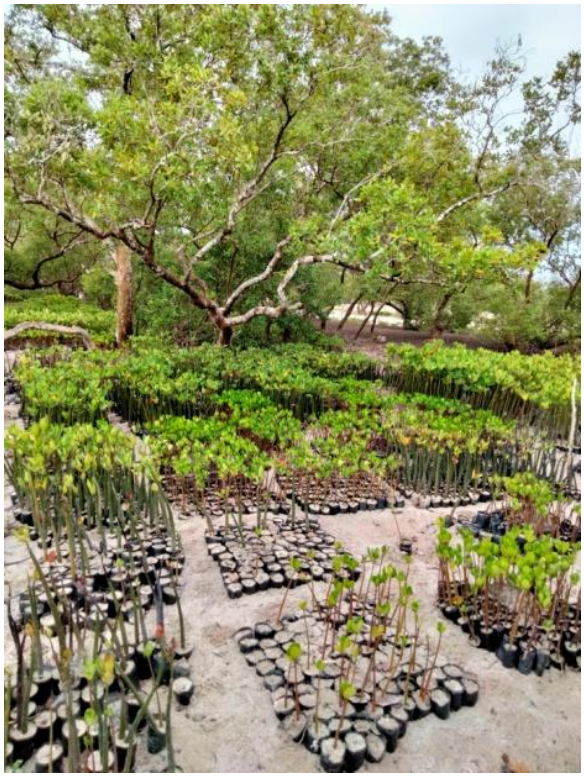


Figure 8: Hindrances to adaptation to climate change

4.3 Coping Mechanisms

The declining fish catch and income has on the one hand compelled fishers to diversify fishing gears and to use more efficient but destructive fishing gears. The use of destructive fishing gears is not sustainable. Some of the destructive gears such as beach seines which is still being used particularly in Lamu despite being banned, destroy the coastal and marine habitats thus reducing their productivity. Many communities that depend on the coastal and marine ecosystems have opted to restore some of the degraded habitats such as mangroves, corals and seagrass (see plate 1 for mangrove restoration including development of mangrove tree nurseries going on in the coast of Kenya).



Mangrove tree nursery

Promotion of ecotourism to diversify livelihoods

Plate 1: Mangrove restoration and livelihood diversification along the coast of Kenya

Farmers on the other hand have responded differently to climate variability. The occurrence of frequent and extended droughts have pushed farmers to expand cultivation, change planting seasons, use fast maturing seeds, reduce fallows, use drought resistant varieties, diversification of crops so that if one fails, at least they are likely to get a harvest on the others, construct deep wells, engage in wage employment or in charcoal, timber and brick production. Temporal diversification within farming is therefore common in response to the changing rainfall patterns.

4.4 Detailed methodology for managers/policy makers

Based on the methodology that has been detailed in section 3.0 above, which involved collection of data using a long questionnaire with many questions under each domain, it was established that only a limited number of questions are needed to measure sensitivity and estimate the sensitivity index and to measure social adaptive capacity and estimate the social

adaptive capacity index. The most critical indicators and their corresponding relevant questions are summarized in the Table 8 below.

Table 8: Summary of the most critical indicators for the determination of the social climate change vulnerability index

Dimension	Domain	Critical Indicator	Relevant question	Explanation
Sensitivity	Livelihood	Employment Status	What is your employment status?	This refers to the employment of the household head. If the employment is sensitive to climate change, this indicator should be considered zero
		Percentage of catch from fishing sold	Typically, what percentage of your catch from fishing or gleaning do you sell?	This indicator measures the ability of local communities to earn income from fisheries and the extent to which they depend on the marine resources
		Percentage of income from the main activity	List the main sources of income to the family and score them in order of priority and include the average amount per activity. *A 3 column matrix is used with "activity" in column 1, priority in column 2 and average income in column 3*	This indicator measures the extent to which local communities diversify income sources to be resilient. If people derive income from the same source then they become more sensitive
		Time	How long have you	Households become

