Climate Change Vulnerability Assessment in Mangrove regions of Sierra Leone

Full Report

January 2018

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The report was prepared by the Center for International Earth Science Information Network (CIESIN) of the Earth Institute of Columbia University. The vulnerability assessment was led by CIESIN under contract with Tetra Tech, and CIESIN also led the analysis and report development. In addition to the CIESIN lead researcher, Sylwia Trzaska, the field research was conducted by a team comprised of representatives from the WA BiCC technical unit in Freetown, Fourah Bay College, Njala University, the National Protected Areas Authority (NPAA), Environmental Protection Agency (EPA), the Ministry of Agriculture, Forestry and Food Security, the Ministry of Lands, Country Planning and Environment, the Ministry of Fisheries and Marine Resources, Conservation Society of Sierra Leone and other stakeholders.

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Cover page: The village of Jamaika, Yawri Bay, Sierra Leone, June 2016
Credit: S. Trzaska

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Acronyms

CIESIN	Center for International Earth Science Information Network (CIESIN), the Earth Institute at Columbia University
CMA	Community Management Association
CSSL	Conservation Society of Sierra Leone
DFID	UK Department for International Development
DHS	Demographic and Health Survey
EPA	Environmental Protection Agency
EWS	Early Warning System
FBC	Fourah Bay College
GLCME	Guinea Current Large Marine Ecosystem
HFIAS	USAID's Household Food Insecurity Access Scale
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
MAFFS	Ministry of Agriculture, Fisheries, and Food Security
MFMR	Ministry of Fisheries and Marine Resources
MOHC	The Met Office Hadley Centre
MRU	Manu River Union
NAPA	National Adaptation Programme of Action
NPAA	National Protected Areas Agency
NU	Njala University
PRA	participatory rural appraisal
RCM	Regional Climate Model
RCP	Representation Concentration Pathway
SRES	IPCC Special Report on Emissions Scenarios
SRTM	Shuttle Radar Topography Mission
USAID	US Agency for International Development
VA	vulnerability assessment
WA BiCC	West Africa Biodiversity and Climate Change project

Executive Summary

Rationale

The purpose of this coastal climate change vulnerability assessment (VA) is to understand factors that contribute to the vulnerability and resilience of communities and mangrove ecosystems in coastal Sierra Leone. The goal is to inform the design of project interventions, including climate adaptation activities under the West Africa Biodiversity and Climate Change (WA BiCC) project. The work was led by the Center for International Earth Science Information Network (CIESIN) at Columbia University, and included a team of field researchers drawn from WA BiCC staff, Fourah Bay College, Njala University, the National Protected Areas Authority (NPAA), Environmental Protection Agency (EPA), the Ministry of Agriculture, Forestry and Food Security, the Ministry of Lands, Country Planning and Environment, the Ministry of Fisheries and Marine Resources, Conservation Society of Sierra Leone and other stakeholders.

Approach

A preliminary scoping mission in February 2016 concluded that the communities that will be most adversely impacted by the effects of climate change such as sea level rise and increased storm intensity are coastal fishing villages that are located in or near mangroves. Furthermore, studies suggest that the mangroves themselves, important to coastal resilience, will be adversely affected by climate change. Thus, the VA focuses on coastal fishing communities like the one captured in Figure 1. Given that the study aims to inform adaptation strategies at the community level we adopted a bottom-up approach and gained some degree of generalizability and scalability of the recommendations by studying mangrove forests and populations in the four primary mangrove regions in Sierra Leone (from North to South): The Scarcies River Estuary, the Sierra Leone River Estuary (SLRE), Yawri Bay, and the Sherbro River Estuary.

Figure E.1: General view of the village of Njajeiam. This view is typical of fishermen villages surveyed in this VA: dense build-up only few feet above the water level. Visible On the foreground are makeshift protections from the impacts of waves and storm surge. July 2016. Credit: S. Trzaska.

The VA seeks to determine the relative vulnerability of fishing communities and ecosystems – sometimes referred to in the literature as the coupled socio-ecological system – through household surveys, participatory rural appraisals and mangrove forest inventories. The VA was carried out in 12 clusters comprising one mangrove transect and two villages, distributed across the four regions. Figure 2 displays the location of each cluster of villages and transects in the four regions: Scarcies (blue dots), Sierra Leone River Estuary (SLRE) (orange dots), Yawri (green dots), Sherbro, (purple dots). A total of 261 household interviews were conducted addressing a variety of issues related to economic assets, wellbeing, livelihoods, food security, fish harvesting and processing, use of mangroves, and awareness of climate change issues. Participatory Rural Appraisals (PRAs) were also conducted in each settlement, with separate male and female participants for a total of 96 group meetings. Finally, 12 mangrove transects were inventoried, assessing mangrove health in the form of species mix, biomass density, and water depth. Three teams of 12 experts were trained then deployed to the field. The training included a review of methods as well as hands-on testing and refinement of the instruments in the Sierra Leone River Estuary (SLRE).

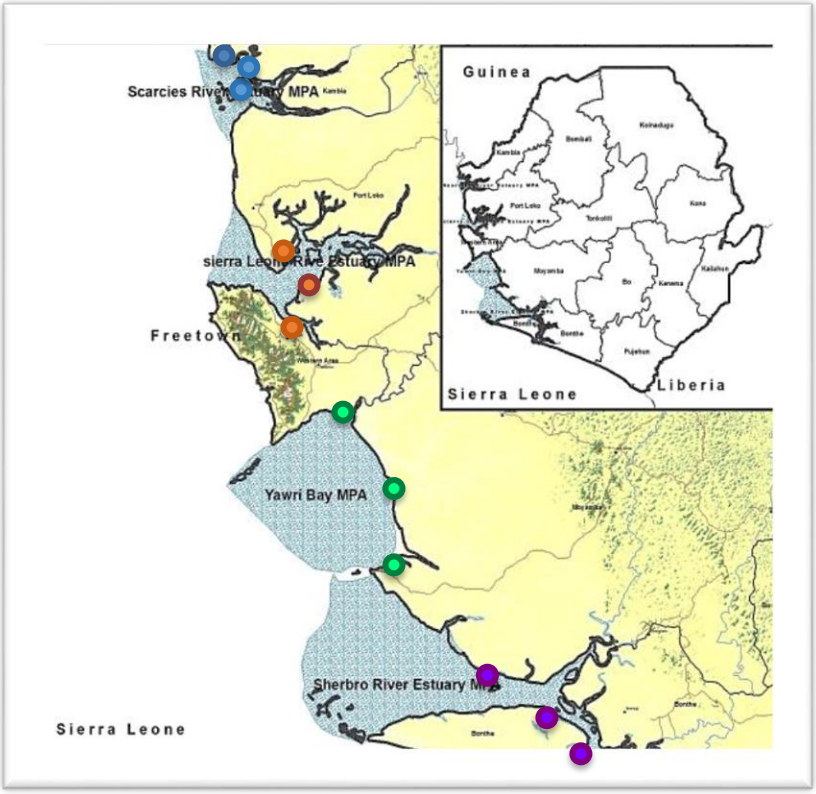


Figure E.2: Map of the household survey and mangrove transects locations

Main findings

Socio-economic characteristics of the populations

The demographic characteristics of the populations surveyed are comparable to those of rural populations of Sierra Leone as a whole, as inferred from national census and Demographic and Health Survey (DHS) results. The socioeconomic analyses show **very high poverty levels** and **low education levels**. Around 60% of the respondents (adults)

reported no education and those levels reached 70% for women. Eighty-five percent of the respondents fell in the **severely food insecure** category of the USAID Household Food Insecurity Access Scale[1], and this rate reached 100% in some locations. Access to **clean water and adequate sanitation** is generally low. Although sanitation conditions are comparable to national results for rural areas, they might affect the coastal populations more strongly as space is limited, and the potential for contaminating water supplies and surrounding water bodies is high. Similarly, while reported levels of access to improved water sources are comparable to national levels, experience shows that these are often outside of the villages and water is actually brought in containers, which means that the water can easily become contaminated.

As expected, **livelihood strategies** are dominated by fishing and related activities but the overall diversification is low, with a median value of 1.9 activities per household and 30% reporting only one activity. Diversification is larger in smaller settlements, indicating that households need to engage in more activities to insure their subsistence. Fish smoking is mostly carried out by women and, based on interviews, may actually cost more than is received in compensation through commercialization. The absence of alternative fish preserving methods means that these households have few choices but to engage in smoking. Around 30% of the households engage in farming but the rates strongly vary according to location, ranging from over 85% to none in several locations.

Access to **savings and credit** is low. Only 25% of the households had engaged in any type of savings scheme, and less than 10% of households had accessed credit in the past year. The highest frequencies of credit are linked to microcredits from NGOs and local credit rotation schemes. Access to saving schemes significantly depends on the size of the settlements with 46% of respondents having accessed saving schemes in larger locations and only 18% in smaller.

Overall the population has low **access to information**. About 30% of the surveyed households indicated having constrained access to schools and markets, and more than 40% have limited or no **access to health centers**. In some small villages access to all three vital resources is severely constrained. Over 90% of the respondents indicated not reading a newspaper but 60% indicated listening to the radio, although this percentage drops dramatically in small villages. Yet, nearly two thirds of the respondents own or have access to a cell phone.

Access to **aid and social networks** appears to be low as well, with 40% of respondents stating they have not received any aid of any kind in the past year and 40% not participating in any groups and associations other than religious.

[1] The survey was conducted in July, which corresponds to the 'hunger season'. The results may have been affected by the timing of the survey.

Climate and environment

Sierra Leone enjoys a tropical climate with a **prolonged and abundant rainy season** from May to November. Due to the orientation of the coast and main mountain ranges the coastal regions are among the wettest regions in Africa receiving close to 3,000mm of rainfall per year. Rainfall varies on interannual and decadal time scales but the variations are low compare to the total amounts received, with a coefficient of variation of the order of 11%, and no clear, significant trend in rainfall is observed. Temperatures, on the other hand, have risen at the rate of **0.14ºC per decade**. Climate change projections indicate no or small tendency of rainfall increase and a consistent increase in temperatures. Thus, if managed properly water resources should not be a threat to Sierra Leone while temperature change may affect ecosystems and agricultural systems in the long term.

High winds and floods are the main climate/weather-related disaster with high impacts reported by the communities. However, while the majority (63%) of the respondents said they have heard about **climate change** and believe it is happening, more than one third indicated they did not consider this to be a major concern for their community. The low ranking of climate and environmental issues in the spectrum of current preoccupations was further confirmed in focus group discussions, where participants emphasized other development issues (poverty, food security, and access to markets, among others) and is characteristic of many communities in developing countries.

Total **mangrove** cover in Sierra Leone is estimated to have decreased by approximately 25% since 1990, but very unequally among regions: while the decrease reaches 46% in the Scarcies River Estuary, due to widespread conversion of the land to rice farms, mangrove cover has marginally increased in Ywari Bay and Sherbro River Estuary and significantly increased in SLRE due to reforestation efforts. *Avicennia germinans* is the dominant species in all the regions but Sherbro, where *Rhizophora Racemosa* dominates. Despite deforestation, the remaining mangroves in the Scarcies region are in good health, with high species diversity, mature forest and high regeneration level, indicating high regeneration potential should human pressures be lowered or better managed. The Sherbro area is on the opposite end of the spectrum, with lowest species diversification, highly dominated by *Rhizophora Racemosa*, with the oldest trees and lowest regeneration rates, showing high commercial potential but low current regeneration potential. SLRE has the youngest forests, a sign of past and current exploitation of the forest, while the Yawri Bay has fewer adult trees but the highest number of seedlings, both showing signs of good potential for regeneration and sustainability.

Mangroves are perceived mainly as source of fuel wood, with 70% of the households reporting a reliance on mangrove wood for cooking and smoking fish, and this proportion reached 100% in several smaller localities. Approximately 48% of respondents have noticed a decrease in mangrove cover in the past decade, but nearly 30% could not tell the difference. There is a shared perception that the decrease is

linked to human activities rather than changes in climate, and nearly two thirds of respondents stated a willingness to participate in conservation/restoration activities.

According to the focus groups, most **natural resources** – farmland, fishing grounds, mangroves, other forests, and sand – are open access. A small minority of focus group participants mention traditional or government restrictions, with the highest being traditional restrictions for farm land. This view of natural resources as essentially open access may influence behaviors around resource capture, and under such circumstances there can be little incentive for conservation and sustainable management. Eighty-seven percent of respondents engaged in fishing activities indicated the resource has decreased and linked it to overfishing and bad fishing practices (too many fishermen and trawlers, and catching juveniles) rather than to changes in the environment.

Aggregated Wealth and Vulnerability measures

The highest proportions of households in the highest category of the **wealth index** are found in the urban and peri-urban settlements of Tombo, Tssana, Dibye Water, Bonthe and York Islands. Villages with high proportions of households in the lowest wealth index category exist in all four regions. Those are usually the smallest and most remote villages.

Scores on a **community vulnerability index** combining various socio-economic and climate impact factors show limited degree of spatial organization. Highest **exposure** levels are recorded in the Scarcies River Estuary, while Yawri Bay and SLRE have lowest exposure levels (owing to higher ground) but highest **sensitivity** levels, independently of locality size. Villages in the Scarcies and SLRE are composed of households with all five levels of **adaptive capacity**, independently of settlement size and accessibility. Yawri Bay and Sherbro settlements show a very contrasting adaptive capacity picture, with larger and more accessible settlements dominated by households with higher adaptive capacity while smaller, more remote villages are dominated by households with lowest adaptive capacity.

An **ecosystem vulnerability index** comprises indicators of mangrove quality and health together with anthropogenic pressures and community readiness to engage in conservation activities. As with the community vulnerability index, it shows limited spatial clustering. The SLRE and Yawri Bay regions have marginally lower vulnerability, but transects within each region show highly variable levels of vulnerability. An **overall vulnerability index** combining the community and ecosystem indices shows higher vulnerability in the Scarcies and Sherbro regions, linked to high exposure (Scarcies) and low adaptive capacity (Sherbro), while SLRE and Yawri Bay have somewhat lower overall vulnerability, despite higher sensitivity of the communities.

Adaptation Solutions

Climate-related stressors rank relatively low among community concerns, which instead are dominated by concerns over lack of resources and education, constrained access to markets, food insecurity, health problems and inadequate shelter. **Adaptation solutions**

spontaneously listed in focus groups fall into four categories: reforestation and climate awareness, infrastructure, livelihood and financial strategies, water and sanitation, and health, broadly corresponding to exposure, adaptive capacity and sensitivity in the vulnerability framework. Building resilience in the region will require attention to not just environmental remediation, but also to awareness building/access to information and meeting basic needs.

Focus group participants ranked from low to high their preference, the degree of difficulty, the ability of the community to organize, and need for external assistance associated with each solution. The **most desirable** solutions were also deemed by the respondents to be most difficult and most likely to need external support. Among such solutions the highest ranked were: reforestation, house improvements, drainage systems (to mitigate flooding), local water supplies, river embankments, and expansion of farming and fishing. They address mainly exposure and, to some extent, sensitivity of the populations. Highly preferred, easy to implement solutions with little dependency on external assistance include: savings schemes, climate awareness, improving farming, improving roads and building schools. These mostly address adaptive capacity. Preferences change when villagers considered modified climatic conditions, such as a potential increase in the amplitude and/or frequency of harmful climatic events. Reforestation, drainage system and increase in fishing activities all showed a strong decrease in preference for at least 50% of participants, indicating that these solutions are not seen as very effective to address potentially increased occurrence or magnitude of disasters. **Strong increase in preference** under climate change scenarios was recorded for: sturdier homes, saving groups, improved water supplies, and health facilities. This shows that solutions leading to more secure and healthier living conditions would be the priority for the majority of the respondents.

Recommendations

Based on the findings of this study we suggest the following set of recommendations:

- **Improve Sierra Leone's capacity to monitor environmental conditions and projected impacts of climate change.** This includes building the capacity of the Meteorological Agency of Sierra Leone to provide quality information about past, current and future climate conditions based on local data; monitoring of physical and chemical properties of water and its levels in the coastal areas; and developing research to assess climate impacts on ecosystems and economic sectors tailored to Sierra Leone's context.
- **Improve natural environment management practices,** focusing on sustainable, community-based mangrove management that recognizes the variety of ecosystem services mangrove provides and accounts for different mangrove vulnerabilities in different regions; and on improvement of coastal water quality as well as of the coastal dynamics. Build a national mangrove management system based on the pilot systems developed in different communities, following a bottom-up approach.

- **Lower exposure to climate/weather disasters,** in particular to heavy winds and floods, through early warning systems, and through supporting community in better understanding potential changes in disaster risk and, where relevant, support community organizations to establish protective infrastructures (drainage, higher embankments, wind barriers) and/or increase their capacity to combat the disasters, such as fires due to heavy winds, and mitigate their effects.
- **Lower the sensibility** of the populations through support to livelihood diversification, improved food security, health, sanitation and housing conditions. Design specific portfolio of actions focusing on female headed-households, given current very low education levels and very limited livelihood opportunities available to women.
- **Increase the adaptive capacity** of the populations through climate impacts, sea level rise and related risks awareness building and improved access to information (including early warning systems), education and financial instruments targeting specifically populations in the mangrove areas.

Several interventions are akin to standard development interventions but the selection was based on communities' preferences, given their current status, capacities and current and projected climate impacts. Given very high levels of exposure and overall vulnerability of the fishing communities living within the mangrove areas in Sierra Leone such standard development interventions are a prerequisite to building resilience of these communities in the wake of changing climate conditions.

1. Introduction

This coastal climate change vulnerability assessment (VA) was conducted to inform the WA BiCC project on coastal adaptation interventions in the mangrove forest areas of Sierra Leone. Given that data are sparse and often outdated, the VA also provides a socio-economic and environmental baseline for this region.

In the future, these coastal regions will be affected by sea level rise, increase in temperature and climate extremes such as high winds and storminess, and changes in weather patterns (e.g., amounts and distribution of rainfall). In this context, mangroves play an important role in resilience to climate change by providing protection against erosion and strong winds. They also build the resilience of these communities, which are economically dependent on fisheries, by serving as fish nurseries and by providing fire wood for fish smoking. However, mangroves will be adversely affected by the effects of climate change through sea level rise and changes in water characteristics and sedimentation patterns. Those stressors will add to current, human-induced stressors such as pollution, unsustainable harvesting, and deforestation for agricultural land conversion.

Protecting and conserving mangroves will alleviate some of the effects of climate change in the future, but these efforts can only be initiated and sustained with the support of local populations. Hence, in order to co-design interventions with the local population, WA BiCC needs to understand their basic needs and livelihood strategies and their perceptions vis-à-vis climate change and the status of mangroves and fisheries. By the same token, an understanding of the differential vulnerability of local communities is necessary in order to best target interventions.

In July 2016, CIESIN/Columbia University led a VA with a team comprised of staff and researchers from the WA BiCC Freetown project office, Fourah Bay College, Njala University, and a number of government and NGO partners. The purpose was to collect data pertaining to the socio-economic status of fishing communities and their perceptions on climate, mangroves, and fisheries. The team surveyed neighboring mangrove ecosystems to understand ecosystem health and human pressures. This report presents the findings.

The report is organized as follows: Section 2 presents the VA methodology; Section 3 describes the results of the socioeconomic assessment of fishing communities living in four major mangrove forest areas; Section 4 presents results of a climate and environmental assessment, including mangroves; Section 5 presents summary results of vulnerability in the villages in the four regions; and Section 6 provides a discussion of results and recommendations. Technical annexes provide additional methodological details and results.

2. The methodology

The approach: top-down vs bottom-up?

It is widely recognized that climate change is global in nature, but that impacts will vary by region and that adaptation strategies need to be developed locally. Climate change adaptation planning happens at the nexus of different scales – larger scale processes impinging upon local systems and processes, which in turn can affect the larger scale systems. There is a vast body of literature discussing both approaches and their relative merits,[2] but to summarize:

- **Top-Down** approaches tend to be technical, science and scenario driven. They rely on scientific research and climate model projections of future climate to assess the risks associated with future climate change. They usually consist of a sequence of analyses beginning with projections of future emission trends, moving on to the development of climate scenarios, then to biophysical impact studies and the identification of adaptive options. Owing to the high level of uncertainty involved in top-down assessments, much of the research in this field stops at the impact assessment stage, and does not provide specific recommendations for adaptation. They are often developed to guide infrastructure investments or risk mitigation strategies.
- **Bottom-Up** approaches are generally focused on the notion of vulnerability. They assume that by addressing vulnerability today it is possible to reduce vulnerability under future climates. Vulnerability is defined as a characteristic of social and ecological systems that is generated by multiple factors and processes, including the state of the environment, climate exposure, and socioeconomic factors such as wealth, health, educational status, social equity, and food security. These approaches are well suited to development agency time-frames and are often participatory, relying on knowledge and expertise from local stakeholders. They are less focused on future climate scenarios than they are on current variability and change. These approaches can also consider past efforts to cope with or respond to impacts related to climate variability and climate change. They assume that in the face of uncertainty over climate change projections and impacts, adapting to present day climate variability/change is a good proxy for near term climate change.

[2] A useful review with accompanying references is provided by Reiser (2014). This summary draws heavily on that review.

Dessai and Hulme (2004) developed a useful schematic for both approaches (Fig. 2.1) and suggest that the two approaches are not necessarily contradictory. While they can be complementary, they do have different climate information requirements (e.g., climate projections vs. historical climate). Table 2.1 summarizes the main characteristics of both approaches.

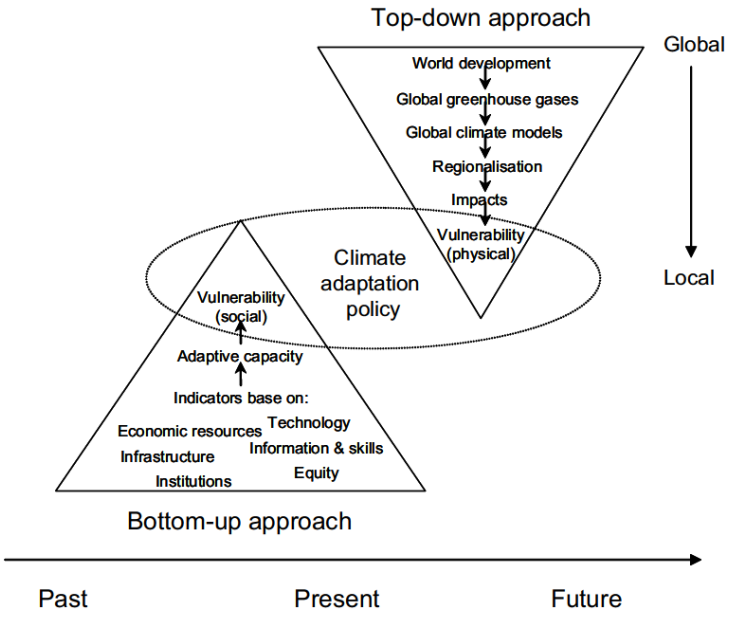


Figure 2.1: Top-down and bottom-up approaches to climate change adaptation. Source: Dessai and Hulme (2004)

Table 2.1: Differences between Top-down and Bottom-up approaches to adaptation planning

Top-down	Bottom-up
Bio-physical vulnerability	Social vulnerability
Physical or natural exposure units (e.g., watersheds, ecosystems)	Social exposure units (e.g., households, communities)
Ignores humans	Considers humans
Driven by federal or provincial legislation	Driven by local stakeholders or agencies
High-level policy-makers, technical analysts	Broad stakeholder engagement
Uses climate projections	Uses historical climate data
Focus on mid- and long-term future (e.g., 2050s or 2080s	Focus on past and present conditions to inform policy-making today and in near-term
Financial and human resources in place	Limited financial and human resources

Source: CCME, 2015.

Given the scarcity of data to develop downscaled climate change scenarios and their impacts in the coastal zones of Sierra Leone and its overall better fit to the developing country context and the shorter time-frames of the WA BiCC project, we have chosen to conduct a bottom-up vulnerability assessment (VA). In addition, given the unavailability of historical climate information for the coastal areas of Sierra Leone, we also base our assessment of climate impacts on direct recall by respondents, which were collected along with other information on social vulnerability.

Preliminary information gathering and area/population selection

The coastal areas in Sierra Leone

The Sierra Leone coastline stretches for about 506 km and the continental shelf extends for about 27,500 sq. km. This considerable continental shelf, combined with the local currents, creates a substantial upwelling that places Sierra Leone within one of the world's most productive marine ecosystems (Heymans and Vakily, 2004; GCLME, 2013). The western tip of Sherbro Island delimits two contrasting coastal waters: to the north, the shelf reaches a width of 125km, and to the south it tapers to about 32km. Thus the coastal sector north of Sherbro Island is more productive than the southern sector bordering with Liberia. Most of the artisanal fishing activities occur around the estuaries of three rivers, the Scarcies, Sierra Leone and Sherbro, as well as around Yawri Bay (IUCN, 2007).

Fisheries are the life-blood of coastal villages in Sierra Leone, and represent the major source of income and livelihoods for fishermen and those (mostly women) involved in fish processing marketing and distribution. They also support a secondary economy of boat building, wood cutting, transporting fish, weaving baskets, selling fishing gears and petty trading. Around 40,000 artisanal fishers and their families operate about 12,000 fishing boats leading to, according to some reports, employment of 500,000 people in the fisheries sector. Fisheries represent around 10% of the GDP of Sierra Leone. Fish are also the most affordable and widely available protein source, and constitute 80% of animal protein consumed in the country (EJF, 2009). Fisheries contribute significantly to poverty reduction and food security in Sierra Leone.

Figure 2.2: Boat loaded with smoked fish leaving Yeliboya in the Scarcies region.

A study in the 1980s estimated that 47% of Sierra Leone's coastline is covered with mangroves (Chong, 1987), with a total area of 171,600 hectares. CIESIN calculated a 2013 estimate, based on Landsat imagery processed by the US Geological Survey (Tappan *forthcoming*), finding a total of 152,575 hectares. Fishing is the main

occupation of inhabitants in mangrove areas, which also coincide with the most fisheries dependent areas. This is no surprise, as mangroves constitute an important habitat for fish, shrimp and other marine fauna.

Mangroves also provide an essential source of wood. According to field observations, the *Rhizophora* species has been heavily harvested for fuelwood for fish smoking, whereas *Avicennia* is harvested mainly for fuelwood for salt processing and experiences less exploitation (IUCN, 2007). The population of Sierra Leone is in general heavily dependent on fuelwood for domestic energy. Ninety percent of household energy is for cooking of which 97% is in the form of firewood and charcoal (IUCN, 2007). In mangrove areas mangrove fuel-wood is additionally used for fish processing, especially for fish smoking. Unlike agriculture, which is seasonal, fisheries and forestry activities such as firewood production and charcoal making offer year round employment opportunities. The supply of these commodities to towns and other areas of concentrated demand is fully commercialized. Mangrove is also exploited as poles for construction and household furniture.

In addition to their direct benefits to the economy and livelihoods, mangroves also play an important role in resilience of local systems as barriers for storm protection in the control of flood and coastal erosion.

In Sierra Leone, despite sporadic efforts to control cutting by government authorities, mangroves are not legally protected. The only regulations are through traditional restrictions or international treaties affecting all countries along the coast. Fishing and wood cutting, which constitute the most important economic activities in the area, are controlled by traditional by-laws imposed by chiefdom authorities and Community Management Associations (CMAs) in the fishing communities. The efficiency of this approach to management needs to be assessed (IUCN, 2007).

Findings from the scoping visit

A preliminary visit to Sierra Leone's coastal area (Scarcies, Yawri Bay and Sherbro Island) from February 1-12, 2016 by a WA BiCC team[3] supports the findings above and provided a number of additional observations (cf. de Sherbinin and Trzaska, 2016):

- Mangroves are under varying degrees of pressure in Sierra Leone, ranging from high pressure and rapid depletion in the Scarcies Basin to the North, to slightly lower pressure and still more abundant mangrove resources in the Sherbro River basin to the South.
- Mangroves are currently used for construction and fuel wood and, in the fishing communities, for smoking fish. In high fishing/fish processing and trade areas, local stands are often depleted and wood is shipped from further away.

[3] The team was comprised of representatives from CIESIN, WA BiCC, Wetlands International, NPAA and MRU.

- Mangrove cutting is unregulated and the resource is perceived as inexhaustible, even in places where it was depleted. It is being brought from areas further away with implications on the prices. For fish smoking, few alternatives exist, and efforts to introduce more efficient smoke houses have had limited success.
- Generally, fishing communities rely more on mangrove resources and benefit more from ecosystem services than communities with other livelihood types (e.g. farming), and thus they may see larger benefits from mangrove restoration and conservation/management measures.
- Communities are aware of the importance of mangroves for fisheries, and there is growing appreciation of their benefits for coastal protection (shielding from winds and limiting coastal erosion).
- In many areas, however, short-term subsistence needs take precedence over long-term stewardship of mangroves. Furthermore, apart from relatively small areas where there are traditional management systems in place, they are largely perceived as an open access resource, with consequent lack of incentives for conservation.
- Fishing communities complained several times that they rarely benefit from development projects, presumably due to accessibility issues.

Figure 2.3: Landscape typical of the Great Scarcies river where the mangroves on the banks have been replaced by rice farming. Note the erosion of the unprotected banks. The dwellings are usually on higher grounds and populations have access to other type of wood thus they do not see the direct benefits of mangrove restoration, rather see it as competition with rice farming.

After the scoping visit, the WA BiCC project decided to focus the VA on fishing communities in mangrove areas. While the mangrove area may seem not suitable for human settlements, the scoping visit and subsequent examination of satellite data and imagery shows a multitude of small (and less small) settlements within the mangrove areas in Sierra Leone, as depicted in Figure 2.4 where settlements are overlaid on the most recent available mangrove extent data from 2014, and that of year 2000.

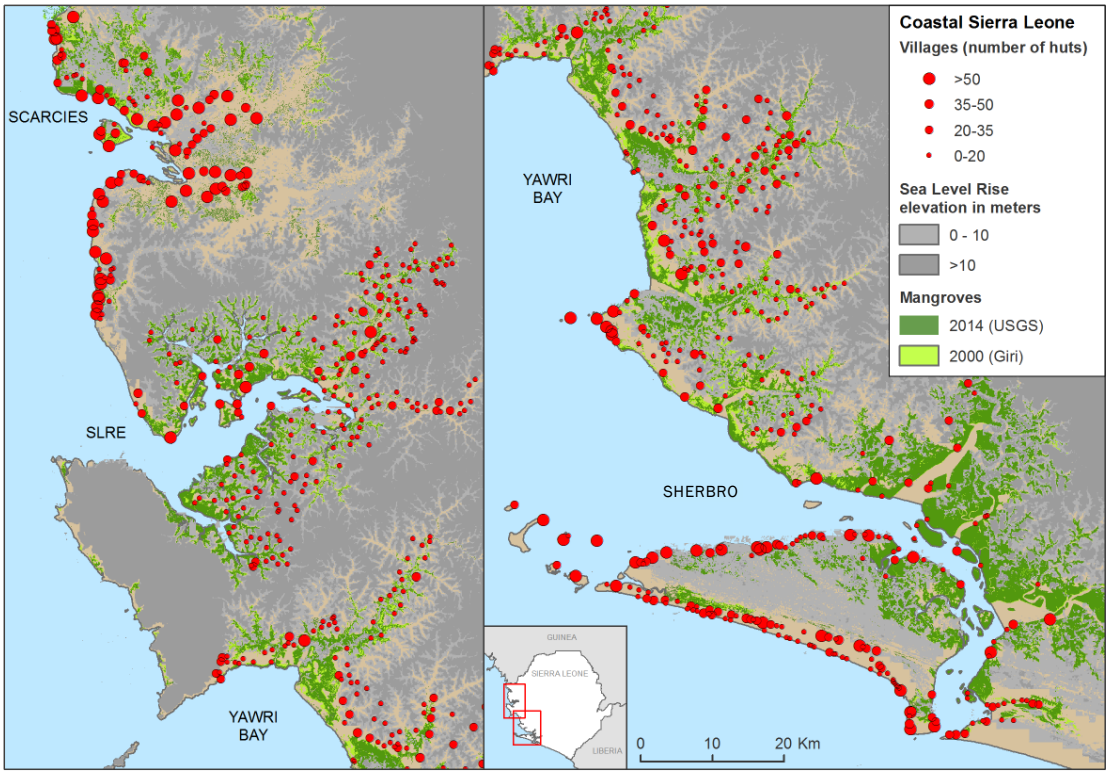


Figure 2.4: Mangrove extent as of 2014 (dark green) and 2000 (light green), along with mangrove settlement size and location information. Sources: The year 2000 mangrove layer is from Giri et al. (2013), and the 2014 mangrove layer is from unpublished data provided by Gray Tappan, USGS Eros Data Center. Note that both the 2013 and 2000 layers used Landsat imagery, but that the methods differed, and hence the mangrove layers are not directly comparable.

Area selection

Because of the intricate relationship between mangroves and fishing populations nearby and the important role mangroves play in alleviating some of the effects of climate change, the VA focused on mangrove areas. The largest mangroves systems in Sierra Leone remain within the estuaries of the Scarcies River, the Sierra Leone River and Sherbro River as well as along the Yawri Bay (Figure 2.5). They were selected as marine protected areas (MPAs)[4], where community based management associations have been created. Those areas also concentrate the majority of artisanal fishing activities.

[4] The MPAs are restricted to coastal marine habitats (including estuarine mangrove ecosystems). For further information on the management of mangroves, see the Resources and Governance section of Section 4.

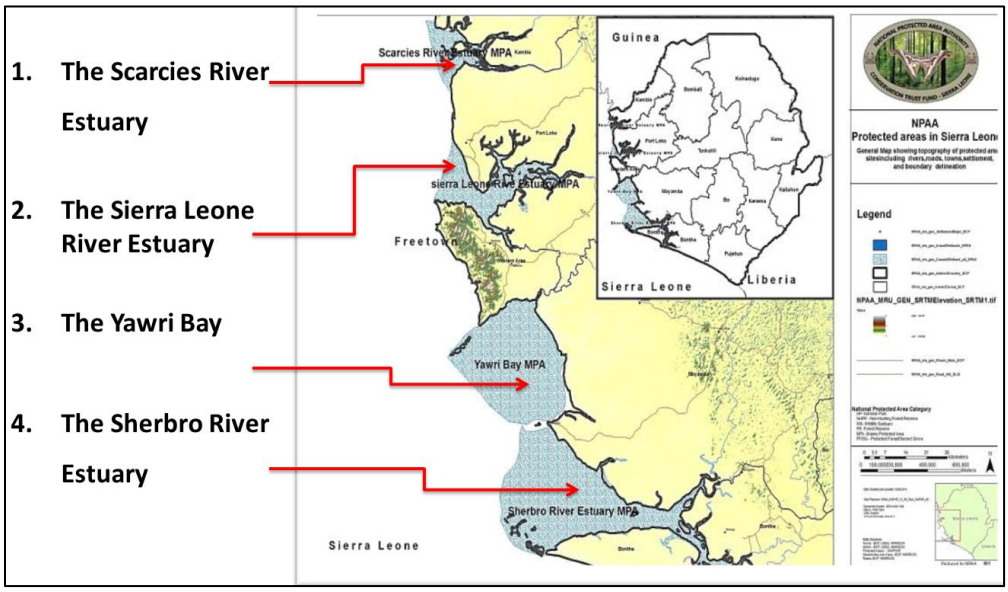


Figure 2.5. Location of major mangrove areas in Sierra Leone

The main characteristics of these four areas, which became the focus of this VA, can be summarized as follows:

Northern shore of the Greater Scarcies River mouth - Kambia district

This area represents 7.6% of Sierra Leone mangroves, in large patches of compact mangroves. Mangroves extend inland 8-10 km and up to 15 km along the rivers. Inland trees can be tall and of commercial quality. The area is highly populated with large economic activity from fishing where large amounts of smoked fish are exported inland, to Freetown and Guinea.

Mangroves have been cut-down and depleted for rice cultivation upstream in both Great Scarcies and Little Scarcies Rivers, and in this area the largest deforestation is seen. Around the mouth of the river communities seem to have little access to other types of wood for fuel and construction and indicated that wood comes from farther upstream.

A rapid assessment during the scoping visit pointed to potential overexploitation of mangroves for fuel-wood and other uses as well as conversion to farmland, as the fertility of the current rice paddies decreases. Communities see mangroves as protection against storms, wind and erosion.

Freetown Area: Mouth of Sierra Leone River - Port Loko and Western area rural districts, a RAMSAR site

Estimated mangrove cover in this area is 19.9% of the total mangrove cover of Sierra Leone, but is less compact, and tends to be concentrated along different tributaries,

extending between 0.5 and 3km inland. Mangroves are more shrubby and often freshwater swamps extend behind. 295,000 hectares of this estuary is protected under the Ramsar Convention.

The estuary is under numerous environmental threats including:

- industrial development and pollution: the estuary hosts two major industrial ports Queen Elizabeth II Quay, and the iron ore dedicated port of Pepel and a number of industrial sites.
- urbanization: urban extension as well as development of hotel and related industries; for example, unauthorized housing development has caused the removal of about 20 hectares of mangrove vegetation over the past five years alone.
- vegetation clearance for fuel wood and other usages
- poor waste disposal
- sand mining
- unsustainable fishing

The Conservation Society of Sierra Leone has led some tree replanting in the past but laments that efforts are undermined by diverse pressures on the area.[5]

The main threats in this area come from urbanization and industrial activities. The area deserves a special focus and protection as the only Ramsar site in Sierra Leone.

Yawri Bay - Moyamba district

Mangroves in this area represent 14.3% of the total mangrove cover, in the form of a coastal belt 1-5 km deep with a few relatively compact patches. Dense mangroves extend further inland, up to 20 km, along the three main rivers, Ribi, Bumpe and Kagboroo creek.

Fishing is an important activity with Tombo and Shenge ports supplying most of the fish consumed in Freetown. Its intensity has been increased by the development of small artisanal fishing projects in many communities, funded by various agencies, especially UNDP and AFRICARE. Other economic activities include salt production, which requires large quantities of fuel wood and agriculture including rice.

Some deforestation is noticeable on maps generated using remote sensing imagery from 2000 and 2013. Interviewees in Tombo indicated that mangrove wood comes from farther away. Improved fish smoking ovens, which were promoted by a project in the area, did not gain much attraction with local populations.

Heavy metal poisoning from large-scale mining operations upstream by Vimetco and Sierra Rutile Mining Companies is suggested to have caused fish kills within the Yawri Bay.

[5] See http://www.sierraexpressmedia.com/?p=66445.

Mangroves in the Yawri Bay may suffer from overexploitation for fish smoking and salt production and clearing for rice paddies. The proximity to Freetown may influence the amounts of extraction.

Sherbro Island Area - Bonthe district

Mangroves in the Sherbro Island area are part of the Sherbro River mangrove system which concentrates the largest part of the total mangrove in Sierra Leone - 58.2%. Extensive areas of large trees (*Rhizophora racemosa*), up to 40 m, can be found in the Sherbro River complex. The scoping visit unveiled that mangroves seem in good shape and are not overexploited and the population sees it as unlimited resource. With lower population and levels of extraction and well preserved mangrove system this area has the biggest potential for conservation and introduction of sustainable management practices, although perceptions that mangroves are an inexhaustible resource may undermine conservation efforts.

Summary

After consultation with WA BiCC staff, the study was conducted in all four areas, as they present different states of mangrove forests as well as different economic activities and socio-cultural characteristics, thus different pressures. In this way, common and area-specific needs and interventions will be documented, allowing better targeting of the interventions and policies at different levels.

The methods

A combination of ecosystem and population VA

To inform about needs and intervention opportunities at community level the VA needs to be carried at the community level and in-situ information gathered. The approach used for the VA merged an ecosystem VA with a socio-economic VA, where the vulnerability of each system is a function of its exposure (EX), sensitivity (SE) and adaptive capacity (AC). Figure 2.6 captures the main aspects of this approach.

The socio-economic VA follows the methodology proposed by Hahn et al. (2009) and is based on data collected through household level questionnaires, complemented by Participatory Rural Appraisals (PRAs) based on the approach by Tschakert (2007). The ecosystem VA uses the approach to mangrove vulnerability proposed by Ellison et al. (2012). The detail of the indicators used in the different components of the vulnerability assessment of each sub-system are presented farther in the text, after the description of the instruments.

Note that confidentiality of the information collected from respondents was ensured throughout the process and that respondents were informed about the objectives of the study and the use of the data and were asked to give their consent. The research design was approved by the Columbia University Institutional Review Board (IRB).

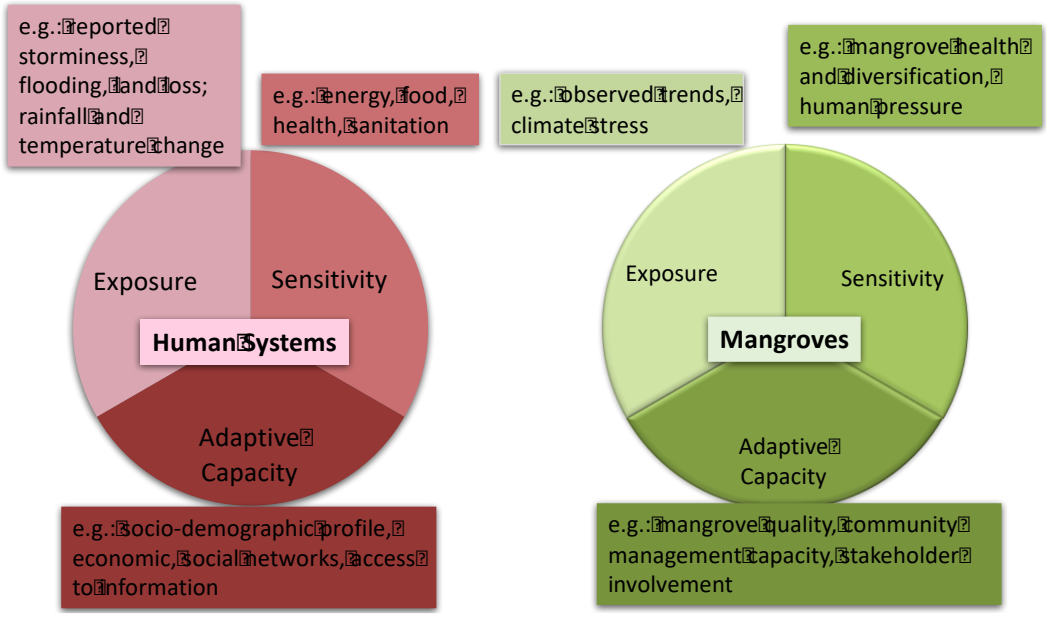


Figure 2.6: Schematic representation of the vulnerability indicators in each vulnerability sub-components: the vulnerability of human systems (left), the vulnerability of the mangrove ecosystems (right).

In the absence of reliable meteorological information with resolution sufficient to discriminate between different locations, we relied on individual reports of impacts of climate-related disasters on households and their assets such as number of floods, number of times a house was destroyed due to weather, number of times members of the household were hurt (or died) in a climatic event. We recognize that some of this information is subjective but the analysis is mostly based on ranking of households and settlements, not on actual values, and the sample size permits us to capture differences in climate impacts between locations.

In addition, we did not attempt to assess the current, or projected quality of the entire marine environment, including water characteristics or fish species. This study is limited to the assessment of the mangrove forest as an important and under-studied resource for the communities and a potential factor in climate change impact reduction. While critical to the assessment of climate change on the environment, monitoring of water characteristics, fish species, sedimentation rates and compositions were beyond the scope of this study. Long term monitoring of such variables needs to be part of the country long-term climate change assessment strategy.

Sampling strategy

The primary goal of the VA was to understand the community vulnerabilities and interactions between communities and mangroves. Therefore, the sampling strategy was limited to investigation of coastal villages that are in close proximity to mangroves or that rely heavily on mangrove wood, together with a forest inventory of neighboring mangroves. The villages were selected through a stratification method where three mangrove transects were first selected in each region among mangroves estimated to

be in best, worst and medium states, based on the satellite-derived maps. Two coastal villages within 2-3 km of the transect (or relying on the mangroves around the transect) were then selected. Thus, in each region the surveys, PRAs and mangrove assessments were conducted in three clusters composed of one transect and two villages for a total of twelve transects and 24 villages spanning the four regions. Table 2.2 summarizes the locations of the villages and Figures 2.7-2.10 show the location of the villages and transects in each region. The number of households surveyed and focus groups conducted depended on the estimated size of the village; in total 261 surveys and 96 PRAs were conducted. Both villages and towns were included in the analysis, in the following areas: Scarcies (5 villages and 1 town), SLRE (4 villages and 1 town), Sherbro (5 villages and 1 town), and Yawri Bay (5 villages and 1 town). About a quarter of the total households were sampled from the four towns included in the analysis.

Table 2.2: Characteristics of the localities surveyed

Administrative Region	Mangrove region	Locality	Number of HH	Population	Source	Year	HH number (est.)	Latitude	Longitude
Northern	Scarcies	Kortumoh	13	1500	Self-reported	unknown	500	8^{0}54'09"N	13^{0}14'16.831"W
	Scarcies	Mahelah	8	200	Self-reported	unknown	17	8^{0}58'17.159"N	13^{0}15'33.985"W
	Scarcies	Makumpa	8	270	Self-reported	unknown	84	8^{0}57'30.149"N	13^{0}14'14.131"W
	Scarcies	Moable village	7					8^{0}53'15.365"N	13^{0}13'32.640"W
	Scarcies	Saswaeyeh	8	300	Self-reported	unknown	50	8^{0}56'52.765"N	13^{0}14'21.389"W
	Scarcies	Yeliboya	20	7000	Self-reported	unknown	500	8^{0}57'06.636"N	13^{0}15'38.120"W
	SLRE	Dibeye water	24	20000	Self-reported	unknown	740	7.1929220	-11.9343220
	SLRE	Gberi Mamanki	10	700	Self-reported	unknown		8^{0}33'44.350"N	13^{0}07'42.718"W
	SLRE	Kafunka	10	386	Self-reported	unknown	200	8^{0}35'30.142"N	13^{0}08'24.522"W
	SLRE	Mange	10					8^{0}29'43.795"N	13^{0}04'39.055"W
	SLRE	Robakka	8					8^{0}29'21.861"N	13^{0}04'40.439"W
Southern	Sherbro	Bonthe	24	9975	City Population	2015	1300	7^{0}31'29.434"N	12^{0}30'00.507"W
	Sherbro	Mopala	14	2500	Self-reported	unknown	705	7^{0}44'48.892"N	12^{0}45'00.385"W
	Sherbro	Mosam	7	500	Self-reported	unknown	120	7^{0}47'53.052"N	12^{0}48'11.593"W
	Sherbro	Njajeiam	6	180	Self-reported	unknown	50	7^{0}36'27.363"N	12^{0}34'53.446"W
	Sherbro	Yangasair	9	200	Self-reported	unknown	50	7^{0}36'41.902"N	12^{0}33'30.276"W
	Sherbro	York Island	13	500	Self-reported	unknown	200	7^{0}32'28.998"N	12^{0}27'47.103"W
	Yawri Bay	Katta Wharf	8	1300	Self-reported	unknown	350	7^{0}55'12.318"N	12^{0}56'01.615"W
	Yawri Bay	Saamu	8	773	Self-reported	unknown	150	8^{0}04'26.472"N	12^{0}51'03.204"W
	Yawri Bay	Seaport	8					8^{0}8’24”	12^{0}55’48”
Western Area	Yawri Bay	Tissana	8	1000	Self-reported	unknown	390	8^{0}14'24.012"N	13^{0}03'40.896"W
	Yawri Bay	Tombo	25	28000	Self-reported	unknown	3000	8°12' 49.1004" N	13° 6' 6.7644'' W
	Yawri Bay	Singbule	8	400	Self-reported	unknown	150		
Total			264						

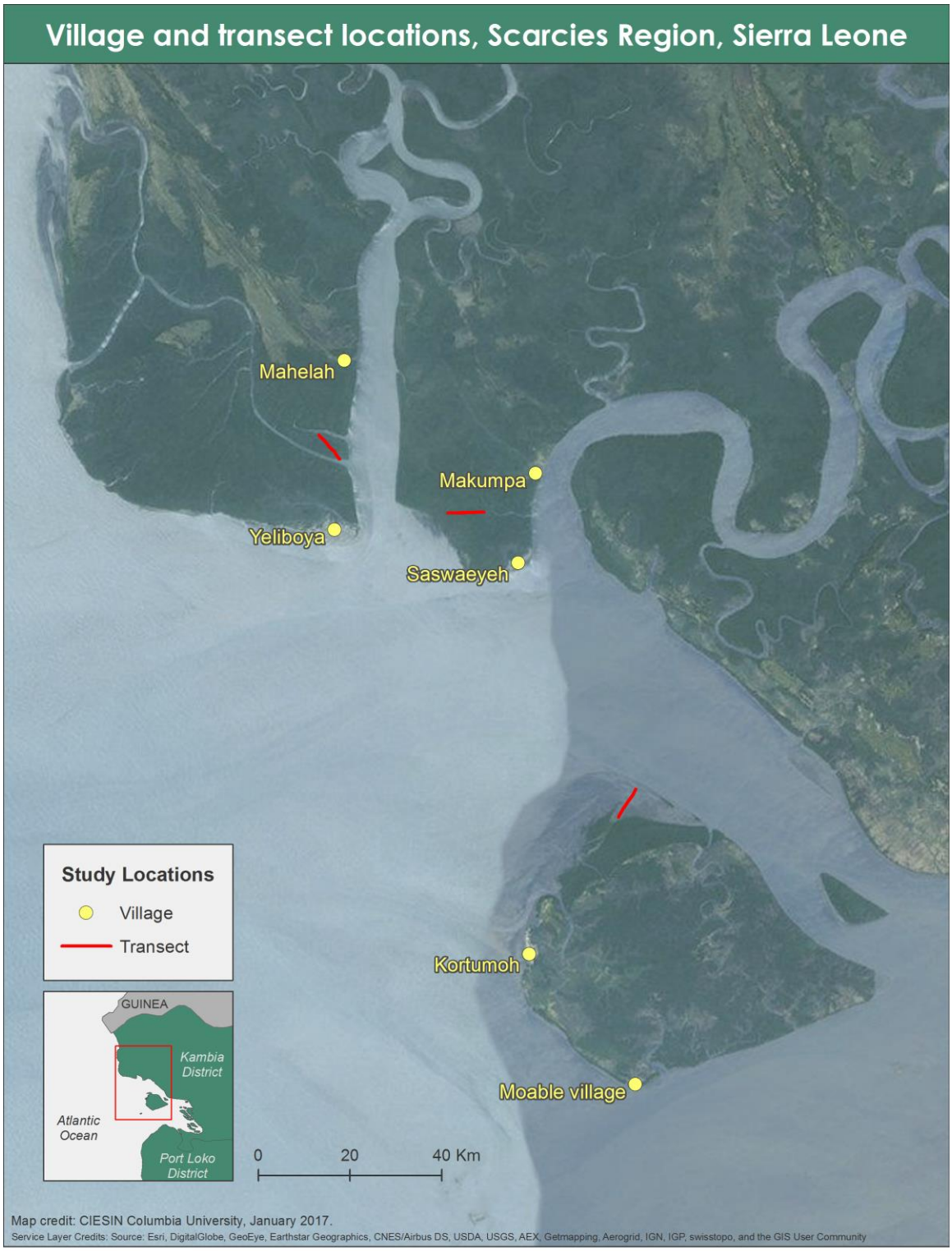


Figure 2.7. Location of villages and transects in the Scarcies region.

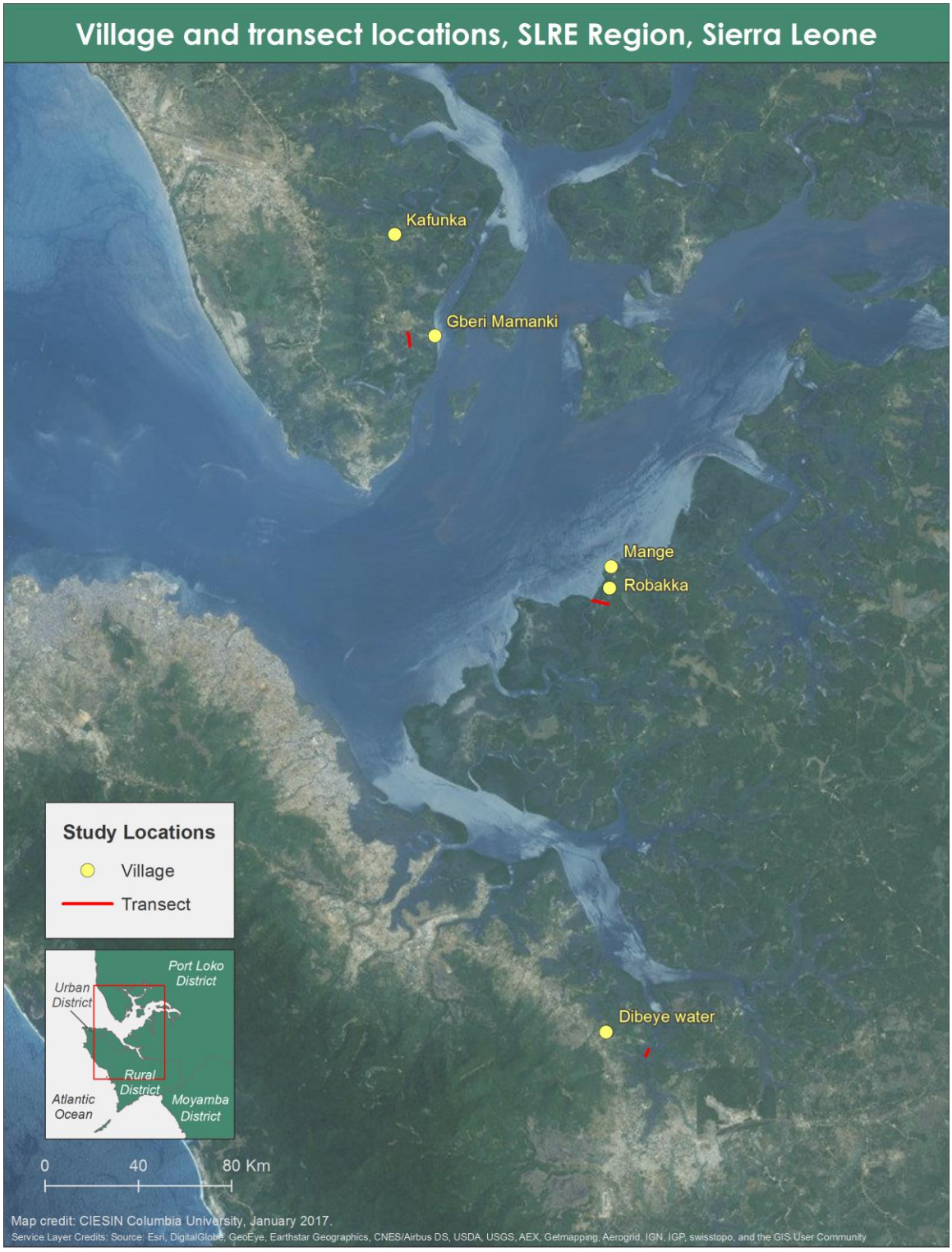


Figure 2.8. Location of villages and transects in the SLRE region.

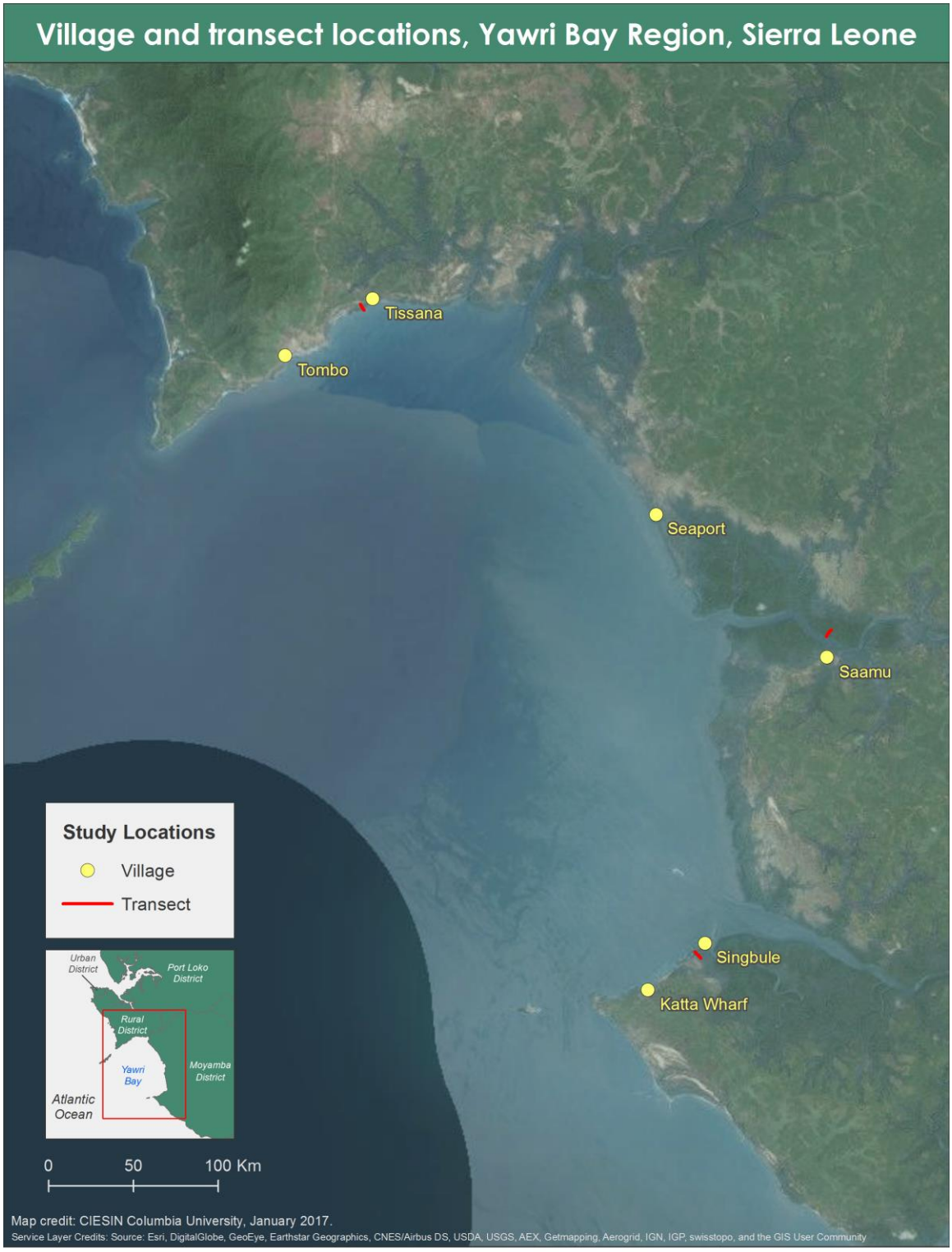


Figure 2.9. Location of villages and transects in the Yawri Bay region.

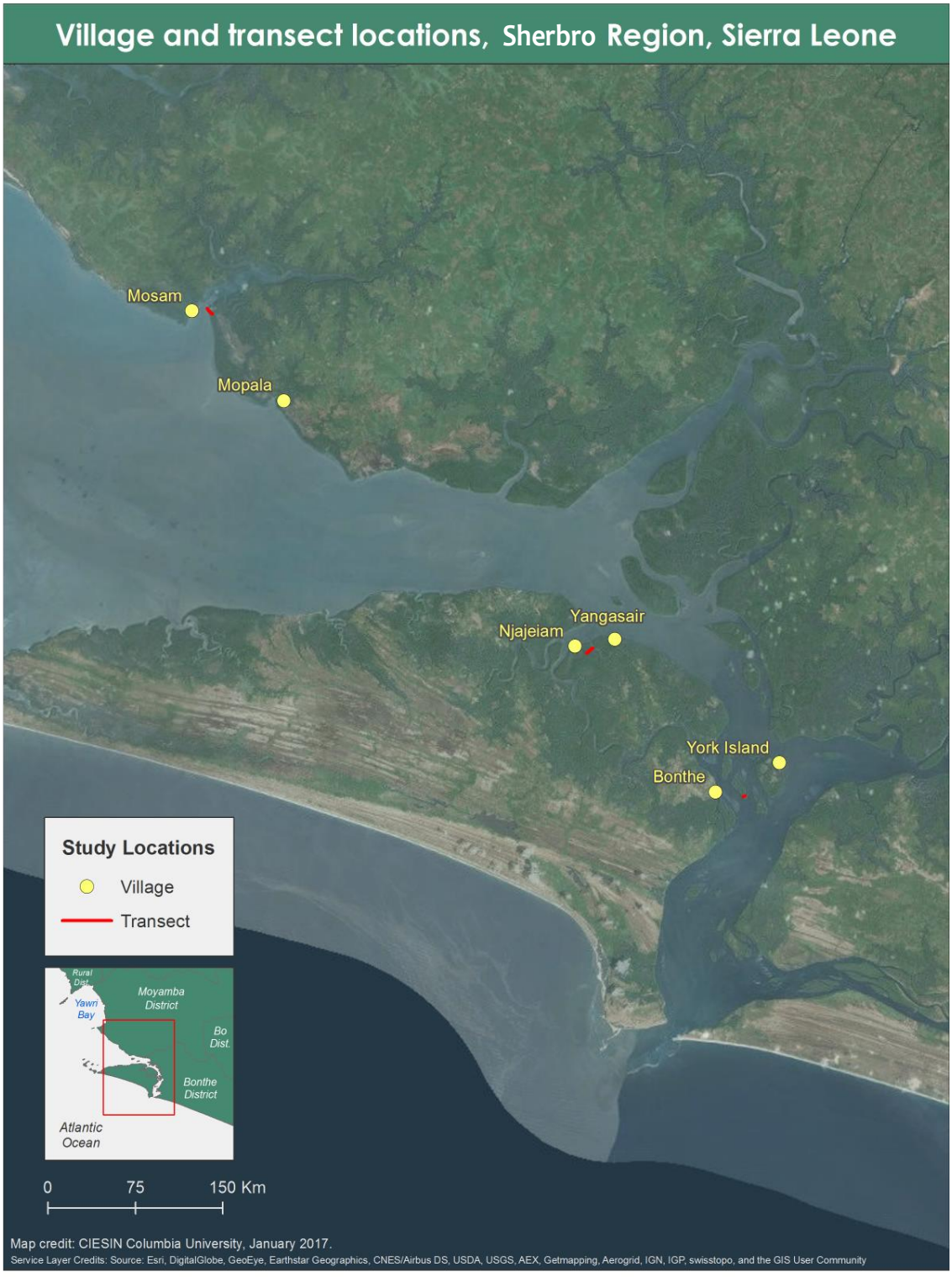


Figure 2.10. Location of villages and transects in the Sherbro region.

The instruments

Household Survey

The survey collected baseline information on the status and wellbeing of households, as well as knowledge, attitudes and practices toward mangrove conservation as well as local perceptions on climate change. The results were compared to national census and Demographic and Health Survey (DHS) results (to check consistency of our results against other data) and to construct indicators of exposure, sensitivity and adaptive capacity.

- **Survey structure**

The household survey included ~170 questions structured in 13 sections, as described below.

1. Generic information, and consent.
2. Demographic information.
3. Literacy.
4. Economic activities.
5. Mangroves.
6. Assets/ basic services, and pressing needs.
7. Food insecurity.
8. Climate change impacts and risk perception.
9. Knowledge, attitude, behavior.
10. External assistance, and community involvement.
11. Customary and formal regulatory frameworks.
12. Housing construction material, and size of banda (fish smoking house).

- **Survey implementation**

The survey was administered to 23 small and medium size settlements. As mentioned above, both small urban (town) and rural (village) settlements were included in the analysis. The percentage of total respondents in the survey was slightly larger in the towns (left side of Figure 2.11) than in the villages.

More details on sections and sub sections of the survey can be found in Annex 3.

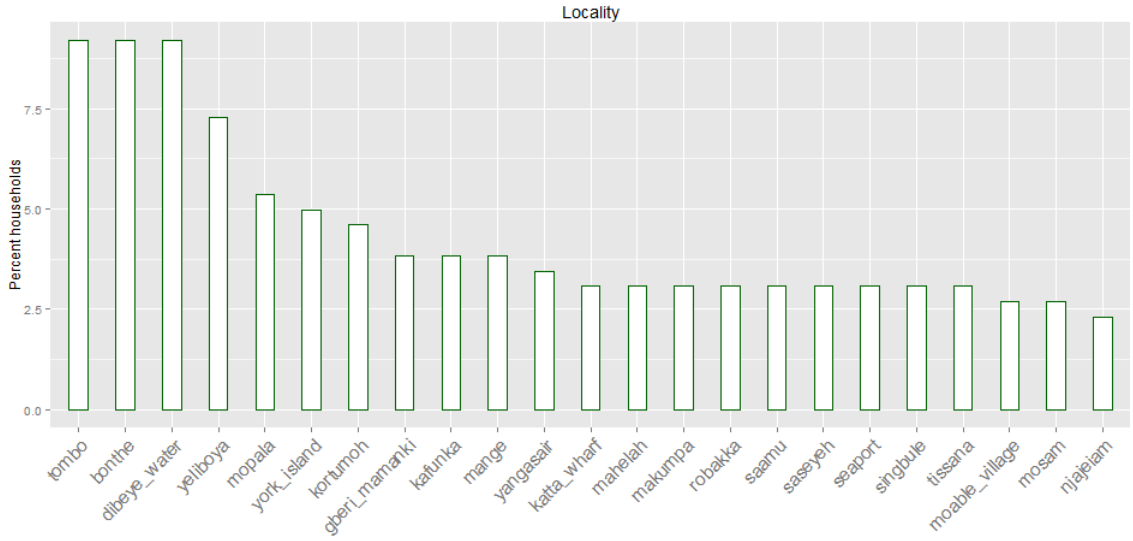


Figure 2.11: Distribution of households surveyed by locality as a percent of all households surveyed

Table 2.3 shows the distribution of interviews. From a total of 264 interviews, only 3 respondents did not consent, with an overall response rate of 98.8% (total of n = 261). As a point comparison, for the 2013 DHS 99.5% of rural households and 99.3% of all households agreed to be interviewed. Among the total response pool, five surveys were incomplete, but for the preliminary analysis, both complete and incomplete cases were considered.

Table 2.3. Summary of survey completion analysis

Survey result code	# Interviews	Consented?	% Interviews
Completed	256	Yes = 256, No = 0	96.97%
Declined	2	Yes = 0, No = 2	0.76%
No competent member	1	Yes = 0, No = 1	0.38%
Partly completed	5	Yes = 5, No = 0	1.89%
Total	264	Yes = 261, No = 3	100 %

Participatory Rural Appraisal

The purpose of the focus group discussions (or participatory rural appraisal, henceforth collectively referred to as “PRA”) was to get a broader picture of coastal climate impacts, community resilience, coping/adaptation mechanisms, and the role of mangrove ecosystems in promoting resilience. It also explored gender issues in terms of differences in perception of major problems/stresses or available solutions to climate-related problems, as well as gender differences in access to resources. The PRA complemented the household survey and field research being conducted along the

mangrove transects. The PRAs were conducted in the same villages as the household surveys and included a broader group of respondents.

The PRA included the following modules:

1. Participatory risk ranking and scoring – to highlight problems that are most relevant for enhancing resilience/adaptive capacity, and to understand how important climate stress is compared to other livelihood hazards. As pointed out by Reid and Vogel (2006), climate stressors are rarely the only concern or stress that constrain quality of life in rural, resource-poor communities in Africa.
2. Climate-related stressors and mental mapping – to elicit the positive and negative consequences of climate change and variability, for both people and the environment, and discuss solutions, including feasibility, community readiness, barriers and needs for external assistance.
3. Coping/Adapting to climate change – to review the proposed coping and adaptation strategies under a possible future in which a given climatic extreme was greater in magnitude or were to occur twice as often or last much longer. Participants explored which coping and adaptation strategies would still be viable in this context.
4. Participatory resource and risk mapping – to indicate any access agreements or restrictions as well as different hazards or risks to the main resources of the community. Examples might include zones susceptible to periodic flooding, areas that have suffered erosion, or lands / soil types that are susceptible to drought.

A detailed guide to the PRA and forms to record the responses can be found in Annex 3.

All PRA exercises were conducted with groups of 10-12 participants, and lasted 2-3 hours. One facilitator and one or two note takers/assistant facilitators were present for each PRA. Three teams of two PRA facilitators were trained during one week and tested the PRA instruments in a test location, then implemented the survey over the period of 10 days. Each team visited eight villages. The protocol followed for the PRA activities is found in Annex 2.

Fig 2.12: Participatory Rural Appraisal with a group of of women in Katta Warf, Yawr Bay, July 2016. Credit: S. Trzaska.

In larger settlements four PRAs were conducted (one for women 18-30, one for women above 30, one for men 18-30 and one for men above 30) while in smaller locations, to ensure that the groups were large enough, only one discussion group per gender was organized. A number of gender-specific questions were included in the additional discussion questions in the forms for each exercise.

Ecosystem Vulnerability Assessment

This assessment drew strongly on the methodologies described in Ellison et al. (2012), Clausen et al. (2010), and Ajonina (2011). The main elements of exposure, sensitivity and adaptive capacity are detailed below.

The potential effects of climate change on mangroves have been described by Ellison et al. (2012) as follows:

- rising sea level: forest health, forest productivity, recruitment, inundation period, sedimentation rates, impacts on forest mortality, dieback from seaward edge, migration landward dependent on sediment input, topography and human modifications;
- extreme storms: forest productivity, recruitment, sedimentation rates; impacts: forests damaged or destroyed, ground elevation change, erosion or sediment

smothering; increased waves and winds: sedimentation rates, recruitment; changes in forest coverage, depending on whether coasts are accreting or eroding;

- increased rainfall: sediment inputs, ground water, salinity, productivity; impacts: increased sediments and maintenance of surface elevation, increased ground water, increased diversity, increased productivity, increased recruitment;
- reduced rainfall: sediment input, groundwater, salinity; impacts: reduced sediments and relative subsidence, landward migration, reduced ground water, reduced photosynthesis, productivity, species turnover reduced diversity;
- reduced humidity: photosynthesis, forest productivity; impacts: reduced productivity, species turnover, reduced diversity;
- increased air/sea temperature: respiration, photosynthesis, forest productivity; impacts: reduced productivity at low latitudes and increased winter productivity at high latitudes;
- enhanced CO2: photosynthesis, respiration, biomass allocation, forest productivity; impacts: increased productivity subject to limited factors of salinity, humidity and nutrients; soil elevation gain; and
- UV-B radiation: minor impacts to morphology, photosynthesis, and forest productivity.

The stressors described above affect mangroves to various degrees and their future values can be estimated only with large uncertainties. While the effects of enhanced CO_2 or UV-B radiation are marginal and beyond the scope of this study, sea level rise, and extreme storms more directly affect the mangroves. However, their changes in the future can only be accessed in terms of likely scenarios and will most probably be uniform across Sierra Leone.

- **Vulnerability Indicators for the VA of the mangrove system**

Some of the indicators presented by Ellison et al. (2012) can only be obtained through long-term observation and monitoring, some require sophisticated measurement techniques, not possible within this assessment. Thus, in our methodology we followed the general approach proposed by Ellison et al. and designed our indicators based on data collected during the forest inventories and during the household surveys. Detailed lists of indicators and data collected to estimate the vulnerability of mangroves along different transects is presented in table 2.5.

- **Forest inventory conducted**

A forest inventory was conducted along 12 transects of 500m (or less) long. In each transect plots of 5m (2m for seedlings/saplings) in diameter were delimited every 50m as indicated in Figure 2.13. The following parameters were collected on paper forms (see Annex 4) that were later digitized:

a. Number and type of mammals, birds, and crustaceans visible from the location; presence of fish (type if possible)

b. Main vegetation/patch type
c. Dominant mangrove species
d. Type of human activity (cutting, clearing, cultivating, etc.)
e. Evidence of regeneration
f. Height of high tide mark on mangrove roots using meter stick (vertical distance from sand/mud to water mark on roots)
g. Patch type
h. Number of adult mangrove species
i. Height (distance between collar and top of tree) and diameter (at collar) of mangrove measured every 10th tree
j. Presence of diebacks and/or human activities (e.g. harvesting of roots, wood, etc.)
k. Number of individual seedlings and identification if seedlings in general are short, medium, and/or tall
l. Seedling species

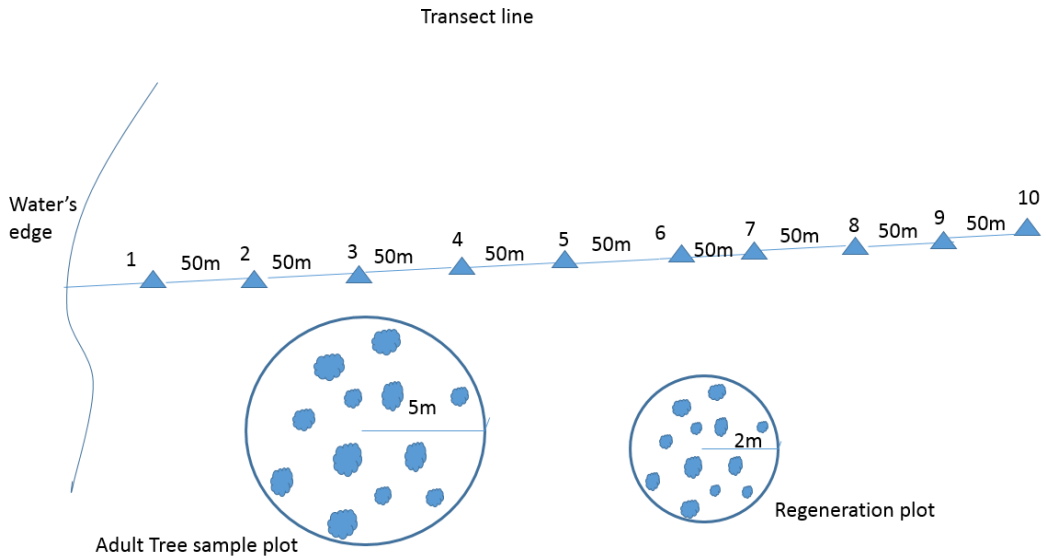


Figure 2.13. Transect design

Data collection

The data were collected by three teams composed of four household survey enumerators (three enumerators and one supervisor), four PRA facilitators and two mangrove surveyors. A total of 12 household enumerators, 12 PRA facilitators and 6 mangrove surveyors were recruited from Fourah Bay College, Njala Universiy and partnering institutions (National Protected Areas Agency, Environmental Protection Agency, MAFFS, and Ministry of Land) (see Annex 5 for full list). Prior to deployment the enumerators were trained on their respective instruments during one week training session (July 11-15, 2016) that included a one day field-test in a location near Freetown as well as training on the ethics of data collection.

Figure 2.14: PRA team during the training session in Freetown, July 11-15, 2016

The three teams were then deployed in four regions during the period July 16-26, 2016, with each team covering respectively the Scarcies, the Yawri Bay and the Sherbro regions as well as one cluster in the SLRE region. An additional 'roving' team composed of the VA lead (S. Trzaska), WABiCC VA coordinator (G. Ganda), socio-economic survey expert (S. Weekes) and mangrove expert (A. Lebbie) visited each team twice during the data collection, to observe the work and provide guidance.

WABiCC teams were assisted in each village by locally recruited facilitators to help organize the meetings and facilitate the contact with the households as well as to assist with the progression along the transects in the mangrove. A dedicated village scoping mission had been conducted by WABiCC staff and the VA lead end of June 2016 to obtain authorizations to conduct the study from the local authorities, identify local staff as well as design the logistics.

Household survey data were collected directly In electronic form on hand-held devices and transferred to a secure repository accessible only to the VA lead, to ensure anonymity of the data collected. PRA and mangrove data were collected on paper forms and subsequently digitized.

Data Analysis

Data analysis was carried out by CIESIN between August and November 2016. It included PRA and forest data digitization; household survey, PRA and forest inventory data quality control and cleaning and various analyses detailed in subsequent sections. Household survey data were analyzed at national and regional levels and, where relevant, compared to national indicators from censuses (2004 and preliminary results of 2015) and the 2013 DHS survey to compare the selected populations to general population of Sierra Leone. Differences by gender were also analyzed as well as by larger and smaller settlements. The data were further analyzed at the household and village level to obtain indicators relevant to the assessment of vulnerability of populations to climate change, such as wealth index, and aggregates of vulnerability sub-components, exposure, sensitivity and adaptive capacity. Analyses were carried using an additive method to combine the sub-components. The results of the PRA were aggregated to national levels to present the overall picture of, for example, stressors and adaptation solutions, and to regional levels to highlight potential differences between regions. Where relevant, analyses were also carried with respect to gender. Forest inventory data were aggregated to transect level to present main characteristics of the mangroves and human activities. Finally indicators from both assessments were combined to assess the vulnerabilities of the socio-economic and eco-systems at the village and regional levels.

Combined Vulnerability analysis

Indicators retained in the combined Vulnerability Analysis

Data collected through the household survey and in the mangrove transects were subsequently used to construct the combined vulnerability at the village level as well as at the household level, for the socio-economic data. The tables below summarize the indicators used in each of the vulnerability components.

Table 2.4. Summary of the indicators used to estimate populations Exposure, Sensitivity and Adaptive Capacity in each location based on data collected through the household surveys.

VULNERABILITY OF POPULATIONS		
Dimension of V	**Sub-dimen-sions of V**	**Indicator**
ADAP-TIVE CAPA-CITY	Socio-demographic profile	Dependency ratio
		% Female-headed households
		% Head of households have not attended school
		Livelihood diversification (simplified) – inverse
		Fish livelihood diversification – inverse
		% households who solely depend on fish-related activities for their livelihood
		% households who mainly depend on mangrove-related activities for their livelihood
		% households who solely depend on agriculture-related activities for their livelihood
		Wealth index
	Economic	% households with no access to credit
		% households with no access to any savings scheme
	Social networks	Number of group memberships or associations households members belong to
		Number of times households received support from (all categories), in the past year
		Number of times households provided help/support to (all categories), in the past year
	Access to information	% households with constrained access to health centers, in the past 12 months
		% households with constrained access to schools, in the past 12 months
		% households with constrained access to markets (local/regional), in the past year
		% households respondents who did not listen to the radio last month
		% households respondents who did not read the newspaper last month
SENSI-TIVITY	Energy	% households solely dependent on wood from mangroves for energy supply
	Food	Food security score (HFIAS)
		Number of months households struggle to find food
		% households with food supply impacted by natural disasters
	Health	% households that do not treat drinking water
		% households where place for handwashing was observed
		% households where no soap or detergent for handwashing was observed
		% households where respondent was too sick to work within the past 12 months
		Number of days lost due to illness in the past 12 months
EXPO-SURE	Climate	Number of floods, droughts, windy, and high-temp events in the past 5 years
		Duration (in days) of floods, droughts, windy and high-temp events in the past 5 years.
		% households with an injury or death as a result of natural disasters
		% households with houses destroyed as a result of natural disasters
		% households with smokehouse destroyed as a result of natural disasters
		% households with boat destroyed as a result of natural disasters

Table 2.5: Summary of the indicators used to estimate mangrove Exposure, Sensitivity and Adaptive Capacity in each transect based on data collected through the forest inventories and household surveys.

MANGROVE VULNERABILITY		
Dimension of V	**Sub-dimensions of vulnerability**	**Indicator**
ADAPTIVE CAPACITY	Mangrove quality	Number of regeneration divided by number of adults averaged by species present (0 to 1)
		The proportion of adult trees that are not Avicennia species . Value range from 0 (poor) to 1 (good)
		The length of transect in meters. Less than 500m means less mangrove
	Community engagement/ knowledge	% households willing to engage in reforestation/restoration without compensation
		% households reporting existing rules for mangrove access
SENSITI-VITY	Mangrove health and diversification	Shannon Index of diversity. Value range from 0 (no diversity) greater than 0 more diversity
		Proportion of adult stems that are dead. Value range from 0 (no dead stems) 100 (all dead)
	Human Pressure	Number of plots registering cutting, clearing or farming
		Population estimates
		% households engaging in Ag
		% households where mangrove is the main economic activity
		number of different uses of mangrove wood
EXPO-SURE	Observed trends	% households reporting decrease in mangrove cover
	Climate stress	number of floods/windy events etc experienced over past 5 years
		% households with houses destroyed

Computation of aggregated indicators

Given different information types and units for each indicator, each indicator was normalized on a scale 0 to 1 by the equation:

$$\mathrm{I}_{i,j} = \frac{D_{i,j} - Min(D_{i,j})}{Max(D_{i,j}) - Min(D_{i,j})}$$

where $I_{i,j}$ is the normalized indicator, $D_{i,j}$ is the value of the indicator extracted from the survey, i designates the i^{th} indicator in the given component and j the location.

In each location, indicators for each vulnerability component were averaged and then normalized again so that the values for EX, SE and lack of AC were again in the range 0 to 1, with 0 being the lowest EX/SE/lack of AC (*i.e.*, the lowest vulnerability) and 1 the highest. To make results easier to interpret, and so as not to suggest that 0 represents no vulnerability, the individual components were rescaled from 1 to 6 (from low to high).

3. Socio-economic Characteristics of Communities

This section presents details of the analysis of the socio-economic characteristics of the households collected through the household survey. In the first part results were aggregated for the entire sample or at the level of each region and compared to national data where available. After basic demographic characteristics of the populations the presentation of the results follows a progression from indicators of sensitivity to indicators of adaptive capacity. In the second part of this section analyses at the household level are presented (wealth index, and social vulnerability).

Analysis at national and regional scales

Demographic and Basic Development Indicators

Age and Sex distribution

The age and sex distribution of household members is found in Figure 3.1. As expected in a developing country, the sampled household population has a young age distribution.

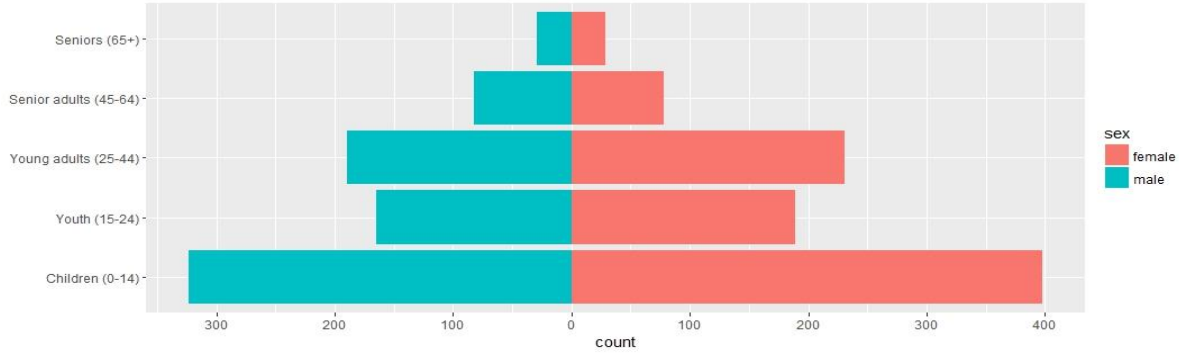


Figure 3.1. Age and sex distribution of household members

Based on a sample of 1,714 individuals, the median age was 18, consistent with national median ages, and the average age was 22.04. According to the UN, Sierra Leone's national median age in 2010 was 18.1,[6] and the national average age in 2015 was 18.5.[7]

The sex ratio of the sampled population, measured as the number of males per 100 females, was as follows:

- Scarcies: 90.27
- Sherbro: 87.35
- SLRE: 70.86

[6] United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: The 2015 Revision, custom data acquired via website.
[7] Idem.

- Yawri Bay: 94.84

This compares with the 2004 Sierra Leone national census sex ratio of 94, and the 2015 census provisional results of 96. Figure 3.2 shows the percent male and female household members by region. SLRE may have a lower sex ratio owing to its proximity to Freetown, since it is likely that more male members of households would relocate to the city for work.

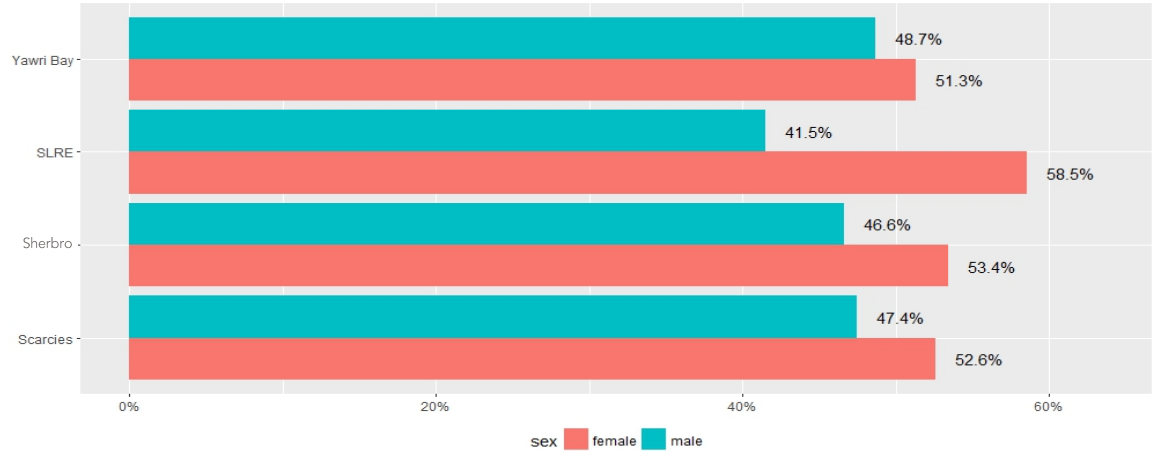


Figure 3.2. Percent of male and female household members by region

Gender distribution of the heads of households

Figure 3.3 shows the percentage of household heads who are male and female in the sample by region, with vertical lines showing the 2013 DHS national average rural percentages (males: 74.6%, females: 25.4%). Gender distribution of household heads in the fishing communities living within mangrove areas is comparable to the national average in rural areas with, however, most regions having slightly lower numbers of female headed households and slightly higher numbers of male headed households than the national averages, except for Sherbro. Figure 3.4 additionally shows the gender distribution of heads of households by size of the locality. In small localities household heads are dominantly male (84%) above national levels for rural households, and female-headed households are less frequent than national averages. Conversely, in larger localities fishing households are female-led more often than indicated by national averages

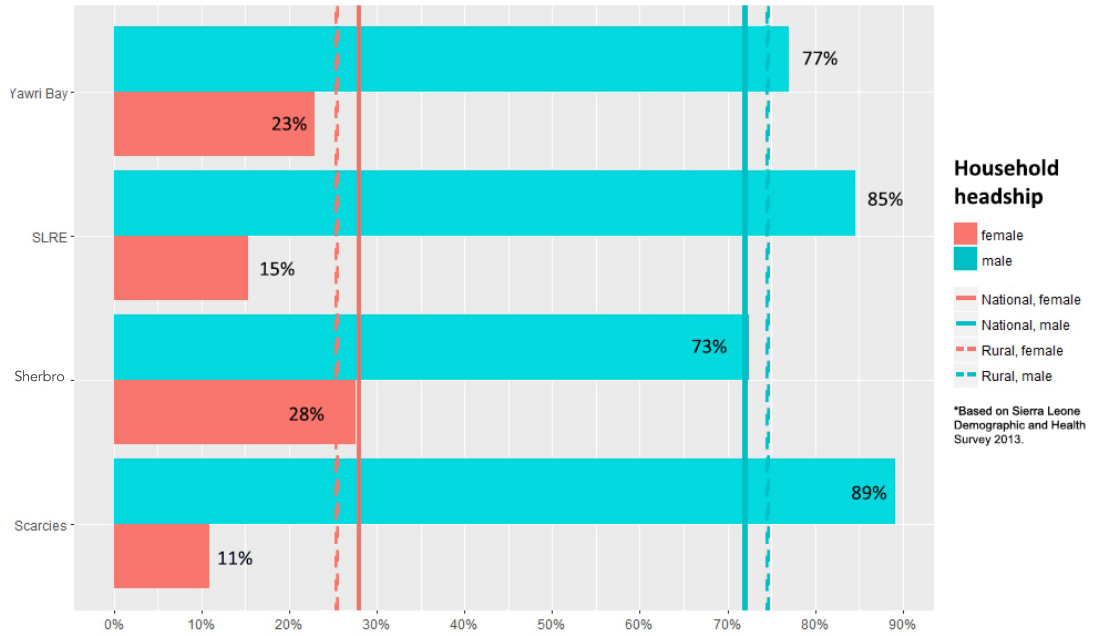


Figure 3.3. Sex of heads of households by region

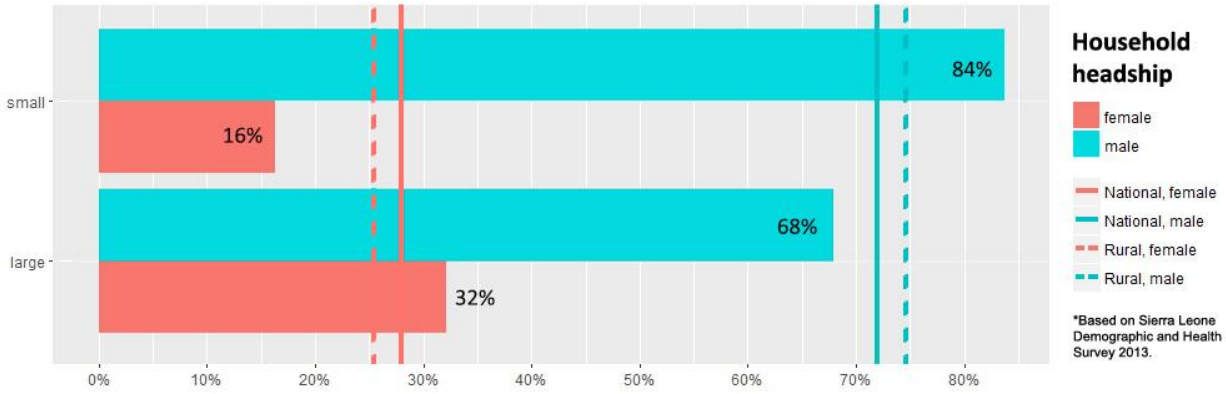


Figure 3.4. Sex of heads of households by size of locality

Dependency ratio

The age-dependency ratio (Figure 3.5) is measured as the ratio of the household population that is aged 0-14 and 65 or older (i.e., considered not in age to work) to the working-age population, aged 15-64. The red vertical line indicates the national age-dependency ratio in 2015.[8] In general the dependency ratio of the sampled population compares well with the national average and is slightly higher, with the exception of the Scarcies. Yawri Bay has the highest dependency ratio, and Scarcies has the lowest, possibly owing to the fact that some families send their children away for school in that region. Note that compared to global averages of around 54, age dependency is very high in Sierra Leone.

[8] Data from http://data.worldbank.org/indicator/SP.POP.DPND?locations=SL&name_desc=true

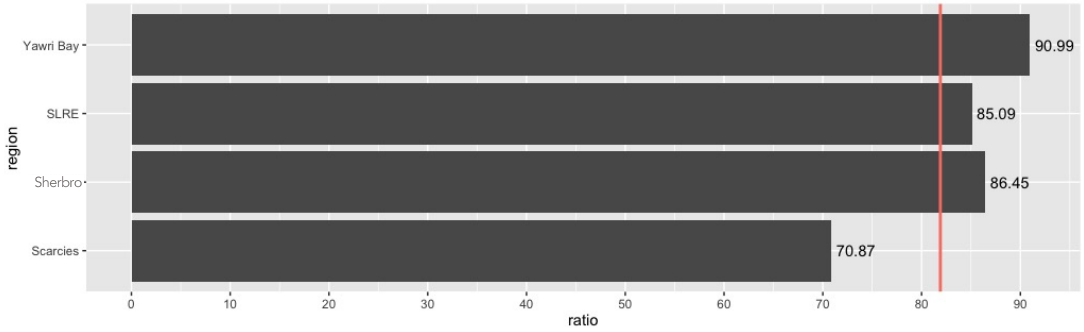


Figure 3.5. Age-dependency ratio, measured as number of dependents per 100 adults, by region. The pink line shows the national average.

Education levels

The education level of respondents (Figure 3.6) shows generally very low levels of schooling in all the regions. Fully two-thirds of respondents (168 people) reported no education and only 9 percent (24 people) reported incomplete or complete primary education. Surprisingly, 17 percent (43 people) had incomplete or complete secondary level education, which is higher than the levels for primary education alone.

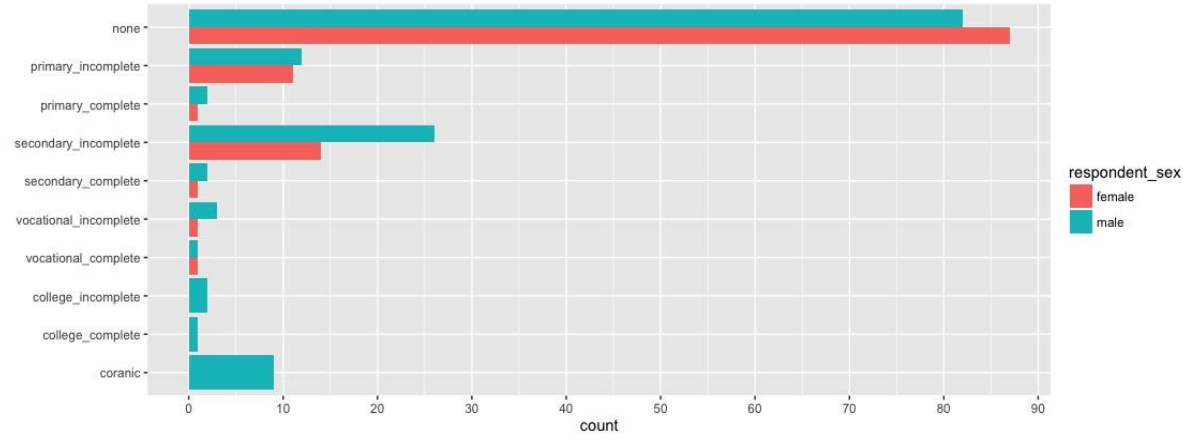


Figure 3.6: The number of respondents (out of 256) by level of schooling by sex

Figure 3.7 provides a closer look at the percentage of male and female respondents aged 18-49 with no education compared to national, urban and rural averages from the DHS.[9] In our sample, the gap in schooling between male and female respondents is considerable, regardless of the size of the locality. Female respondents living in small villages are the most education-deprived, with levels surpassing rural averages. Except the latter case, overall education levels in our sample are close to rural averages for the country as a whole.

[9] The DHS considers all males and females ages 15-49 for the calculation of educational attainment indicators. In our survey, this indicator only considers respondents ages 18 -49.

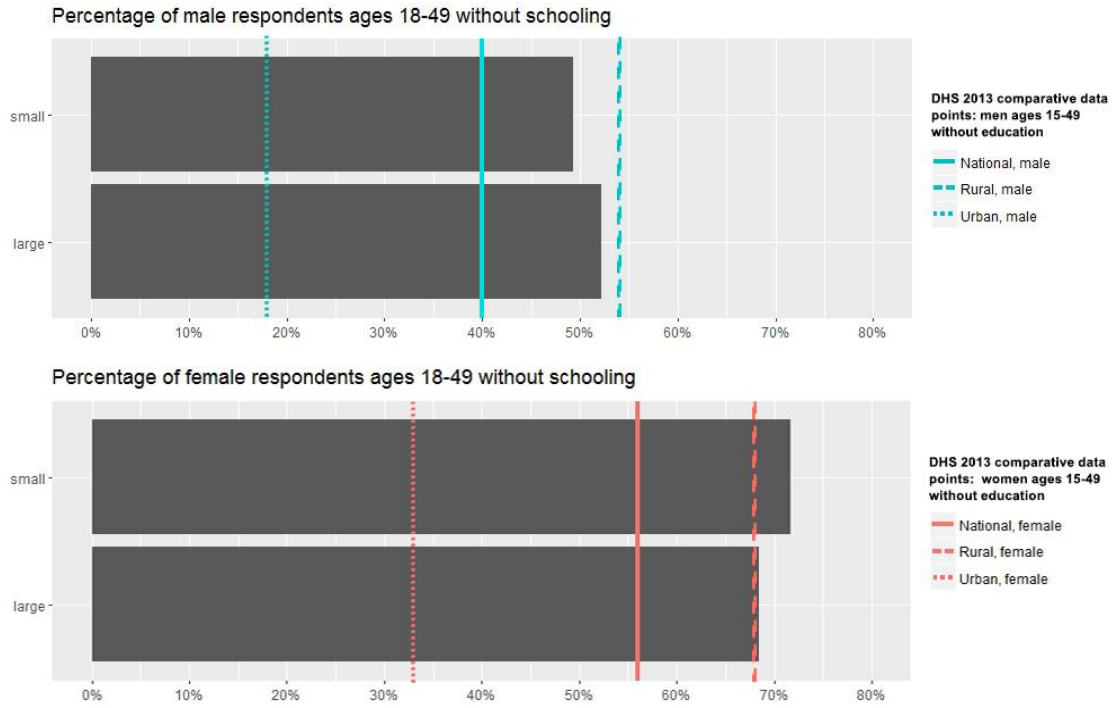


Figure 3.7. Percentage of respondents without schooling by size of locality, with DHS' national, urban, and rural levels for comparison

Water and Sanitation

In terms of other aspects of human development, the sampled population generally has a higher percentage of improved sources of drinking water than the national average (Figure 3.8). In our sample, 74% of households have access to an improved source of drinking water, based on a reclassification of local water sources, and following WHO-JMP and DHS' global definitions and categories.[10] In all four regions, overall access to improved water sources lies between national and urban levels as per DHS 2013 estimates, with households in Yawri Bay close to urban levels and households in the SLRE area similar to the national average.

[10] See http://www.wssinfo.org/definitions-methods/watsan-categories/

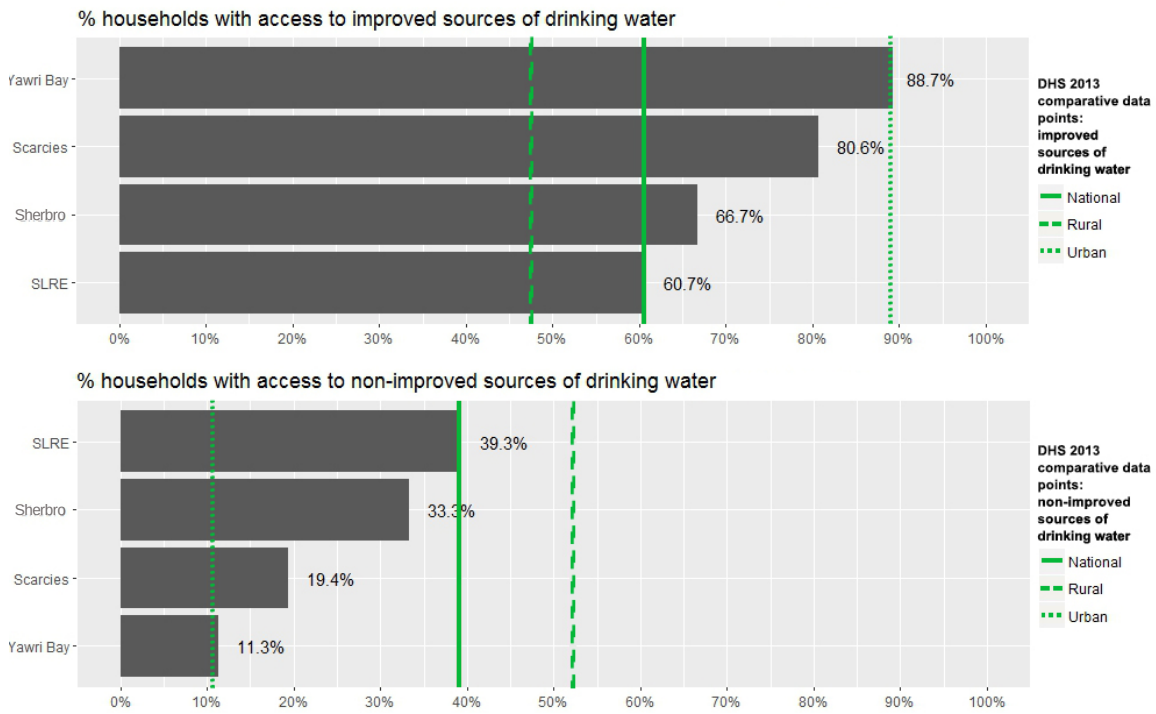


Figure 3.8. Percentage of households with improved versus non-improved water sources, by region

The higher than national average percentages of access to improved sources of drinking water in the study regions may however need to be requalified: they may reflect the fact that in some communities, such as Yeliboya in the Scarcies region, water is brought to the community by boat in containers (jerry cans, fig. 3.9) from improved wells located elsewhere but that no good quality water is available within the village itself.[11]

Figure 3.9: Containers of clean water brought from mainland on the beach of Yeliboya, March 2016. Credit: S. Trzaska.

[11] Quoting DHS: "Even if the household obtains water from an improved source, water that must be fetched from a source that is not immediately accessible to the household may be contaminated during transport or storage."

Figure 3.10 presents the percentage of households with access to improved and unimproved sanitation facilities (as defined by the WHO-UNICEF Joint Monitoring Program). In our sample, most households have an inadequate access to sanitation facilities: only 39.4% of households have access to an improved facility, whereas the remainder (60.6%) have access to either an unimproved facility, or none. Compared to the 2013 DHS urban and rural estimates, our results are close to those for rural settings, with 36.3% of households with access to improved sanitation facilities, compared to urban households where 76% have access to improved facilities.

These results need to be qualified, since unimproved facilities are highly constrained by lack of open space surrounding villages during the rainy season, and often consist of the beach or other locations nearby, leading to fecal contamination of water. Open defecation on beaches also affects populations as they go to and from boats and collect shellfish. Risks of contamination of seafood with pathogens and prevalence of diseases like cholera and typhoid are high.