Dimension	Domain	Critical Indicator	Relevant question	Explanation
		conducting the activity	been engaged in this activity as the main source of income?	more sensitive if they depend on vulnerable marine resources and they develop only the same activity for a long time
	Demographic	Sex	Sex of the respondent: [1] Female [0] Male	This is a categorical variable that determines whether household head is male or female. Generally in the coast of Kenya, female headed households are considered to be more sensitive to climate change impacts
		Years living in the village	How many years have you lived in this village?	This indicator measures how long one has lived in a village. The time spent in a village might limit peoples' willingness to move to another place, if necessary
		Percentage of children in the household	How many people are currently in your household, including yourself? *(Specify number of people in terms of adult male, adult female, female children, male children)*	If the percentage of children is higher in the household then it becomes more sensitive. Children were considered to include all people below the age of 18 years
		Family dependency	How many family members are	This indicator evaluates the household's ability

Dimension	Domain	Critical Indicator	Relevant question	Explanation
			employed?	to sustain itself if one household member becomes unavailable
	Cultural	Appreciation of biodiversity	Do you think that it is important that people participate in biodiversity preservation? Do you think that the daily activities of local people might impact on biodiversity, or What areas of the marine environment/resources are of special interest to communities for cultural or religious purposes?	Understanding and appreciation of biodiversity, including associated cultural habits might reduce the sensitivity of the ecosystem and human community by increasing the willingness to participate in the protection of the ecosystems
		Identity and pride	How do you feel about your village, environment and marine resources? Are you willing to protect them as your home land and culture? Or Is fishing your primarylivelihood how much do you agree with this statement?“I could easily stop fishing, and make my living	Feeling pride of the land and resources increase the willingness to participate in the protection of ecosystem and climate change adaptation actions

Dimension	Domain	Critical Indicator	Relevant question	Explanation
			on land"	
		Appreciation of lifestyle	How much do you like your lifestyle in the village?	When villagers appreciate their lifestyle, they are most likely to participate in actions to protect the environment and adaptation actions
	Health	Age	Age (in years)	The age considered here, is the age of household head. If the respondent is a representative of the household head, it is the age of household head to be recorded
		Nutritional dependency/ Food security	Typically, what percentage of your catch from fishing or gleaning do you retain for own consumption?	Nutritional dependency was evaluated based on access to food
		Sense of place	Supposing that for some reason you were moving away from your current village, how would you feel about leaving?	The time spent in the village gives a person a sense of home/belonging, and this makes it difficult to move to another place, when required. This effect is comparable with special mobility
Adaptive capacity	Learning	Level of education	What level of formal education have you attained?	It is the education of household head that was considered. Highly educated household heads have high

Dimension	Domain	Critical Indicator	Relevant question	Explanation
				adaptive capacity
		Knowledge of rules	1. Are there places where people are not supposed to fish, nor use certain gears, etc.? **2.** Who created the rules? 3. Do people still fish there? If so, how many people?,**OR** 1. In your opinion, are the marine resources managed well? 2. Is there effective enforcement of rules and regulations governing marine resources? 3. Are the local communities involved in marine resources management? If yes, how?	This indicator evaluates if there are rules regarding marine resources and if the rules are known (1) Places where people are not supposed to fish, (2) Certain fishing gears that people are not supposed to use, (3) Certain times that people are not supposed to fish, (4) Certain species or types of fish that people are not supposed to catch. If the rules are either not established or know, this will result on low adaptive capacity
		Access to information	1. Have you heard of climate change or global warming? 2. From which source did you get information about climate change?	Access to information on climate change, adaptation measures and early warning increases the adaptive capacity of the community
	Assets	Material	Please tick all the	Having the assets

Dimension	Domain	Critical Indicator	Relevant question	Explanation
		style of life	household items or facilities present in the household. Also record the number of each asset owned by the household (cooking pots, radios/cassettes, DVD/VCD players, mattresses, mobile phone, smart phone sortables, flushing toilet, indoor piped water, washing machine, computers, electric refrigerators or freezers, livestock (cattle/goats/pigs/sheep/chicken/donkey),TV, satellite dishes, private toilet, roof material, wall material, floor material, electricity, other)	means high adaptive capacity and not having means low adaptive capacity
		Community Infrastructures	How are the communities governed? How do the communities relate with higher levels of government? How do you classify the quality of community	How the communities relate with higher levels of government determines their social adaptive capacity. Further, community infrastructures such as hospitals, schools and coastal protection infrastructures