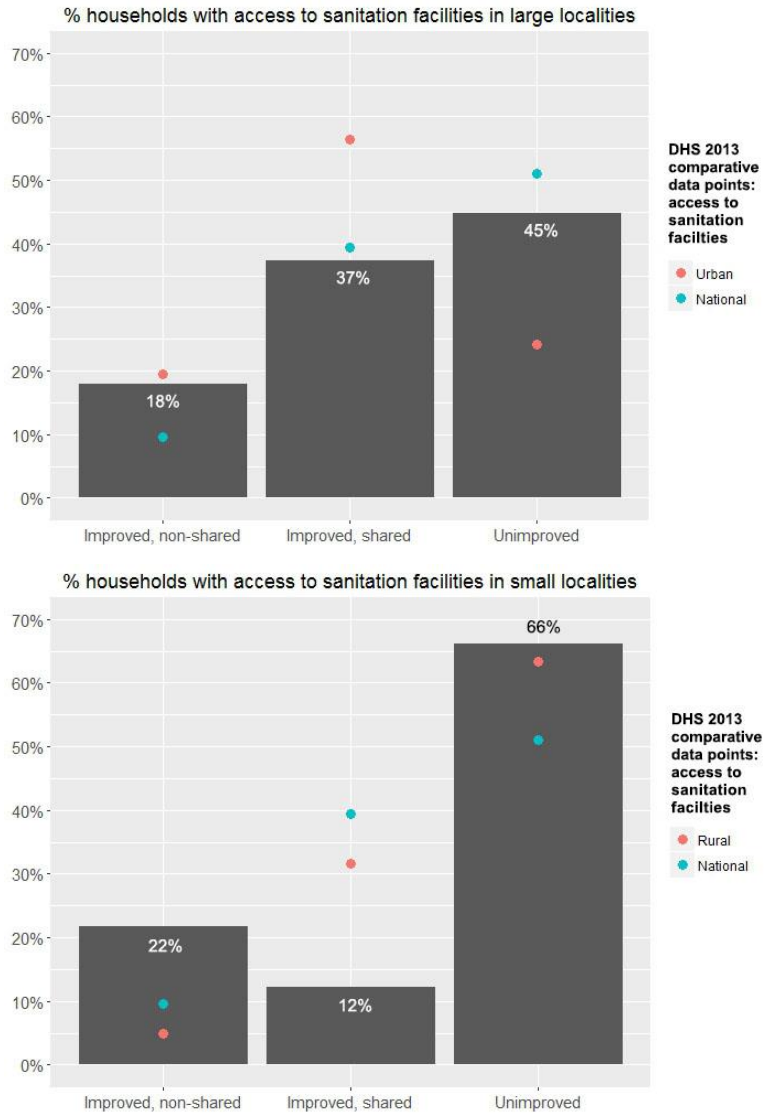


Figure 3.10. Percentage of households with access to sanitation facilities, by type; top: large localities; bottom: small localities.

Migration

• Composition of non-natives among respondents

Almost half (51%) of the respondents in the sample were born in the village where the interview took place, and the other half (49%, n = 127) are from elsewhere. Among the non-native respondents, 56% are women and 44% are men. The vast majority of the non-native respondents are married or living as married (85%), and 58% are heads of households. In terms of education, 67% have never attended school, 8% had attended or completed primary school, 20% had attended or completed secondary or vocational school, and the remainder is distributed among Koranic studies or higher level education.

• Time of arrival in the settlement

As Figure 3.11 shows, most non-native respondents are residents within their respective village for the past 17-20 years (i.e., since 2000 or so). If we categorize non-native respondents by the length of residence in the current village, we could say that individuals who arrived in the past two years can be considered newcomers. Individuals residing in the current village between 3 to 9 years can be considered medium-term migrants. The rest -- individuals living in the current place of residence for 10 or more years -- can be considered settled migrants. Based on our sample, the vast majority of non-native respondents are settled migrants (64%), followed by medium-term (24%), and lastly newcomers (13%).

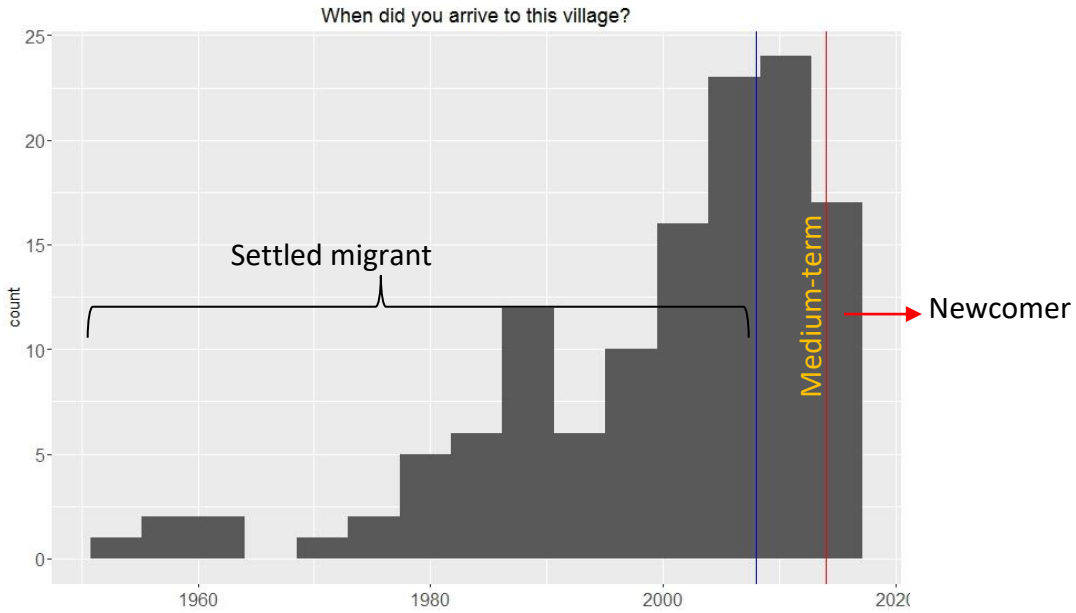


Figure 3.11: Year of arrival of non-native respondents to the current place of residence.

Looking at Sierra Leone's history, the period comprising the post-civil war and reconstruction era (2002- 2013) includes the most in-migration (43% of non-native residents arrived in that period), followed by the civil war (1991-2001) and autocracy (1970-1990) periods, each with 20% of non-native respondents (Figure 3.12).

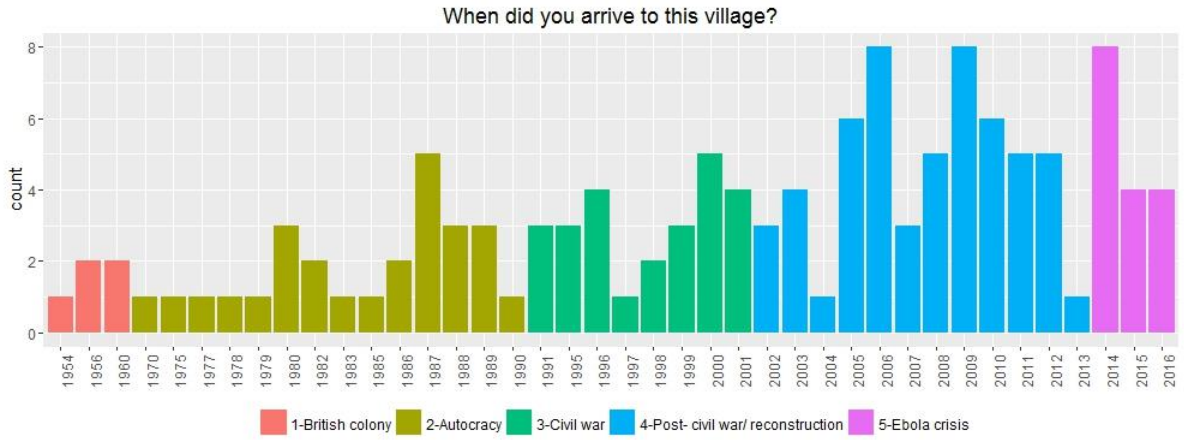


Figure 3.11: Year of arrival of non-native respondents to the current place of residence, by year.

	Scarcies	Shebro	SLRE	Yawri Bay
Bo	0	3	1	1
Bombali	1	0	0	2
Bonthe	0	12	0	0
Kailahun	0	0	1	0
Kambia	16	0	0	1
Kenema	0	2	1	1
Koinadugu	1	0	0	0
Kono	0	0	5	0
Moyamba	0	6	3	6
Outside Sierra Leone	1	0	0	1
Port Loko	15	0	11	9
Pujehun	0	1	0	0
Tonkolili	1	3	1	1
Western Rural	2	0	1	4
Western Urban	1	0	10	2

Figure 3.13: Non-native respondent's previous place of residence, by region.

Figure 3.13 shows the spatial breakdown of previous places of residence, by region. In this chart it is possible to discern the main flows between districts and sampled regions. For example, the majority of migrants to the Scarcies came from Kambia and Port- Loko, and the majority of migrants to Sherbro came from Bonthe. In all cases, the places of origin with relatively high frequencies have been districts adjacent to the sampled regions.

- **Main reasons of residence change**

The most common reason for changing residence is marriage (~40%), followed by change of residence for the whole family (20%) and search of employment (15%). The least frequent reasons to change residence are natural calamities and other (Figure 3.14).

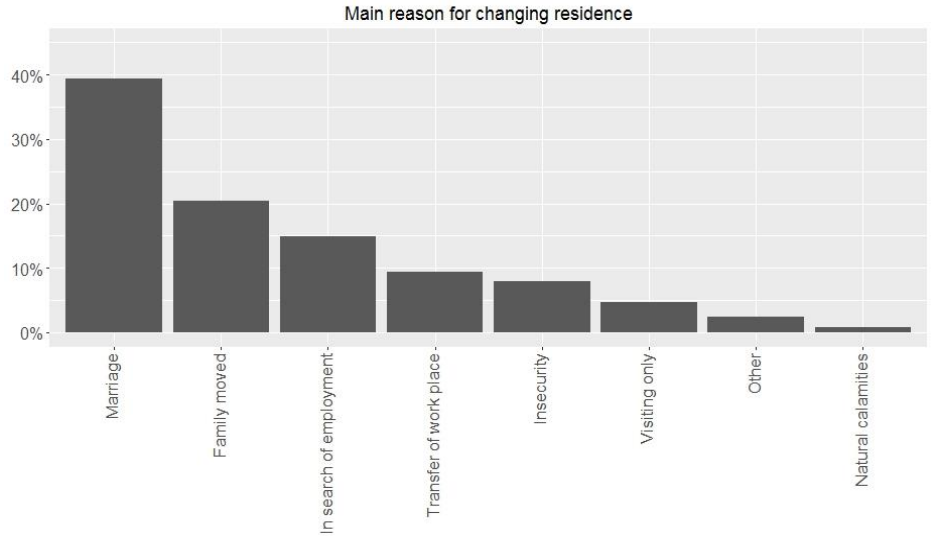


Figure 3.14: Main reasons for changing residence

- **Seasonal migration**

Almost one quarter of respondents (24%, n = 63) mentioned changing residences seasonally for at least three months. From those seasonal migrants, close to two thirds, (64%) reported migrating to rural settlements, and the rest temporally moving to urban settlements. In terms of regional breakdown, Sherbro presents the higher frequency of respondents migrating temporally to other rural areas, whereas the rest of the regions maintain an almost equal distribution (see figure 3.15).

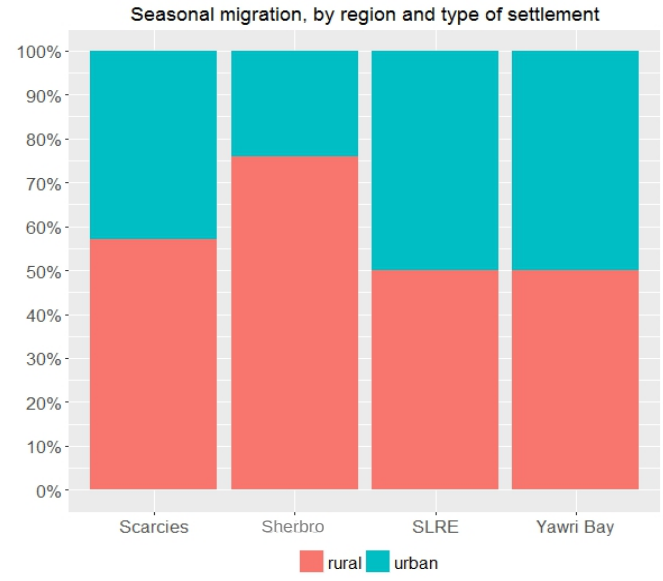


Figure 3.15: Seasonal migration by region and type of settlement.

The most common reason for seasonal migration was 'family/ friends visit', which represented almost half of responses (49%). In turn, business, trade, or other livelihood/ employment activities were close to 40%, comprised of the following: fishing-related activities (16%), in search of employment (13%), and business/ trade (11%). Education (8%) and agriculture-related (3%) activities were the least frequent reasons to migrate seasonally.

- **Languages spoken and understood at home**

The vast majority of households speak and understand more than one language. The most common languages are Krio and Temne. The least common languages include Kissi, Maninka, Limba, Loko, and Kono (see figure 3.16).

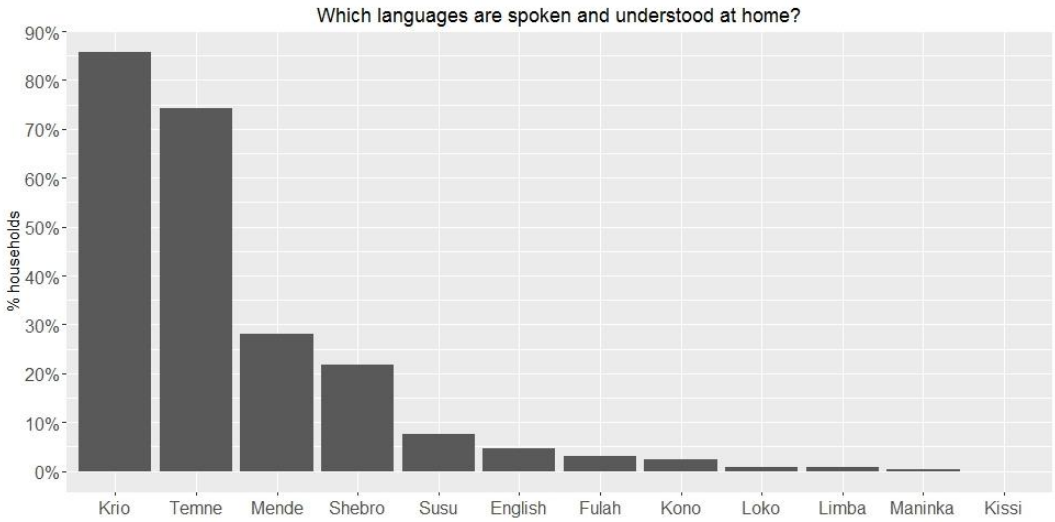


Figure 3.16: Languages spoken and understood at home. This question allowed for multiple selection, hence the sum of percentages does not equal 100% of households.

Livelihoods Strategies

Overall strategies of the households

Figure 3.17 shows the proportion of households who mentioned specific livelihood strategies. It includes recoded answers from the cleaning process, as well as two new variables (i.e. buy and sell fish, and trades). Respondents were allowed to select more than one strategy, so the sum of percentages does not equal 100%. As one might expect, fishing and fish processing dominate the strategies. Small business and subsistence agriculture are also relatively common, followed by logging mangroves and a range of other less important livelihood activities.

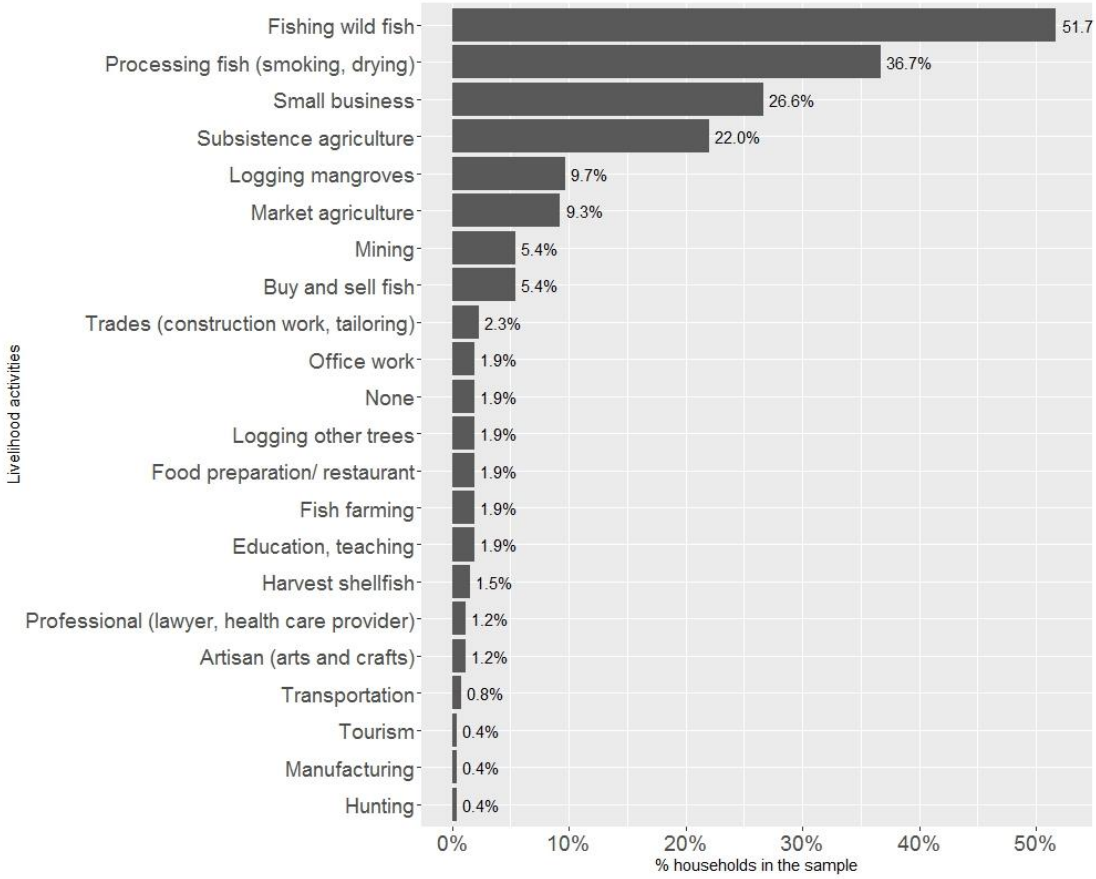


Figure 3.17. Percentage of households by livelihood strategy

Figure 3.18 shows incidence of livelihood strategies by region, and figure 3.19 shows incidence of livelihood strategies by size of locality. SLRE shows the higher diversification of livelihood strategies, probably because of the proximity to Freetown as well as the fact that villages are located on higher ground, which permits agriculture. Scarcies and Sherbro regions show fewer livelihood strategies, mostly aggregated in two clusters around fishing and agriculture for the Scarcies, and fishing, mangroves, and small commercial activities in Sherbro. In fact, 'processing fish' was mentioned by most households (68.5%) as a predominant economic activity in the region.

In the Scarcies River Estuary rice cultivation/farming is quite widespread, following the trend along the river itself, and large areas of mangroves have been cut for rice paddies. Households in the SLRE and Sherbro regions did mention logging wood from mangroves or other trees as part of their economic activities. In addition, Sherbro is known for its oysters, which are exported to Freetown after processing (cooking and smoking).

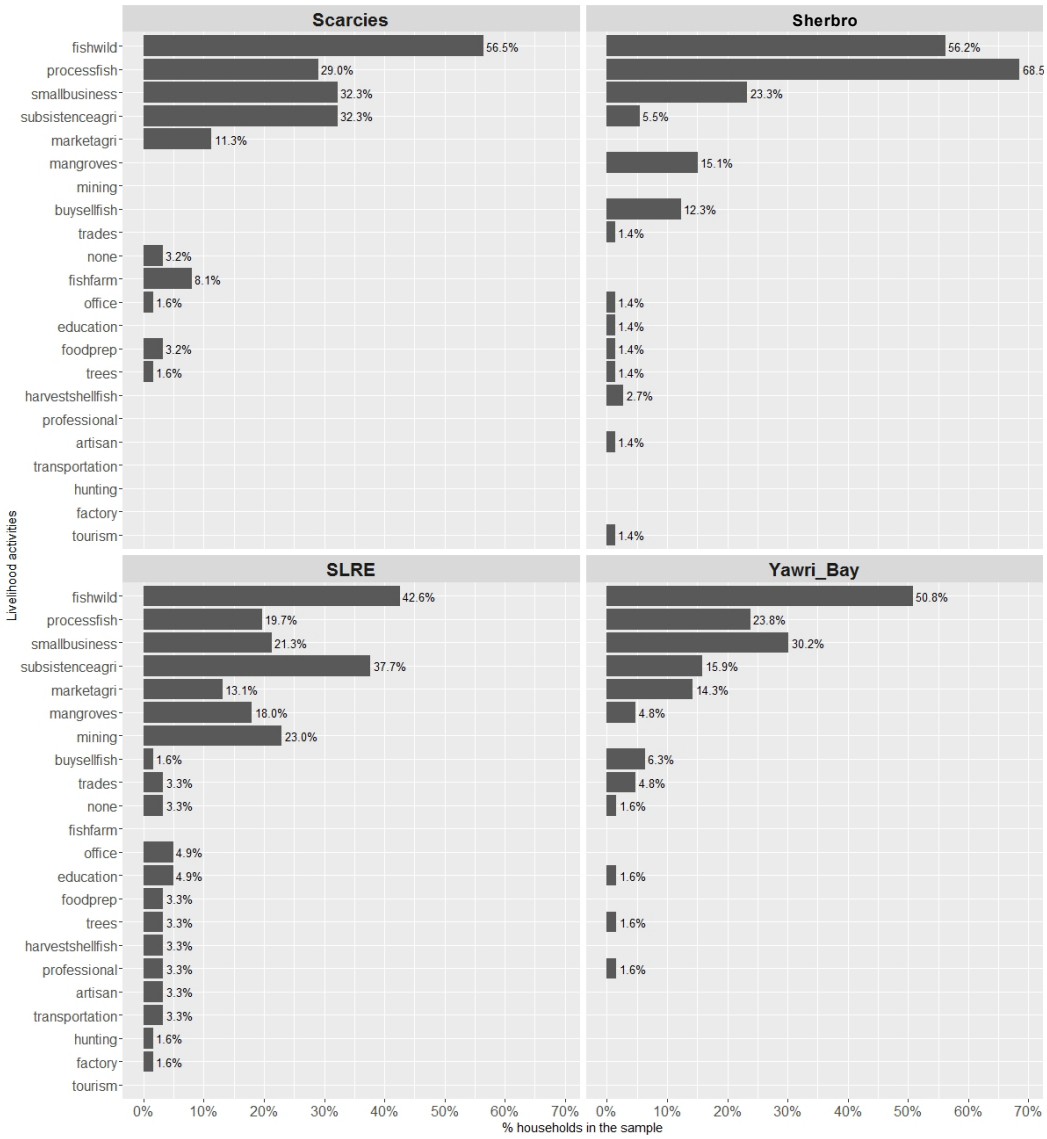


Figure 3.18. Incidence of livelihood strategies by region

It is interesting that smaller localities in our sample appear to have more diversified household livelihoods (Figure 3.19). This finding is consistent with rural settings in developing countries, where households tend to rely on more than one economic activity as part of their support system.

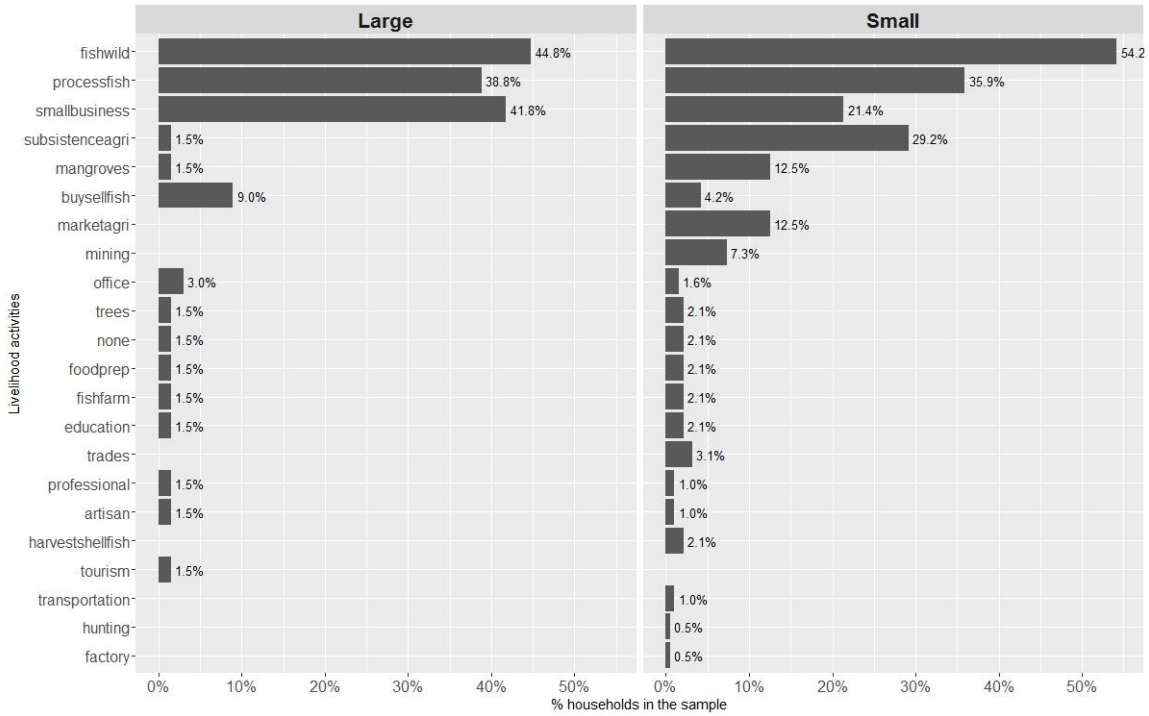


Figure 3.19. Incidence of livelihood strategies by size of locality

Codes for figures 3.2 and 3.3: Fishing wild fish (fishwild), Fish farming (fishfarm), Processing fish (smoking, drying) (processfish), Buy and sell shellfish (buyshellfish), Harvest shellfish (harvestshellfish), Logging mangroves (mangroves), Logging trees in forests (trees), Subsistence agriculture (farming or ranching) (subsistanceagr), Market agriculture (farming or ranching) (marketagr), Mining (mining), Trades (welding, tailoring, carpentry, painter, construction worker, building contractor) (trades), Office work (office), Food preparation or restaurant (foodprep), Education/teaching (education), Professional (lawyer, health care provider) (professional), Artisan (arts and crafts) (artisan), Transportation (shipping, trucking) (transportation), Factory or manufacturing (factory), Tourism (tourism), Hunting (hunting).

Figure 3.20 summarizes the count of livelihoods by household. The average and median number of livelihood strategies for all households is 1.9 and 2, respectively. Most of the households rely in very few activities for their livelihood and one-third of households (90 total) reported only one livelihood. Looking at the split by size of locality, our sample shows an average and median number of livelihoods of 1.5 and 1, respectively, in large localities, and an average and median number of livelihoods of 1.96 and 2, respectively, in small localities.

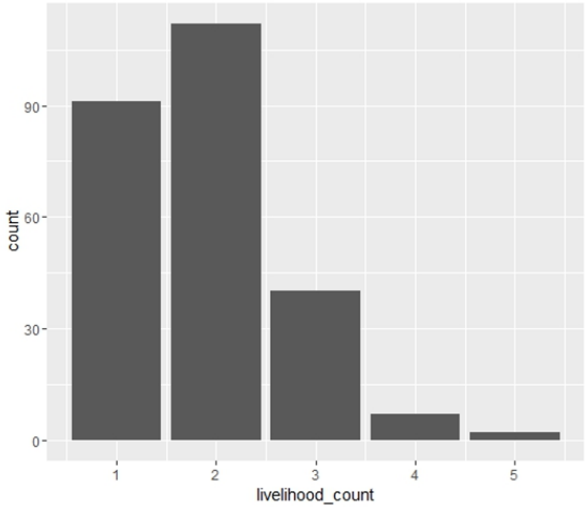


Figure 3.20 Count of livelihood strategies mentioned by households

In addition to measuring the frequency of incidence, we also calculated an index of the relative importance of each livelihood activity within the household. During the interview, each respondent was given 20 pebbles to allocate among the stated livelihood strategies. Respondents were asked to represent the relative importance of the stated livelihoods by assigning a representative number of pebbles. This approach allowed us to obtain a quantitative metric of the relative importance that each of the livelihood activities has within the household economy. Subsequently, the median score across all households was summarized as the importance index, and then re-scaled from 0 to 100. Figure 3.21 provides a visual summary of this analysis: incidence is showed on the x-axis; importance is shown on the y-axis; the size of the bubble represents the number of households that mentioned each particular livelihood, and the color of the bubble depicts a broader classification of livelihood activities.

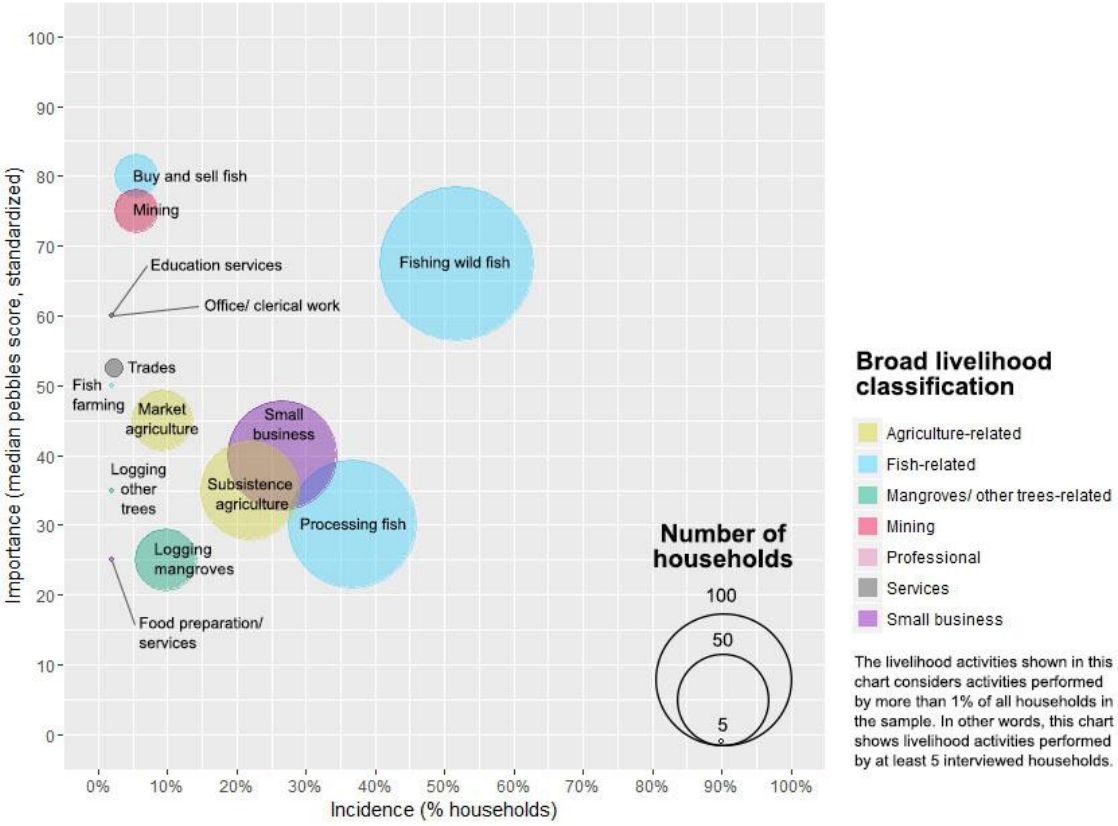


Figure 3.21. Incidence and relative importance of livelihood strategies

As seen in Figure 3.21, fishing is an important source of livelihood, and is practiced by a significant portion of the sample. After fishing, the next highest incidence activities are fish processing, subsistence agriculture, and small commercial activities. This suggests that income diversification is an important livelihood strategy, and from the literature we know this creates greater household resilience. Diversification is likely to remain an important part of resilience-building activities in the coastal zone.

Interestingly, logging mangroves is neither practiced by many households (~10%), nor did it receive a high score at the importance scale. Though practiced by very few households, mining and buying-and-selling fish received the high scores for importance, largely because those households are highly dependent on those activities. Services, professional activities, and clerical work are among livelihood sources for very few households in the sample (less than 5%), though the relative importance to those households' economies is comparably high.

Farming livelihoods

Farming is not the main focus of this study but approximately 30% of the respondents indicated agriculture as one of their livelihood strategies. the distribution is very uneven, with settlements where more than 85% engage in farming to some extent and locations where no farming has been reported (Figure 3.22).

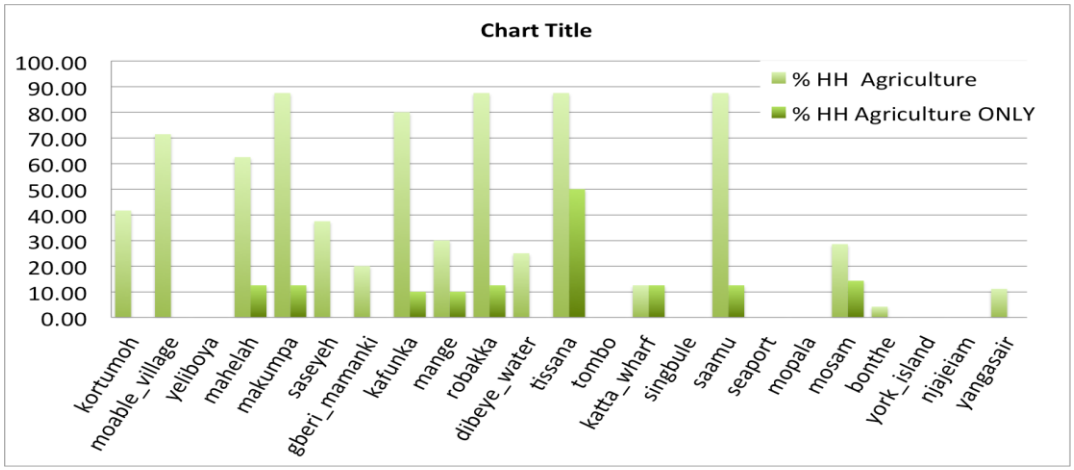


Figure 3.22. Percentage of households engaging in agriculture and percentage of households where agriculture is the only economic activity.

Fishing Livelihoods

- **Fishing wild fish**

Frequency of fishing trips

Since wild caught fishing is the most frequent livelihood for the sampled households, here we drill down into the results on fishing. Figure 3.23 presents the percent of households reporting different numbers of fishing trips in the week prior to the survey. Nearly 50% of the respondents

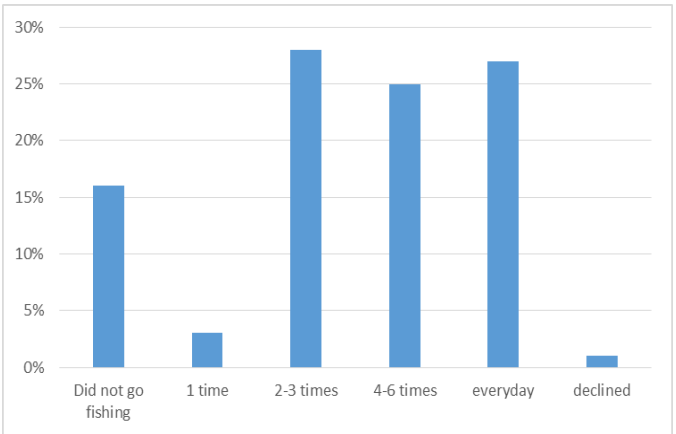


Figure. 3.23. Percent of households reporting a given number of fishing trips in the week prior to the survey.

reported that a member of their family went fishing in the week prior to the survey. Among those households, most report going 2-3 times per week, closely followed by households who go every day.

Figure 3.24 shows the regional breakdown of the frequency of fishing trips reported by households in the week prior to the survey (as percentages). All regions host fisheries-dependent communities, but in Sherbro and Yawri Bay the frequency of trips is highest, with 61 and 53 percent, respectively, fishing 4 or more days per week. Figure 3.19 further shows the frequency of fishing trips by size of locality. In large communities the answer is dominated by 4-6 per week and "did not go", indicating that perhaps household members tend to be employed by larger companies rather than own their own boat. In small localities many more fishermen tend to go out every day. Note that the survey was conducted in the low fishing season and that these numbers may change during the peak of the season.

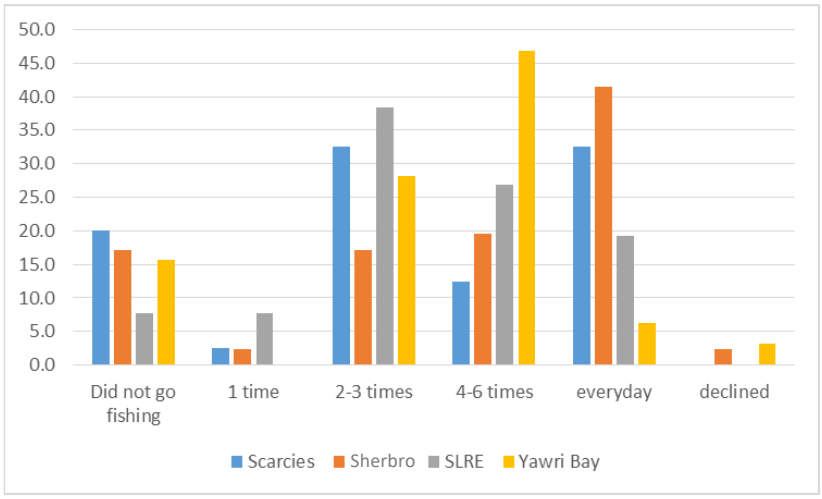


Figure 3.24. Percent of households reporting a given number of fishing trips in the week prior to the survey, by region

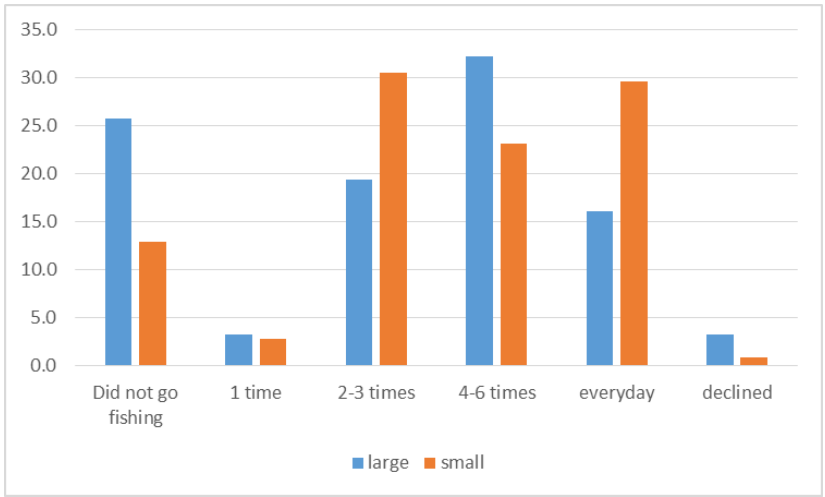


Figure 3.25. Percent of households reporting a given number of fishing trips in the week prior to the survey, by size of locality

Species distribution

Figure 3.26 (left) shows the list of fish species caught by households, ordered by frequency. This question was multiple choice, so households were able to select more than one fish species, without any limit on the number of fish species selected.

Figure 3.26 (right) shows the distribution of the number of fish species caught by households. The average value for all households is 5.58 species, and the median value is 5. Figure 3.27 shows the distribution of fishing diversification, by size of locality. It is notable that small communities tend to diversify more than large communities, perhaps because of their higher dependence on wild fish catch, or perhaps because of the difference in the type of gear. For example, larger communities may have larger boats that can go out to sea farther.

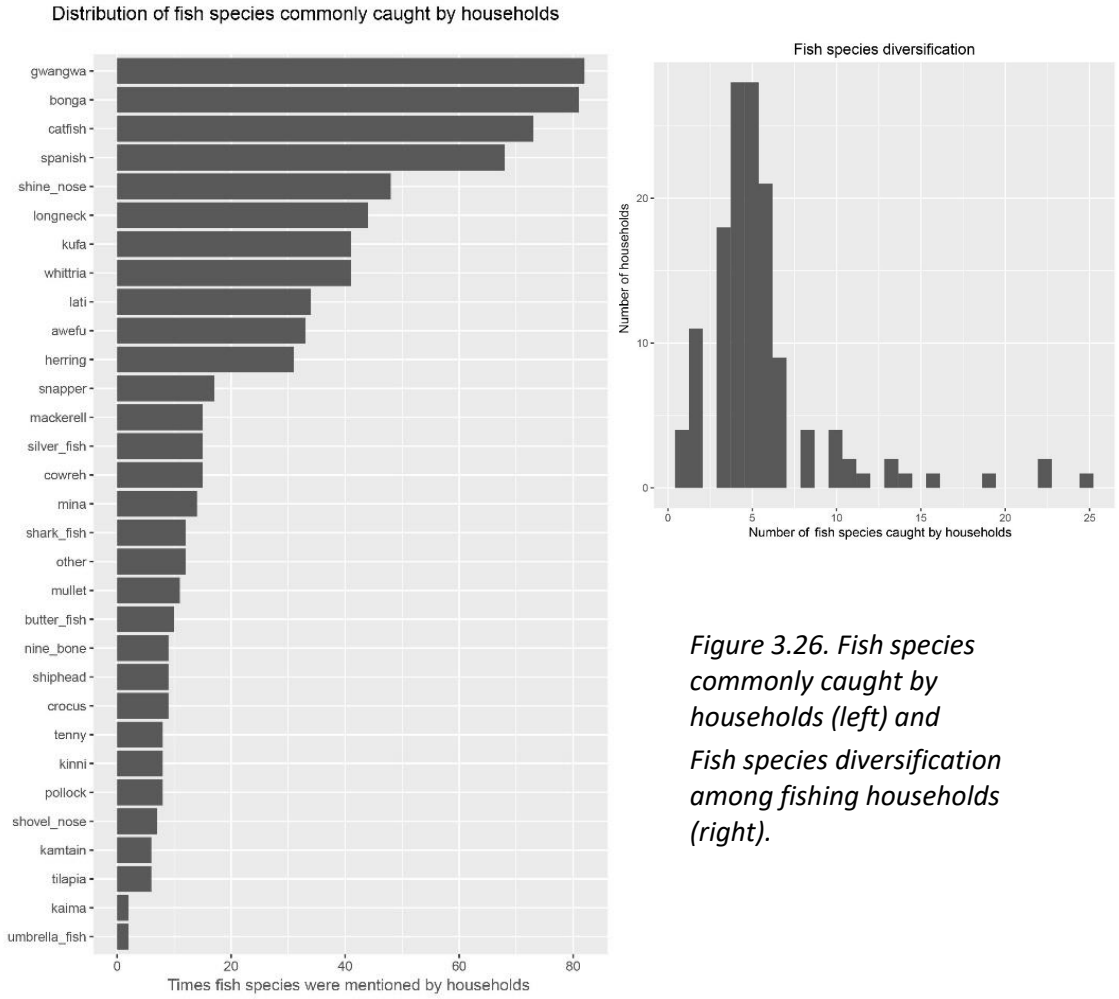


Figure 3.26. Fish species commonly caught by households (left) and

Fish species diversification among fishing households (right).

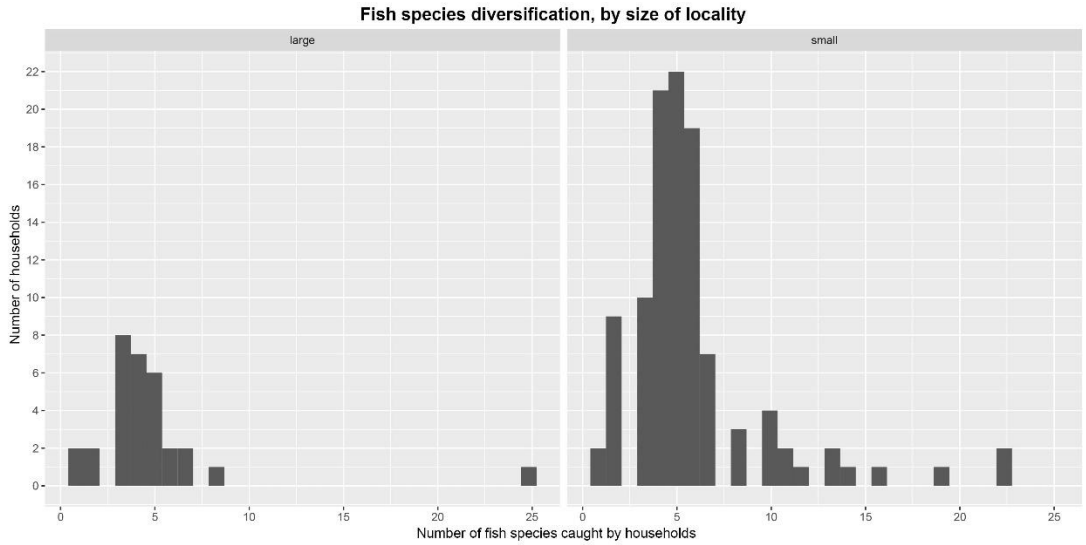


Figure 3.27 Fish species diversification among fishing households, by large and small locality

Perceptions of fish resource evolution

Respondents were asked if, in the past five years, they had observed less fish or more fish available among the areas that are usually accessed by members of the household. Eighty-seven percent of respondents answered less fish, 3% answered more, and 10% said there was no difference. Respondents who answered 'less fish' were then given a list of factors that could contribute to this decline, and were asked to list the top three reasons why they observed observe less fish available over the past five years. Figure 3.28 presents the results. The average ranks are generally in the range of 2-2.5, so the interest is in the incidence (X axis). This shows that close to 70% of respondents reporting 'many fishermen', followed by 'catch young fish' (meaning fingerlings or juveniles) (40%), and 'foreign fleets' (35%) – which also had the highest average rank. Issues that were named by fewer respondents are on the left side of the chart – including rising water temperatures (though with a high rank) and low fish diversification at about 15%.

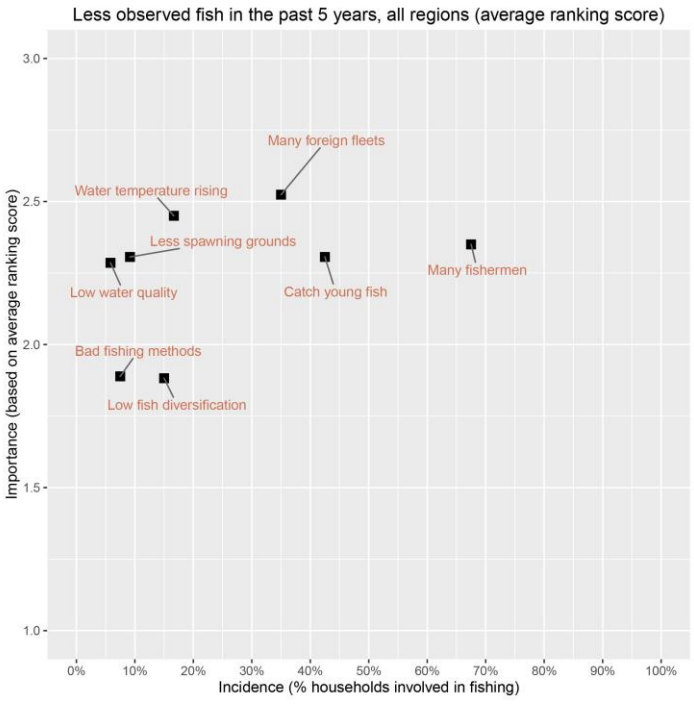


Figure 3.28. Perceived importance of different factors in the decline of fish

- **Fish Smoking and trading**

There is a high specialization within the fish value chain with fish-processing done nearly exclusively by women. In the absence of electricity and a cold chain, fish are most often processed in the villages before being shipped to local and regional markets or abroad. Fish processing involves hard-drying fish by smoking it on open grills (locally known 'banda') using in most cases wood harvested in neighboring mangrove forests. Mangrove wood is used fresh (not dried) and generates a lot of smoke and low temperature heat. *Rhizophora* is the largely preferred species of mangrove for smoking purposes.

Although the survey included questions about the smoking process such as quantities of fish smoked and wood used in the previous week, as well as prices, most of the respondents were not engaged directly in the process thus we believe their responses, when given, may not be accurate enough. Quantitative estimates of wood used during a household survey were additionally complicated by the fact that in different regions (and even villages within the same region) fish and wood could be sold in very different units (from a piece to a dozen to a 'bath' for fish and from a bundle to a stick for mangrove wood) and these were not always available to measure. Prices are also subject to seasonal variations.

Individual interviews with key informants (women smoking fish) conducted by the roving team uncovered that women pay for every input to the process: fish and wood bought at the boat or the beach but also additional labor from adult members of the family and neighbors. Because of high fire risks, the bandas are never left unattended. Women do not keep precise records of expenditures and sale prices and the roving team attempted to make estimates in different villages. The price and quantity ranges communicated in different villages indicated that profits from the activity are minimal if not negative. When asked, numerous women confirmed that they do not always make a profit from individual sales but that overall, in the long term they try not to lose money and that they engage in this activity because 'they cannot simply stay without doing anything'. However, the reliability of this information is questionable as respondents may want to conceal the profits made from public disclosure and from strangers who may potentially bring external support to the communities. Estimates communicated by Dr. Sankoh

Fig. 3.29: Woman fish-smoker in Bonthe, July 20, 2016. Credit S. Trzaska

point towards profit levels similar to those of fishermen but more investigation is needed to provide a wider sample of profit estimates. There is a general perception that smoking fish is a very lucrative activity and this needs to be further confirmed.

The only exception with higher profit levels in our experience were cases of women (and men) who specialize in trading fish that is already smoked: collecting fish from different bandas and shipping it to the regional market or even longer distances. However, as data indicate, the number of individuals engaging in such activity is low, compared to the number who smoke fish. If smoking fish effectively is much less profitable than it is generally believed female-headed households that rely on fish-related activities for subsistence may be among most vulnerable and may require further study/attention.

Accessibility

Means of transportation to access the nearest health center, school, local market, and regional market

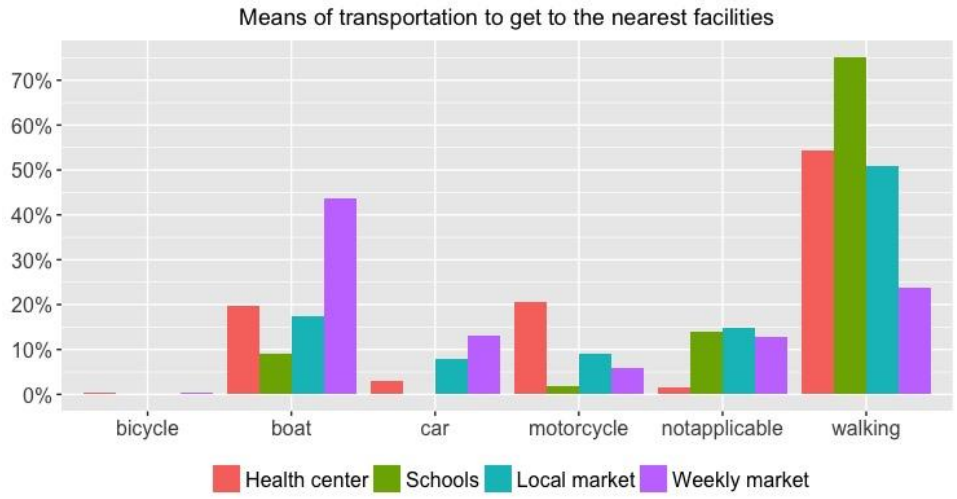


Figure 3.30: Means of transportation to get to the nearest facilities, as reported by households

In our sample, the most common mean of transportation, as reported by households, is walking (Figure 3.30). Though, there are certain differences depending on where individuals go. For instance, children generally walk to school. Access to regional (weekly) markets, or 'luma', are mostly done by boat, but local markets are mostly accessed by foot. Visits to health centers are a mix between walking, boat, and motorcycle rides. Almost none of the households reported traveling by bicycle. However, a portion of households did reply that some of the visits to schools, local markets and/or regional markets 'did not apply' to them.

Constraints in access to the nearest health center, school, local market, and regional market in the past 12 months

During the survey, questions about constrained access to the nearest facilities (i.e., health centers, schools, local and regional markets) were posed to respondents, based on their experience for the past 12 months. Figure 3.31 shows the distribution of

responses with transportation and/or access constraints. Around one-half of households reported having accessibility problems when trying to go to the respective weekly market; and an almost equal portion reported having the same constraints when they visit their nearest health center. Nearly one third of households reported accessibility constraints when going to school, or to the corresponding local market.

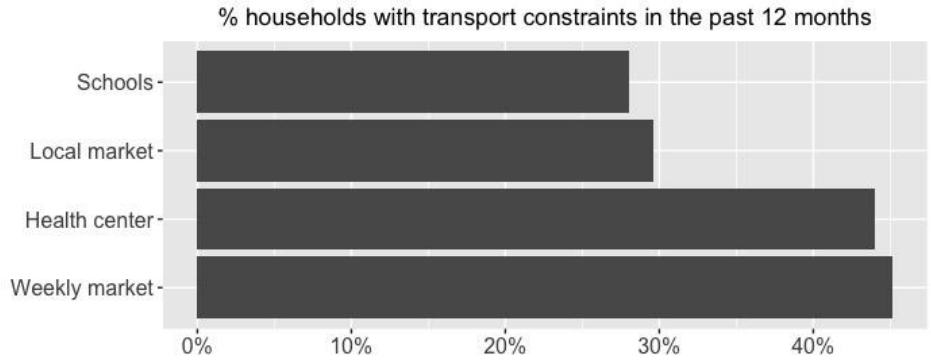


Figure3.31: Percentage of households with transport constraints in the past 12 months

Constraints on access by region

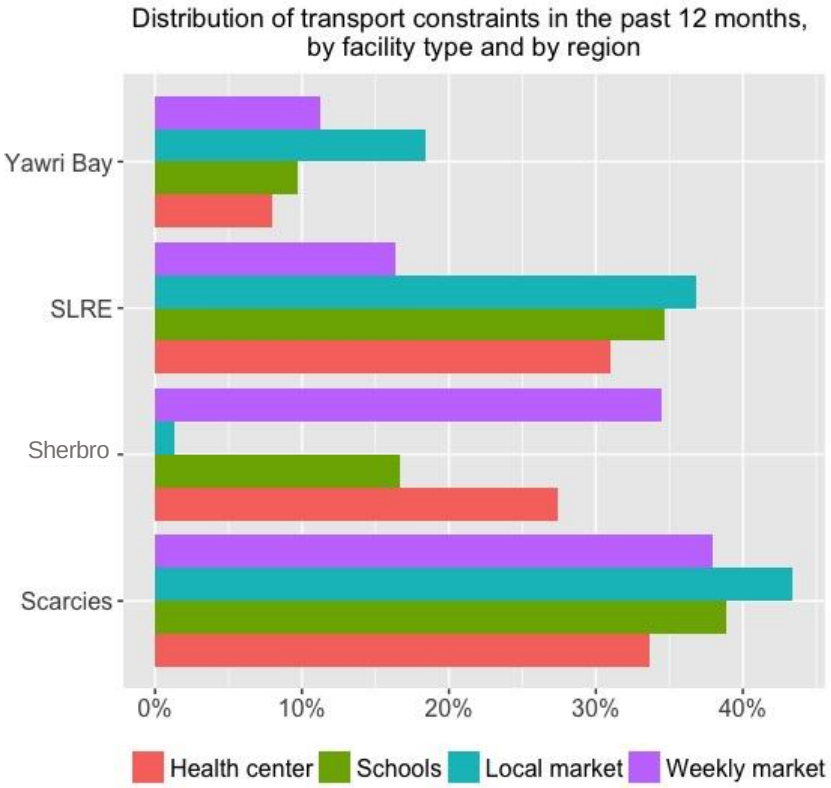


Figure 3.32: Distribution of transport constraints in the past 12 months, by facility type and by region

Looking at the distribution of transportation and/or access constraints by facility type, we find differences between those and regions. Considering only the responses from households with constrained accessibility to facilities,[12] we found that the region with the most limitations in terms of accessibility for all four facility types is the Scarcies; and the region with the least limitations is Yawri Bay. In the case of Sherbro, it is interesting to note that access to local markets is not as problematic as it is to the weekly market. The SLRE presents a higher incidence of accessibility constraints to local markets as opposed to weekly markets.

Dominant reasons constraining access to the different facilities

Respondents were asked to select (or list 'other', if applicable) potential reasons that could be attributable to the limited transportation and/or accessibility constraints to health centers, schools, and local and weekly markets. Respondents were able to select more than one option. We list only the top-3 reasons per facility type.

In terms of potential reasons that would prevent respondents to have unconstrained access to health centers, nearly two-thirds of responses with limited access (62%) were attributed to the lack of cash for transportation, close to 40% to high water levels, and 22% to the presence of mud. The reasons cited for lack of access to local markets and schools are similar.

In the case of weekly markets, an equal portion of respondents indicated lack of cash and high water levels as two important constraints to get to the weekly market. Almost one quarter (23%) of constrained-access cases also mentioned the presence of low water levels as another reason for limited accessibility.

Access to Credit and Savings Mechanisms

Access to credit has been shown to be important to a number of development outcomes, and is also important for risk reduction and resilience building, so here we investigate households' access to credit and their approach to saving.

Access to credit and savings mechanisms at the household level

According to our sample, only 10% of households had access to credit instruments, and 26% of the households indicated having participated in savings schemes in the past 12 months. Table 3.1 shows the distribution of credit mechanisms that households reported having access to. Very few households reported having access to credit (only 25 households within the whole sample). The highest frequencies correspond to microcredit mechanisms from NGOs, and local credit rotation schemes. Our questionnaire however did not capture frequent reliance on short term credit for daily

[12] As implied from #2, the number of households who reported having transportation and/or accessibility difficulties to get to the four different facilities varies by type of facility. In that sense, we have 116 households that reported transportation difficulties to get to the weekly market; 113 households for the health facilities; 76 households for local markets, and 72 for schools. Figure 3.32 shows the breakdown of these cases, by region.

expenditures, such as fuel, food and other supplies, between fishermen and fish traders/processors where the amounts borrowed by the fishermen are paid back once the daily catch is sold.

Table 3.1: Types of credit mechanisms that households reported having access to in the past 12 months.

Types of credit mechanism	No. of Households	Freq[13]
1- Loan from bank	0	0 %
2- Microcredit from a financial institution	3	12%
3- Microcredit from a NGO	9	36%
4- Personal loan from another individual, or middlemen	3	12%
5- Credit from stores	0	0 %
6- Rotating credit schemes	9	36%
7- Other	2	8 %

Table 3.2 shows the distribution of saving instruments available to households. Only three savings instruments were identified by household respondents. More than half reported saving in cash (52%), followed by local savings groups (41%). Very few households rely on savings accounts in banking institutions (14%).

Table 3.2. Types of savings instruments to which households reported having access in the past 12 months.

Types of savings instruments	No. of Households	Freq[14]
1- Cash	34	52%
2- Livestock	0	0 % [15]
3- Grains/ seeds	0	0 % [3]
4- Property: land, house	0	0 % [3]
5- Savings account in a bank	9	14%
6- Village savings associations	27	41%
7- Declined to answer	1	1.5%

[13] Percentages do not sum up 100% because households could select more than one credit mechanism.
[14] Idem.
[15] It was surprising to find zero values in these instances. When these results were cross-checked with other similar questions within the survey, some inconsistencies were found. For instance, 86% of households in the sample reported owning the structure where they currently dwell, and 33% owning a separate structure elsewhere, as opposed to zero households reporting property (land or house) as part of a savings scheme. This discrepancy may be due to an interpretation issue. When a direct question is posed (i.e. do you own a house?) it may be straightforward to answer yes or no. However, when the same question is posed as if the physical asset is considered an investment or a savings scheme, the answer may not come as direct as before, and may be open to different forms of interpretation.

Impact of savings on access to credit

Based on our sample, the chance of having access to any credit mechanism given that members of the same household had access to a saving instrument is 21%. Of the 66 households with access to a savings instrument, only 14 had access to a credit mechanism. The odds of having access to a credit mechanism when members of the household have access to savings is 0.27. In other words, we expect one household out of four to have access to a credit mechanism, given its current savings. On the other hand, the chances of having access to any credit mechanism given that members of the household did not have access to saving instruments in the same period is 5.7%. In summary, sampled households are more likely to have access to credit services when members of the household participate in a savings mechanism.

Gender differences in access to credit and savings mechanisms

In our sample, 80% of households are male-headed and 20% are female-headed. When it comes to credit or savings access and participation, 20% of female-headed households have access to credit mechanisms compared to 9% of male-headed households. While the difference is large, it is not statistically significant. Looking at savings participation in our sample, 41% of female-headed households participate in savings mechanisms, contrasted to 23% male-headed households. Once again, these results are not statistically significant.

Credit and savings accessibility, based on the size of the settlement

Based in our sample, 18% of households living in large localities had access to credit mechanisms, as opposed to only 7% of households living in small villages. The odds of accessing any type of credit mechanism within large villages is almost 1 in 5 (0.22), compared to almost 1 in 12 (0.07) for households in small villages.

In terms of responses related to savings instruments, 46% of households living in large localities had access to savings instruments, compared to 18% of the households located in small localities (a statistically significant difference). About 86% of households in large localities have access to a savings instrument, whereas the on 23% in smaller localities have such access..

Credit and savings accessibility, based on house and land ownership

In our study, house owners are defined as the group of households that declared owning the housing structure in the locality where the survey took place or elsewhere. Based on our sample, 9.6% of house owners accessed a credit mechanism in the past 12 months, whereas 10.7 % of non-owners accessed credit. The odds of accessing credit is almost the same for the two groups (0.11 for house owners versus 0.12 for non-house owners). Thus, owning a house does not enhance credit access. An equal proportion of owners (25.7%) and non- owners (25%) had access to savings instruments in the past 12 months.

In our survey land owners are those who own at least one acre of land. Not all agriculture-dependent households own land, and very few had access to either credit or savings services. Only three land-owning households had access to credit schemes, and six land-owning households had access to savings instruments.

Distribution of housing ownership

In our sample, 89% of the households own a house, either in the locality where the interview took place (56%, 144 households), elsewhere (3.5%, 9 households), or both (30%, 76 households). Only 11% of the sample (28 households) do not own any housing property (Figure 3.33).

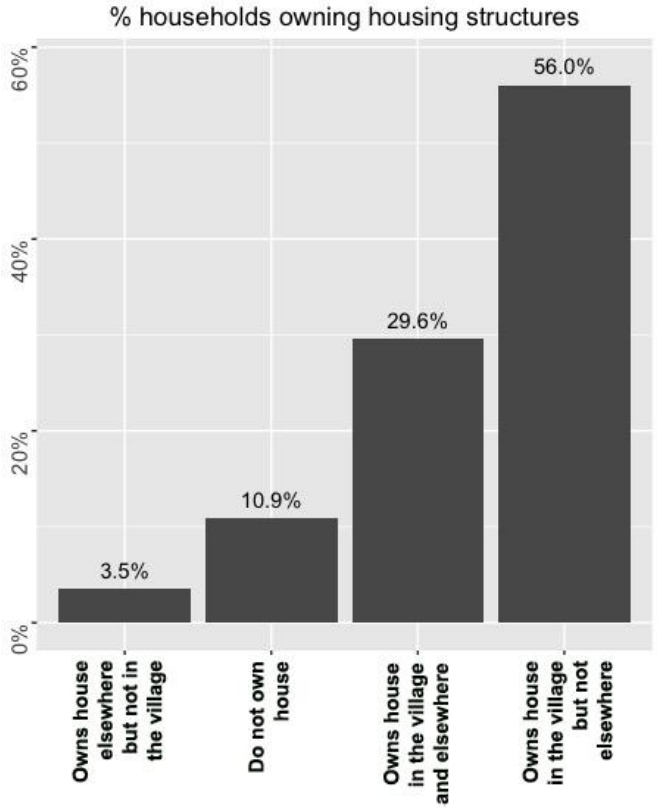


Figure 3.33. Percentage of households that own housing structures

Exposure to communication media

Exposure to newspapers and written media

Interviewees were asked whether in the past month they usually read a newspaper or a magazine, and were provided with the following frequencies: never, up to 3 days per week, 4 to 6 days per week, or every day. Out of 256 valid responses, only 11 households or 4% of the responses declared having read the newspaper or a magazine in the past month. None of the respondents declared reading the newspaper or magazines every day. In contrast, the vast majority of the respondents (96%) mentioned they did not read a newspaper or magazine in the past month (Figure 3.34).

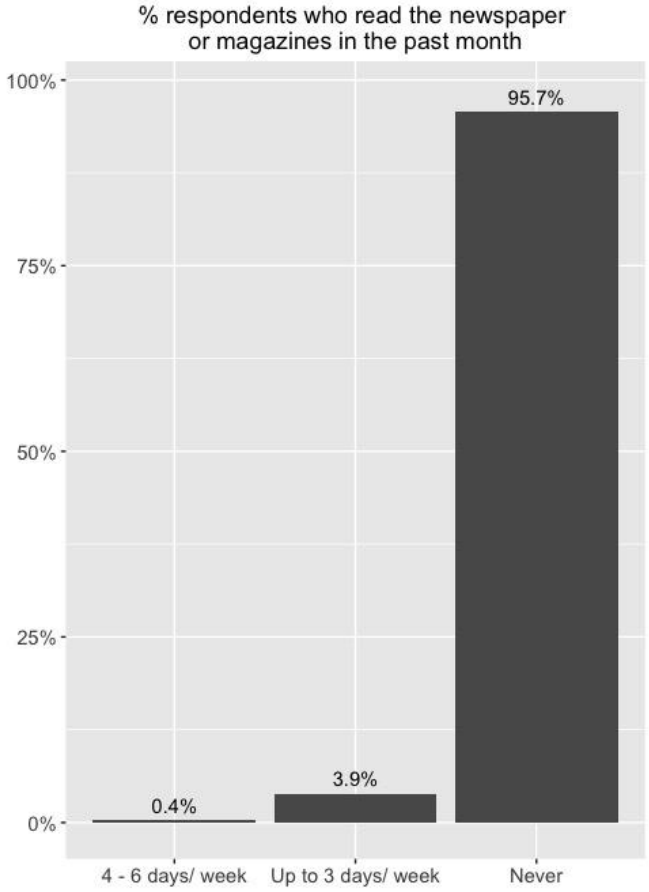


Figure 3.34. Percentage of respondents who read the newspaper or magazines in the past month.

When respondents were asked about specific publications they usually read, names such as: “Awoko”, “Standard Times”, or “Newsweek Newspaper”, “Daily News”, or “No preference/ other” were mentioned.

Exposure to radio and audible media

Based on our sample, about half (59%) of respondents had listened to the radio at least once per week in the past month. Twenty-two percent of respondents said they listened to the radio every day (Figure 3.35). For those respondents who do listen to the radio, 83% declared having a radio at home, and only 17% do not own a radio at home.

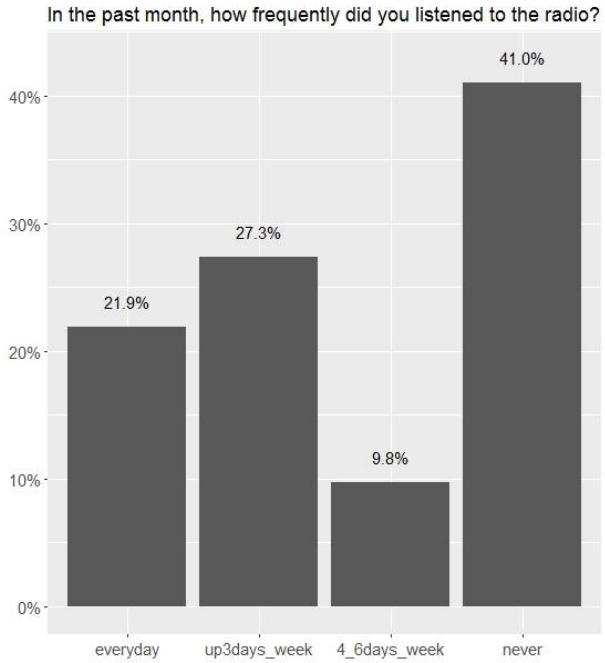


Figure 3.35. Frequency of responses in regards to exposure to radio in the past month.

Seventy two percent of the entire sample (184 respondents) declared owning or using a mobile phone regularly. Of the 151 individuals who listened to the radio at least once per week, 85% declared owning or using another person's mobile phone. Only 21 respondents indicated they used a smartphone.[16]

In terms of energy sources from where households could power radios, only one household in the entire sample had access to electricity. In terms of power through diesel or other generators, 7% of households in the entire sample (i.e., 18 households) declared owning a generator. From those, only 12 households declared listening to the radio at least once per week. These 12 households represent only 8% of radio listeners in our sample.

In our sample, 11% of respondents (28 households) said they own a solar panel. From those, 21 declared listening to the radio at least once per week. These 21 households represent 14% of radio listeners in our sample.

Most radio-listeners listen to AYV or SLBC radio stations (47% and 43% of radio-listeners respondents, respectively). Other radio stations were mentioned, presumably local stations such as Lion Mountain or Sky radio (1.3% and 2.6% radio-listeners respondents, respectively). About 15% of radio-listener respondents declared not having a favorite radio station (Figure 3.36).

[16] Respondents were asked which mobile phone operative system was used. Answer choices such as "Android", "iPhone", "Blackberry", and "Microsoft" were recoded as "smartphone". All other responses (i.e. "Not a smartphone", "Not sure/ do not know", "Other") were recoded as "not a smartphone, or don't know".

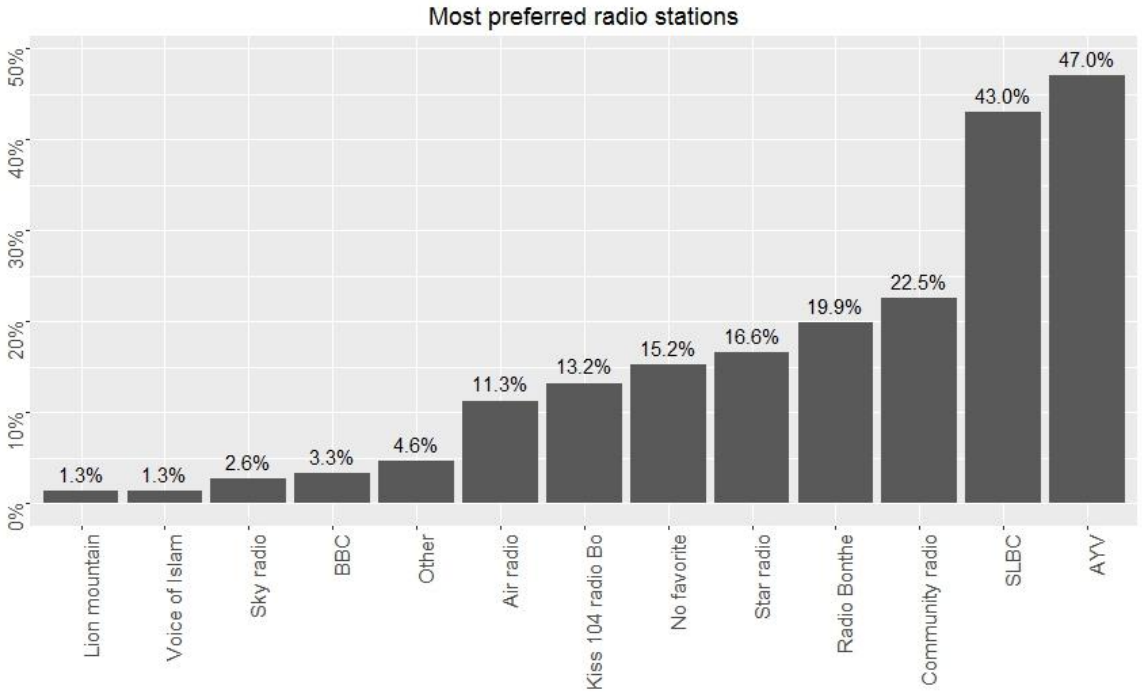


Figure 3.36. Most preferred radio stations, as mentioned by households. Respondents were able to select more than one radio station, therefore figures do not sum 100%.

Participation in Groups and Associations

Seventy-four percent of sampled households belong to religious groups, followed by cultural groups (28%), and fishermen associations (22%). By grouping labor-related groups (i.e., fishermen, farmers, other labor, and mining), we can then rank this category in second place, with 42% of households. Figure 3.38 shows the distribution of membership by households.

By contrast, 12% of our sample did not belong to any group or association. If religious groups are excluded, 36% did not belong to any social group or association. The average number of groups or associations to which households belonged to is 1.95.

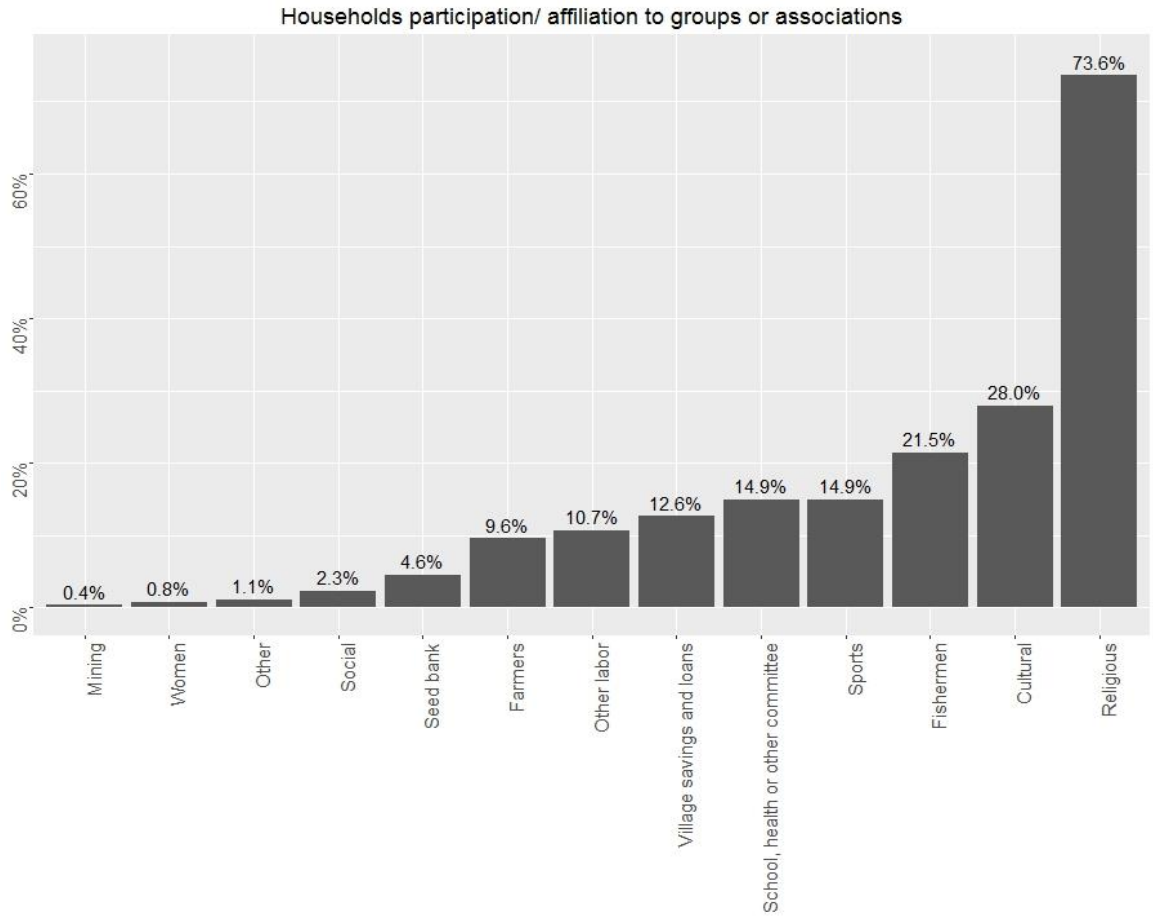


Figure 3.39. Household participation and/or affiliation to groups or associations. Respondents were able to select more than one affiliation, therefore figures do not sum 100%.

Food Security

For this topic, the survey inquired about different access levels to food in the month prior to the survey. This metric has the limitation of being illustrative of the period June-July, only. The methodology followed to calculate this metric can be found in the USAID's Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide.[17] The HFIAS documents households' food security and access over the month preceding the interview.

[17] http://www.fantaproject.org/monitoring-and-evaluation/household-food-insecurity-access-scale-hfias

Distribution of households with respect to the estimated food insecurity score

Households score very low on food security. In our sample, the vast majority of households (77%) were classified as 'severely food insecure', 11% as 'moderately food insecure', and less than 1% as 'mildly food insecure'. Only 11% of the sample classified as 'food secure'. The percentage of households classified in severely food insecure category range from 50% and 100% depending on the location (Figure 3.40). While some bias in the responses cannot be excluded, the survey was conducted during the 'hunger season' and reflects the extent to which households are food insecure during that period. In addition, fifty percent of the households report not having enough food to meet their family's needs for two to four months a year.

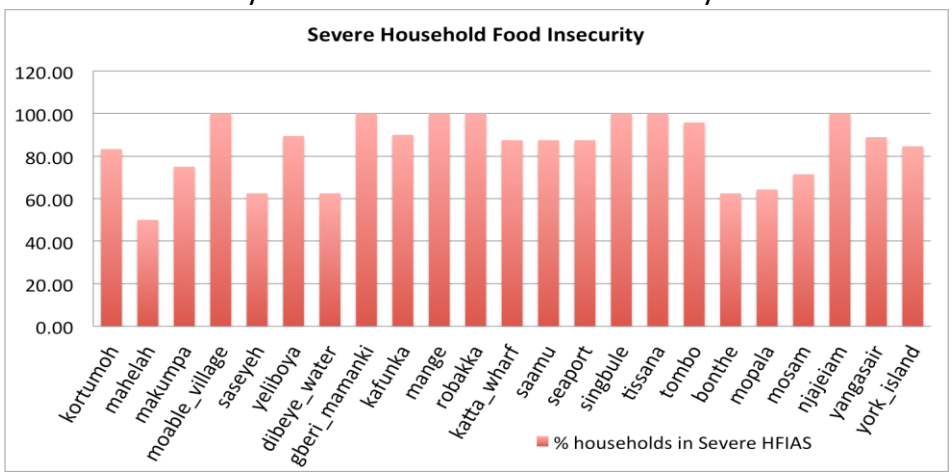


Figure 3.40: Percentage of households falling the severely food insecure category of the HFIAS

Distribution of different categories of food security by region

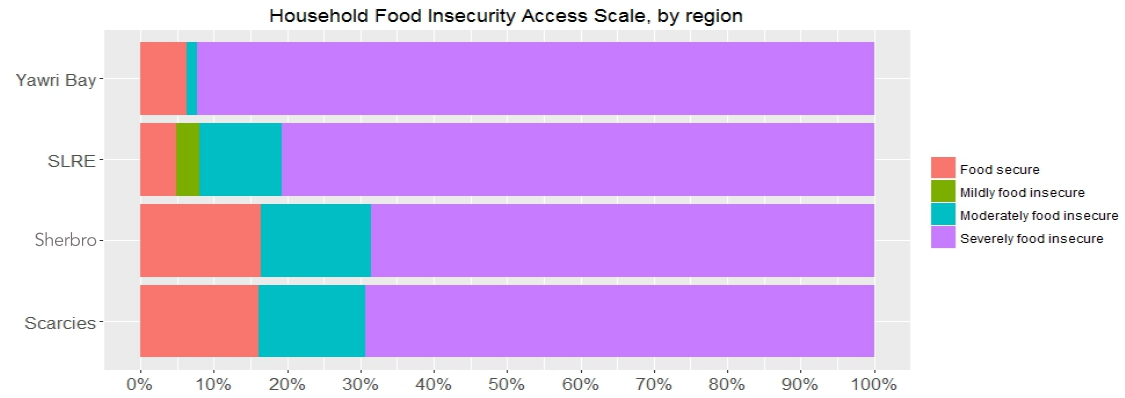


Figure 3.41: Household Food Insecurity Access Scale (HFIAS) indicator, by region.

Figure 3.41 shows the distribution of the HFIAS across the four regions in the study. Based on our sample, Sherbro and the Scarcies present very similar food access profiles (~15% food secure households, ~15% moderately food insecure households, ~70% severely food insecure households). Yawri Bay presents the highest percentage of households with severe food insecurity (92%) at the time the survey was conducted.

Economic activities associated with high food insecurity

Food insecurity or security status does not appear to be related to economic activities. For all livelihood types, disparities between either high or low food security levels are visible. Perhaps the most pronounced difference is within the fish-related category, which denotes the highest food security variation. Fish-related activities also contain the highest percentage of households classified as 'severely food insecure' (~80%), as well as 'food secure' households (13%)—likely because it is the most frequent economic activity in our sample.

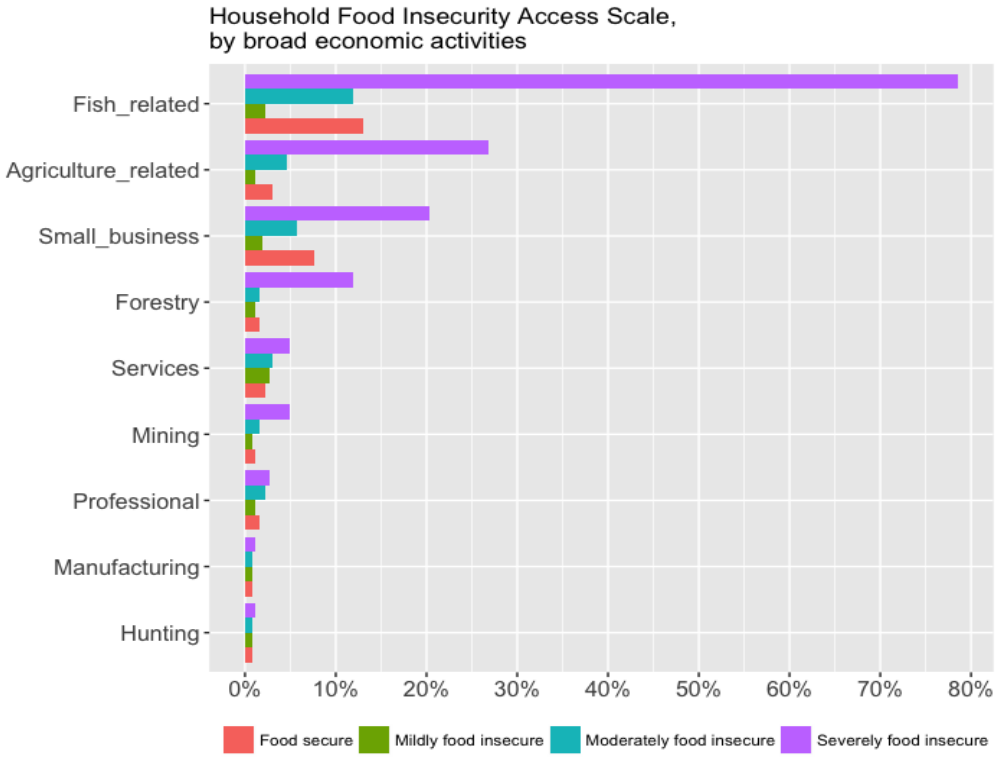


Figure 3.42: Household Food Insecurity Access Scale (HFIAS), by broad economic activities. Please note that households were able to select more than one economic activity, therefore the sum of all HFIAS does not equal 100%

Estimated levels of food security and number of economic activities

Based on our sample, there is no association between the number of livelihood activities and the estimated levels of food security. As figure 3.43 shows, households classified as 'food secure' pursue the same number of economic activities, on average, compared to households categorized as 'severely food insecure' (1.8 activities). 'Mildly food insecure' households pursue an average of 1.5 activities, and 'moderately food insecure' households have the highest average number of activities, with 1.9.

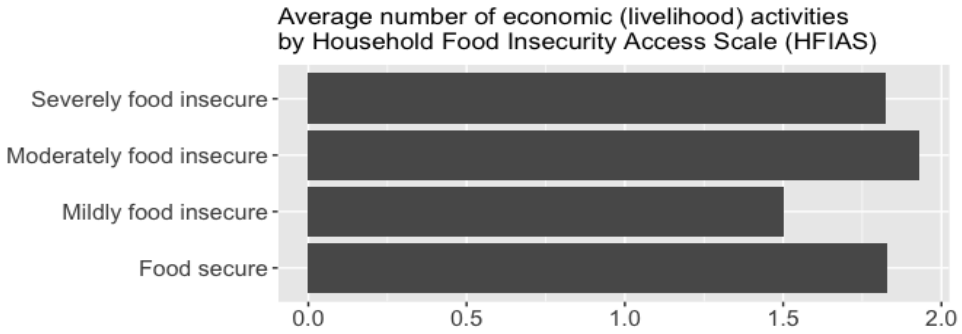


Figure 3.43: Average number of economic (livelihood) activities pursued by households, broken down by HFIAS level.

Food security and access to credit and/or savings

Our sample suggests that access to credit instruments does not condition the level of food security in the household. As figure 3.44 shows, it does not matter whether members of the household have access to credit, because the majority of those households are categorized as 'severely food insecure' based on the HFIAS. Moreover, 'food secure' households declared not having access to credit instruments. Therefore, having access to credit does not make a difference in terms of food security levels.

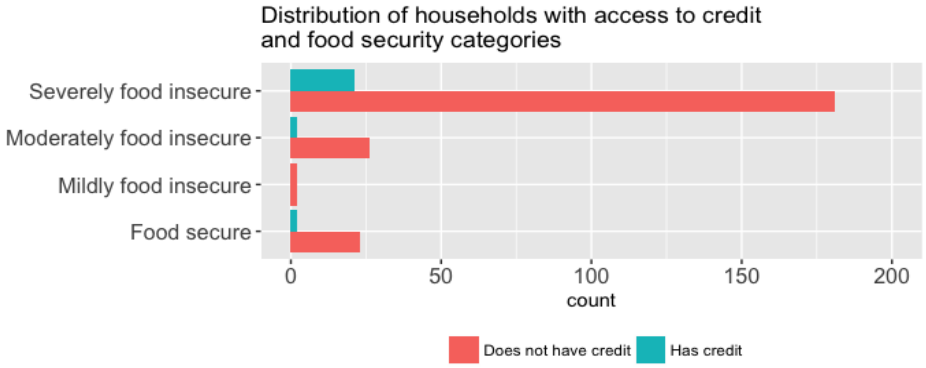


Figure 3.44: Distribution of credit access and food security categories

Likewise, our sample suggests that having access to savings does not result in better access to food. On the contrary, the majority of households with access to savings instruments lie within the 'severely food insecure' category. Moreover, most 'food secure' households do not have access to savings. Therefore, access to savings instruments in our sample is not conditional to food security levels.

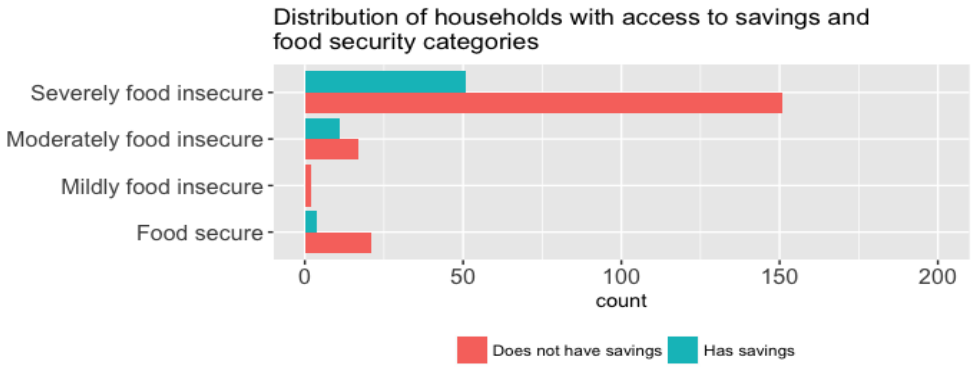


Figure 3.45: Distribution of households with access to savings and food security categories.

Household level analysis of socio-economic vulnerability

In this sub-section, we present the results obtained by classifying individual households into five categories according to recorded levels of wealth index then exposure, sensitivity, lack of adaptive capacity and overall vulnerability. The distribution of households in each category for each village are reported on maps.

Household wealth

Table 3.3 presents the indicators in the computation of the wealth index at the household level, and Figure 3.46 presents results. There is not a very strong spatial pattern in household wealth, but typically larger towns have a higher proportion of households in the upper wealth quintiles.

Table 3.3: Indicators used in the computation of the wealth index.

CATEGORY	Assets (household services)	Livestock ownership	Source of drinking water	Sanitation (type of toilet)	Wall material used for house	Floor material used for house	Roof material used for house
VARIABLES	house_own electricity internet computer radio phone mobile television table bicycle bed motorcycle chairs auto_truck refrigerator generator solar stove bednet	cattle sheep goats poultry pigs no lstock	rainwater well_p well_np tap surface_water tub pipe spring_p spring_np pipe_d tanker bottle other	toilet_none toilet_latrine_s toilet_latrine_h toilet_latrine_ws toilet_latrine_vp toilet_latrine_fp toilet_flush_s toilet_flush_st toilet_compost toilet_bucket toilet_other	bricks cement_block concrete dirt_palm mud_wood nowalls rice_tarpolin stone_cement wood zinc_metal	earth mud_palm concrete dung wood_plank ceramic carpet	corrugated palm_leaf palm_reed plastic_tent thatch rustic_mat wood_shingles

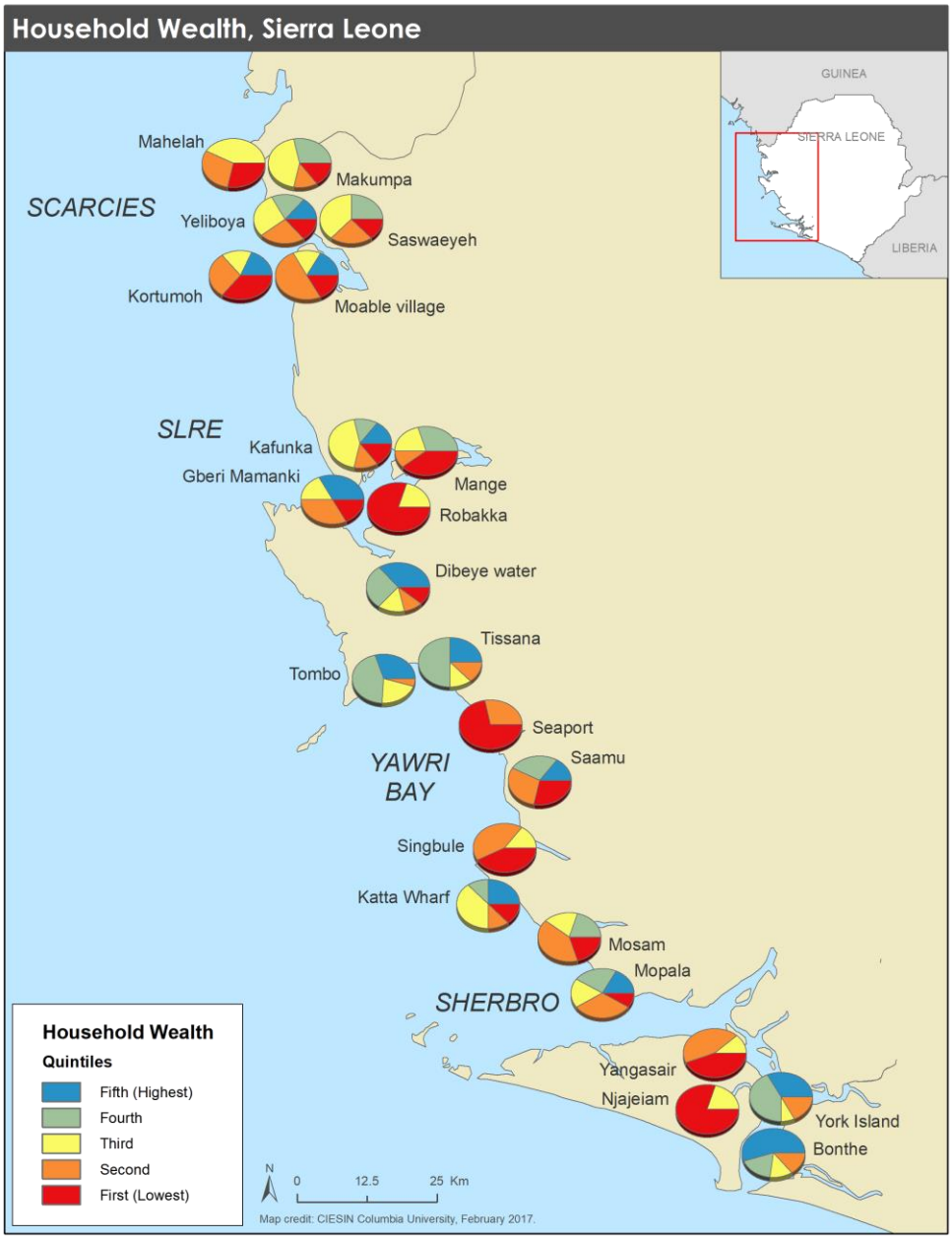


Figure 3.46: map of the distribution of households by wealth category in each village.

Vulnerability and its components at household level

To calculate the socio-economic vulnerability of households, we used the indicators summarized in Table 2.4 of the methods section. We used an additive method to calculate the vulnerability index in which indicators were added (with the appropriate sign) and normalized within the framework of Exposure, Sensitivity and Adaptive Capacity. Results below show the proportions of households falling in each of the five categories corresponding to lowest, second lowest, middle, high and highest levels of

exposure, sensitivity, lack of adaptive capacity and vulnerability. It needs to be kept in mind that these levels are relative within the population. Objectively speaking, from a global perspective, most of the populations in this region would be considered highly vulnerable.

Exposure

The indicators used in the calculation of exposure can be found in Table 2.4, and results are presented in Figure 3.47.

The highest proportions of highly exposed households are observed in the Scarcies (except Mahela, which is a community located on higher grounds) and In Kafunka (SLRE), while SLRE and Yawri Bay (with the exception of Seaport) generally exhibit lower proportions of highly exposed households. The settlements on and around Sherbro Island show a relatively equal distribution of exposure categories among households, while Singbule and Mopala show very contrasted distribution with households either strongly or mildly exposed.

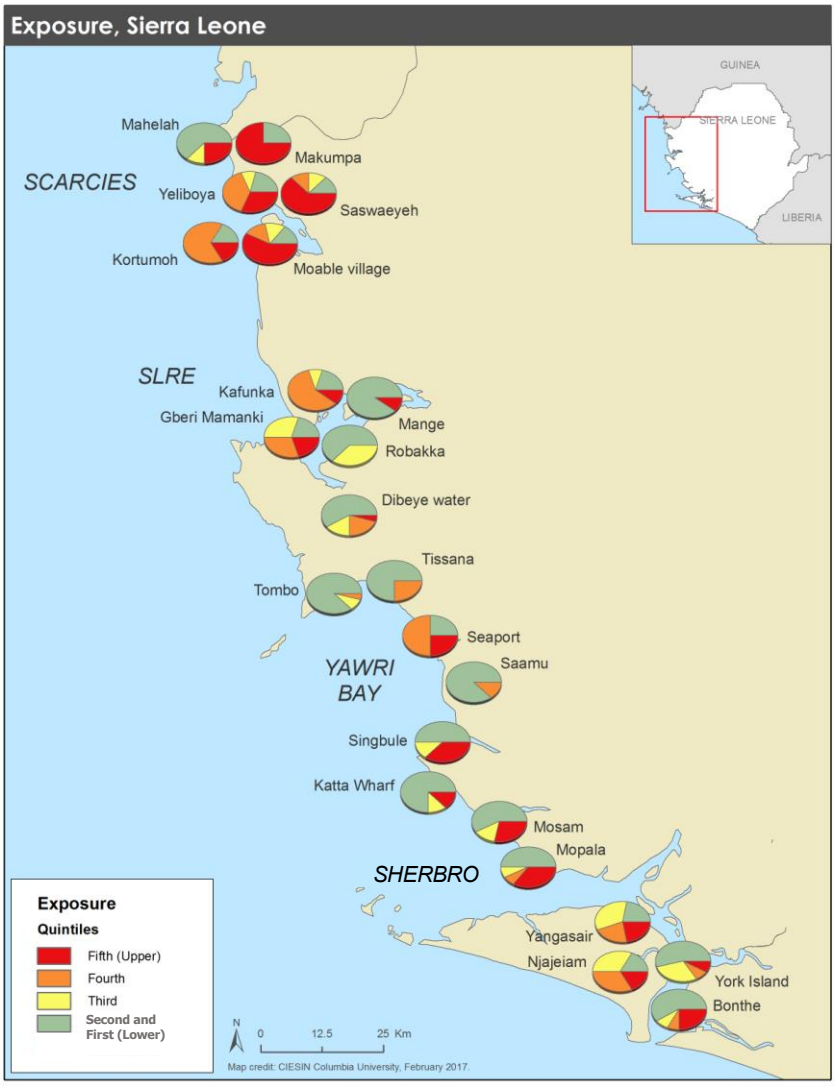


Figure 3.47: map of proportion of households falling in each of the five quintiles of exposure, defined over the total sample of households. Red denotes highest exposure while blue is the lowest exposure, among the whole population surveyed. Lowest levels of exposure were reported by more than 20% of households and the categories 1 and 2 were pooled together in this analysis.

Sensitivity

Sensitivity shows a different spatial pattern (Figure 3.48), with high proportions of less sensitive households in the Scarcies and parts of SLRE (Kafunka, Gberi, and Mamaki), compared with higher sensitivity in the South (especially for Seaport and Singbule). Highest levels of highly sensitive households correspond to villages with the highest proportions of the least wealthy households (Seaport, Singbule, Yangasair, and Njajaiem), although the variables used to compute both are different. These are also villages with high proportions of households lacking adaptive capacity.

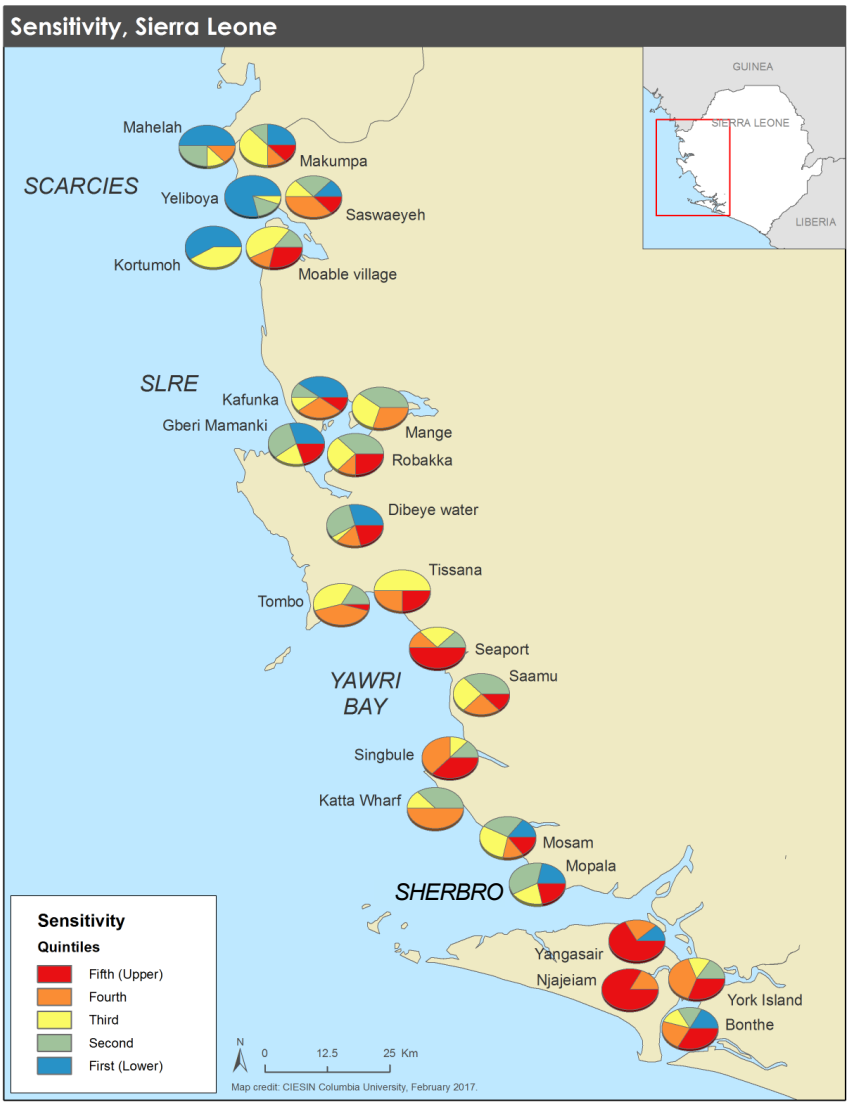


Figure 3.48: map of proportion of households falling in each of the five quintiles of sensitivity, defined over the total sample of households. Red denotes highest sensitivity while blue is the lowest sensitivity, among the whole population surveyed.

Adaptive capacity

In Figure 3.49, Northern parts of the area studied, from the Scarcies to northern edge of Yawri Bay show a mixture of households with different levels of adaptive capacity while the villages in the southern half, with the exception of Bonthe and York Island, and Katta

Wharf to some extent, are dominated by households more severely lacking adaptive capacity.