Dimension	Domain	Critical Indicator	Relevant question	Explanation
			infrastructures, hospitals, schools, coastal protection infrastructures, etc?	determine high adaptive capacity
		Access to credits	Do you have access to credit facilities? Explain	Access to credits reveals high adaptive capacity
	Flexibility	Livelihood multiplicity	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?	The respondent selects the livelihood options within the list in the Household questionnaire. High number of options indicates high adaptive capacity
		Adapt to live without fishing	If fishing is your primary occupation, how much do you agree with this statement? "I could easily stop fishing, and make my living on land"	This indicator evaluates the ability to leave if fishing in the area becomes unsustainable activity. This indicator is relevant for Mozambique as coastal country where there are people depending greatly on fishing
		Gear	Which fishing gears does your household use?	This evaluates the possibility of harvesting marine resources, thus making the respondents able to adapt in case of changing in the fishing methods caused by reduction of resources

Dimension	Domain	Critical Indicator	Relevant question	Explanation
				availability
		Spatial mobility	Supposing that for some reason you were moving away from your current village, how would you feel about leaving?	By responding the question "Supposing that for some reason you were moving away from your current village, how would you feel about leaving?" reveals the willingness to move if required to leave in another area
	Agency	Perceived capacity to change	How much do you agree or disagree with this statement: *"People like me have influence on the management of marine resources"*	Perceived capacity to influence change signifies high adaptive capacity
		Recognition of causality	What can be done to increase availability of fish in the sea around here?	Recognition of management affecting availability and quality of marine resources represents high adaptive capacity because enables the community on willing to participate in the management
		Level of participation	Currently, are you involved in the following aspects of marine resources management? a) decisions about marine resource use (attending meetings	This indicator measures the involvement of the community in different aspects of marine resources management

Dimension	Domain	Critical Indicator	Relevant question	Explanation
			about marine resources) b) management of marine resources	
	Organizatio n	Trust in organization	In general, how much do you trust the following people? People in your village, village leaders, marine resource management group, NGOs, Government	This indicator measures how much the community trust on the organizations, that include, other people in the village, village leaders, marine resources management, NGOs and government
		Community cohesion	Is there any conflict over marine resources here? If yes, how often does this conflict occur?	The absence of conflicts over resource use indicates a high social cohesion
		Linking Social capital	Are there times when you went to someone else for help? If the answer is yes, who do you go to for help in times of need?	Ability of community members to help each other in times of need demonstrates the existence of social networks that translate to high social capital and higher adaptive capacity

5 RECOMMENDED CLIMATE CHANGE ADAPTATION OPTIONS

Considering the importance of planning towards the success of any development or related intervention, there is need for both National Government and County Governments in the coast of Kenya to mainstream climate change adaptation planning and implementation in climate

policy and planning processes. Since adaptation options often take long to implement, both medium-term and long-term planning and accelerated implementation of climate change adaptation options is important to close adaptation gaps, across the study sites, recognizing that there are constraints that need to be dealt with. The planning process should be participatory and all inclusive and should have effective regulation and monitoring systems and financial and technological resources and capabilities to support implementation.

Provision of basic social services, infrastructure, livelihood diversification and employment, strengthening of food production and supply systems, and community-based adaptation are critical towards enhancing the quality of life and livelihoods, particularly of low-income groups, and the vulnerable and marginalized groups in the society. The National and County Governments should seek to develop effective partnerships with the private sector organizations and the civil society in order to mobilize resources across scales to provide infrastructure and services to enhance the adaptive capacity of communities along the coast of Kenya. At Vanga and its environs, construction of irrigation canals or water ways to re-direct part of the River Umba flow to the original flood plain to support rice farming would be critical. This should be complemented with introduction of water-efficient drip-irrigation to support sustainable farming of different crops. At Mida Creek, shallow wells can be constructed to support irrigation using climate smart technologies such as drip-irrigation. Development of access roads to facilitate transportation of fish from the landing sites is needed particularly at Vanga where the neighboring villages such as Jimbo become inaccessible during the heavy rains. Provision of infrastructure and services should further be supported by factoring in climate change impacts and risks in the design and planning of development interventions to enhance resilience and human well-being.