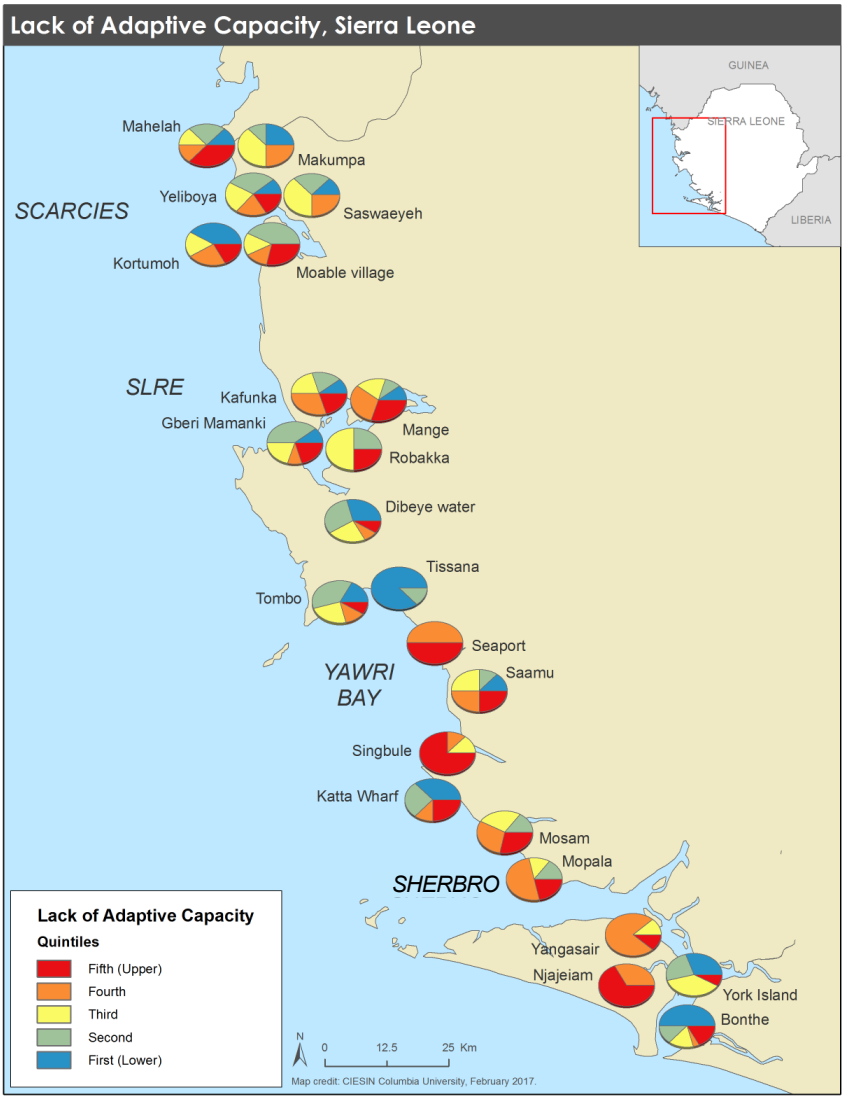


Figure 3.49: map of proportion of households falling in each of the five quintiles of lack of adaptive capacity, defined over the total sample of households. Red denotes highest lack of adaptive capacity while blue is the lowest lack of AC (highest levels of adaptive capacity among this population).

Overall Vulnerability

Figure 3.50 shows that, for a few villages, almost all households fall in the highest or second highest quintiles of vulnerability (e.g., Njajelam and Yangasair in the Sherbro region). Singbule and Seaport in the Yawri region, and Moable in the Scarcies region, also have notably high proportions of highly vulnerable households. By contrast, villages at the northern end of Yawri Bay and in SLRE, as well as Mahelah in the Scarcies region, tend to have low proportions of households in the highest vulnerability categories.

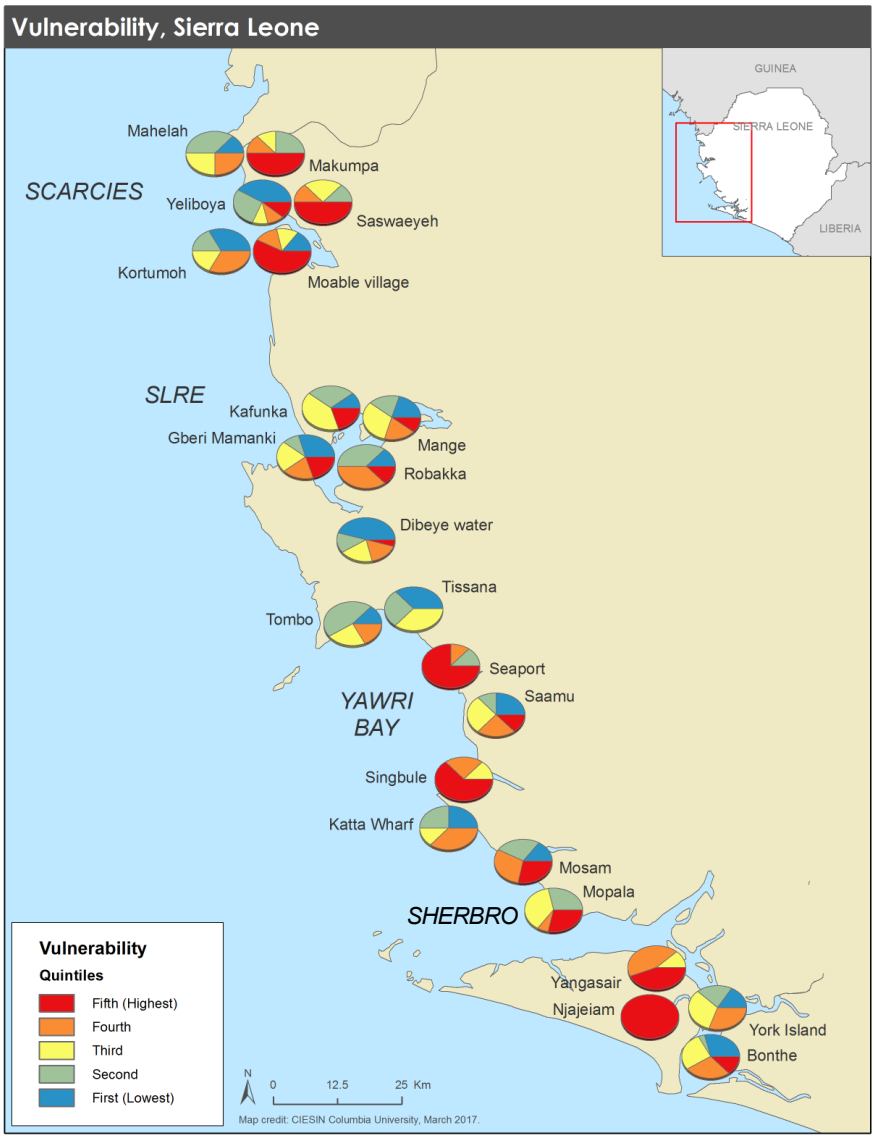


Figure 3.50: map of proportion of households falling in each of the five quintiles of vulnerability, defined over the total sample of households. Red denotes highest vulnerability while blue is the vulnerability.

4. Climate and Environment

In this section we address the characteristics of the climate of Sierra Leone, respondents' perceptions of climate changes, and results of the mangrove assessment. The mangrove assessment includes results from the transects as well as household survey and PRA results on community use and perceptions of mangrove health, and reported management systems.

The climate of Sierra Leone

Average rainfall and temperature

Sierra Leone has a tropical climate with two pronounced seasons: a wet season from May to October, and a dry season from November to April. The average temperature also demonstrates a well-defined seasonal cycle, with a maximum around March, and a secondary maximum around October/ November, separated by lower temperatures during the rainy season.

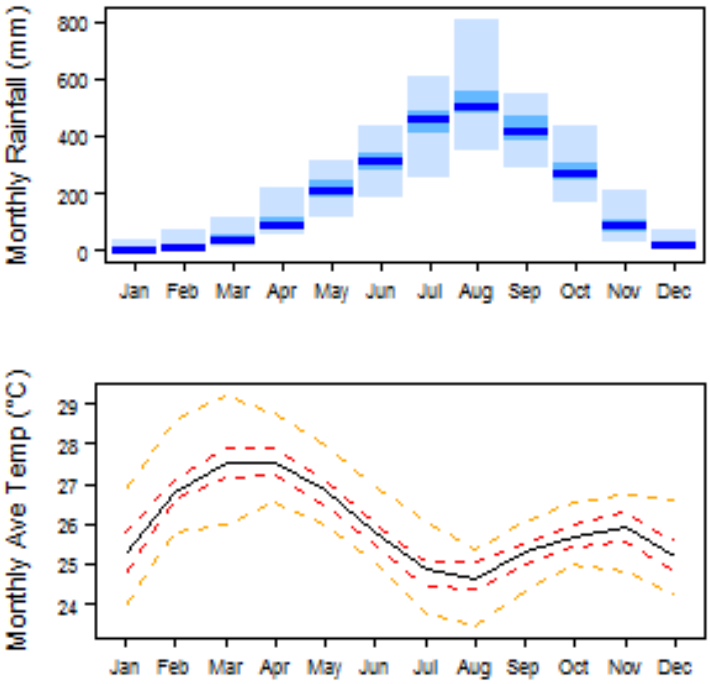


Figure 4.1. Average monthly rainfall (upper panel, mm/month) and temperature in Sierra Leone. (lower panel, in C). Plots based on CRU data (Jones and Harris 2013). Rainfall, upper panel, in mm/month; 1950 – 2012 median (dark blue , interquartile range (medium blue) and max and min for each month (light blue). Temperature, lower panel, in C; dotted lines represent interquartile and maximum and minimum ranges. Source: British Geological Survey, 2015.

This seasonality is linked with the seasonal changes in the direction of dominant winds in Western Tropical Atlantic, with southwesterly winds bringing moist air inland over West Africa from approximately May to November. During the remainder of the year most of the West Africa is under the influence of dry, northeasterly winds from the Sahara, called Harmattan (Figure 4.2). The inland penetration of moisture culminates in August which is the peak of the Sahelian rainy season, then withdraws southward. Thus, rainfall in Sierra Leone is part of a larger scale system, the West African Monsoon, which dominates climate over the region.

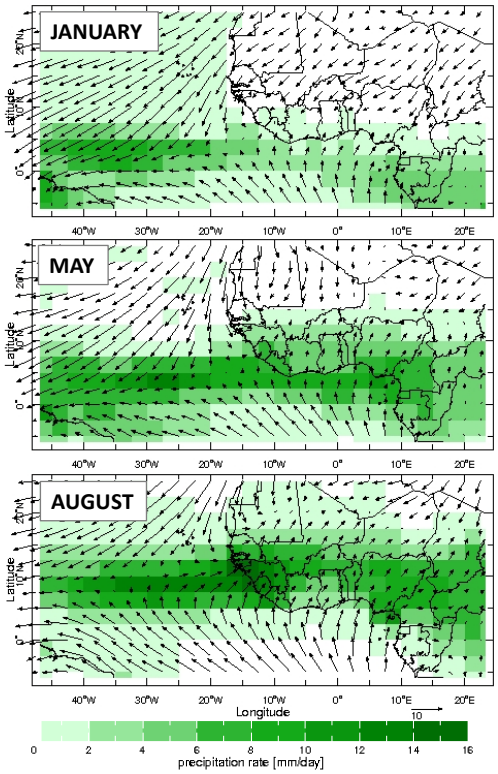


Figure 4.2: Average surface wind and rainfall over Western Tropical Atlantic and West Africa for January, May and August. Source: IRI maproom.

This large scale atmospheric system further interacts with local features, such as topography, to produce local climate. The specific orientation of the coast in Sierra Leone – perpendicular to the moisture-bearing winds – combined with the regional topography (Figure 4.3) makes the coast spanning Guinea, Sierra Leone and Liberia the wettest part of West Africa, and among the wettest regions in the world, with rainfall exceeding 4000mm/year. Rainfall decreases inland.

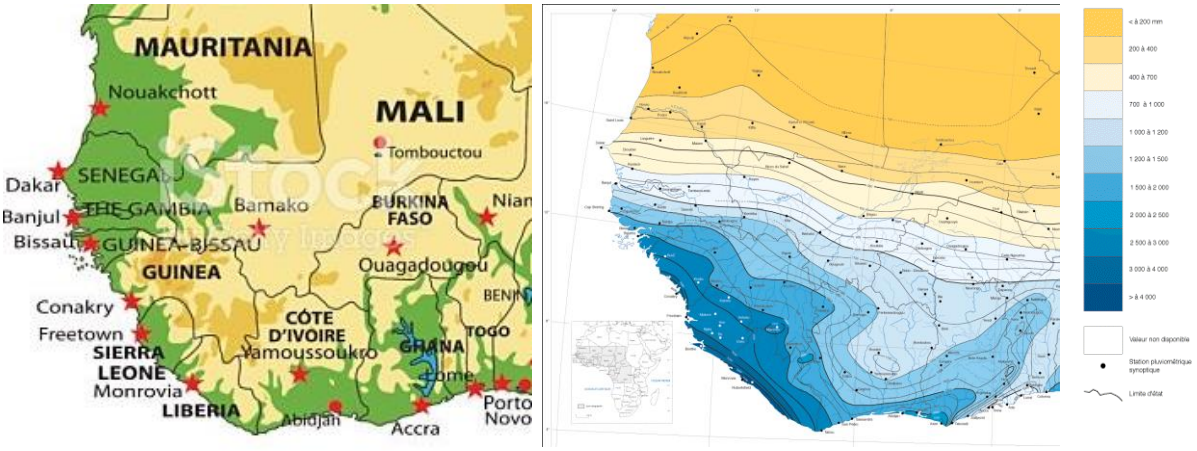


Figure 4.3: Simplified topography (left) and average annual rainfall (right) in West Africa. Sources: www.istockphoto.com and IRD (http://www.cartographie.ird.fr/pluvio.htm)

Thus, unlike in many other regions in West Africa, and in particular the Sahel, water is abundant in Sierra Leone, although access to clean water is still an issue. Water resources are however beyond the scope of this VA.

Climate variability

While Sierra Leone is overall a water rich, there are variations in rainfall depending on whether slopes are windward or leeward, or by valley or higher elevation lcoations. Figure 4.4 shows more detailed spatial distribution of average annual rainfall in Sierra Leone based on different sources and different periods. The estimated annual rainfall can differ by 200mm and, while the overall progressive inland decrease of the annual rainfall is preserved in both maps its exact orientation as well as local maxima differ between the two maps. Both maps cover different time periods with some overlap but

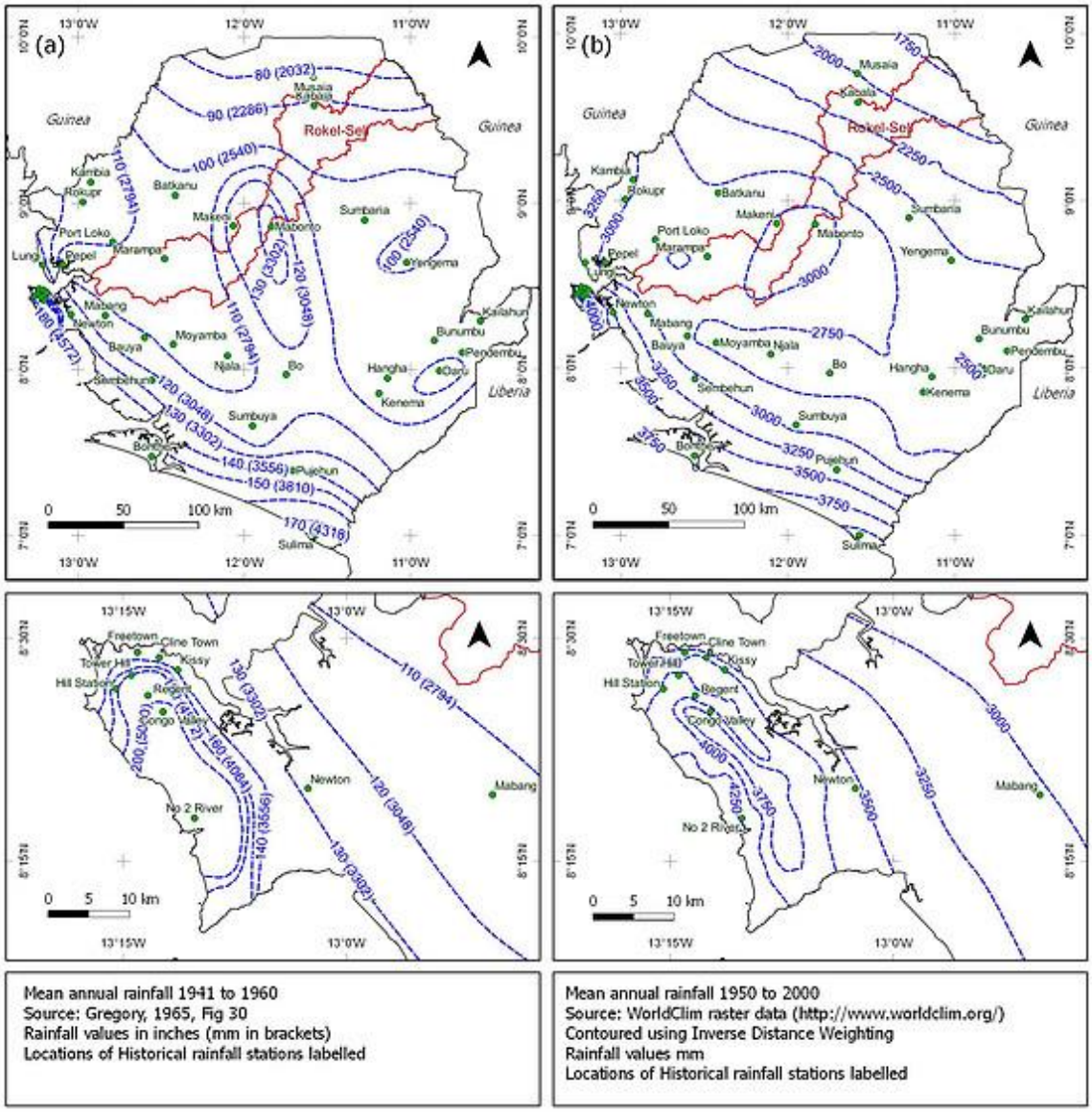


Figure 4.4: Average annual rainfall for the periods 1941-1960 and 1950 -2000, from different sources. Source: https://www.salonewatersecurity.com/maps

most importantly they were elaborated using different methods (cf. discussion on climate information in Sierra Leone in the sub-section below).

In addition to spatial variations, rainfall amounts and timing vary between years as well as on longer time-scales. This is called decadal variability. Such variability is intrinsic to the climate system and independent of climate change, which is the long term modifications in average characteristics of the climate, such as annual totals and timing of the seasons. Interannual and decadal variations arise from the interactions between ocean and atmosphere in the climate system and are independent from the changes in atmospheric composition underlying climate change. Interannual variations can reach up to 30% of the annual total (e.g. in parts of the Sahel) and, in regions where decadal variability is strong it can mask or amplify climate change. Decadal variability is noticeable in the West African Monsoon, and particularly in the Sahel (Figure 4.5) where it was responsible for the multiyear droughts of the 1970s and 1980s, which caused famines and profound changes in the societies. Decadal variability has been observed in other regions of the globe such as East Africa (Lyons and de Witt, 2012) and in Atlantic hurricane activity (Chylek and Lesins, 2008). In the coastal regions of West Africa interannual variability dominates but the decadal signal is still present (Figure 4.5).

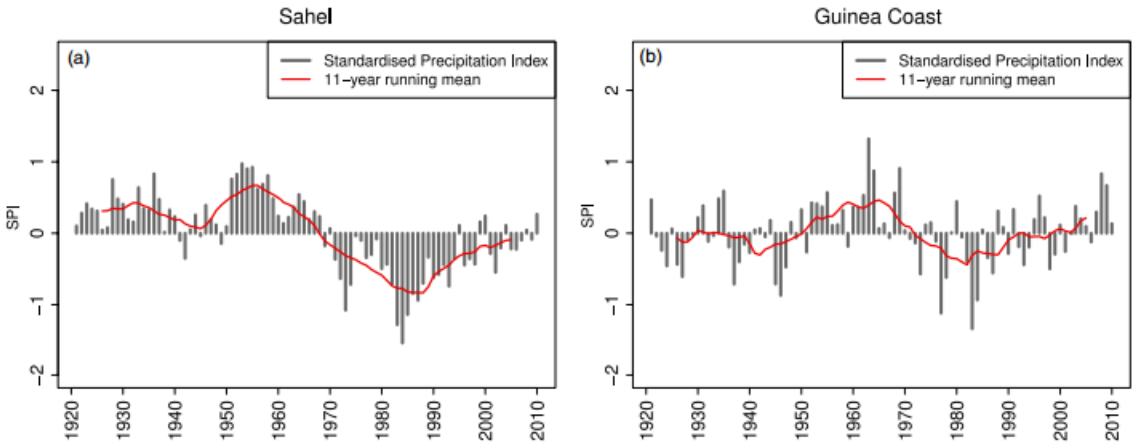


Figure 4.5: The Standardized Precipitation Index for 12 months (SPI-12) and its 11-year running mean for (a) the Sahel and (b) the Guinea Coast between 1921 and 2010, based on records in approximately 76 stations across West Africa for the period 1921-2010 and over 300 stations over the period 1980-2010 . Source: Sanogo et al., 2015.

In a recent study by Sylla et al. (2016) assessing trends in seasonal (May-September) mean temperature over West Africa for the period 1983-2010 based on two observational datasets a clear, statistically significant warming trend is detected over parts of West Africa (Figure 4.6). Countries such as Ghana, Cote d'Ivoire, Guinea, Sierra Leone, and Senegal in the Gulf of Guinea and west Sahel, have experienced the most significant and warmest signals ranging from 0.2 °C to more than 0.5 °C per decade. This is consistent with the latest IPCC report (IPCC, 2013) and a recent study from Padgham et al. (2015) stating that the whole of West Africa has warmed between 0.3 and 1°C in recent decades. However, the exact amplitude of the trend and areas affected differ between the two sets of projections in Figure 4.6, highlighting the limitations of using

global datasets for localized decision making. It is interesting to note that most of the Sahel does not exhibit a significant warming trend and even hints towards cooling in the CRU dataset. This could be related to the fact that the period considered for trend calculation coincides with upward trend in precipitation and higher precipitation will have a cooling effect on seasonal temperature. This again highlights the importance of the decadal variability in West Africa and the necessity for accounting for it in climate analyses in this region.

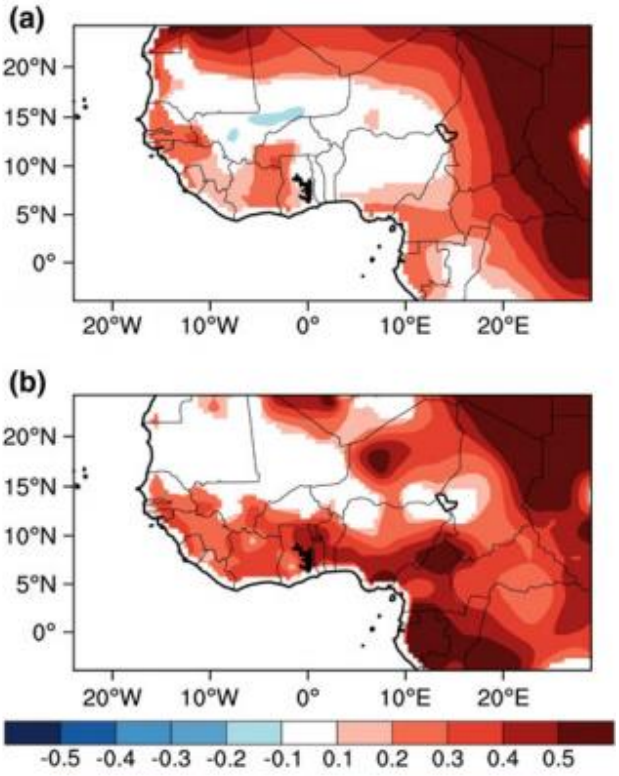


Figure 4.6: Linear trends in mean seasonal (May–September) temperature over West Africa for the period 1983–2010. Only areas where the trend is statistically significant at the 90 % level are shaded. (a) CRU Temperature trend: 1983–2010. (b) UDEL Temperature trend: 1983–2010. Source: Sylla et al., 2016.

More localized analysis of recent evolution in rainfall and temperature in coastal areas of Sierra Leone based on the CRU dataset is presented below. All four regions show very similar behavior so an average for all four regions only is presented. Rainfall seasonal total average over the period 1951-2014 is around 2700mm with a standard deviation of approximately 300mm and a coefficient of variation[18] of 11%. The figure 4.7 presents anomalies around that average (blue bars). It is clearly dominated by interannual variability, similar to the one for the entire coastal region presented above. It also shows multi-year periods of higher and lower rainfall (red lines) but the periodicity is shorter than in the study of Sanogo *et al.* 2015 and the anomalies as well as the multiyear persistence of the anomalies seem to vanish towards the end of the period. This could be an artefact of fewer in-situ observations available for inclusion in the gridding procedure.

In contrast, temperature is clearly dominated by an increasing trend of approximately 0.14C per decade, consistent with the results od Syla *et al.* 2016. Note that interannual variations are also present and that the amplitude of the trend may change according to the period considered.

[18] The standard deviation is a useful measure of rainfall variability. Assuming a normal distribution 66% of all the recorded values are comprise between average $\pm$ 1standard deviation and 98% of the values between average $\pm$ 2 standard deviations. The coefficient of variation relates the standard deviation to the average rainfall and equals standard deviation /average, expressed in percentages.

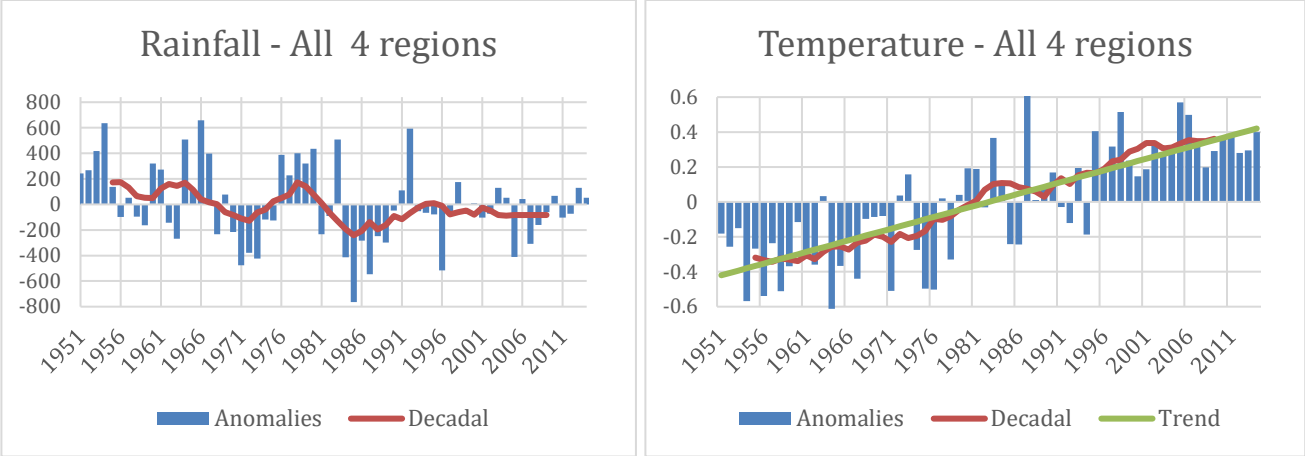


Figure 4.7: Anomalies of rainfall and temperature for the May-November season in the coastal areas of Sierra Leone, over the period 1951-2014. Data Source: CRU, (Harris et al. 2014)

In addition to the changes above, Sierra Leone's National Adaptation Programme of Action (Government of Sierra Leone, 2007) notes that the characteristics of the seasons have changed. Particularly, the Harmattan period (dry season) in recent times is reported to be warmer than in the past. It is also observed that the pre-monsoon period which runs from April to June is now associated with stronger winds and more frequent rain/storms causing greater damage to lives and property. Calmer and dryer weather now appears to be associated with the September/November period which was usually characterized by frequent thunder and lightning and short but heavy rainfall. Certain areas of the country have experienced rain delays and/or succession of dry spells and torrential rains leading to flooding. Changes in the characteristics of the seasons have been linked to impacts such as water shortages in Freetown and flooding, although changes in water demand and land use linked to fast urbanization are certainly also at play here.

Climate Information availability and accessibility

The above claims by NAPA are not supported in the report by data, analyses or reference to peer-reviewed studies. The information seems to stem from "studies relating to climate change and National Adaptation Program of Action carried out in recent times as well as NAPA regional workshop reports" (Government of Sierra Leone, 2007) without precise references. Most of the results above are from analyses performed at larger, regional scales, often using global gridded data. The only map of annual rainfall distribution over Sierra Leone based on in-situ observation that the VA team has been able to access dates to 1965 (Figure 4.4). Discussions with the Meteorological Agency of Sierra Leone during the scoping visit indicated that most of the data collected through standard meteorological instruments is still archived on paper and it is not ready to be analyzed. The density of the stations has decreased, although automatic stations have been installed recently with the support of UKAid and UK Met Office in an effort to rebuild Sierra Leone capacity to monitor its own climate.

Climate monitoring with *in situ* instrumentation and analyses of collected data are critical to identification of natural climate variability and long term climate changes. This is even more critical in a country like Sierra Leone with strong spatial variability in climate due to the topography. Global data sets, even if they seem to have high resolution, are based on observations available to the teams that build the data. If little in situ information is available, the values in grid points are simple interpolations from existing measurements. In data poor regions grid cells may have no observations at all and the values provided may stem from observations several hundred kilometers away. Thus, while such data sets may give an impression of completeness they may not represent the reality.[19]

Satellite-based datasets need also to be treated with care as they are only estimates of rainfall, based on the temperature at the top of the clouds. The amount of rainfall produced by a cloud with the same vertical development will however depend on the type of rain producing mechanisms (typically convection in the tropics) and the terrain below. Here again the estimates use algorithms based on data available to the teams which density is incomparably higher in temperate zones when compared to the tropics. Satellite data also cover the period 1982-present, which corresponds to the 'recovery' period of rainfall in West Africa and do not permit us to estimate the full range of variability over long periods of time.

In a nutshell, global gridded datasets are only as good as the data they are based on and their density. In Sierra Leone, they may not represent the reality accurately as well as capture the sharp spatial variations in rainfall and temperature, specific to this country. It is customary to validate such datasets against in situ observations.

Accurate in situ observations are necessary to assess local climate variability and change as well to downscale and bias correct projections and carry out impact analyses. Climate models used in projections do not capture well sharp spatial variations in climate such as those found in Sierra Leone. Moreover, they also have difficulties correctly reproducing the main characteristics of the West African Monsoon, such as the rainbelt location and rainfall intensities as well as he interannual and decadal variability. Without assessing and correcting such biases it is difficult to narrow the range of projected climate changes as well as contextualize them in current climate variability. Impact models will also be very sensitive to inaccuracies in the models. In the absence of in situ data allowing bias correction and downscaling of the projections only large tendencies can be derived for Sierra Leone.

[19] For example, Worldclim high resolution gridded rainfall estimates interpolate rainfall between stations available to Worldclim, provided that the records span at least 10 years within the 1950-2000 period. Thus, the interpolation can be done between records spanning different periods and on different sides of mountain ranges. This, together with differences in time span, could explain the differences in annual amounts and spatial patterns between the maps in Figure 4.4. In addition, Wordlclim only provides average rainfall and does not allow estimating variability and trends.

Projected changes in climate in Sierra Leone

In this section, we describe climate projection results from two studies that focused on Sierra Leone and West Africa, with the caveats and limitations described above.

In the first study The Met Office Hadley Centre (MOHC) provides high resolution climate projections for regions of West Africa as well as country factsheets showing projections and impacts. The MOHC uses an ensemble of Regional Climate Model (RCM) simulations to provide baseline and future climate projections. The model simulations were run from December 1949 to December 2099 using the MOHC regional climate modelling system, PRECIS, with 50km resolution over the Africa CORDEX domain (Jones et al., 2012), It. generates a range of future climate scenarios under the IPCC Special Report on Emissions Scenarios (SRES) medium high A1B emissions scenario,

Figures 4.8 and 4.9 show temperature and precipitation simulations for Sierra Leone, for the baseline period (1971-2000), and projected changes for the near future (2020-2049) and far future (2070-2099), based on RCM models with the lowest and highest projected sensitivities in the far future time period (Hartley et al., 2015). As shown in Figure 4.8, as much as a 1.5˚C increase in annually averaged surface temperature can be expected in the 2020-2049 time period. In 2070-2099, a 2.0-4.5˚C increase is projected to occur. Note, however, the lack of details in the maps accounting for the topography, especially in the reference-period map.

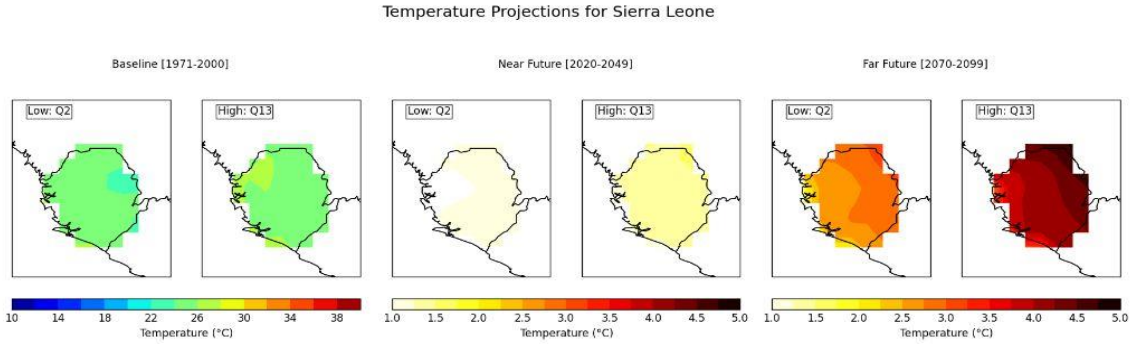


Figure 4.8. Sierra Leone annually averaged surface temperature (˚C) simulations for the baseline period (1971-2000) and projected changes for the near future (2020-2049) and far future (2070-2099). Source: Hartley et al., 201.

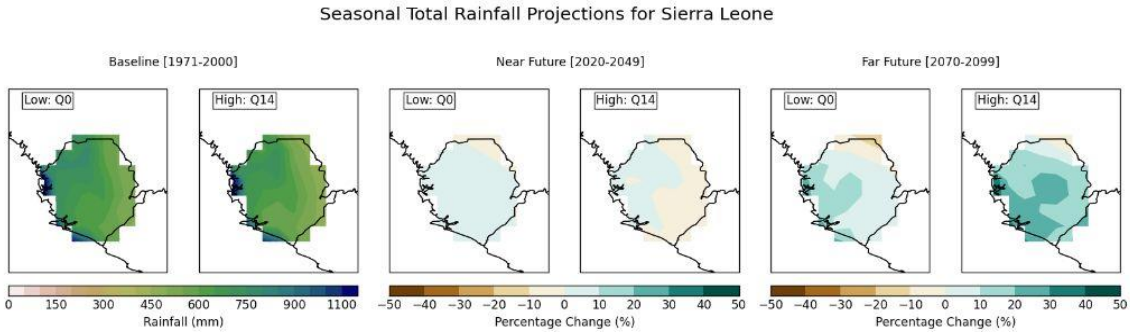


Figure 4.9. Same as figure 4.8 but Sierra Leone precipitation (seasonal total rainfall (mm) in the JAS season) Source: Hartley et al., 2015.

Rainfall for the reference period also show relatively little spatial patterns and is potentially underestimating the amounts (only the amounts for July to September are shown, which account for approximately half of the rainy season in Sierra Leone – a simple extrapolation of the values hown indicates that the seasonal amounts might be underestimated). Weak changes in rainfall amounts are expected to occur for the 2020-2049 period, with a potential increase of about 10% increase on the coast and a 10% decrease inland. In the far future, as much as a 30% increase in rainfall is predicted on the coast and a 20% decrease inland. The overall potential increase in the precipitations is consistent with the IPCC assessment that under hanged climate the hydrological cycle may increase in intensity, meaning more rainfall, and potentially more frequent extreme events, in regions currently receiving large amounts of rainfall.

In the second study Sylla et al. (2016) assessed future climate change over the West Africa region using a set of RCMs participating in the CORDEX program and available for the West African domain for temperature and precipitation projections. A multimodel ensemble approach was carried out to increase robustness of the results. In Figure 4.10, the CORDEX multimodel long-term time series of seasonal (May-September) mean temperature and precipitation anomalies are shown along with the range of possible values averaged for the Sahel, the Gulf of Guinea and all of West Africa during the historical (1970–2005) and the future (2006–2100) periods for both RCP8.5 and RCP4.5. Anomalies are calculated with respect to the seasonal mean of the reference period 1976–2005. The CORDEX time series are in accordance with IPCC findings, which indicate that the regions have undergone significant warming in recent decades that will be amplified in the future in all of the greenhouse gas (GHG) forcing scenario. Considering a “business as usual” (high level GHG) forcing scenario (RCP8.5) and a mid-level one (RCP4.5), the warming rate gradually increases and reaches its maximum in 2100. Temperature changes in the two forcing scenarios diverge around 2050 and this divergence is greatest in 2100. Potential warming is projected to range from 1.5 to 6.5°C in West Africa, with the Sahel experiencing the largest increases and the Guinea Coast region the lowest (Sylla et al., 2016).

Mean precipitation change over West Africa and the two subregions shows a less evident trend and mostly oscillates between −10 and 10%, with a maximum range between −30 and 30%, indicating that projected precipitation is highly uncertain over the region. It is interesting to note that the range of uncertainty gradually increases as the RCP forcing increases (i.e., as the time frame increases), suggesting that the different RCMs generate substantially different responses to a larger forcing. The largest uncertainty is found in the Sahel, which is most likely caused by differential model representation of the West Africa Monsoon and its interactions with deep convection. Although most of West Africa experiences minimal change as a whole, some areas are projected to experience some precipitation increase (5–10 %) in the Gulf of Guinea, including Sierra Leone, Liberia and Cote d’Ivoire, and over the East Sahel, in countries such as Niger and Chad (Sylla et al., 2016). Note that whatever the rainfall projections, the temperature increases described above will drive an increase in evapotranspiration,

meaning potential decreases in available moisture for crops even if rainfall increases slightly.

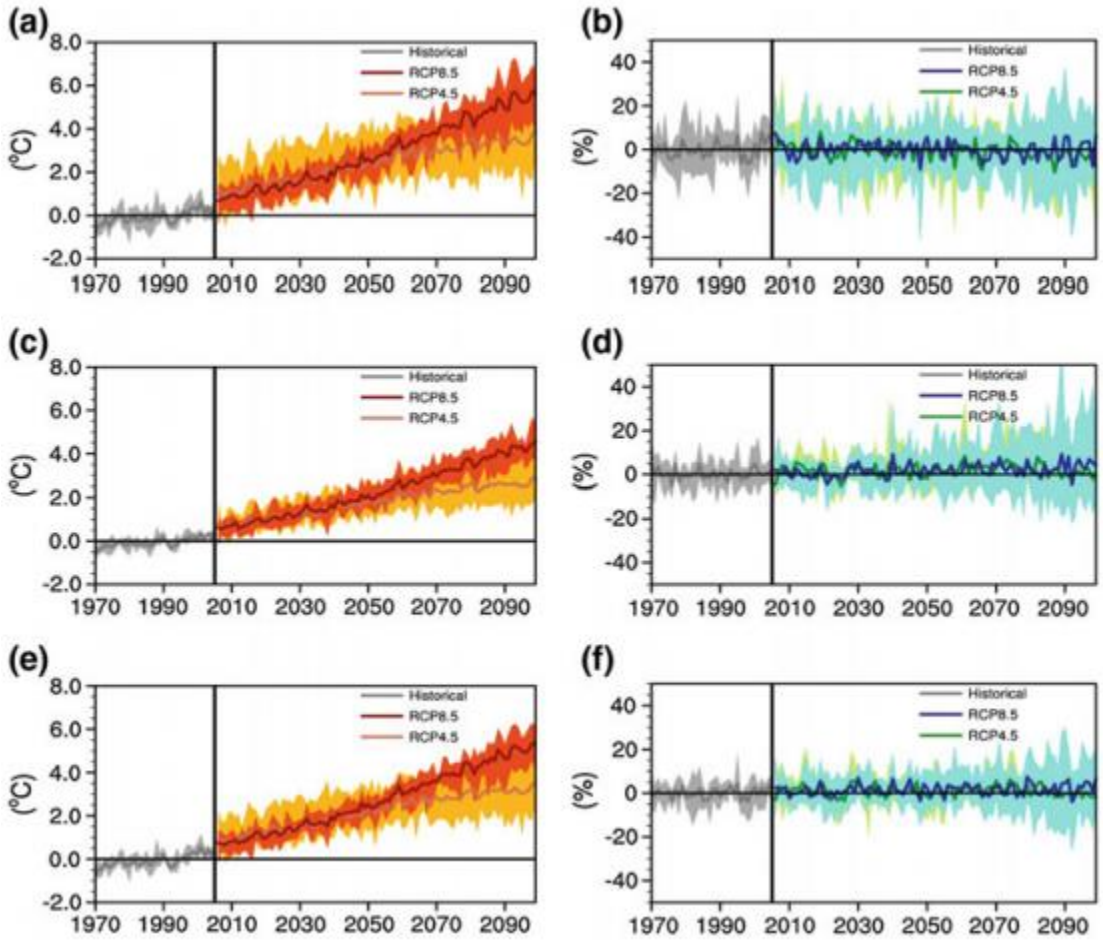


Figure 4.10: Long-term time series (1970–2100) of seasonal (May–September) mean temperature (left panels) and precipitation (right panels) anomalies spatially averaged for the Sahel (upper panels), the Gulf of Guinea (middle panels) and West Africa (lower panels) for both RCP4.5 and RCP8.5 based on multimodel CORDEX simulations. Anomalies are calculated with respect to the seasonal mean 1976–2005 period. The shaded areas denote ensemble maxima and minima. (a) Sahel temperature change. (b) Sahel precipitation change. (c) Guinea temperature change. (d) Guinea precipitation change. (e) West Africa temperature change. (f) West Africa precipitation change. Source: Sylla et al., 2016.

In summary: the information on projected changes in climate of Sierra Leone relies currently on large scale regional studies. They indicate that while the temperature is overall projected to increase, rainfall may also increase although here uncertainties are large. However, current results that may not fully account for spatial differentials within the country and are not discussed within the current levels of climate variability observed in Sierra Leone. In addition, information on current and projected changes in climate do not provide us with information on their impacts on the communities.

Climate Impacts and Perceptions

In this section, we present climate impacts on coastal communities in mangrove areas, as reported by the communities themselves, as well as current coping and adaptive strategies and potential changes in community preferences for different strategies. The results are based on the household survey and PRA.

Importance of climate variability and change for the communities

Household survey respondents were asked questions that gauge the importance they attach to climate change, such as whether they've heard of and believe in climate change, any negative impacts they've experienced that they believe to be related to climate change, and how significant an issue it is for their community.

Climate change was first defined for respondents. Sixty three percent of respondents have heard of climate change and believe that it is happening, and another 20% have heard of it but are not sure if it is true or not. Only 6% did not believe in it, and another 12% had never heard of it. Almost half of respondents (45%) agreed that climate change causes negative impacts that adversely affected their livelihoods, and a quarter strongly agreed (Figure 4.11). Seven percent disagreed and 23% did not have an opinion.

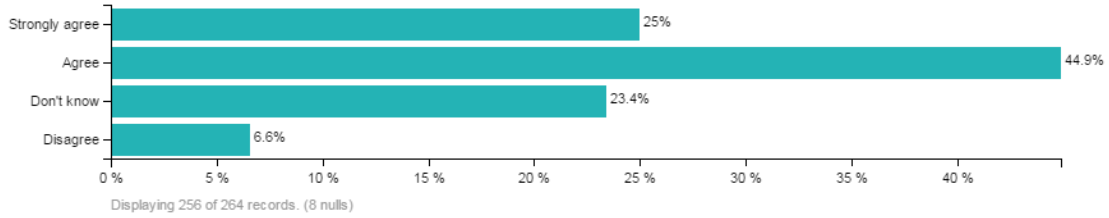


Figure 4.11: Percent of respondents agreeing or disagreeing with the statement "climate change causes negative impacts on livelihoods"

Interestingly, when asked if they agreed with the statement "climate change is not a big problem for my community at this time", 37% agreed or strongly agreed and 37% disagreed or strongly disagreed, with roughly a quarter of respondent's in between or uncertain (Figure 4.12).

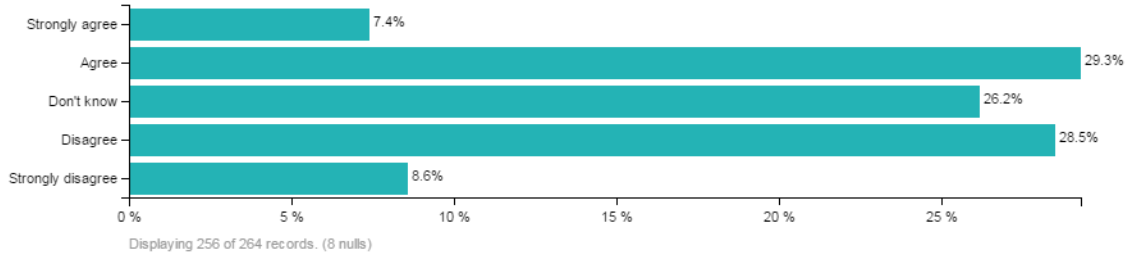


Figure 4.12: Percent of respondents agreeing or disagreeing with the statement "climate change is not a big problem for my community at this time"

This result is consistent with the results of Reid and Vogel (2006) who pointed that climate stressors are rarely the only concern or stress that constrain 'quality of life' in rural, resource-poor communities in Africa. The terms concern, worry, stress, stressor, hazard, and threat are used here interchangeably as they all reflect "threats to people and the things they value" (Kates and Kasperson, 1983). It is further confirmed by the results of the PRA where the participants had to list than rank their main worries according to their importance in their lives and their frequency. The incidence (the frequency at which a given worry was listed), the average importance given by participants and the frequency are captured in the fig. 4.13. The red arrows highlight flooding and other environmental issues. The latter includes fire, heavy winds, erosion, high temperatures, storms/wind, heavy rains, low temperatures, deforestation, climate change, cutting of mangroves, and construction in wetland areas.

Money issues and lack of education, market access, government aid, and community centers were top of the list in terms of importance. Food, housing, health, fishing materials, water and transportation were mentioned frequently as well. Money issues, lack of government aid, lack of mosques, and lack of toilets and problems with fishing materials and lack of food are all issues that villagers worry about at least once a week if not daily. By comparison, the aggregated environmental and flooding issues barely make the cut in terms of issues that were brought up spontaneously by villagers.

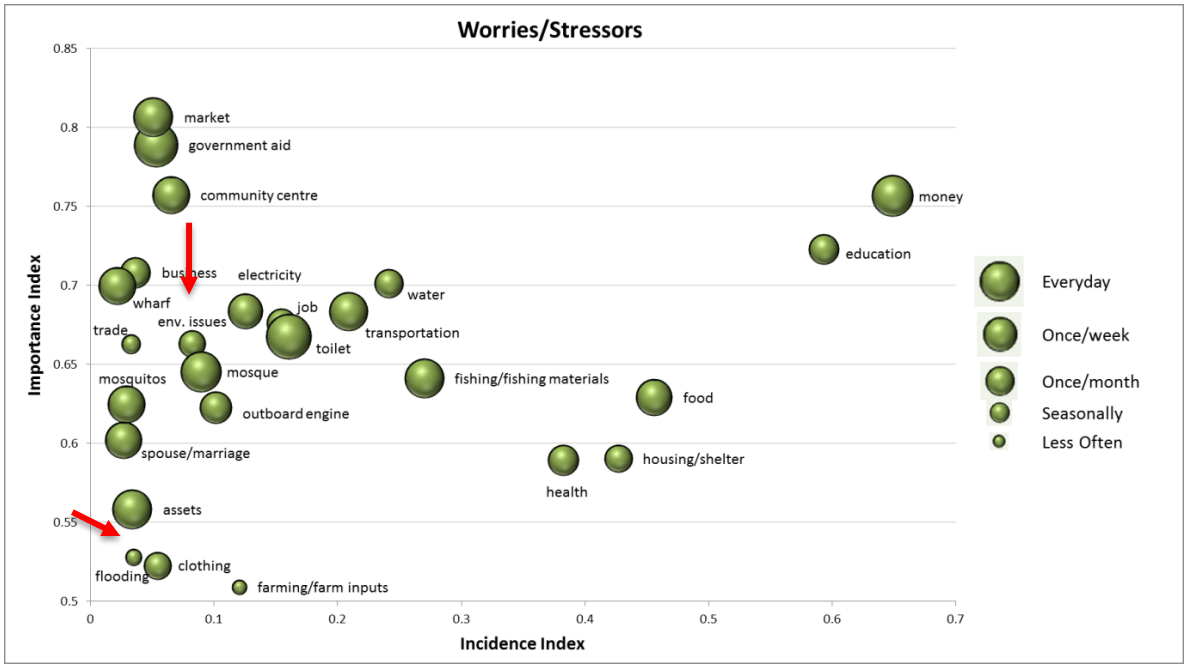


Figure 4.13: Most common worries/stressors identified by participants in group discussions for entire region.

Separate male and female focus groups (Figures 4.14 and 4.15, respectively) found different issues were of primary concern. Money was a primary concern for both, but men had a slightly higher incidence and importance score for education, jobs, and government aid. It is also notable that they ranked a bit higher aggregated

environmental issues. For women, lack of electricity is of greatest importance, while issues of food and housing were of slightly greater incidence than for men.

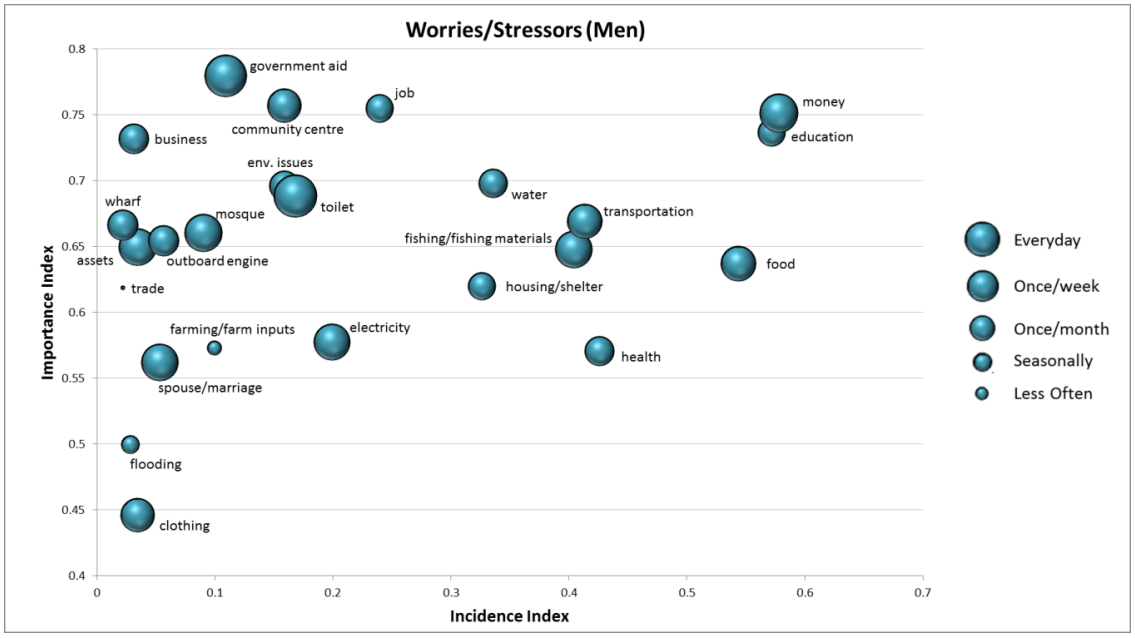


Figure 4.14: Most common worries/stressors identified by male participants in group discussions

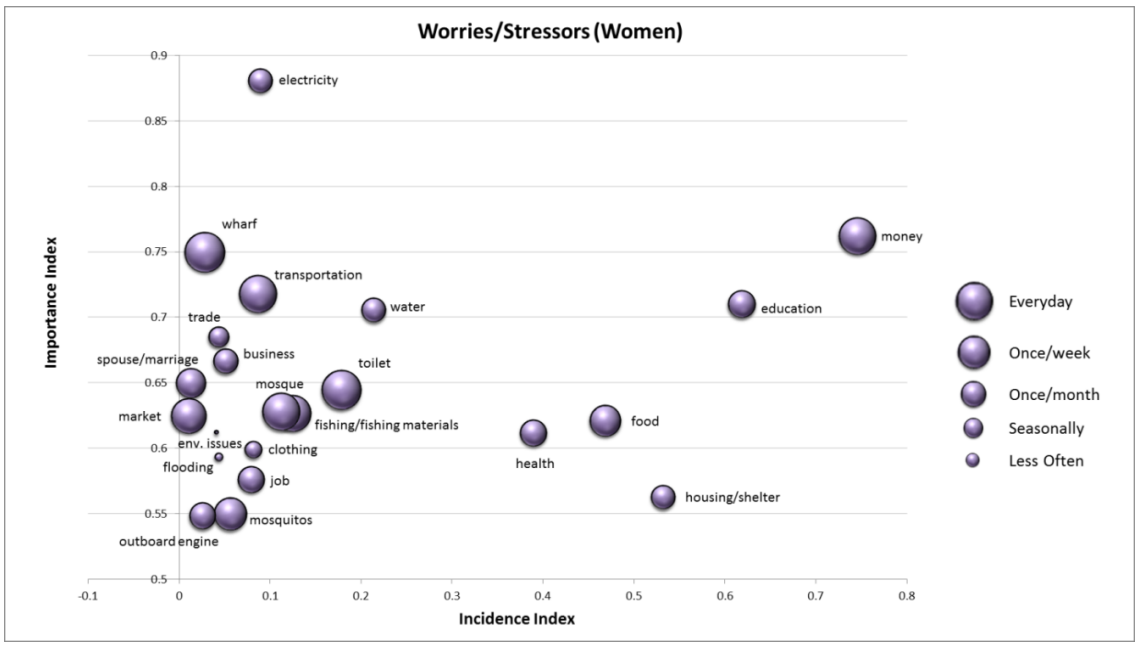


Figure 4.15: Most common worries/stressors identified by female participants in group discussions

Impacts of climate events experienced by the communities.

Each focus group was asked to list extreme events that have occurred in the past ten years. Figure 4.16 shows the percentage of focus groups across all regions that identified the occurrence of particular climate and environmental events. The most commonly mentioned climate/environmental event is high temperature, closely followed by heavy rain, flood, storm, and heavy winds. There is a steeper drop off in responses regarding drought, low temperatures, and fire, and deforestation, erosion, landslides and sea level rise are all below ten percent. This is consistent with water abundance in the coastal areas of Sierra Leone, as mentioned in the general description of the climate in Sierra Leone.

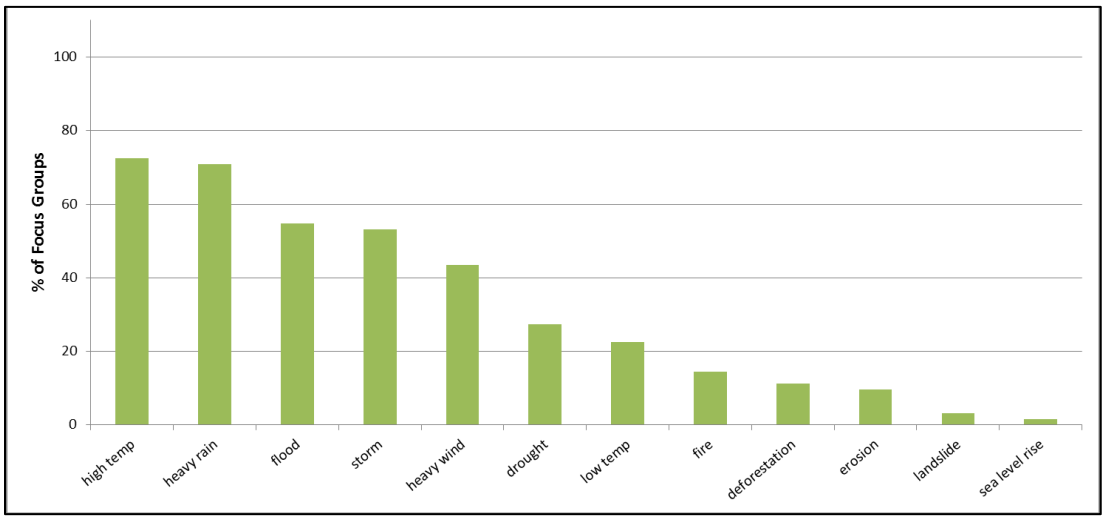


Figure 4.16: The frequency with which respondents mentioned climate and environmental events

Regional breakdowns show some differences. For the Scarcies region (Figure 4.17a), the most frequently mentioned climate/environmental event is flooding, followed by storm, heavy rain, and fire. It is conceivable that mangrove depletion and deforestation upstream in the Scarcies basin has exacerbated riparian flooding, and that this is a reason for its high frequency (93%). For the SLRE region (Figure 4.17b), the most frequently mentioned climate/environmental event is high temperature followed by heavy rain. For the Yawri Bay region (Figure 4.17c), the most frequently mentioned climate/environmental event is high temperature, closely followed by heavy rain. For the Sherbro region (Figure 4.17d), the most frequently mentioned climate/environmental event, at 100% of respondents, is heavy rain, closely followed by high temperature. Heavy winds are much more frequently mentioned in this region compared to the others. Finally, it is notable that heavy rain shows up in the top three in every region.

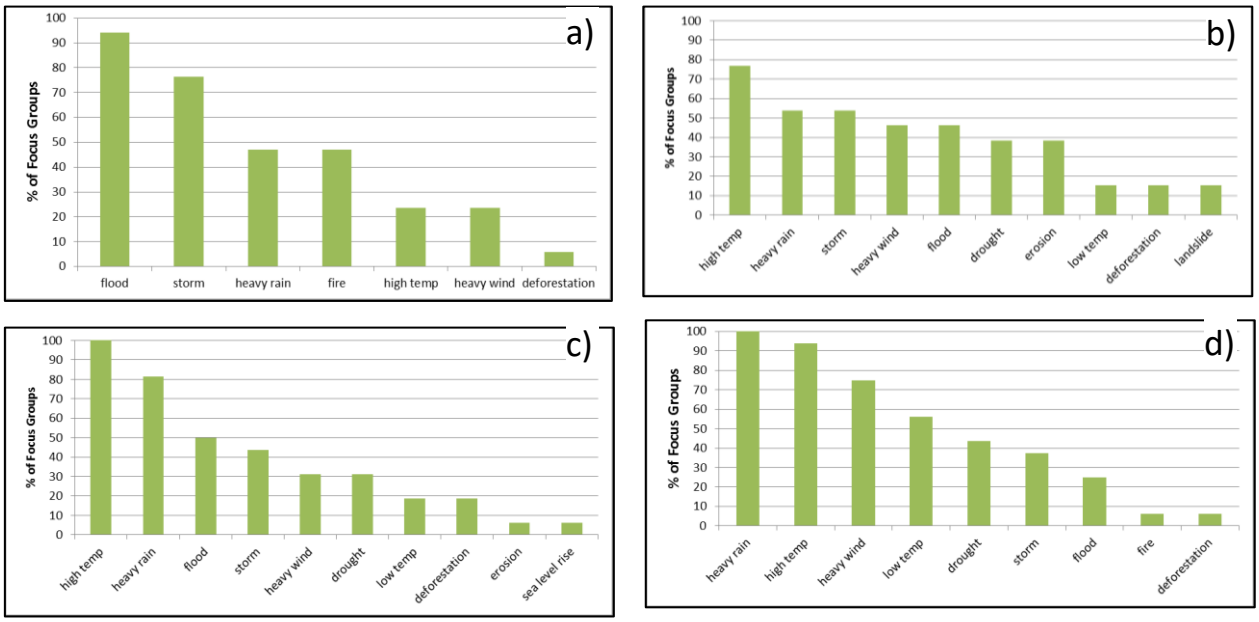


Figure 4.17: The frequency with which respondents mentioned climate and environmental events for: (a) Scarcies region, (b) SLRE region, (c) Yawri region, and (d) Sherbro

The ranking of the importance of impacts of different climate related hazards was assessed in Household surveys. Figure 4.18 shows the relative importance (or impacts) of various climate hazards over the past five years on the Y axis, with the percent of households affected (X axis). Importance ranges from 1 for not important to 5 for very important. Most hazards range from 4-5, with larger bubbles indicating the median number of times over five years the respondents were affected.

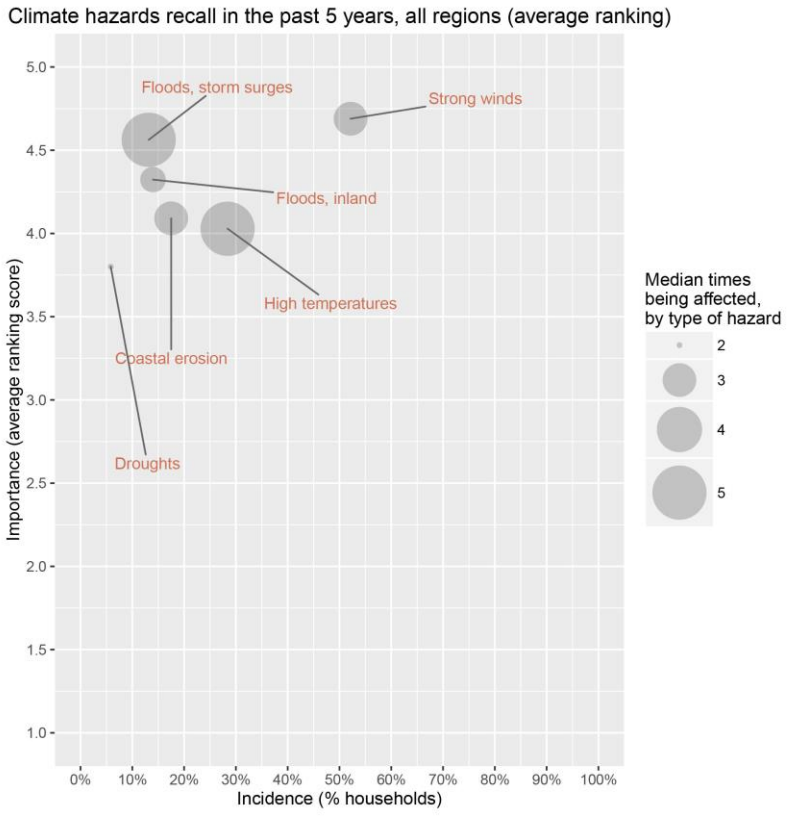


Figure 4.18: Relative rank of climate hazards by the percent of households affected and the median number of times over the past five years that respondents were affected (bubble size)

Fifty percent of respondents indicated they had been affected by strong winds, and this was also high on the importance scale. About 12% of households report being affected by floods and storm surges, and this is second highest after winds on the importance scale, but with even more frequent occurrence (the median is annual occurrence). Almost 30% of households reported high temperatures, and this is also a frequently occurring event.

Further investigation carried out with representatives of different communities in December 2016 helped us to better understand the importance of different climate risks: Heavy winds are ranked highest because they cause fires (from smoke houses and cooking stoves) which propagate quickly through densely build villages and can completely destroy houses and other household belongings in very short time. They are difficult to contain and feared by individuals in all communities. Winds also cause destruction of roofs and even houses as well capsizing of the boats – mostly passenger boats were cited. Floods have been cited more often in the context of salt water intrusion, salinization and loss of farmland and/or crops as well as wells in some instances. Thus, heavy winds cause more immediate and more feared destruction to properties that need to be addressed quickly and require fast mobilization of means. They also seem less predictable while floods are a frequent seasonal phenomenon that can be better anticipated and managed and may cause less destruction.

Perceived changes in climate events and their frequency

Communities' and individual's perceptions of changes in climate were collected through the PRAs and household surveys.

Respondents were asked if they've observed any changes in climate in their area. Figure 4.19 shows that a large number had observed more frequent abnormal conditions (e.g. stronger winds, droughts, heat waves, etc.), followed by more intense storms, more extreme heat, more intense and frequent flooding, and coastal erosion.

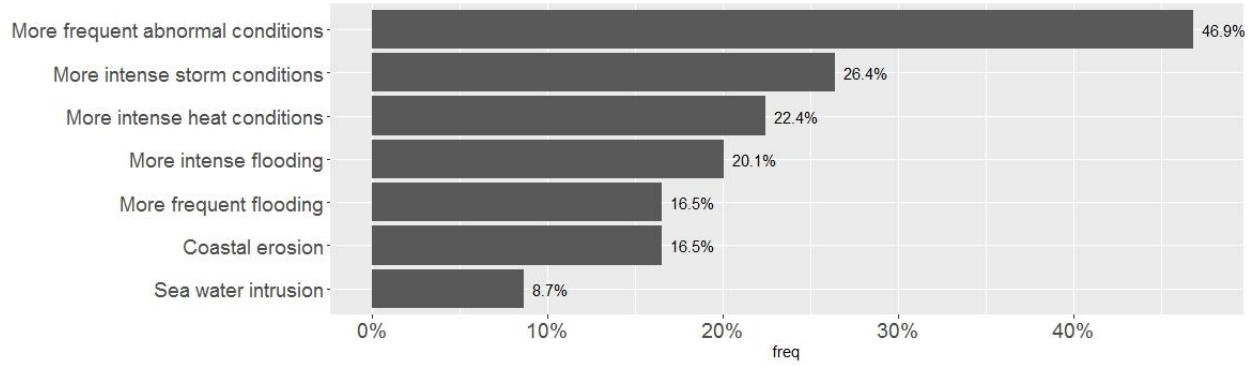


Figure 4.19: Respondents reporting negative impacts of climate change in their area

The perceived changes in rainfall and temperature have also been captured in focus groups. A large majority of focus groups (for all regions) perceive that both average temperature and total precipitation have risen (fig. 4.20). Participants are more confident in temperature increase than in rainfall, with nearly 25% reporting decrease in

rainfall vs. only 2% for temperature. However, a higher percentage (25%) of respondents said that precipitation had declined, compared to 2% for temperature.

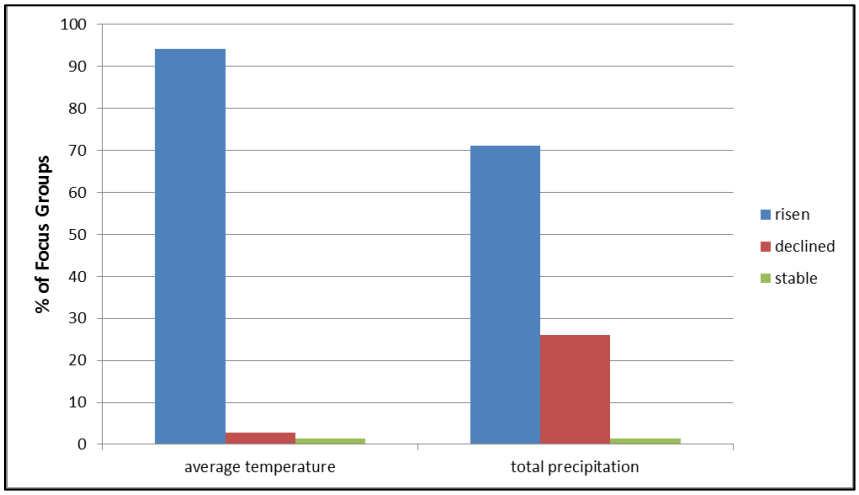


Figure 4.20: Perceived changes in temperature and precipitation

A vast majority of the participants to focus groups reported increase in severity of rainy events and winds (more than 85% of focus groups) as well as high temperatures (about 78%) but were more split about the low temperatures (fig. 4.21).

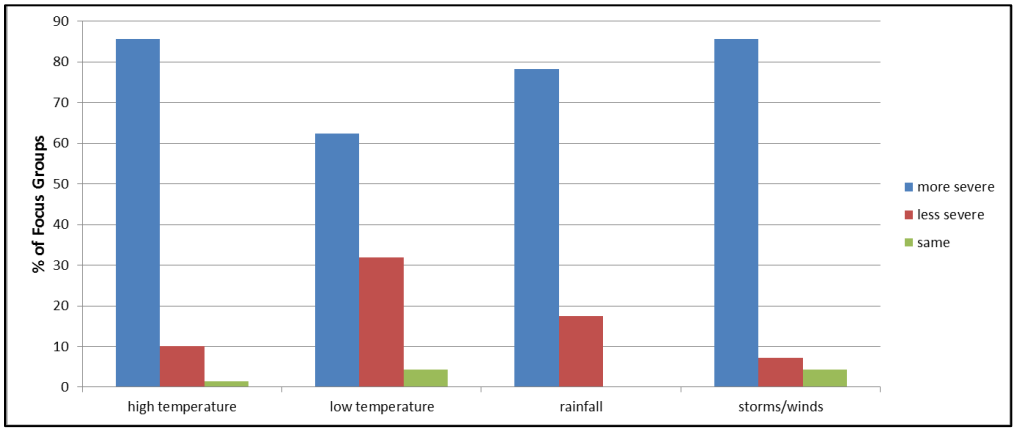


Figure 4.10: Perceived changes in terms of the severity or duration of extremes

Participants to focus groups were split as to changes in predictability of rainfall and winds but reported that predictability of temperature has decreased (fig. 4.22).

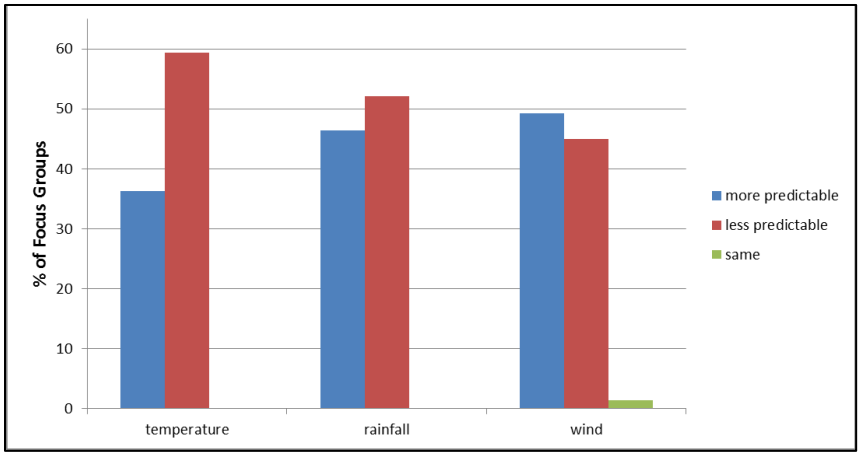


Figure 4.22: Perceived change in climate variability/predictability

The overall perceptions are consistent with the temperature trend reported in various data analyses and potential changes in severity of the storms and winds consistent with the increased hydrological cycle under changing climate. However, they need to be further confirmed by an analysis of *in situ*, daily data for the coastal regions. Perceptions of temperature increase or frequency/intensity of storms can be biased by changes in living conditions: the replacement of thatched roofs (higher thermal insulation) by zinc roofs (lower thermal insulation) can have an impact on people's perception of increased temperature; similarly, the higher costs of non-local building materials such as zinc for the roof or cement may also influence people's perceptions of the intensity of storms and winds. This should not undermine however the impact of climate/weather on the living conditions of the populations in the coastal zones of Sierra Leone.

Climate Adaptation Solutions

Adaptation Solutions listed by participants

Focus groups were asked to list particular climate adaptation solutions that have been implemented in the past or should be carried out as a result of the aforementioned climate and environmental events. Since a wide range of solutions were mentioned, they were interpreted and summarized as identified by each bar in the chart below. They were further categorized into livelihood diversity and financial strategies, construction and infrastructure maintenance, and water, sanitation, and health. Reforestation, increase awareness, and transportation to neighboring village did not fall into a category and therefore they are shown independently. As shown in figure 4.23, reforestation was listed as an adaptation strategy by approximately 67% of focus groups. This number might be biased since the participants knew that mangrove conservation is one of the WA BiCC project's focus areas. Construction of homes, which includes making them sturdier and/or using local materials, as well as construction of drainage systems were also mentioned frequently. Livelihood diversification is also important, with roughly 20% of participants referring to increased farming activities and contributions to the "osusu" traditional money pooling system.

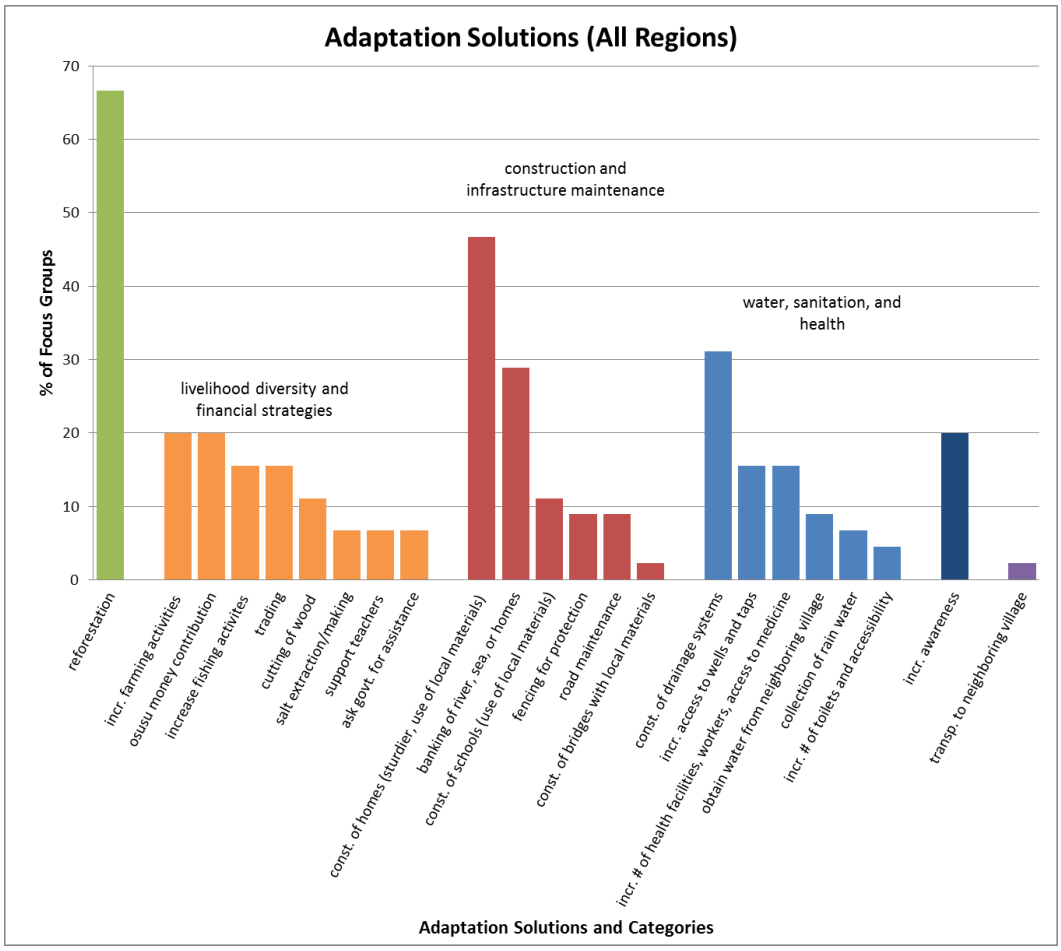
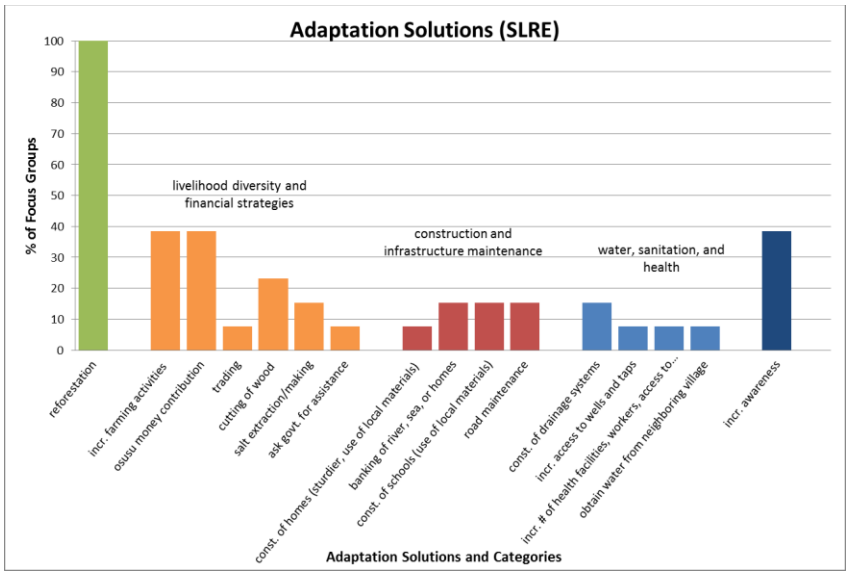
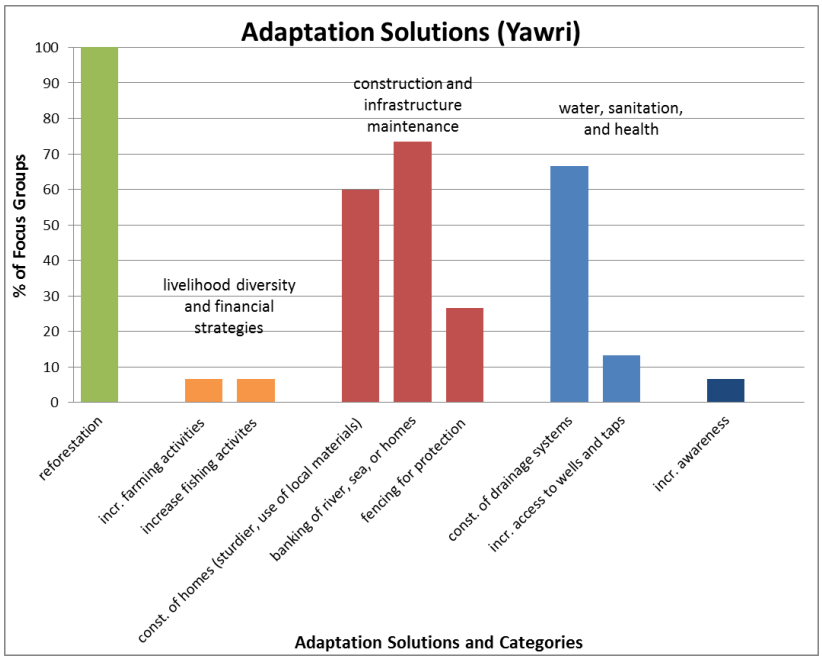


Figure 4.23: Adaptation solutions for all regions

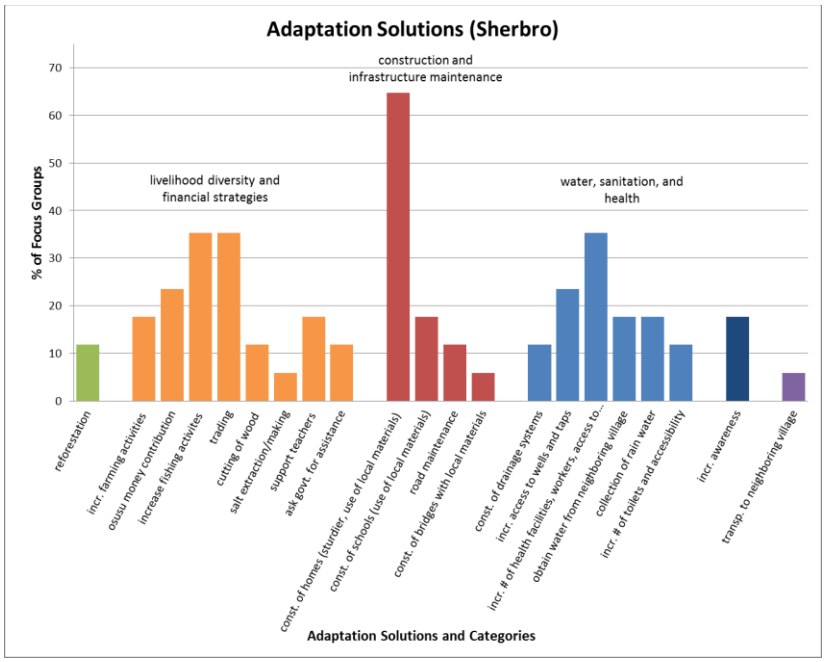
Regional breakdowns, with the exception of the Scarcies region, where the questions on adaptation solutions were not asked, are found in the following figures. For the SLRE region (Figure 4.24a), reforestation was identified by all focus groups as a climate adaptation solution. For the Yawri region (Figure 4.24b), reforestation was also identified by all focus groups as a climate adaptation solution. Additionally, banking of river, sea, or homes and construction of drainage systems was frequently listed. An adaptation solution that was mentioned only in Yawri and in no other region was fencing for protection against floods and storms. In comparison to results for the entire region, in which reforestation was the most commonly identified adaptation solution, Sherbo listed the construction of homes (sturdier, use of local materials) most frequently (Figure 4.24c). This is probably because rates of deforestation are much lower in this region.


Adaptation Solutions (SLRE)
% of Focus Groups
100
90
80
70
60
50
40
30
20
10
0
livelihood diversity and financial strategies
construction and infrastructure maintenance
water, sanitation, and health
reforestation
incr. farming activities
osusu money contribution
trading
cutting of wood
salt extraction/making
ask govt. for assistance
const. of homes (sturdier, use of local materials)
banking of river, sea, or homes
const. of schools (use of local materials)
road maintenance
const. of drainage systems
incr. access to wells and taps
incr. # of health facilities, workers, access to...
obtain water from neighboring village
incr. awareness
Adaptation Solutions and Categories

(a)


Adaptation Solutions (Yawri)
% of Focus Groups
100
90
80
70
60
50
40
30
20
10
0
construction and infrastructure maintenance
water, sanitation, and health
livelihood diversity and financial strategies
reforestation
incr. farming activities
increase fishing activites
const. of homes (sturdier, use of local materials)
banking of river, sea, or homes
fencing for protection
const. of drainage systems
incr. access to wells and taps
incr. awareness
Adaptation Solutions and Categories

(b)



(c)

Figure 4.24. Adaptation solutions for (a) SLRE region, (b) Yawri region, and (c) Sherbro region

Adaptation Solutions Prioritization

A condensed list of adaptation measures with frequency values was provided as part of the PRA data analysis. As mentioned, only data for the Sherbro, SLRE, and Yawri Bay regions were available. All three were then aggregated to produce overall PRA results on adaptation strategies to climate change impacts. This exercise takes metrics on four dimensions:

1. Degree of preference for this adaptation response
2. Difficulty/level of effort required
3. Ability for community to organize to respond, and
4. Dependence on outside funding / technical assistance / institutions

Group facilitators took the count of participants who were in agreement with the above dimensions, for each adaptive response. The following questions could be answered out of the data collected.

Overall description of the data

A total of 23 adaptive responses were identified through participatory rapid appraisal methods.

Figure 4.25 provides a representation of the solutions in the dimensions of preference, difficulty, ability and dependence on external aid. Protection of homes and reforestation have high percentages of respondents who prefer these options, and can be done with community self-organization. But respondents also apparently feel that they need external financial or technical assistance to undertake these activities.

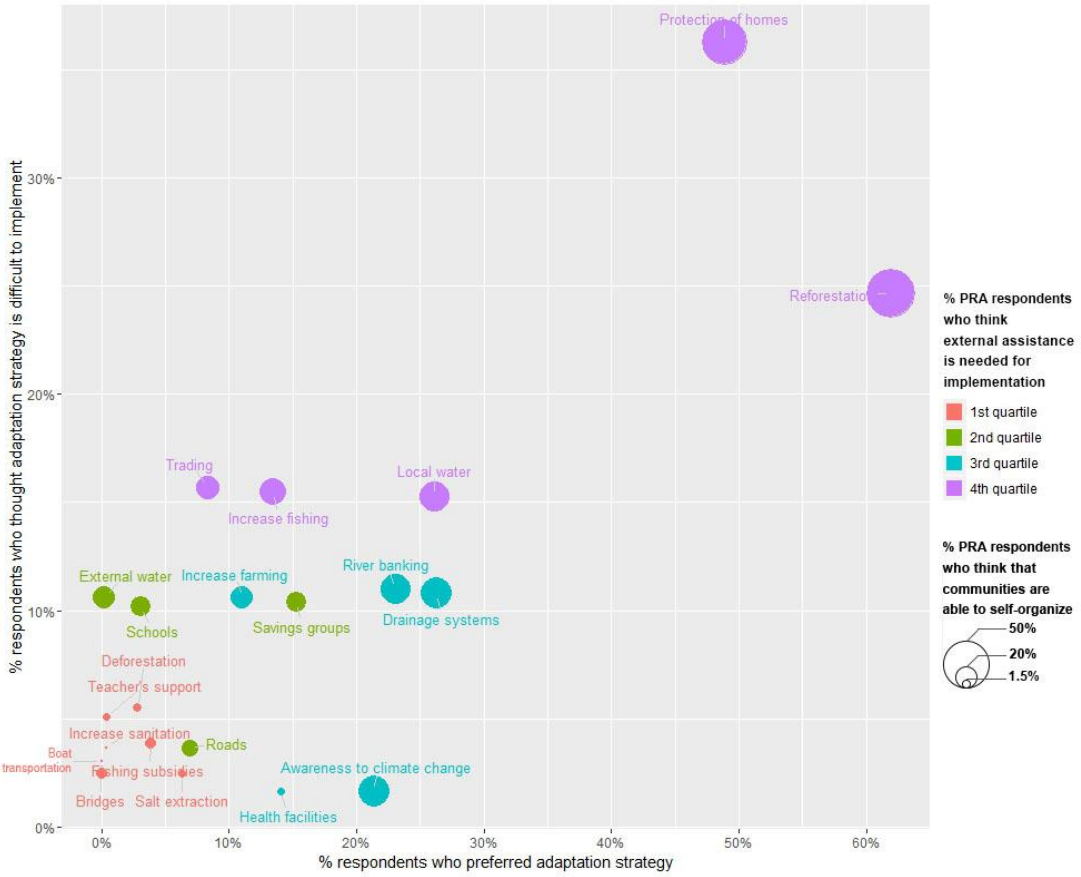


Figure 4.25: Representation of the adaptation solution according to the preference (X Axis), difficulty of implementation (Y axis), community readiness (size of the bubble) and need for external assistance (color, red is lowest need), in three out of four regions

Level of association among dimensions

A scatter plot matrix, showing the associations between adaptive dimensions is shown in Figure 4.26. Each square is a visual representation of the level of association between pairs of variables, based on the count of 'hands' for each adaptive strategy. All dimensions exhibit a strong positive and significant association.

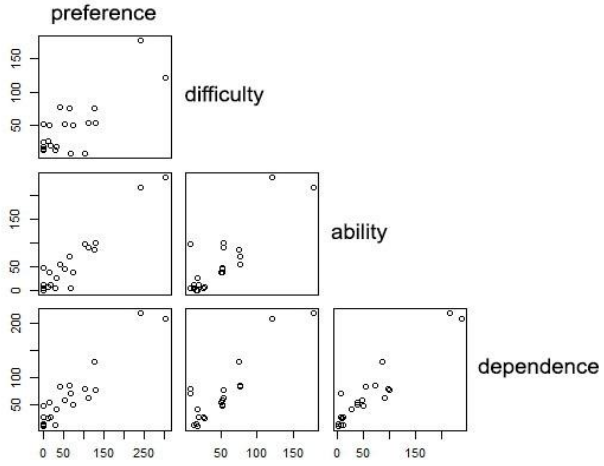


Figure 4.26: Scatterplot matrix of adaptive responses' dimensions

Most and least preferred adaptive responses by respondents in all regions

The median score of adaptive strategies in regards to preference is 41. Since the score represents actual votes from participants to a given strategy, we can say that the median score of 'preference' represents the votes from 8.3% of respondents. The items above the median line (top half) correspond to adaptation measures with relatively strong preference, compared to the other half.

Figure 4.27 shows the adaptive responses preferred by most participants were reforestation, stop deforestation of mangroves and/or nearby forests (62%), construction or protection of houses with studier and/or local materials (49%), construction of drainage systems to divert water (26%), construction of wells, access to water sources locally, and/or rainwater collection (26%), as well as banking of rivers, seashore, and/or homes (23%). The least preferred adaptive responses included the construction of bridges with local materials (0%), as well as transportation by boat to nearby villages (0%), obtain water from neighboring villages (0.2%), increase the number of toilets, and/or sanitation facilities (0.4%), as well as teachers' financial support (0.4%).

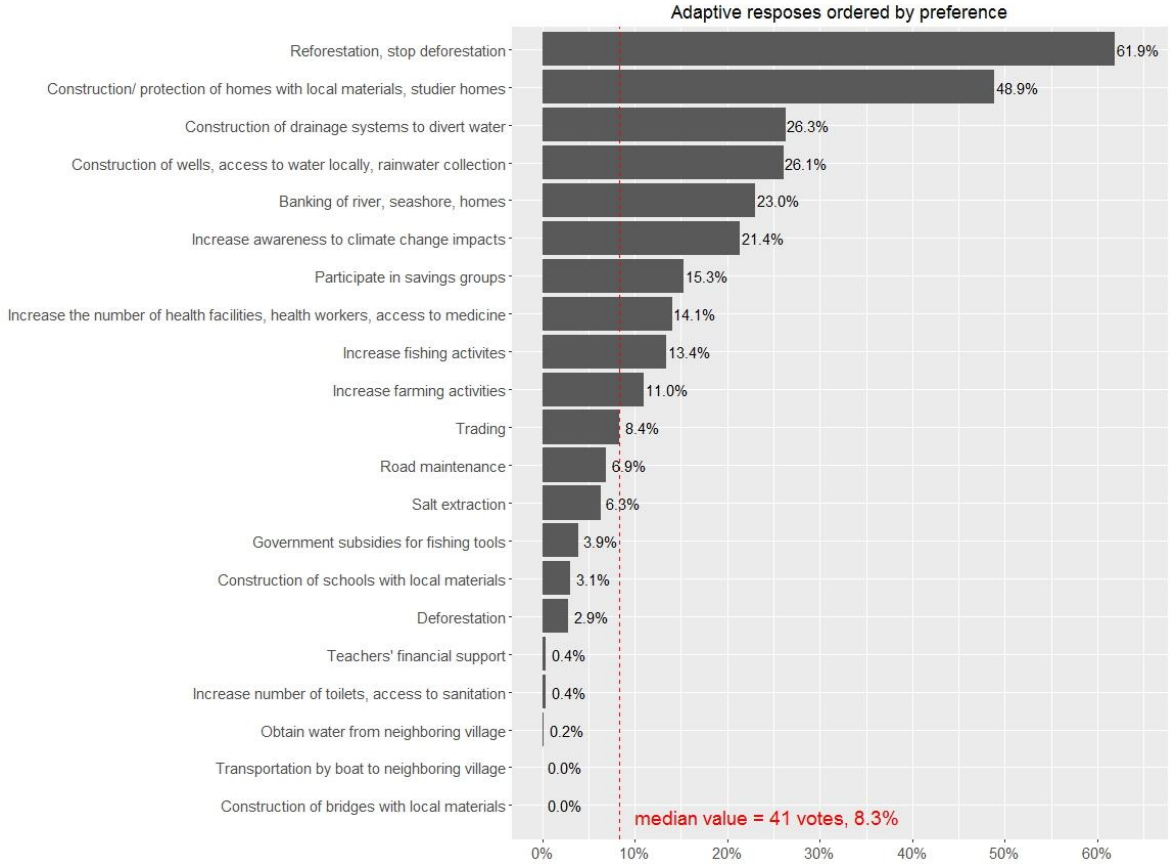


Figure 4.27: Frequency distribution of adaptive strategies as a percentage of PRA participants, ordered by level of preference, in three out of four regions

Adaptive responses considered the most and least difficult to implement by respondents in all regions

The median score of adaptation strategies in regards to difficulty is 50. Since the score represents actual votes from participants to a given strategy, we can say that the median score of 'difficulty' represents the votes from 10.1% of respondents. The items below the median line correspond to relatively easy adaptation measures to implement, based on people's responses.

As it can be seen in figure 4.28, the adaptive strategies considered the most difficult to implement include the construction or protection of homes (36%), reforestation of mangroves or other trees (25%), and then the set of strategies such as trading, fishing activities, and construction of wells or access to local water sources, with 15.7%, 15.5%, and 15.3%, respectively. Contrastingly, the easiest adaptive strategies, as seen by respondents, include the increase of awareness to climate change and increase access to health services (with 1.6% each), construction of bridges and salt extraction (with 2.4% each), and transportation by boat to nearby village (3.1%). Interestingly, deforestation is perceived as a relatively easy strategy to implement by 5.5% of the respondents.

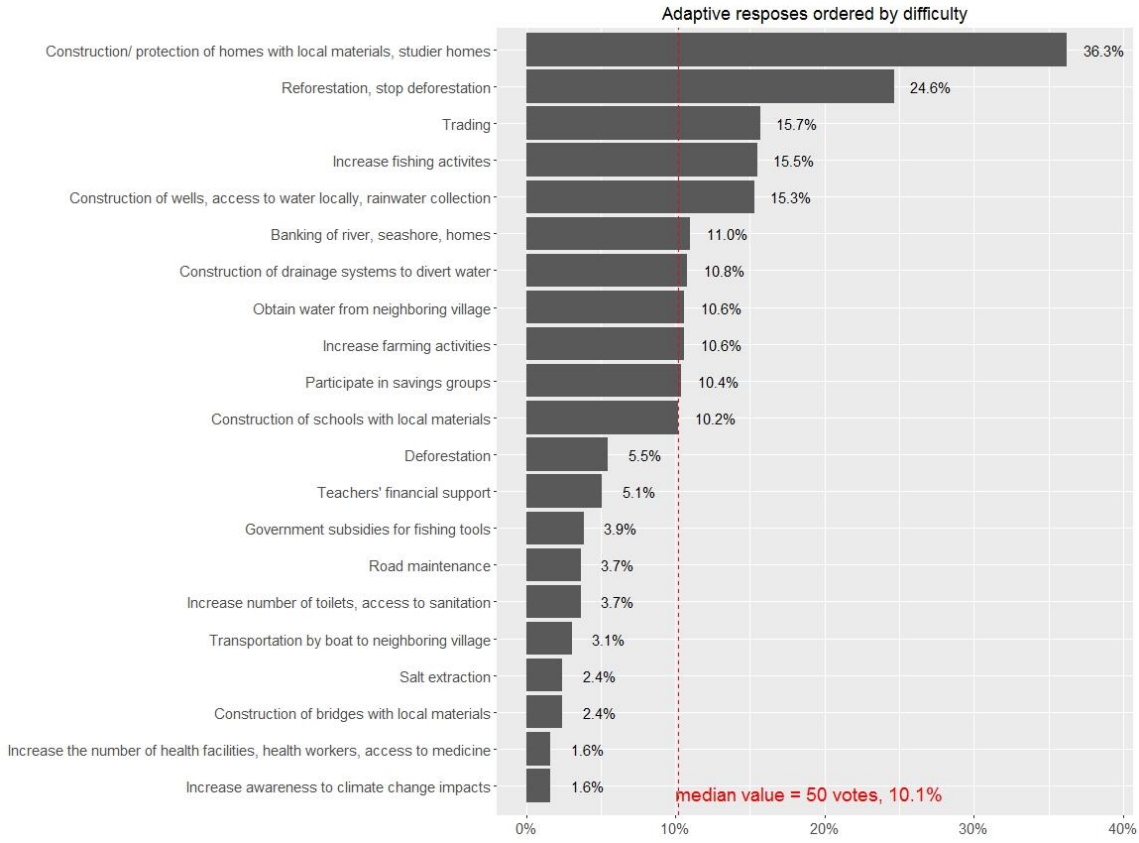


Figure 4.28: Frequency distribution of adaptive responses as a percentage of PRA participants, ordered by level of perceived difficulty, in three out of four regions

Adaptive responses considered the most and least chances for self-organization at the community level

The median score of adaptive strategies in regards to the ability to self-organize at the community level is 39. Since the score represents actual votes from participants to any listed strategy, we can say that the median score of 'ability to community self-organization' represents the votes from 8% of respondents. The items listed within the top half (above the median line) correspond to adaptation strategies with high potential for self-organization at the community level.

Based on Figure 4.29 below, there are 2 top-strategies considered by most of the PRA participants: reforestation and/or stop deforestation of mangroves and other trees species (48.5%), and construction and/or protection of houses to make them studier using local materials (43.8%). Other adaptation strategies with good chances of community buy-in include construction of drainage systems to divert water from flooding (20%) as well as increase awareness to climate change impacts (20%).

Among the strategies with the least chances of community self-organization include increasing the number of toilets and/or sanitation facilities (0.4%), transportation by boat to nearby villages (0.4%), increase the number of health facilities and services (1.2%), and teachers' financial support (1.2%).

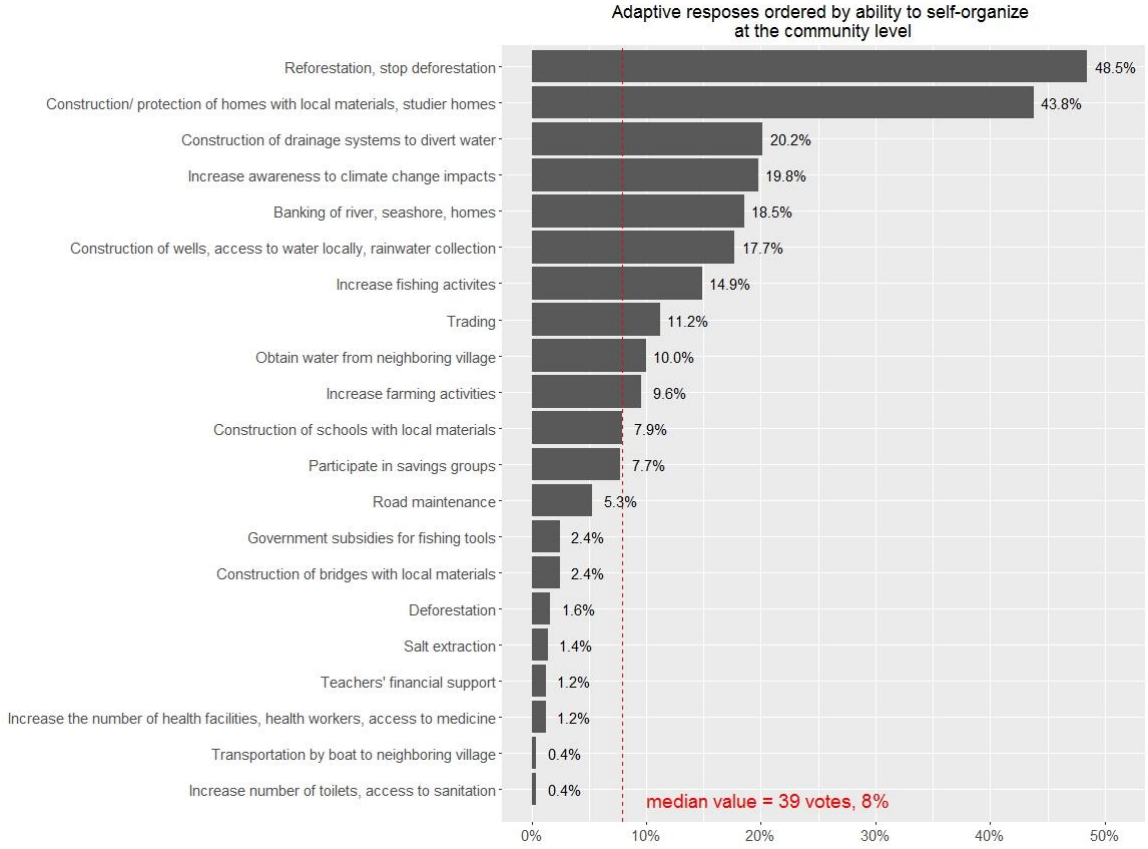


Figure 4.29: Frequency distribution of adaptive responses as a percentage of PRA participants, ordered by the ability for communities to self-organize, in three out of four regions

Adaptive responses considered with the highest and lowest levels of dependency on external funding and/or technical assistance

The median score of adaptive strategies in regards to dependency on external sources of funding, technical assistance and foreign interventions is 55. Since the score represents actual votes from participants to a given strategy, we can say that the median score of 'external dependency' represents the votes from 11% of respondents. The adaptive strategies listed in the upper half (above the median value) represent the ones prone to require external assistance for their implementation.

As can be seen in Figure 4.30, the adaptation strategies with the highest levels of external assistance include construction and/or protection of homes (45%), reforestation and/or stop deforestation of mangroves and other trees species (43%), construction of wells and/or increase access of local water sources (27%), and increasing fishing activities (17%) .

The adaptation strategies with the lowest levels of external assistance include the increase of sanitation facilities (1.8%), construction of bridges (2.4%), salt extraction (2.4%) and transportation by boat to nearby communities (3.1%).