The sensitivity of fisheries sector to climate change and the high reliance of coastal agriculture on rainfall pose a significant challenge to the fisher communities, small scale coastal farmers and the wider coastal economy in Kenya. Targeted research that aims at improving the knowledge base of specific climate change related impacts would greatly benefit the

communities that depend on coastal and marine ecosystems in the coast of Kenya. Improved access to information through an early warning system on climate variability is essential to inform fishers and coastal farmers on decisions regarding the timing of fishing activity and planting of crops. Further, to address the problem of recurring droughts, improved water resources management through appropriate rainwater harvesting and storage technologies could support water-efficient or climate smart irrigation as an adaptive strategy and could improve production during periods when the rains fail.

Protection and restoration of the coastal wetland and coral reefs should be promoted. Coastal wetlands particularly mangroves and seagrass are unique coastal ecosystems in Kenya as they serve as important marine habitats and provide ecosystem goods and services to the adjacent coastal communities. They sustain coastal fisheries and defend the coast against exposure to sea level rise and the storm surges and flood waters. They are also known for storing several tons of carbon in their roots and soils. It is important to allow these wetlands to remain secure through setbacks and limiting encroachment for development. It is also important to identify ecologically sensitive areas such as breeding and nursery grounds and areas of high species diversity for protection using conservation mechanisms that are acceptable to local communities such as establishment or strengthening of co-management areas. The local communities have demonstrated their willingness to support these efforts through their efforts to restore the degraded mangrove and corals in their neighborhoods. Efforts should be made to secure coral reefs from degradation.

Most of the coastal communities in Kenya live in rural areas and many of them are highly vulnerable to climate change. It would be important to integrate climate adaptation into social protection programs, including cash transfers, youth workforce programmes and other social support services, which have proved to be socially feasible in order to increases resilience to climate change, especially when supported by basic services and infrastructure. Globally, social safety nets are increasingly being reconfigured to build adaptive capacities of the most vulnerable communities. According to IPCC (2022), social safety nets that support climate

change adaptation have strong co-benefits with development goals such as education, poverty alleviation, gender inclusion and food security.

Integrating climate change adaptation into social welfare programmes will require some management action without policy change. So far, Kenya National Social Protection Policy of June 2011 provides a robust policy framework for implementation of social protection programmes in Kenya. The policy has five (5) broad objectives; three (3) of which are relevant to climate change interventions namely: (i) Protecting individuals and households from the impact of adverse shocks to their consumption that is capable of pushing them into poverty or into deeper poverty, (ii) Supporting individuals and households to manage these shocks in ways that do not trap them in poverty, and (iii) Promoting synergies and integration among social protection providers as well as positive interactions among stakeholders for the optimal delivery of services.

The policy is anchored on the Constitution of Kenya 2010 Chapter Four on the Bill of Rights with emphasis on Article 43 that guarantees all Kenyans their economic, social, and cultural (ESC) rights, and Article 21 that establishes the progressive realization of social and economic rights and obligates the State to "observe, respect, protect, promote, and fulfill the rights and fundamental freedoms in the Bill of Rights." Even though Article 42 which guarantees all Kenyans the right to a clean and healthy environment, which includes the right (a) to have the environment protected for the benefit of present and future generations through legislative and other measures; and (b) to have obligations relating to the environment, has not been explicitly mentioned in the Policy, objectives (i) and (ii) of the policy which covers protection of individuals and households from the impact of adverse shocks to their consumption and these shocks include climate change that compromises the rights envisaged in Articles 42 and 43.

It is important to promote the adoption of energy saving technologies to reduce the demand for fuelwood and charcoal in both rural and urban areas. Communities depend heavily on

fuelwood which is often sourced from the mangrove of coastal forests to cook. They cannot stop this practice unless they get an appropriate alternative.

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