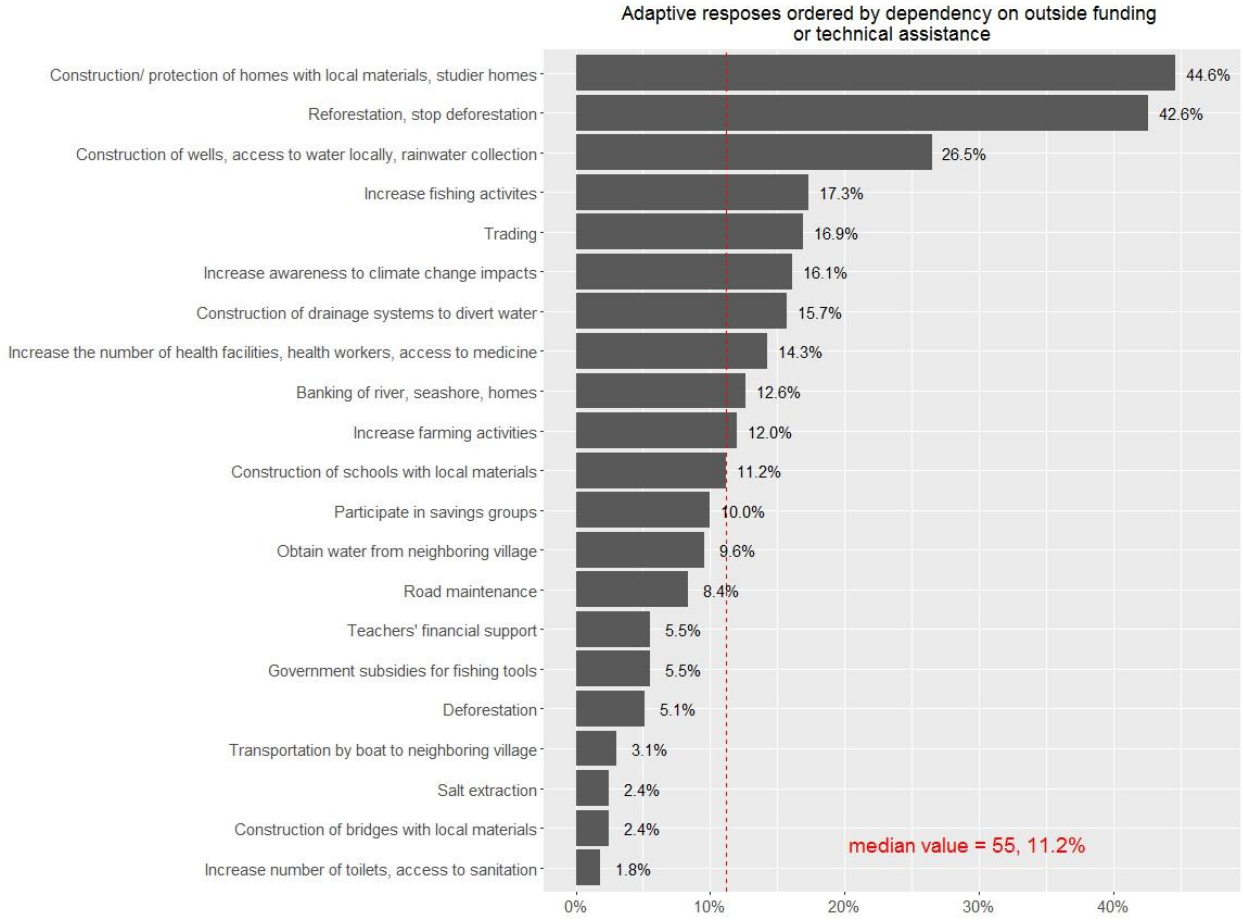


Figure 4.30: Frequency distribution of adaptive responses as a percentage of PRA participants, ordered by level of dependency on outside funding or technical assistance, in all regions.

Adaptive responses that could be considered as quick wins

If we were to choose which adaptation strategies to support in the short term, we would be looking at those that are highly preferred by respondents, with relatively low difficulty to put in place (as perceived by PRA participants), with a relatively high chance for communities to self-organize in order to implement and sustain, and with relatively low external dependency. We will call this arrangement 'Scenario 1'. The ordering of the external dependency dimension could be contested. In order to put adaptation strategies in place, communities may need the assistance of external actors at the onset and during an initial period (i.e., seed funding, technical expertise from NGOs and/or researchers, institutional capacity). However, once strategies are up and running, external dependency may not be entirely necessary for quick implementation; therefore, the external dependency dimension could be flipped (i.e., ordered from high to low). We will call this arrangement 'Scenario 2'.

Assuming that all dimensions have an equal weight, a simple count of ordered strategies based on the parameters outlined as scenario 1 or 2, could give an indication of which adaptation mechanism could be considered as quick wins: positive, near-term results, with relatively low risk. We decided to limit the number of strategies up to 12, in order to capture more than half of the adaptive mechanism listed by participants. Table 4.1 shows the adaptation strategies following the order outlined for Scenario 1, and Table 4.2 shows the same under Scenario 2. Both tables show the strategies labeled as 'quick wins'.

Looking at potential adaptation mechanisms under the conditions listed as Scenario 1 (Table 4.1), the analysis resulted in five adaptation strategies identified as quick wins, which include: participating in savings groups at the community level, increasing awareness to climate change impacts, increase farming activities, road maintenance, and the construction of schools.

Table 4.1. Scenario 1 - adaptation strategies ordered by preference (descending), difficulty (ascending), ability to self-organize (descending), and external dependency (ascending). Only adaptive mechanisms with scores of 3 or 4 were considered 'quick wins'.

Preference (high to low)	Difficulty (low to high)	Ability to self-organize (high to low)	External dependency (low to high)	Quick wins	# counts (equal weight)
REFORESTATION	CLIMATE	REFORESTATION	SANITATION	SAVINGS	4
HOUSE	HEALTH	HOUSE	BRIDGE	CLIMATE	3
DRAIN	BRIDGE	DRAIN	SALTEXTR	FARM	3
LOCALWATER	SALTEXTR	CLIMATE	TRANSPORTATION	ROAD	3
RIVBANK	TRANSPORTATION	RIVBANK	DEFORESTATION	SCHOOLS	3
CLIMATE	SANITATION	LOCALWATER	FISHSUBSIDIES		
SAVINGS	ROAD	FISHING	TEACHERS		
HEALTH	FISHSUBSIDIES	TRADING	ROAD		
FISHING	TEACHERS	EXTWATER	EXTWATER		

FARM	DEFORESTATION	FARM	SAVINGS		
TRADING	SCHOOLS	SCHOOLS	SCHOOLS		
ROAD	SAVINGS	SAVINGS	FARM		

Key: (BRIDGE) Construction of bridges with local materials ; (CLIMATE) Increase awareness to climate change impacts; (DEFORESTATION) Deforestation of mangroves and other trees species; (DRAIN) Construction of drainage systems to divert water; (EXTWATER) Obtain water from neighboring village; (FARM) Increase farming activities; (FISHING) Increase fishing activities; (FISHSUBSIDIES) Government subsidies for fishing tools; (HEALTH) Increase the number of health facilities, health workers, and access to medicine; (HOUSE) Construction/ protection of homes with local materials, studier homes; (LOCALWATER) Construction of wells, access to water locally, rainwater collection; (REFOREST) Reforestation, stop deforestation; (RIVBANK) Banking of river, seashore, homes; (ROAD) Road maintenance; (SALTEXTR) Salt extraction ; (SANITATION) Increase number of toilets, access to sanitation; (SAVINGS) Participate in savings groups; (SCHOOLS) Construction of schools; (TEACHERS) Teachers' financial support; (TRADING) Trading; (TRANSPORTATION) Transportation by boat to neighboring village.

The list of potential quick wins under the conditions listed as Scenario 2 are shown in Table 4.2. There are 12 adaptation mechanisms that resulted as quick wins. Interestingly, almost all quick wins identified under the conditions in Scenario 1 (except for road maintenance) intersect with the ones identified under Scenario 2. In this sense, it is possible that initiatives revolving around these topics may have positive, near-term outcomes: increase awareness to climate change impacts, participating in village savings groups, increase farming, construction of schools. Other initiatives ranked high in 3 out of 4 dimensions include: construction and/or protection of housing structures against climate impacts, reforestation efforts, increase access to local water sources, and protection against flooding (either by draining water, or elevating built structures).

Table 4.2. Scenario 2 - adaptation strategies ordered by preference (descending), difficulty (ascending), ability to self-organize (descending), and external dependency (descending).

Preference (high to low)	Difficulty (low to high)	Ability to self-organize (high to low)	External dependency (high to low)	Quick wins	# counts (equal weight)
REFORESTATION	CLIMATE	REFORESTATION	HOUSE	CLIMATE	4
HOUSE	HEALTH	HOUSE	REFORESTATION	SAVINGS	4
DRAIN	BRIDGE	DRAIN	LOCALWATER	DRAIN	3
LOCALWATER	SALTEXTR	CLIMATE	FISHING	FARM	3
RIVBANK	TRANSPORTATION	RIVBANK	TRADING	FISHING	3
CLIMATE	SANITATION	LOCALWATER	CLIMATE	HEALTH	3
SAVINGS	ROAD	FISHING	DRAIN	HOUSE	3
HEALTH	FISHSUBSIDIES	TRADING	HEALTH	LOCALWATER	3
FISHING	TEACHERS	EXTWATER	RIVBANK	REFORESTATION	3
FARM	DEFORESTATION	FARM	FARM	RIVBANK	3
TRADING	SCHOOLS	SCHOOLS	SCHOOLS	SCHOOLS	3
ROAD	SAVINGS	SAVINGS	SAVINGS	TRADING	3

Adaptive responses could be considered as medium-term interventions

If we were to choose adaptation strategies to support in the medium-term, we would be looking at those that are highly preferred by respondents, categorized as highly difficult to implement by PRA participants, with relatively high chance of communities to self-organize, and with relatively high scores for external dependency. These types of interventions could be considered as communities' wish-lists, which could only be implemented with targeted help from outsiders. We will call this arrangement 'Scenario 3'.

Similar to the previous analysis, we assume an equal weight in all dimensions, and we will limit the number of strategies up to 12. Table 4.3 shows the results for the strategies tagged as 'medium-term'. Issues such as reforestation, construction and/or protection of houses, mechanisms to divert water to protect land and/or built structures from flooding, access to local water sources, increasing farming and fishing practices, as well as community saving schemes and trading mechanism came at the top. Increasing awareness to climate change impacts, as well as construction of new local schools came in second place.

Table 4.3. Scenario 3 - adaptation strategies ordered by preference (descending), difficulty (descending), ability to self-organize (descending), and external dependency (descending).

Preference (high to low)	Difficulty (high to low)	Ability to self-organize (high to low)	External dependency (high to low)	Medium-term interventions	# counts (equal weight)
REFORESTATION	HOUSE	REFORESTATION	HOUSE	REFORESTATION	4
HOUSE	REFORESTATION	HOUSE	REFORESTATION	HOUSE	4
DRAIN	TRADING	DRAIN	LOCALWATER	DRAIN	4
LOCALWATER	FISHING	CLIMATE	FISHING	LOCALWATER	4
RIVBANK	LOCALWATER	RIVBANK	TRADING	RIVBANK	4
CLIMATE	RIVBANK	LOCALWATER	CLIMATE	FARM	4
SAVINGS	DRAIN	FISHING	DRAIN	FISHING	4
HEALTH	FARM	TRADING	HEALTH	SAVINGS	4
FISHING	EXTWATER	EXTWATER	RIVBANK	TRADING	4
FARM	SAVINGS	FARM	FARM	CLIMATE	3
TRADING	SCHOOLS	SCHOOLS	SCHOOLS	SCHOOLS	3
ROAD	DEFORESTATION	SAVINGS	SAVINGS		

Changes in preference of adaptive solutions under climate change scenarios.

The participants were also asked how their preference for a given solution, among the ones they listed in their respective groups, would change given that climate related disaster would change in frequency, intensity or duration. No new options were discussed, only the ones previously listed. Figure 4.31 shows the average changes in preference for each solution expressed as 'much less preferred', 'less preferred', 'more

preferred' and 'much more preferred'. While the degree of preference (as well as difficulty, ability to organize and reliance on external support) were recorded In the previous question as percentage of respondents expressing strong positive opinion about these attributes of the solutions, here the responses were recorded for the focus group as a whole. To allow comparison with the response to the previous question the answer of the focus group on the change of preference was weighted by the size of the group, then divided by the total number of individuals who indicated strong preference for the solution to obtain the percentage of respondents in each preference-change category who initially favored the solution. These changes are now represented as percentage of the initial percentage of respondents favoring the solution.

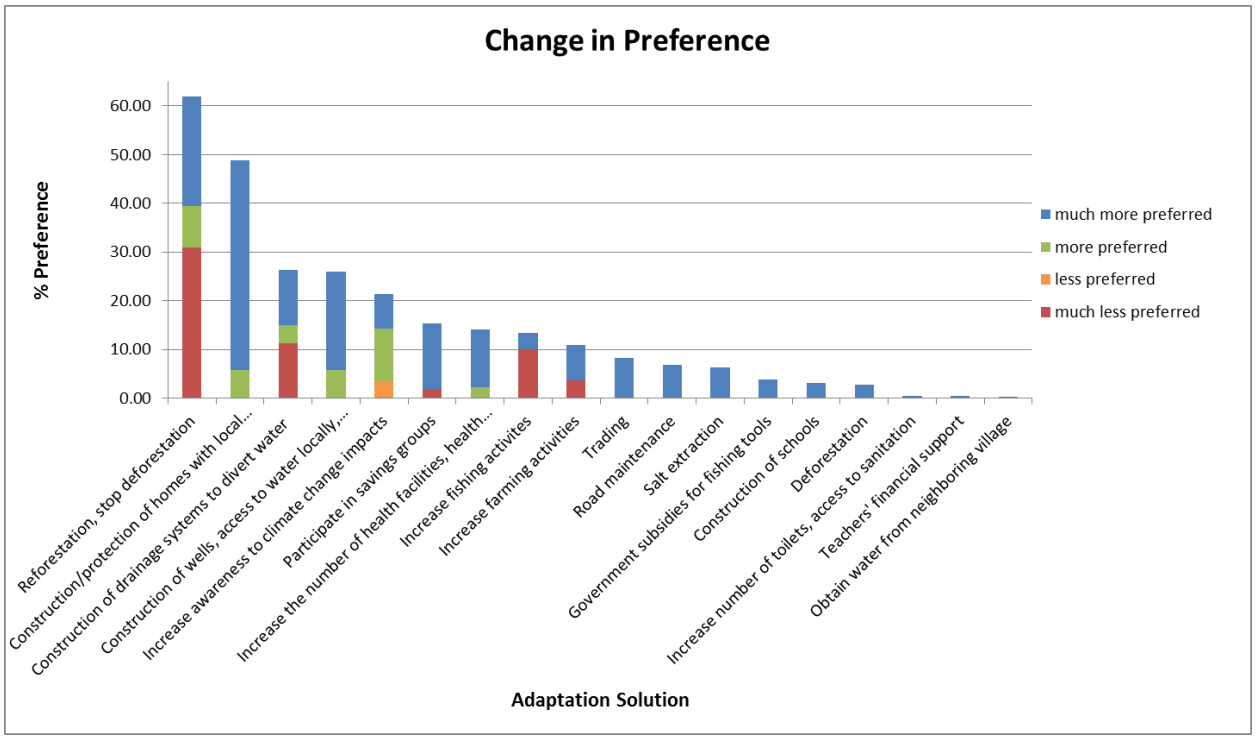


Figure 4.31: Change in the preference for a given solution as percentage of the initial preference score when considering potential future climate impacts. Blue bar indicates the percentage of participants favoring given solution that will prefer it much more, green – more, orange – less and red – much less.

We focus here on the nine solutions for which at least 10% of the respondents indicated a strong preference. Several of the solutions initially favored by more than 10% of the participants showed a strong decrease in the preference (red bar). Reforestation, drainage system and increase in fishing activities all showed a strong decrease in preference for at least 50% of participants (more than 80% for fishing activities) indicating that these solutions are not seen as very effective to address potentially increased occurrence or magnitude of disasters by 50% of the participants who favored

them initially. However, with the exception of fishing, they also recorded an increase in preference for 50% of the respondents. The other three solutions that recorded a decrease in preference only recorded it marginally and were dominated by increase in preference.

A strong increase in preference was recorded for: sturdier homes, saving groups, wells/local water and health facilities, with sturdier homes recording much stronger preference for more than 80% of the focus groups who listed this as desirable solution. This shows that solutions leading to more secure and healthier living conditions would be the priority for the majority of the respondents.

Mangroves

The WA BiCC project has a significant interest in mangrove conservation, since mangrove ecosystems contribute to resilience to climate change. In this section, we present the results of an assessment of the change of mangrove forest extent in Sierra Leone, the results of the in-situ surveys along the transects and communities' perceptions of mangrove.

Change in mangrove cover In Sierra Leone

This mapping was done as part of establishing the forest cover baseline for the four WA BiCC focus areas in coastal Sierra Leone. In order to achieve this, CIESIN completed a mapping effort utilizing satellite images for the baseline year of 2016. Landsat 8 images (spatial resolution: 30m) were compiled from winter/spring of 2016 into a cloud-free composite on the Google Earth Engine (GEE) platform. The low elevation coastal zone was identified by selecting elevation < 40 m utilizing the Shuttle Radar Topography Mission (SRTM) digital elevation data (spatial resolution: 30m). An unsupervised classification technique (Fatoyinbo and Simard, 2013) was utilized to classify the mosaicked image into 4 broad land cover types – (1) water/wetland, (2) mangrove, (3) other vegetation, and (4) built/bare soil (Figure 4.32). A total of 200 validation points were collected from high-resolution Sentinel-2 images (spatial resolution: 10m for visible bands) from the same time-period on GEE platform. The overall accuracy of the classification is very high, at 95.5%.

CIESIN also completed similar mapping exercise for 1990, in order to quantify the changes in mangrove extents between 1990 and 2016 in the focus areas (Figure 4.33). Multiple buffers –1km, 2.5km, 5km – were created from the coastline inland for each of the four regions to quantify mangrove changes over time (Table 4.3).

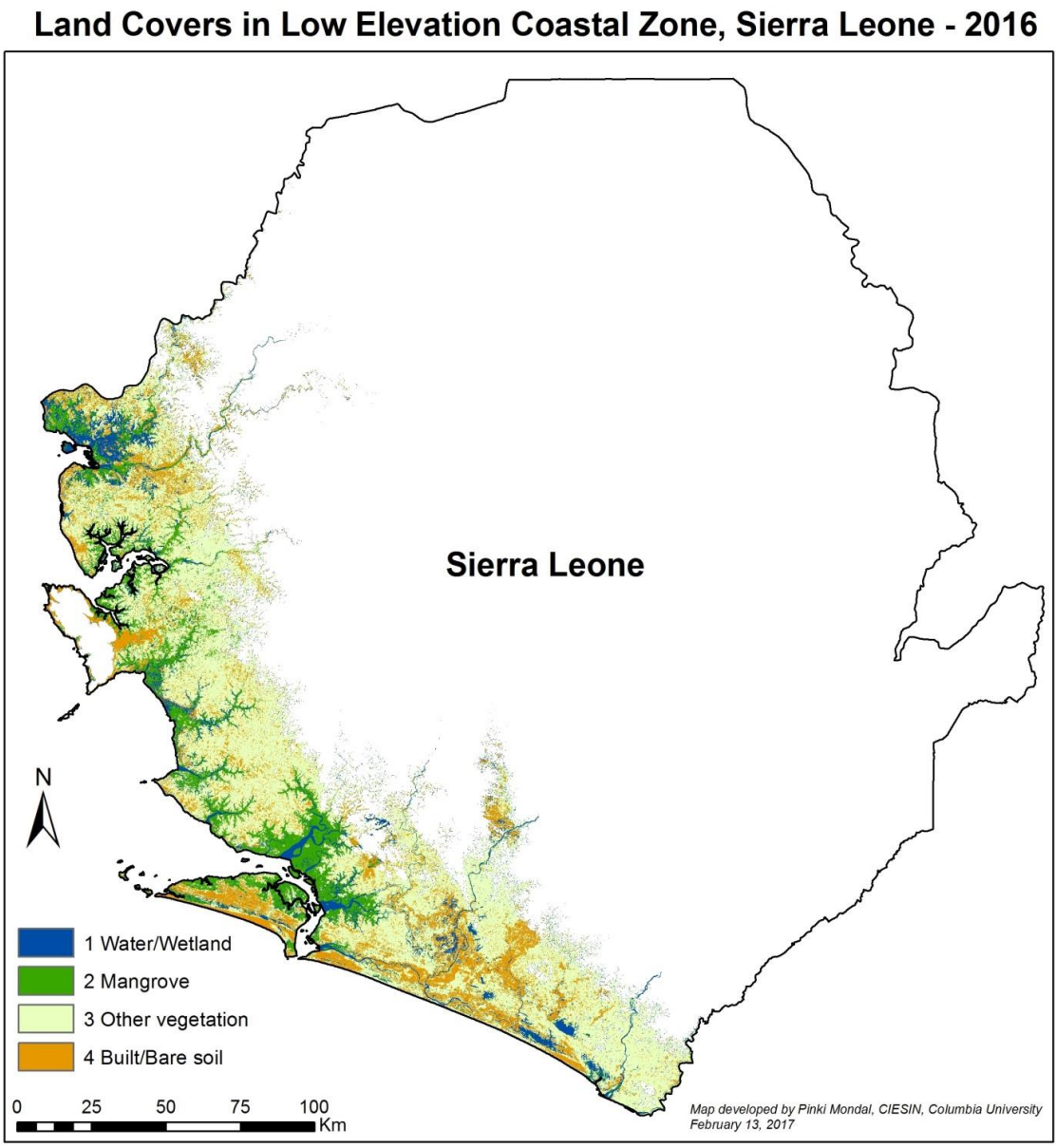


Figure 4.32: Land covers in low elevation coastal zone (elevation < 40m) of Sierra Leone

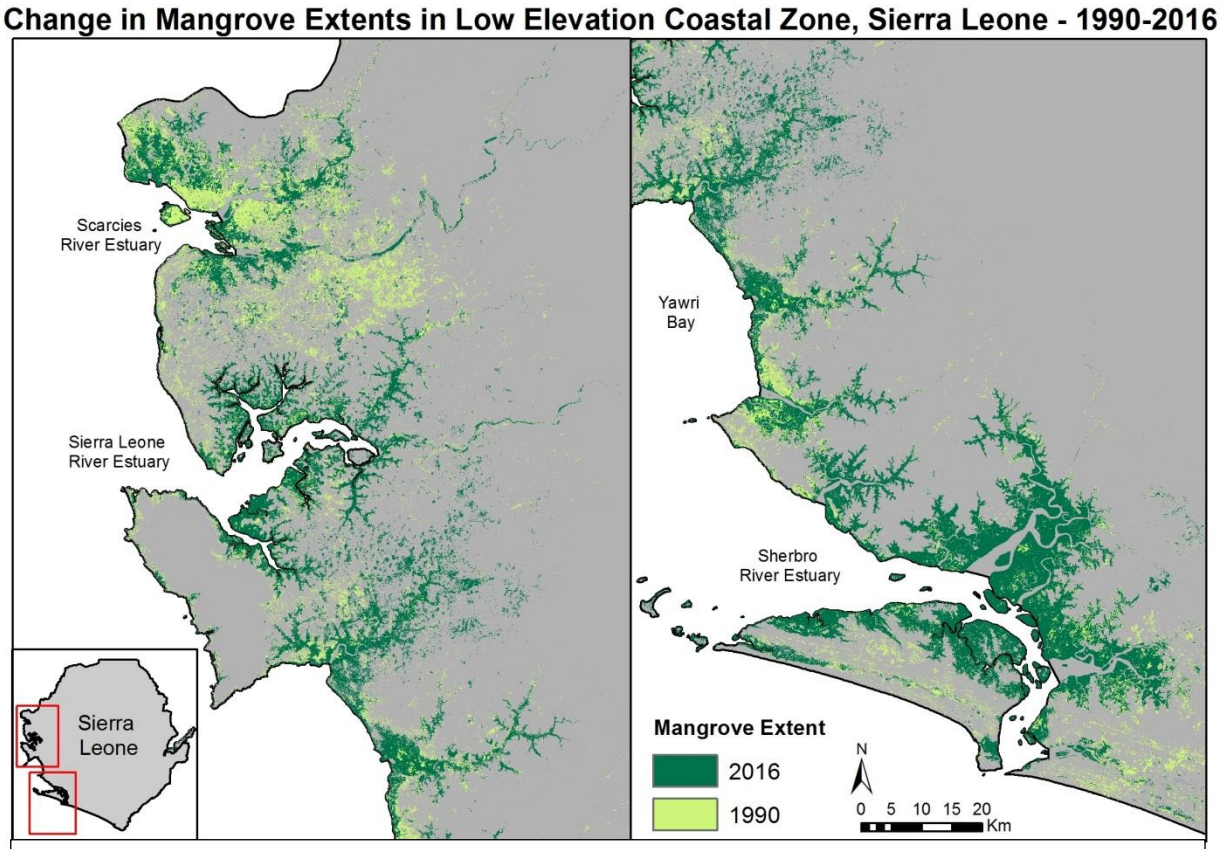


Figure 4.33: Changes in mangrove extents in coastal Sierra Leone between 1990 and 2016. Light green color represents mangrove loss between 1990 and 2016.

For the analysis of mangrove forest cover change in the near coastal zone, Table 4.3 shows that overall mangrove cover in Sierra Leone has decreased by 25% between 1990 and 2016, but large differences are observed between regions. The largest decrease in mangrove cover, of up to 46% for the 1km buffer (and easily seen in Figure 4.33), is observed in the Scarcies River Estuary and is linked with the transformation of mangrove areas to rice farming. However, it is worth noting that the SLRE has seen increases in mangrove cover across all buffer extents, linked with reforestation efforts (fig. 4.34). The other three regions have seen declines for the largest (5km) buffer size, which can be partly linked to the conversion of the partially flooded areas adjacent to higher ground to rice paddies by farming communities (fig. 4.35).

Table 4.3: Summary of mangrove extents (area in sq. km.) during 1990 and 2016 for the four focus areas in coastal Sierra Leone. Light green cells denote mangrove gain, while light red cells denote mangrove loss during 1990-2016.

Region	1 km buffer			2.5 km buffer			5 km buffer		
	1990	2016	Change relative change	1990	2016	Change relative change	1990	2016	Change relative change
Sierra Leone River Estuary	131.98	160.67	28.69 22%	213.04	248.72	35.68 17%	262.02	291.12	29.10 11%
Sherbro River Estuary	337.42	356.47	19.06 6%	591.58	606.21	14.63 2%	768.76	763.76	-5.00 -1%
Scarcies River Estuary	31.98	17.33	-14.64 -46%	73.47	42.35	-31.12 -42%	142.83	90.67	-52.16 -37%
Yawri Bay	14.35	15.56	1.21 8%	60.16	54.95	-5.20 -9%	138.41	114.08	-24.33 -18%
	1990	2016	Overall change Relative change						
Coastal Sierra Leone	2433.92	1827.92	-606.01 -25%						

Figure 4.34: Reforested mangrove area in the SLRE region. All the mangrove trees are of same age, and relatively young. Photo Credit: S. Trzaska, June 2016

Figure 4.35: looking in the direction of the sea shore, from one of the farming villages in Yawri Bay. The sea is a few miles away. The landscape consists of patches of land high enough to allow trees to grow intermingled with flooded areas that have been cleared for rice culture. Not visible from this picture is the mangrove that covers areas closer to the sea. This village is located far enough from the sea and the mangrove area and has enough other wood sources that there is no fishing activity nor mangrove cutting. Photo Credit: S. Trzaska, June 2016

Mangrove status in selected sites

This section details some of the findings from the twelve transects surveyed in the four regions. The maps below present the transects overlaid on satellite pictures of the surroundings. The exact coordinates of the plots can be obtained on request.

Individual Transects

Transect locations were recorded using GPS devices. Figure 4.36 provides maps of the mangrove transects.

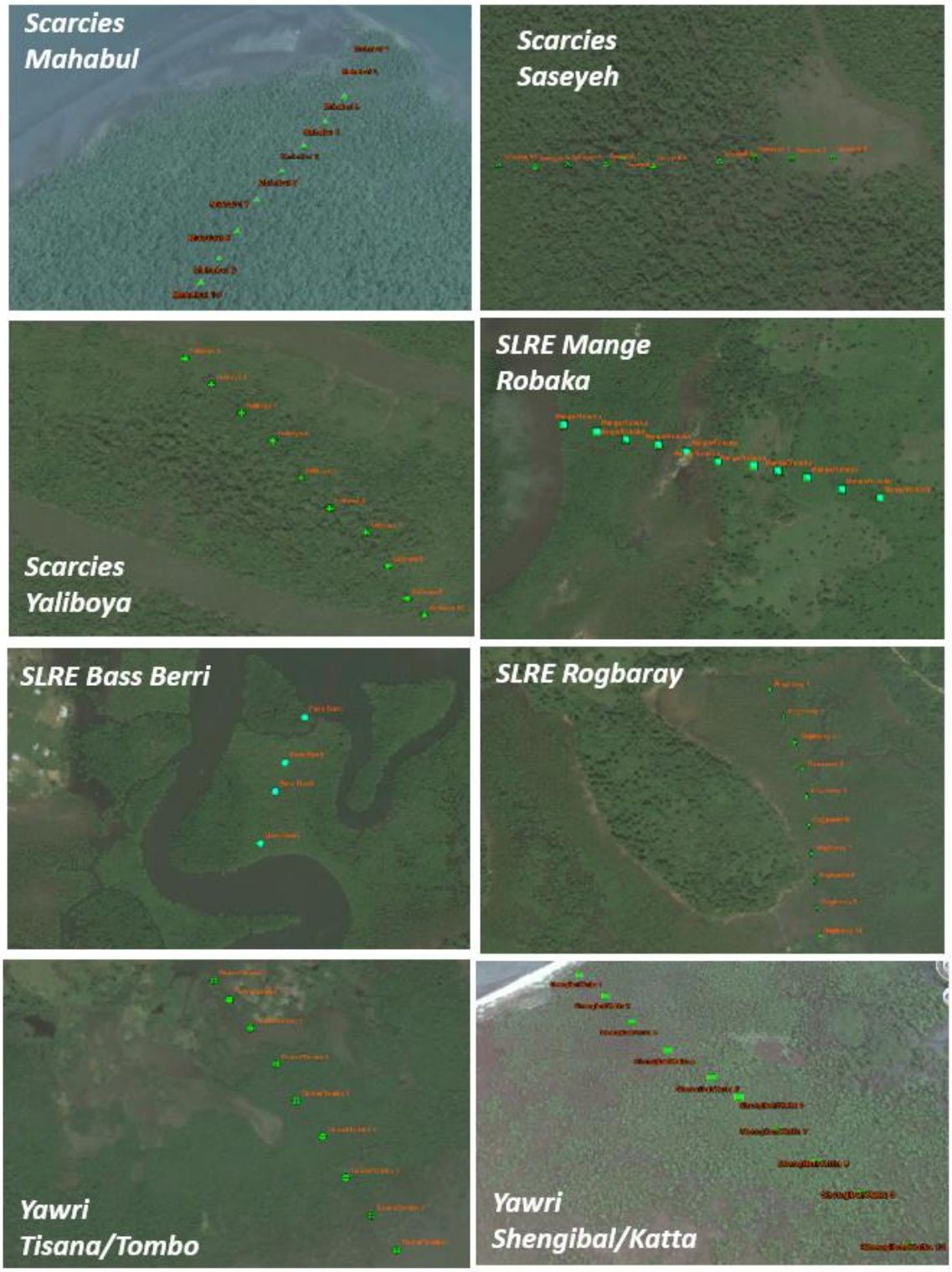


Figure 4.35. Maps of individual transects overlaid on World Imagery - Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

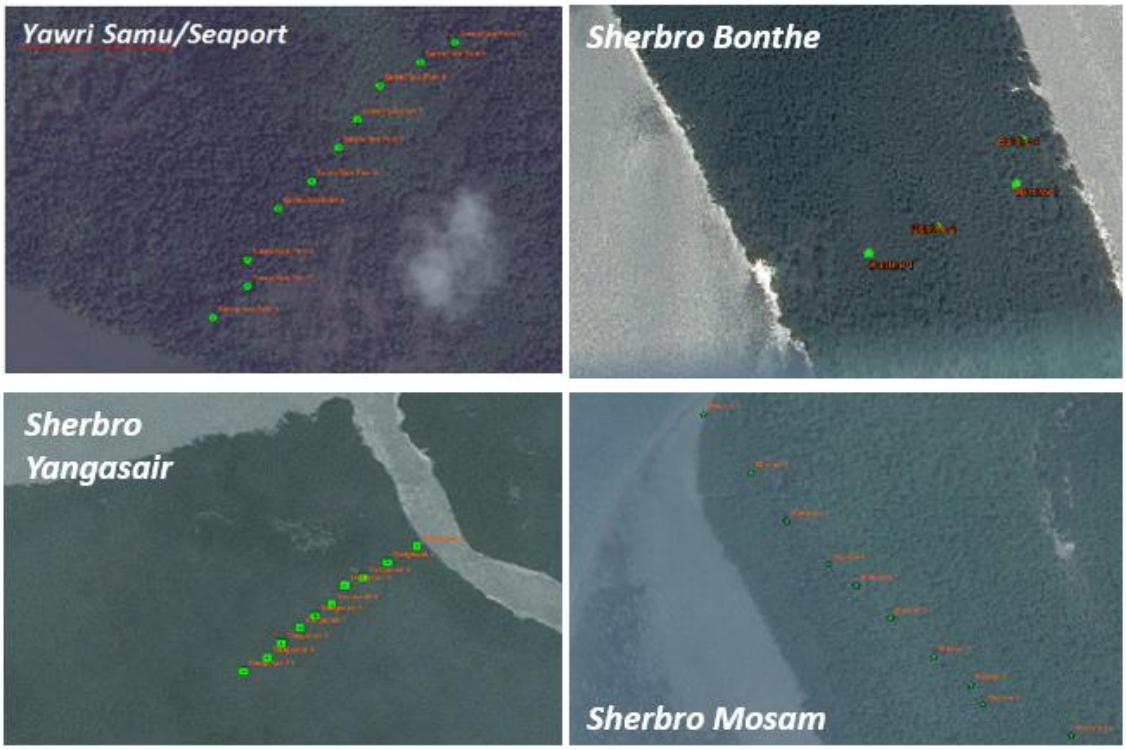


Figure 4.35 (continued). Maps of individual transects overlaid on World Imagery - Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Mangrove composition

A total of five species of mangrove were recorded across the three regions, namely *Avicennia germinans,* which constitute about 70% of all trees in the most northern areas and in Yawri Bay, followed by *Rhizophora racemose, Rizophora harissonii, Laguncularia racemose* and *Rhizophora mangle*. The highest number of species are recorder in the Scarcies and SLRE (five) while only three are present in Yawri Bay and Sherbro River Estuary, where *Rhizophora Harissonii* and *Rhizophora* mange are not present. SLRE has the largest number of non-mangrove species observed. In Sherbro area *Rhizophora Racemosa* is the most abundant species while it is relatively rare in the Scarcies. The lower proportions of *Rhizophora Recemosa* in some areas could be due to overharvesting.

Table 4.4. Average mangrove forest composition in each of the four regions. The numbers are averaged over all the plots in all three transects in each region

Analysis Factor	Scarcies	Yawri Bay	SLRE	Sherbro
Number of Mangrove Species	5	3	5	3
Avicennia germinans (%)	75.33	66.33	19.00	37.67
Rhizophora harissonii(%)	4.00	0	18.00	0
Rhizophora mangle (%)	3.67	0	3.67	0
Rhizophora racemosa (%)	15.00	25.67	37.33	61.33
Laguncularia racemosa (%)	0.02	8.00	6.67	1.00
Anisophylia laurina (%)	0	0	5.33	0
Other non-Mangrove spp (%)	0	0	10.00	0

Size of the trees

Figure 4.37 presents further details on the basal area, height and number of adult trees in the four regions. Sherbro region records show the largest basal area, lowest number of adult trees per hectare and the tallest trees. It is reasonable to conclude that the forest in Sherbro area are the oldest. Highest density of trees is found the forests in the Scarcies and Yawri Bay regions, with medium basal areas and tree heights pointing to mature forests. Lowest basal areas, lowest tree height with medium adult tree density are observed in the SLRE region, pointing to youngest forest and probably the highest exploitation levels. Note that the transects were conducted outside of the main re-forestation areas.

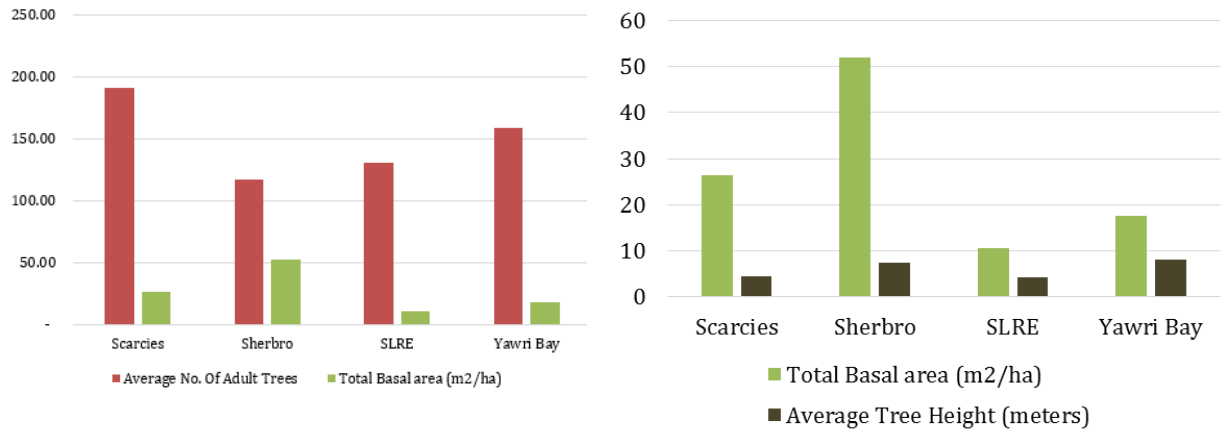


Figure 4.37: Left: average number of adult trees (red) and average basal area (green) in each region; Right: average number of adult trees red) and average basal area (green) in each region

Figure 4.38. Adult mangrove trees in the Sherbro area. Photo credit: S. Trzaska, February 2016

Sensitivity of the forest

Here we explore indicators related to the sensitivity and adaptive capacity of the forest such as human pressure (through cutting) or regeneration capacity. Cutting is present in all plots but the highest rates were observed in Sherbro River Estuary, while the other regions seem to experience lower levels of cutting. At the same time Sherbro shows the lowest density of seedlings and the highest proportion of plots without regeneration. The highest presence of farming within the transects is in the Scarcies, which is consistent also with the highest deforestation levels noted in previous sections.

Figure 4.39. Young seedlings in the mangrove forest. Photo credit: A. Lebbie, July 2016.

Table 4.5: Cutting and regeneration levels in the mangrove forests surveyed in four regions.

Evaluation factor	Scarcies	Yawri Bay	SLRE	Sherbro
Average No. of adult trees/plot	191	117	131	159
No. of seedlings per ha	5926	6480	4545	717
No of plots with zero regeneration	10%	17%	28%	43%
No. of plots with cutting	60%	54%	56%	80%
No. of plots with cultivation	7%	0%	0%	0%

In summary, the mangroves that have not been converted to farming in the Scarcies region are doing relatively well, with high species diversity, mature forest and high regeneration levels. They are under pressure from cutting and farming but if human pressures are limited they have high potential to remain resilient. The Sherbro region is on the opposite side of the spectrum, with lowest species diversification, highly dominated by *Rhizophora Racemosa*, with the oldest trees and lowest regeneration rates. It is unclear why the regeneration is so low, nor is it clear why there is a predominance of one species. This requires further investigation of the environmental determinants on the mangroves in this region. Human pressure is also high and this could be due to the presence of large trees in highly desirable species. Overall deforestation rates and conversion to rice paddy are lowest in that area. This area has probably the highest commercial potential provided proper management strategies are put in place. SLRE has the youngest forests, and the greatest signs of past and current exploitation of the forest (perhaps owing to proximity to Freetown). But the regeneration rates and species diversity indicate a healthy forest provided that human pressures are limited. Yawri Bay has fewer adult trees but the highest number of seedlings and is expected to recover easily if protected and sustainably managed.

Communities use and perceptions of mangroves and changes in mangrove forests

The results from the analysis of transect data indicate various degrees of resilience of the mangrove forests in the four regions. Some of the vulnerabilities are related to the forest characteristics themselves, such as species composition, some are linked with human pressures on the forests. In this section, we examine in more detail the type of pressures exercised by the communities, their perceptions of the changes in the mangroves and the main causes as well as the willingness of the communities to participate in mangrove reforestation/management efforts. The results are based on the questions in the households' surveys pertaining to the importance of the mangroves in the livelihoods, perception of changes in mangrove abundance, and the household use of mangrove wood.

Different uses of mangrove wood

Respondents were asked to list as many benefits of mangroves as they could. Figure 4.40 shows that the most important benefit, with more than double the next highest response, was as a source of fuelwood. This was followed by fish breeding habitat, source of building materials, and two that relate to climate impacts, the way in which they protect shorelines from strong winds (thereby reducing the impact of storms) and help reduce sea erosion. Twelve percent of respondents stated that they did not know any benefits.

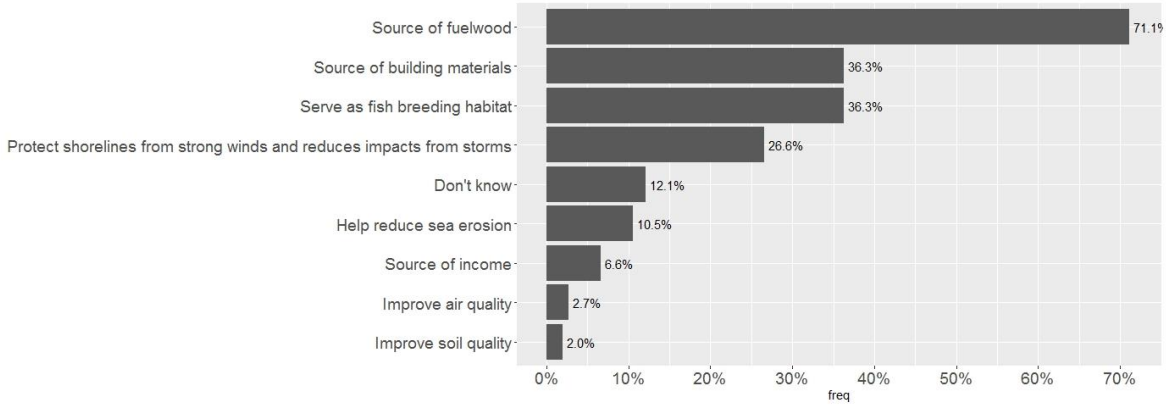


Figure 4.40: Mangrove benefits

Figure 4.41. Freshly cut mangrove 'sticks' off-loaded on the beach In Yeliboya. Such sticks are used for cooking and fish smoking. Photo credit: S. Trzaska, June 2016

Figure 4.42. Mangrove logs ready for shipping in Singbule. Photo credit: S. Trzaska, July 2016

The survey also included questions on the frequency of use of mangrove wood for various uses. Seventy percent of respondents said that their households had used mangrove wood in the past four weeks. Figure 4.43 shows that there is a high dependence on mangrove wood for cooking, fish smoking, and construction, with a smaller amount of charcoal production and furniture making activity.

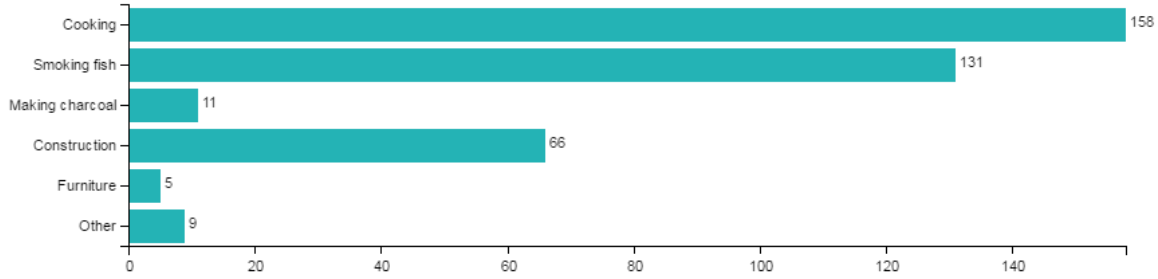


Figure 4.43: Number of respondents reporting different uses of mangrove wood in the household

Changes in the mangrove forests

Respondents were asked if, in the past 5 years, they had observed less mangroves or more mangroves than before among the areas that they or their households accessed (Figure 4.44). Forty-eight percent responded less, 30% reported that they could not discern a difference, 14% reported more than before, and 30% could not tell the difference. Results were similar but not identical when respondents were asked about the size of the mangrove forest near their community. Forty percent said that they are shrinking, 10% said they are about the same, and 15% said they are growing, and 34% were not sure. While in both cases more than 40%, the largest category, found that mangrove stands have declined in abundance, it is also true that a large percentage either don't know or cannot tell the difference. A distinct minority feel that mangrove stands are increasing.

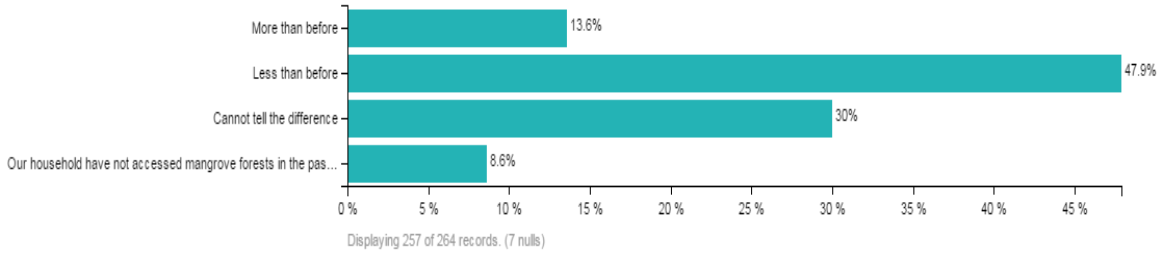


Figure 4.44: Percent of respondents agreeing with statements concerning the state of mangroves in the past five years compared with before

Figure 4.45 shows, among those who perceive that there are less mangrove forests than before, what they perceive to be the primary drivers of mangrove loss, and how they perceive the relative importance of those factors (with three being the highest importance). The biggest factor in terms of percentage of respondents and rank is that mangroves are an important livelihood source, followed closely by the fact that mangroves are an important source of energy. Construction material was mentioned by about 60% of respondents but has a lower rank than pest infestations, and about 10% of respondents felt that the decline is owing to natural cycles and not human activities. The low rank and incidence of cropland expansion may reflect that this is an issue primarily in the Scarcies.

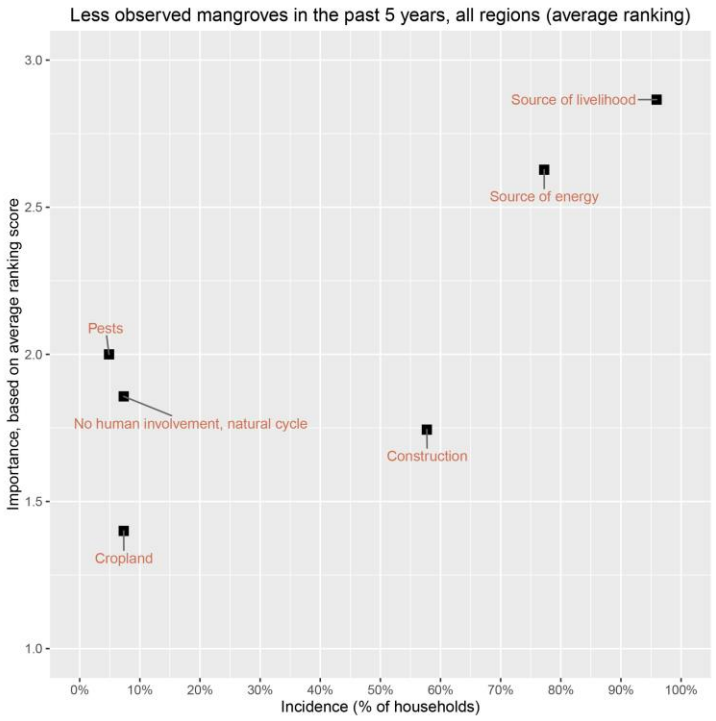


Figure 4.46: The incidence and average rank of factors driving mangrove loss

Willingness to engage in mangrove restoration/preservation

Finally, the survey asked a number of questions related to respondents' willingness to engage in activities to re-plant and preserve mangroves with or without compensation.

Figure 4.47 shows that almost two-thirds of respondents would be willing to participate without compensation, while one-quarter would not. Of the 44% who said no or were non-committal, 65% said they would engage in such activities with compensation, and the remaining 35% said no or remained non-committal.

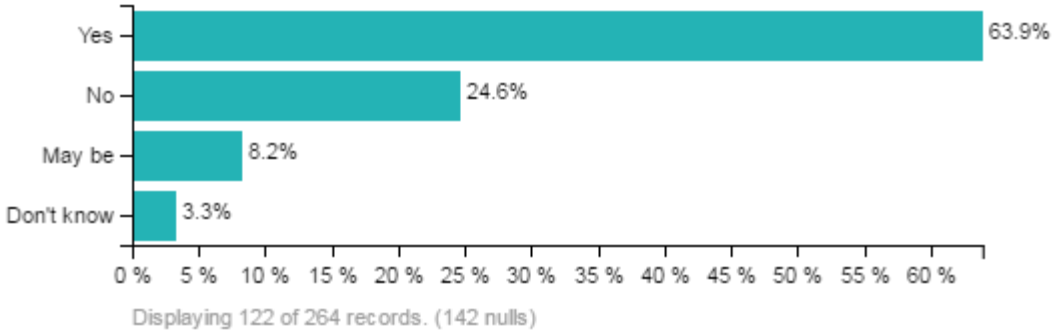


Figure 4.47: Percent of respondents who are willing to engage in activities to re-plant and preserve mangroves without compensation

Rules governing access and use of mangrove forests

When asked if there were traditional agreements or customary rules in place to access mangroves, approximately one quarter said yes, and one half said no, and another quarter did not know (see next section for an explanation of actual regulatory systems in place for mangroves). The results by region in Figure 4.48 show broadly similar responses across the regions, with Yawri Bay having a higher proportion of respondents who do not know. The discrepancy in the yes and no responses could be due to different traditional or customary rules across villages, or it may simply reflect a lack of awareness of rules that are in fact in place. In terms of government established legal restrictions, forty-five percent are aware that there are laws and regulations in place to protect mangroves, but 18% said they did not believe that such laws exist.

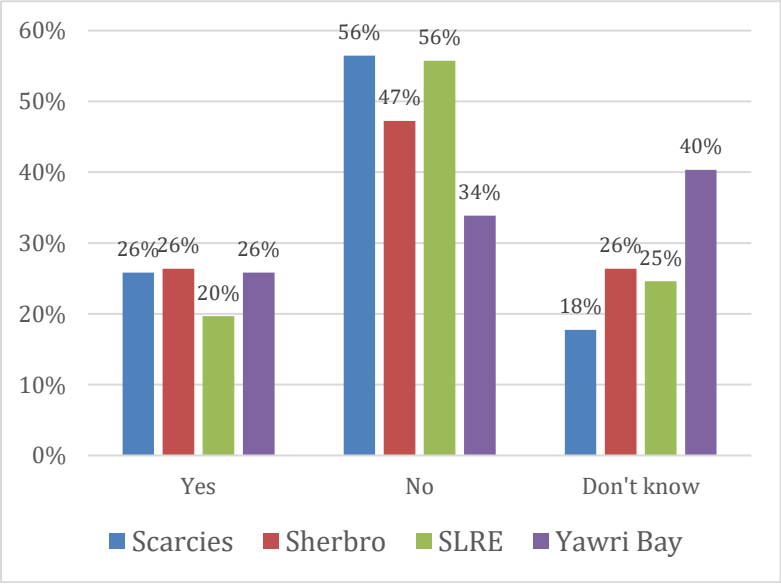


Figure 4.48: Answers to the question "are there traditional agreements or customary rules in place to access manaroves?"

Resources and Governance

In addition to specific questions about climate and mangroves each focus group was asked to list important resources and their associated governance regimes. In addition to the identified "natural" resources (mangrove, farmland, water well, river/stream, fish, sand, forest, sea, oil palm, and livestock), other types of "infrastructural" resources were also mentioned (mosque, secret society, hospital, and market). Governance regimes for each of these resources were: open access, customary restrictions or agreements, and government restrictions. As shown in Figure 4.49, mosque was the most commonly identified resource with almost all respondents identifying it as open access. Mangrove was another frequently mentioned resource with mostly open access but some government restrictions and customary restrictions or agreements.

An important finding is that most natural resources – farm land, water, fish, sand, forests, and oceans – are considered by a large percentage of focus groups as open access. A very small minority of focus groups mention traditional or government restrictions, with the highest being traditional restrictions for farm land. This view of natural resources as essentially open access may influence behaviors around resource capture. In the absence of restrictions – whether governmental, or preferably agreed upon by the community as a whole through co-management of natural resources – benefits can be captured (or privatized) at minimal cost, and there may be a perception that it is best to capture resources quickly, before others do so. In summary, there can be little incentive for conservation.

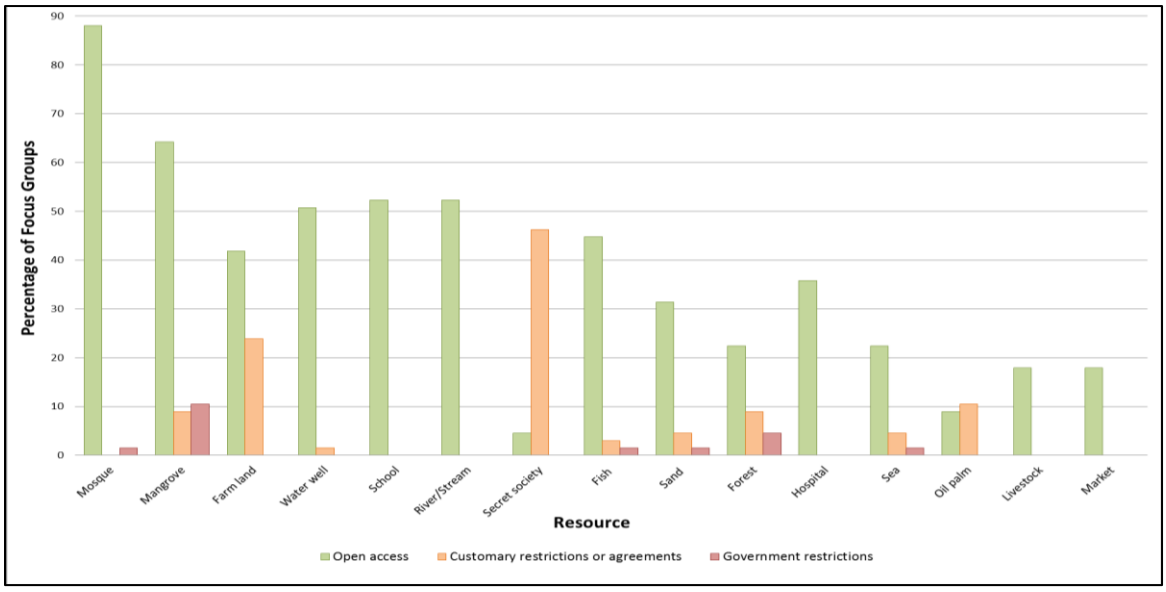


Figure 4.49: Resources and Governance, all regions

We close this section by describing the regulatory systems in place for the management of mangroves in Sierra Leone. Management of the mangroves is hampered by the fact that Ministry of Agriculture, Fisheries, and Food Security (MAFFS) has the mandate to

manage the mangrove (forest resource) whereas Ministry of Fisheries and Marine Resources (MFMR) has a mandate to manage fish and other living resources in the coastal and estuarine habitats. Furthermore, the National Protected Areas Authority (NPAA) has a mandate to conserve replanted areas in Yawri Bay. The result is a confusion over jurisdictional authority. To complicate matters further, both MFMR and MAFFS have devolved the functions of managing/licensing artisanal fisheries and forest exploitation to local councils (as dictated by the Local Government Act of 2004), which can be problematic in terms of sustainable management of the resources. Local councils are mainly interested in rent seeking and lack the capacity to manage resource exploitation. MFMR has therefore adopted the local community management approach with the use of Community Management Associations (Sankoh, *personal comm.*).

5. Overall Vulnerability

The objective of this section is to estimate the relative values of the vulnerability (and its components) of populations and mangroves. Social vulnerability by village was presented in Section 3, so here we only present separate social and ecosystem vulnerabilities by region and a map of aggregated vulnerabilities by village and by region.

Exposure, Sensitivity and Lack of Adaptive Capacity (Adaptive Capacity is inverted so that high scores equate to higher Vulnerability as with Exposure and Sensitivity) were computed based on indicators used previously in, or comparable to, other studies. Indicators used to construct different components of vulnerability are listed in Tables 2.4 and 2.5 of the Methodology section (Section 2).

Vulnerability of socio-economic systems

Aggregated vulnerability scores do not differ that much between regions. The analysis at the village and household level in Section 3 showed that there was no systematic regional pattern in vulnerability: in some regions all the locations surveyed presented similar, medium levels of vulnerability while in some others the results were highly contrasted, with some locations having lowest levels of vulnerability while the others were among the most vulnerable. Spatial distribution of vulnerability seemed to be more related to the size of the village and its remoteness rather than to the region. It is therefore not surprising that vulnerability scores averaged by region (Figure 5.1) do not vary significantly. Variations are slightly greater in individual components of vulnerability (Figure 5.2).

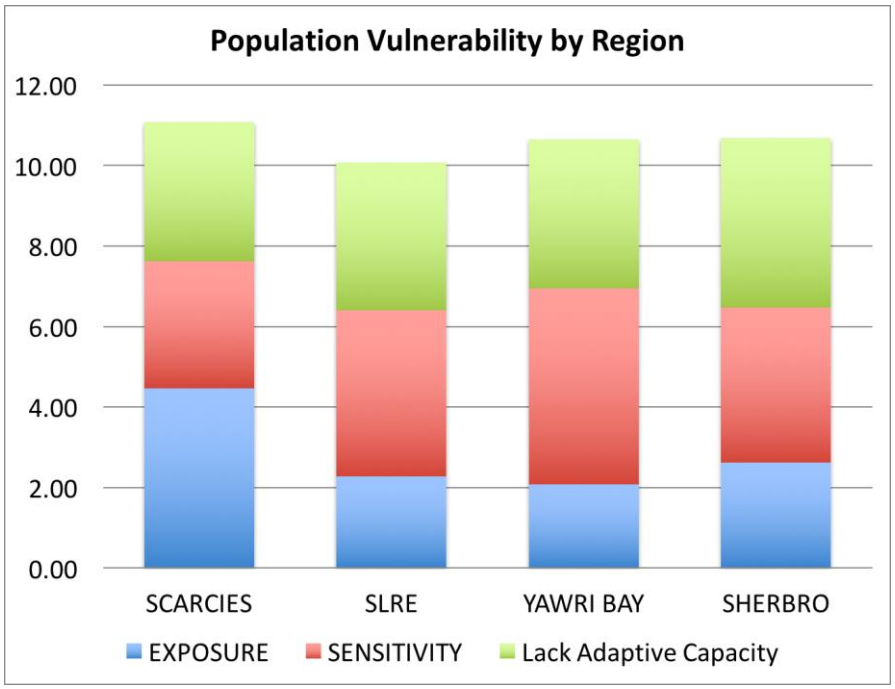


Figure 5.1: Distribution of Exposure, Sensitivity and lack of Adaptive capacity of the socio-economic systems

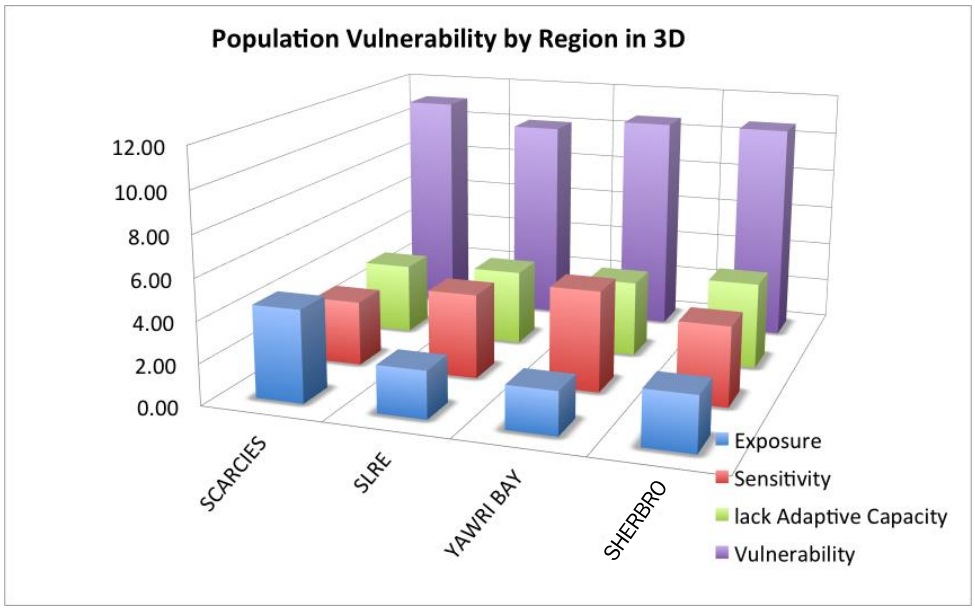


Figure 5.2: Same as figure 5.1 but separating the components of vulnerability

As already noted in the analysis at the household level, communities in the Scarcies report the highest levels of exposure while SLRE and especially Yawri Bay show the highest sensitivity. The lowest levels of adaptive capacity are observed in Sherbro area. In the Scarcies most of the villages surveyed were located on very low lying areas so the high levels of exposure are not surprising. Several villages had the experience of being relocated in the past. Yet villagers prefer remaining in those highly exposed locations to be close to fishing grounds. In SLRE and Yawri Bay, villages that define themselves as fishing communities were usually located on slightly higher, less exposed areas, and farming was quite widespread. Villages in Sherbro area were also mostly situated on very low grounds, close to water, but seemed to be more secluded and often better protected from winds and storms, although makeshift barriers to protect the houses from waves and storm were also wide spread. The high levels of sensitivity in Yawri Bay are linked to the presence of the most sensitive populations in certain, remote villages in the south while Tombo and Tissana in the North, close to Freetown and well connected to the rest of the country, show lowest levels of sensitivity and vulnerability. The low levels of adaptive capacity in the Sherbro region reflect mostly the remoteness and lack of access to infrastructure of several communities there, while Bonthe and York Island exhibit higher adaptive capacity.

Figure 5.3: Village of Moable (Scarcies) at high tide, July 2016. It is easy to imagine the impact of storm surge and high winds on the village Credit: S. Trzaska.

Figure 5.4: Mangroves in front of the Moable village are protected by village rules to shelter the village from high winds. It is rare to see old mangrove trees in front of the villages in the Scarcies. However, this protection is vulnerable to winds since, in the absence of regeneration, the soil is eroded and the roots cannot maintain the trees, which can easily fall. Mangroves are not protected on the other side of the village, where erosion and salt water intrusions are noticeable (not shown) Credit: S. Trzaska.

Figure 5.5: Village of Saseyeh (Scarcies) at low tide, July 2016. In This village all the houses are built on stilts in case of high water levels. This village has already relocated several times in the past. Credit: S. Trzaska.

Figure 5.6: The village of Makumpa (Scarcies) One of the few villages located on higher grounds, where the population defines itself as primarily fishing. Trees, more scattered houses as well as an improved water source are characteristic of villages located on slightly higher grounds. Its size and remoteness contribute however to its overall vulnerability. Credit: S. Trzaska.

Figure 5.7: Villages of Mange (pictured here) and neighboring Robakka in SLRE are also located on higher grounds and present different built-up characteristics than villages located directly on water . Their exposure levels are much lower. Credit: S. Trzaska, July 2016

Figure 5.8: Village of Mosam (Sherbro) at low tide. This village is characteristic of fishing communities of Southern Yawri Bay and Sherbro area with houses made of mud and thatched roofs. Those villages score the lowest on wealth index as well as adaptive capacity components. The absence of protective barriers seems to indicate that the village is less directly exposed to the impacts of storms and winds. Credit: S. Trzaska, July 2016

Mangrove Vulnerability

Vulnerability pattern for the mangroves exhibits a little more of a spatial pattern with higher values in general in the Scarcies and Sherbro regions (Figure 5.9). In the Scarcies the high vulnerability is mostly inked with highest exposure scores, while in the Sherbro region it is the lack of adaptive capacity that is mainly responsible for the high vulnerability. Yawri Bay shows overall the lowest vulnerability (although individual locations may have the highest vulnerability, e.g. Seaport), but the sensitivity is highest there. Note that the low levels of Lack of Adaptive Capacity (i.e. higher Adaptive Capacity) of the mangroves do not necessarily mean that the mangroves have high autonomous Adaptive Capacity without interventions. Rather, as it is the case in the Scarcies, this reflects the high willingness and readiness for the populations to participate in conservation/restoration interventions.

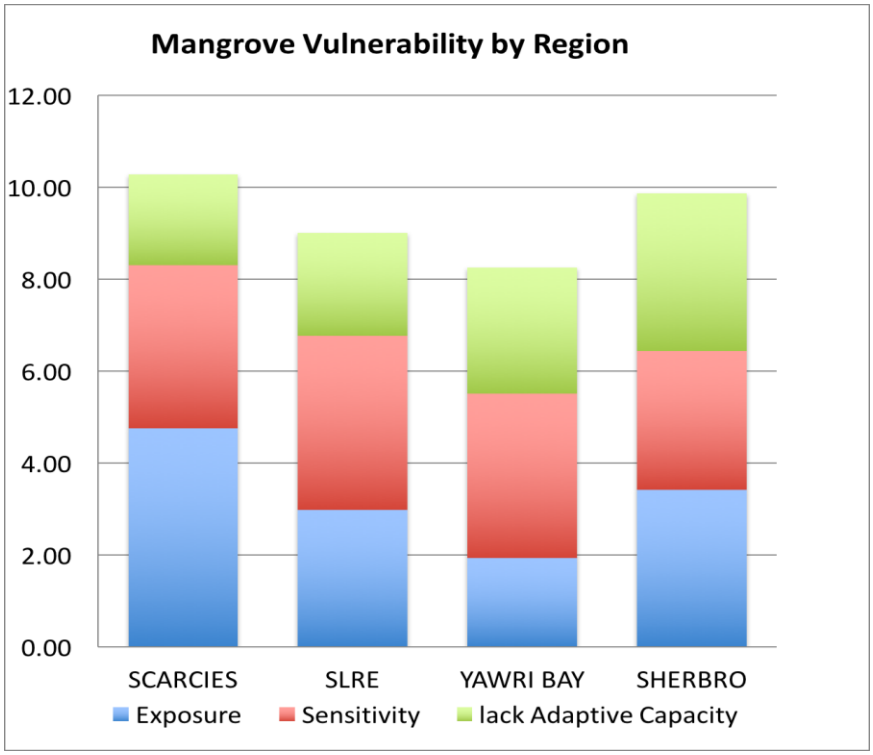


Figure 5.9: Distribution of Exposure, Sensitivity and lack of Adaptive capacity of the mangrove systems aggregated by region

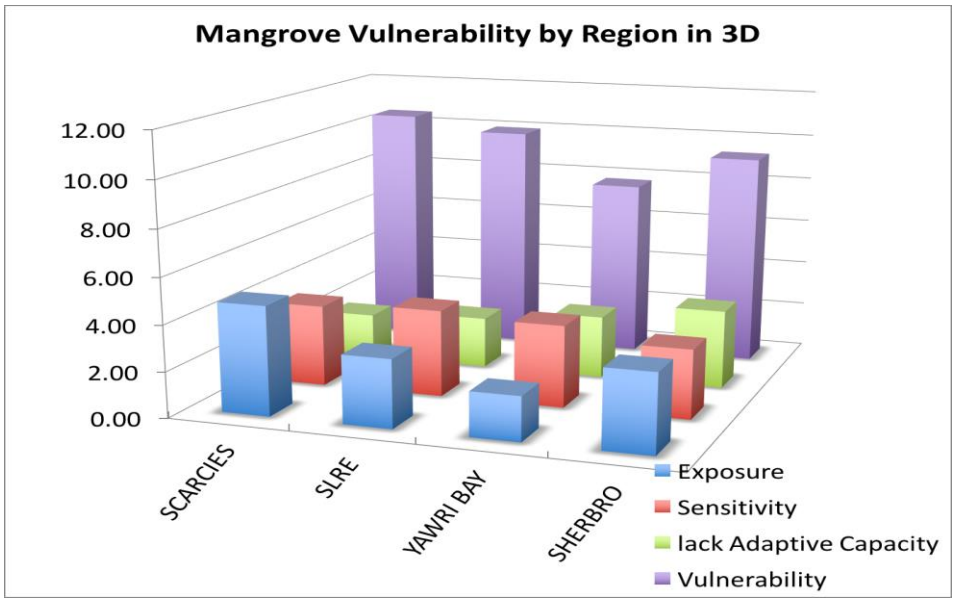


Figure 5.10. Same as Figure 5.9 but with vulnerability components shown separately.

Combined Vulnerability

There is no strict spatial pattern in the combined vulnerability as different locations within the same region exhibit different levels of vulnerability (Figure 5.11). Locations in the Scarcies and Sherbro areas tend to score higher on overall vulnerability, while SLRE and Yawri Bay, with the exception of Seaport, tend to score lower. Those two regions show lower levels of exposure for both systems, mangroves and populations, and tend to show slightly higher sensitivity. But the variability between locations is also highest in these regions. The high levels of vulnerability in the Scarcies are mostly due to high exposure levels, while the lack of AC is among the lowest there (in other words, Adaptive Capacity is high). It is low Adaptive Capacity that is partly responsible for the high vulnerability levels in the Sherbro area. Finally, SLRE's lower socio-economic vulnerability may be a function of proximity to Freetown.

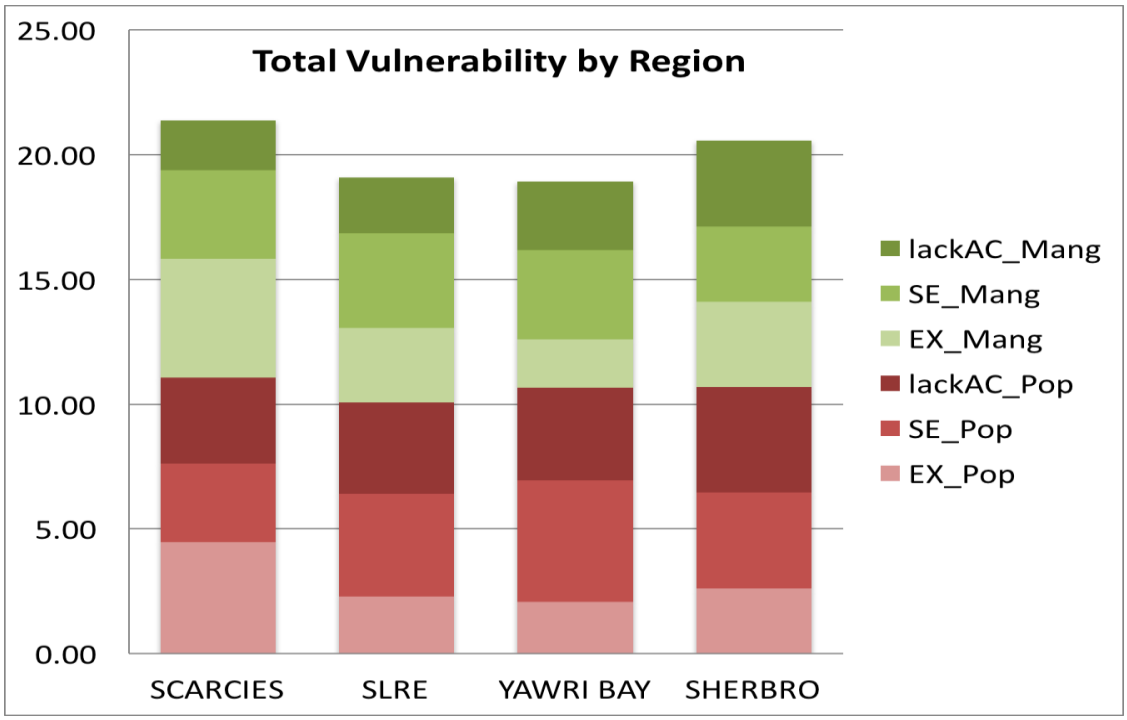


Figure 5.11. Distribution of Exposure, Sensitivity and lack of Adaptive capacity of the socio-economic (red) and mangrove (green) systems summarized by region.

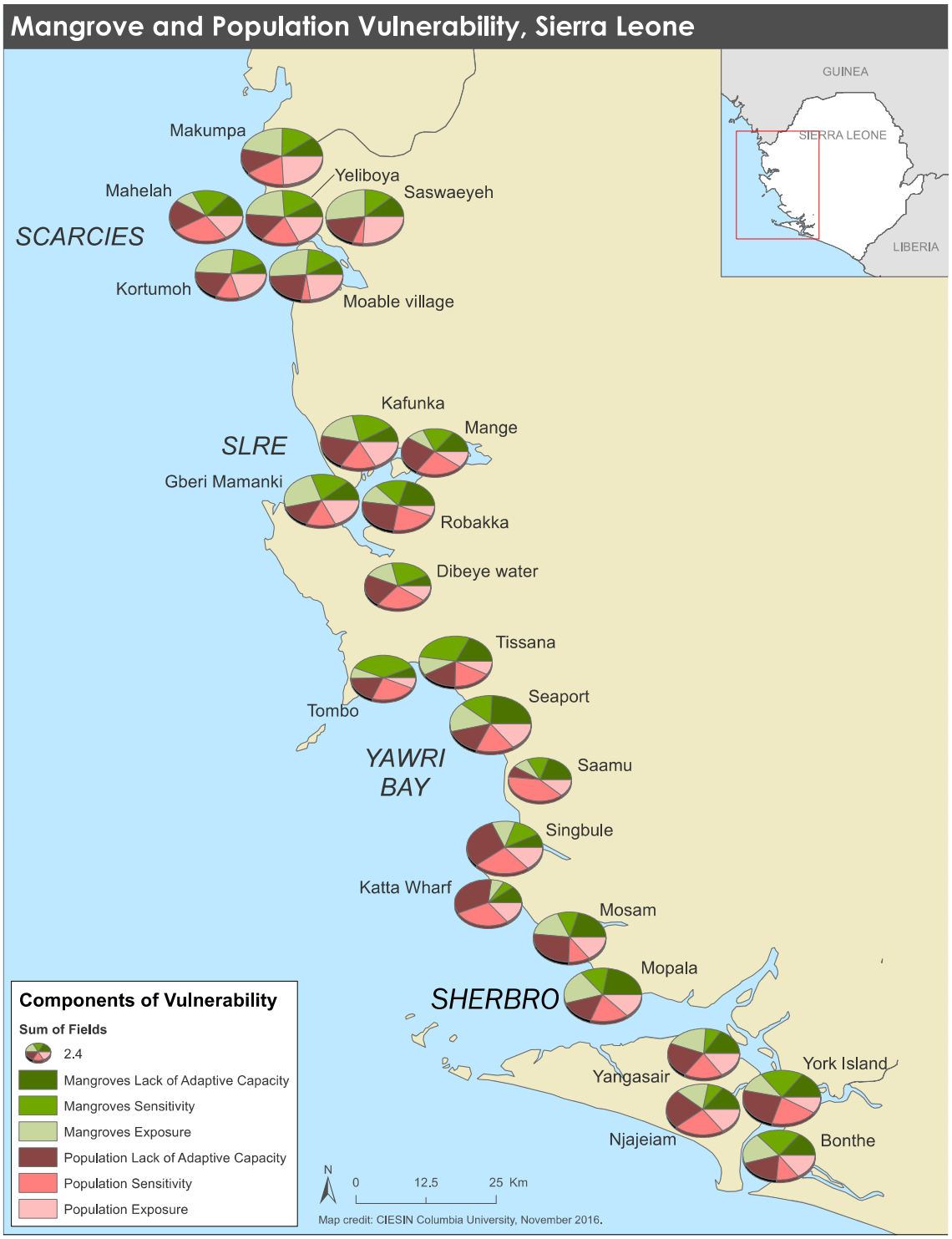


Figure 5.12: Spatial distribution of combined vulnerability by village. Different components of the vulnerability are also shown.

6. Summary, discussion and recommendations

In this vulnerability assessment to climate change of fishing populations in the mangrove areas of Sierra Leone we adopted a bottom-up strategy, collecting data on socio-economic vulnerabilities of the populations through household surveys and participatory rural appraisals, and ecosystem data through forestry transect surveys in the nearby mangrove forests. Data were collected in the four main mangrove regions of Sierra Leone: the Scarcies River Estuary, The Sierra Leone River Estuary (SLRE), Yawri Bay and the Sherbro River Estuary to achieve some degree of generalizability. Household urveys and PRAs were conducted in 24 villages and data were collected in 12 adjacent mangrove transects. Additional mangrove change assessment between 1990 and 2016 was carried out based on satellite data, and we included a desk study on past and future climate changes. This section summarizes and discusses the main findings and proposes a set of recommendations related to vulnerability and resilience to climate change of the human and environmental systems in the coastal zone.

Main findings

Climate in the coastal regions of Sierra Leone

Sierra Leone benefits from a mild tropical climate dominated by one rainy season, the West African Monsoon, from May to November. The interactions between this large scale rain-bearing system and local topography leads to annual rainfall amounts, especially in coastal zones, that are among the highest in Africa. Long term estimates of May-November rainfall in the coastal areas based on global gridded data show an average rainfall amount of about 2,700mm/year. Rainfall exhibits variations on interannual and decadal scales with a coefficient of variation of about 11% and no strong evidence of trends. On the other hand, temperature shows an evident and statistically significant trend of approximately 0.14^{o}C per decade. The Sierra Leone NAPA includes several claims about changes in climate, including the timing of the seasons and extreme events that need to be substantiated by more localized, *in situ* information. Long term projections indicate an overall increase in temperatures ranging between 1.5C and 4C and potential increase in rainfall. Thus, if water resources are managed properly, Sierra Leone should not experience water resource scarcity, but the impact of temperature increase on coastal ecosystems needs further investigation.

Within Sierra Leone, there are local differences in climate owing to sharp topographic and ecological gradients. Global datasets and projections often lack fine scale input, thus the information may lack the granularity and accuracy required for local decisionmaking. However, Sierra Leone currently lacks access to relevant, *in situ* information about climate, and many other environmental factors. It is only by refining and contextualizing this large scale picture that meaningful information can be given about potential changes in climate and their impacts.

Communities living in the mangrove areas are strongly affected by climate and weather variability, although those impacts rank low on their list of major concerns. As can be

expected in a least developed country context, villagers' primary stressors are related to money, jobs and education. The most frequently mentioned climate/weather impacts are related to heavy winds and flooding. Heavy winds cause fires to spread from traditional smoke houses that can destroy houses. These winds also damage roofs, and can cause passenger boats to capsize, leading to loss of property and even life. Fires are particularly feared by inhabitants of densly built-up villages and towns. Flooding seems to occur frequently but is less feared and better coped with by the populations as it is mainly seasonal and operates on slower time frames, most often giving populations time to prepare, according to their means. It is often linked to salt water intrusion and soil and well salinization, thus loss of farm-land and water sources. Hot temperatures are also often cited, but with lower level impacts.

Figure 6.1: Landscape after fire in Yeliboya, Scarcies region. Several houses had completely burned down. Credit: S. Trzaska, February 2016

While nearly almost two-thirds of respondents said they have heard about climate change and believe it happens, one-quarter remain uncertain, and 37% indicate they do not consider this to be a major problem for their community. Such low priority given to climate-related issues is consistent with the results of focus groups and underscores the relatively higher importance of other development issues to the communities. It suggests that resilience building in these communities will partly be a function of meeting basic needs while tending to mangrove health.

Adaptation Solutions

Communities perceive adaptation to climate change as a multidimensional problem and cite various strategies. Spontaneously cited strategies range from climate change awareness building to construction of improved homes, which includes making them sturdier and/or using local materials, as well as construction of drainage systems, livelihood diversification and contributions to the *osusu* traditional money pooling system. Approximately two-thirds of focus groups listed reforestation as an adaptation

strategy. However, results may be biased since the participants knew that mangrove conservation is one of WA BiCC's focus areas.

Solutions were then qualified according to the degree of preference, difficulty, ability of the community to organize and dependence on external assistance. In general protection of homes and reforestation score high on preference and community self-organization but require external financial or technical assistance. Highly preferred, easy to implement, with the community ready to act and low external dependency solutions include: savings, climate awareness, improving farming, and improving roads and building schools. These mostly address the low levels of adaptive capacity. The solutions that are highly preferred by respondents, but categorized as highly difficult to implement with relatively high chance of communities to self-organize, and with relatively high scores for external dependence include: reforestation, house improvements, drainage systems, improved local water supplies, river bank reinforcement, and expansion of farming and fishing. They mainly address exposure and, to some extent, sensitivity of the populations.

These rankings change if modified climatic conditions, such as increase amplitude and/or frequency of harmful climatic events, are considered. Reforestation, drainage systems and increase in fishing activities all showed a strong decrease in preference for at least 50% of participants (more than 80% for fishing activities) indicating that these solutions are not seen as very effective in addressing potentially increased occurrence or magnitude of disasters. Strong increase in preference was recorded for: sturdier homes, saving groups, improved local water supplies and health facilities. This shows that solutions leading to more secure and healthier living conditions would be the priority for the majority of the respondents.

Mangroves

Mangrove cover and composition

Based on satellite estimates Sierra Leone has lost approximately 25% of its mangroves since 1990. The loss varies according to the regions and is highest in the Scarcies with more than 40% of mangrove forests lost to rice farming, while a marginal increase is observed in Ywari Bay and Sherbro regions. Larger increases in mangrove cover in SLRE can be attributed to reforestation efforts.

A total of five species of mangrove were recorded across the three regions, namely *Avicennia germinans,* which constitute about 70% of all trees in the most northern areas and in Yawri Bay, followed by *Rizophora racemose, Rizophora harissonii, Laguncularia racemose* and *Rhizophora mangle*. *Avicennia* dominates in most of the regions with the exception of Sherbro, dominated by *Rizophora racemose.* The Scarcies and SLRE regions have the highest species diversity with all the five species present while in Yawri Bay and Sherbro area only three species were found in the transects surveyed. In general, the mangroves that have not been converted to farming in the Scarcies region are doing

relatively well, with high species diversity, mature forest and high regeneration levels. They are under pressure from cutting and farming but if human pressures are limited they have high potential to remain resilient. Sherbro area is on the opposite side of the spectrum, with lowest species diversification, highly dominated by *Rhizophora Racemosa*, with the oldest trees and lowest regeneration rates. It is unclear why the regeneration is so low, nor is it clear why there is a predominance of one species. This requires further investigation of the environmental determinants of mangrove cover in this region. Human pressure is also high and this could be due to the presence of large trees in highly desirable species. Overall deforestation rates and conversion to rice paddies are lowest in that region. This area has probably the highest commercial potential provided proper management strategies. SLRE has the youngest forests, sign of past and current exploitation of the forest. But the regeneration rates and species diversity indicate a healthy forest provided that human pressures are limited. The Yawri Bay has fewer adult trees but the highest number of seedlings and is expected to recover easily if protected and sustainably managed.

Mangrove use and perceptions by the populations

Mangroves are widely used in the communities. A vast majority of the respondents (71%) indicated fuel wood as main benefit from the mangroves followed by construction and fish breeding sites listed by less than 30% respondents. Respondents recognized that mangrove wood was used in the household in the previous week, mostly for cooking (70%), then fish smoking and less frequently for construction. About 20% of the households indicated using mangroves as the sole source of fuel for smoking fish and those rates are above 70% in locations like Yangasair and York Island, and reach 100% in Njajeiam. Less than 30% of respondents in each region mentioned traditional or customary rules regulating access to mangroves, and the majority said there were no such rules or they did not know about them.

Approximately 48% of the respondents noticed a decrease in mangrove cover, but nearly 30% could not tell the difference. The decrease has been mostly associated with use of wood for livelihoods and fuel, then construction, while pests and natural causes were listed by less than 10% of the respondents. Loss to farmland was listed only marginally, mostly in the Scarcies where mangroves give room for rice paddies. There seem to be a shared perception that the loss of mangroves is linked with human activities. Nearly two-thirds of the respondents indicated their willingness to participate in voluntary mangrove preservation/restoration projects and, among those who would not volunteer, 65% said they would participate in exchange for compensation. These rates depend according to the region with higher levels of potential participation in mangrove reforestation efforts in the Scarcies, which also recorded the highest levels of deforestation. As with the reference to reforestation as an adaption option, it is possible that populations' stated willingness to volunteer time to mangrove replanting was biased by the knowledge that the WA BiCC project had a particular interest in the health of mangrove ecosystems.

Other Environmental Issues

Resource and governance

An important finding is that most natural resources – farm land, water, fish, sand, forests, and oceans – are considered by a large percentage of focus groups as open access. A very small minority of focus groups mention traditional or government restrictions, with the highest being traditional restrictions for farm land. This view of natural resources as essentially open access may influence behaviors around resource capture. In the absence of restrictions – whether governmental, or preferably agreed upon by the community as a whole through co-management of natural resources – benefits can be captured (or privatized) at minimal cost, and there may be a perception that it is best to capture resources quickly, before others do so. Under such circumstances, there can be little incentive for conservation, and mechanisms such as collaborative management may be required to balance rights of access with responsibility for sustainable management.

Perceptions of changing fisheries resources

Eighty seven percent of respondents engaged in fishing activities indicated the resource has decreased and linked it to overfishing and bad fishing practices (too many fishermen and trawlers, and catching juveniles) rather than to changes in the environment. The issue of monofilament nets, which are illegal and result in catching of juvenile fish, was frequently brought up in informal discussions. While there is a strong agreement that this is an extremely harmful practice, it remains the most affordable fishing gear and, in the absence of support for traditional nets, their use will likely remain widespread.

Population characteristics

Demographics

The demographic analysis of the population surveyed indicates that its characteristics closely match those of the general population of Sierra Leone as inferred from the 2004 and 2015 census and the 2013 DHS Survey. The median age of the sample is 18, comparable to the 18.5 found in the 2015 census and the sex ratio (number of males for 100 females) ranges from 86 to 95, comparable to 94 and 96 in the 2004 and 2015 census, respectively. The lowest ratio is recorded in SLRE and could be related to higher levels of migration of males to Freetown in search for work. The gender distribution of households head is again comparable to that of the rural population (27% female, 73% male) with, however slightly lower proportion of female-headed households in most of the regions except in Sherbro. This is mostly due to the much lower prevalence of female-headed households in smaller settlements (16%) while in larger settlements the percentage of female-headed households is larger (32%) than the national or rural percentage.

Education

The education level, albeit low – more than 60% of the respondents report no education – is again comparable to the country rural average and the disparities between men and women are very strong. The percentage of men with no education in both, large and small settlements is respectively 51% and 49% and is lower than country's average for rural population (54%). The percentage of women with no education in large (69%) and small settlements (72%) is larger than the nationwide rural average (68.5%), indicating more constrained access to education for women, even in larger settlements where schools are present. The issue of schooling levels of children, very relevant for the resilience of future generations, was however not directly addressed in the survey and may warrant special attention as about 30% of the respondents report no access to schools.

Sanitation

Access to improved water sources seems better than levels in other rural areas and even the national average, reaching urban levels in Yawri Bay. However, this result needs to be qualified. In numerous settlements no improved sources exist within the village and water is brought from improved sources by container and sold to households, highly burdening their budgets. In addition, even though households indicated accessing water from improved sources, if transported in containers such water may become contaminated.

The percentage of households having access only to unimproved sanitation facilities is higher than the national average and reaches 66% in small settlements (higher than country's average for rural areas of 64%) and 45% in larger settlements (higher than urban average 20%). These results need to be qualified too as unimproved facilities are highly constrained by lack of space and often consist of the beach and are in close proximity to the settlement, leading to contamination of the water surrounding the villages, where populations often walk embarking and disembarking from the boats and where shellfish are collected. Risks of contamination of seafood with pathogens and prevalence of diseases like cholera and typhoid are high.

Food Security

Households score overall very low on food security (i.e., severely food insecure on the USAID Household Food Insecurity Scale which documents households' food security and access over the month preceding the interview). On average 85% reported a situation that placed them in the severely food insecure category and values ranged between 50% and 100% depending on the location. The survey was conducted during the 'hunger season' and reflects the extent to which households are food insecure during that period. Fifty percent of the households report not having enough food to meet their family's needs for two to four months a year.

Livelihood strategies

As expected from the choice of the populations surveyed, livelihood strategies are dominated by fisheries-related activities. More than 50% of households are involved in capture fisheries (as opposed to aquaculture) with an average contribution of 70% to household economy; fish processing is reported by 35% with a contribution of approximately 30% to their economy; followed by farming and small businesses. Logging of the mangroves, albeit reported by only about 10% of households, contributes on average to 30% of those household's economic activity.

Livelihoods have relatively little diversification, with an average of 1.87 activities across all households surveyed and about 30% of households reporting only one activity. Larger diversification exists in smaller localities as compared to larger, consistent with rural settings in developing countries where households tend to rely on more economic activities for their subsistence as a risk management strategy.

Fishing livelihoods

- **Fishing**

Specific questions around fishing activities found that members of the household went fishing mostly 2-3 times, or even every day, in the previous week. There are slight differences between the regions that may be related to the type of fish caught and its availability and differences between large and small settlements that may be indicative of different labor organization, with people working for wages in the larger settlements. Similarly, a smaller diversification of catch is observed in larger settlements (with median number of species less than five) that may be indicative of differences in fishing gear and market opportunities leading to higher specialization, while in smaller settlements there is a higher diversification of the catch (median number of species caught higher than five).

- **Fish smoking and trading**

Fish smoking is traditionally carried out by women. Interviews with women (and some men) engaged in smoking fish and estimates of expenditures (fish, mangrove wood, help) *versus* sale prices indicate that smoking fish is not lucrative, but may be carried out under social pressure, since this is the only way to preserve fish. In the case of female-headed households it may not be sufficient to support a family. However, many women indicated that they did not have other choices of activities. Furthermore, even when informed that their answers would be kept confidential, women may have concealed some information related to revenue from fish smoking.

Farming livelihoods

Approximately 30% of the respondents indicated agriculture as one of their livelihood strategies but the distribution is very uneven, with settlements where more than 85% engage in farming to some extent and locations where no farming has been reported.

Financial Capital

Savings/Credit

Only 25% of the respondents indicated the household accessed any type of savings scheme in the past year, and less than 10% accessed credit. Among those who accessed savings, approximately 21% also accessed credit. It was only 6% among those who reported not accessing any savings scheme. Furthermore the size of the settlement seems to play a role: 46% of households in large settlements indicated accessing savings scheme and only 18% in small localities. This difference is statistically significant. The differences in accessing savings/credit schemes between female-headed and male-headed households are in favor of female-headed households but are not statistically significant (roughly 20% of surveyed households are female-headed).

Ownership

Eighty nine percent of the households indicated owning a house and 29.6% owning more than one house (with the additional house located elsewhere). There is no difference in accessing savings/credit between those who own and do not own a house. Note that assets, including a house, were not considered as savings by the respondents.

Among those households engaging in agriculture, only a few own the land they farm or access savings/credit schemes.

Social Capital and Accessibility

Accessibility

About 30% of the sampled population indicated having no access to schools and local markets and more than 40% had no access to a health center. Several villages like Moable, Sasseyah and Makumpa face strong constraints in access to all three venues.

Participation in groups

Only 25% of respondents do not participate in any group or association but this rate reaches 40% if religious groups are excluded. Participation rates in groups and associations are lowest in small settlements such as Njajeiam, Seaport and Mahela. Support networks are also limited. About 40% of respondents stated they did not receive any kind of support from individuals or organizations.

Media

The overall ability to access information is limited and the main source is radio. Ninety-six percent of the respondents indicated they did not read a newspaper in the past month. About 60% of the respondents indicated listening to at least radio once a week but this rate drops in small localities, where 60% or more of respondents indicated they did not listen to radio in the past month.

The use of cell phones is high: 72% of the respondents indicated having or using a cell phone regularly.

Aggregated indicators

Various indicators related to the household socio-economic profile, economic and social networks, access to information, energy, food, health, climate impacts and household assets were aggregated into a wealth index and vulnerability components: exposure, sensitivity and (lack of) adaptive capacity. A quick correlation analysis showed that none of the three indicators were significantly correlated with the others, indicating that they all were providing information that are not redundant and unlikely to bias the results.

Wealth Index

The highest proportions of households in the wealthiest category and lowest proportions in the lowest categories are found in the urban and peri-urban settlements of Tombo, Tssana, Dibye Water, Bonthe and York Islands. Villages with high proportions of households in the lowest wealth index category exist in all four regions. Those are the small, most remote villages of Seaport, Singbule, Yangasair, Njajaiem, Robakka, Kortumoh and Moable.

Vulnerability of the socio-economic system

The Scarcies region records highest levels of exposure while the lowest levels are observed in Yawri Bay and parts of SLRE, where the villages are often located on higher ground. Several of low-lying villages in the Sherbro area seem to be sheltered from direct impacts of weather and exhibit lower exposure scores.

The sensitivity of the populations is highest in Yawri Bay and Sherbro area and seems independent of locality size.

Villages in the Scarcies and SLRE are composed of households with all five levels of adaptive capacity, independently of settlement size and accessibility. In Yawri Bay and Sherbro settlements show contrasting adaptive capacity pictures, with larger and more accessible settlements dominated by households with higher adaptive capacity while smaller, more remote villages are dominated by households with lowest adaptive capacity.

Combined Vulnerability Assessment

There is no strict spatial pattern to the combined vulnerability as different localities within the same region exhibit different levels of vulnerability. However, localities in the Scarcies and Sherbro areas tend to score higher on overall vulnerability while SLRE and Yawri Bay, with the exception of Seaport, tend to score lower. Higher vulnerability levels in the Scarcies are mostly due to higher exposure levels of the human and mangrove systems while in Sherbro area the vulnerability is linked with low adaptive capacity of both systems. The lower vulnerability of SLRE and Yawri Bay seems to be primarily linked to low exposure levels, while sensitivity and lack of adaptive capacity levels (especially of human systems) are among the highest in several of the villages in Yawri Bay.

Discussion

This study is to our knowledge the most comprehensive attempt to assess the vulnerabilities of the fishing populations living within mangrove areas in Sierra Leone – and perhaps for any coastal region in West Africa. It is based on an extensive data collection in 24 villages and 12 transects across the four main mangrove regions.

While the VA collected a large amount of quantitative data, several aspects of the systems still require further documentation and data collection. Among these:

- **Physical and chemical properties of the water and dynamics of sedimentation**. Such studies give best results if they are part of a longer term monitoring system to document seasonal, interannual and longer term changes. Such monitoring was beyond the scope of this study.
- **Sea level rise**. In this study we have not addressed the issues of sea level rise. Sea level rise at local level depends on many local factors (Rahmstorf, 2012) among which the fact that the sea-level response to global warming will not be globally uniform, since factors like changes in ocean currents (Levermann *et al* .,2005) and the changing gravitational pull of continental ice (Mitrovica *et al.,* 2001) affect the local rise. Secondly, superimposed on the climatic trend is natural variability in sea level, which regionally can be as large as the climatic signal on multi-decadal timescales. Over the past decades, sea level has dropped in some locations even though there has been an increase in global mean sea level (IPCC, 2007). Thirdly, local land uplift or subsidence affects the local sea-level change relative to the coast, both for natural reasons (post-glacial isostatic adjustment centered on regions that were covered by ice sheets during the last ice age) and artificial ones (e.g., extraction of water or oil, as in the Gulf of Mexico). Finally, local vulnerability to sea-level rise depends on many factors. To correctly assess the impacts of sea level rise at local level would require an analysis including past trends in sea-level, projected trends in sea level rise, and historical storm surges. The data for the first and the last elements are not available at this stage and rather than use only global projected trends we have preferred to focus on understanding vulnerabilities experienced by the populations.
- **Food security and nutrition status**. This study found alarmingly low food security status among surveyed populations. A bias in answers cannot be ruled out although the questions were administered according to standard procedures and answers should be compatible with the USAID Food Security Access Scales. It is also possible that the food security score reflects the hunger season during which the study was conducted. It is advisable that several food security surveys be conducted at different times of the year to assess more robustly the food security and nutrition status of the populations.
- **Health issues related to fish-smoking**. Surveys of health-related issues require much higher levels of confidentiality and scrutiny of survey instruments under Columbia University ethics rules. Obtaining such clearance was not compatible with the WA BiCC project time frames. Unstructured interviews with health professionals, which are allowed by Columbia University ethics rules (so long as no individual's specific

conditions are discussed), were conducted by members of the roving team. The results indicate that the most frequent causes for consultation in community health centers are STDs and pneumonia for men. Health professionals indicated no consultation for smoke inhalation or other smoke-related health issues. However, discussions with women smoking fish indicate that health issues related to fish smoking are under-reported as they tend to self-medicate, purchasing medication - mostly ORS for dehydration – directly from peddlers. Several women indicated having been hospitalized after collapsing by the smoker, but given the lack of other livelihood opportunities resumed their activities after being released from the clinic. The impact of smoke on children is also important as young children tend to stay with their mothers and caregivers around the *bandas* and older children often help with the smoking process. No data are available on cancer rates among those involved in fish smoking, but given Sierra Leone's average life expectancy of only 52 years at birth (for women) (PRB, 2016), it may be that cancer is not a major cause of death.

Figure 6.2: Left: Woman sitting in the smoke house in Bonthe. At the time of the picture the grill was folded and not used for smoking fish, only as cooking facility, but it is easy to imagine the smoke women are exposed to while tending the banda, which cannot be left unsupervised. Right: children, especially girls, spend a significant amount of time with their mothers inside the bandas Photo Credit: S. Trzaska, July 2016

- **Health issues related to poor sanitation** also need more attention. Lack of toilet and reliance on the tide to clean the beach lead to high levels of water contamination by fecal matters (Dr. Sankoh, pers. comm.) that lead to outbreaks of water-borne diseases such as cholera and typhoid, since the populations frequently enter contaminated water for various reasons (fishing, shellfish collection, accessing boats for travel etc.). Incidence of water borne diseases and their economic burden on populations should be assessed.

- **The economics of fish smoking**. Although our survey contained questions about quantities of fish smoked and wood used, it appears that in cases where the respondent was not directly involved in fish processing the answers may not be reliable. The survey was conducted during the low fishing season and many *bandas* were not operating. Therefore, little fish and wood were present for the enumerators to investigate. In addition, fish and wood are sold in different units in different regions or even villages, making comparisons of data collected within a broadly-scoped survey difficult. Interviews of women directly engaged in fish smoking activities conducted by the roving team indicated that this activity may generate little income once all the costs and fees, such as the price of the fish at the boat, the cost of the wood, the cost of help (the *bandas* are operating 24 hours and cannot be left unattended once the fire is lit) are accounted for. This is different from the popular knowledge that fish smoking activity is very lucrative. In our experience, it is only lucrative for middle-men (or women) who deal with fish trade, not with smoking fish directly. Other reports (Dr. Sankoh, personal comm.) suggest that women make as much benefit from fish as men. It is possible that answers given were deliberately lowered in our case to ensure that the project comes back with assistance, or that women were deliberately misleading to protect what they perceive to be confidential information. It also is possible that benefits are highly dependent on the type of fish. In any case a larger scale assessment of the economics of fish smoking would be beneficial, especially for female-headed households where there is little access to other types of income, since this type of livelihood may not be sufficient to support a family. It could help designing approaches to livelihood diversification activities for female headed households.
- **Shell-fish harvesting**. In this study we did not address shellfish harvesting activity. It is a widespread activity that also uses significant amounts of mangrove wood to process. Oysters are first cooked and then smoked. In some communities in the Sherbro area it is the main livelihood activity, but a specific project – the DFID supported Darwin initiative in collaboration with Stirling University[20] exclusively focus on oysters in Sierra Leone. The reader is invited to consult projects documentation. WA BiCC may benefit from the approach used to community-level work implemented in that project.
- **Education levels among children.** Our surveys allowed us to collect data related to adult education, showing that they are comparable to national levels for men but are lower for women. However, it did not investigate schooling among children, who will be the generation dealing with the impacts of climate change and need increased capacity to do so. Given the accessibility issues and constraints in access reported by respondents, as well as high overall rank of education on the list of stressors, one may anticipate that schooling and education levels among children living within the mangrove areas will remain low, while they may increase in villages on higher grounds, where the team noticed presence of schools and various education

[20] See http://www.stir.ac.uk/aquaculture-mangrove-oyster/.

supporting programs. Education is an important means of increasing autonomous adaptive capacity of individuals, households and communities and may require specific support in these isolated and vulnerable communities.

- **Migration.** The survey only investigated the in-migration, origin and motivations of the migrants. Most of the in-migration was family-related (e.g. marriage). It is interesting to analyze the outmigration and the net migration in the coastal mangrove communities to assess their levels and the causes of people moving out of the mangrove areas and to which extent this is one of the adaptation strategies already taking place.
- Finally, it is noteworthy that **several economic forces and different actors** are present in the area. In addition to unauthorized foreign fishing boats, several foreign companies have access to fishing grounds legally, and that these activities potentially compete with local populations. Some support directly artisanal fishing through loans and equipment, increasing the motorized fleet and the catch levels. On York Island during scoping meetings, locals explained that many men find employment on boats owned by a South Korean investor.

Figure 6.3: Chinese tuna fishing fleet in the Scarcies River Estuary (right) and a boat belonging to South Korean Company on York Island (left). Photo Credit: S. Trzaska, July 2016

An even larger player started operating recently in the Yawri Bay and Sherbro area – the Neptune Company – leasing new fish processing facilities there and supporting further development of the fleet through loans for fishing equipment. It will be processing the catch in large capacity, specially designed high efficiency smoking ovens. While its business model is not fully disclosed and the company claims it will be processing fish for the local market, its representative indicated that exports to other countries in the region, most notably Ghana, are also planned. It is not clear how this will affect fish availability and prices for the local markets as well as fish-smoking activities for women.

Recommendations

Based on the results of our vulnerability assessment of mangroves and fishing communities living within them, we propose a set of interventions. Some of these recommended activities go beyond the mandate of the WABiCC project, reflecting the most salient needs of the populations and ecosystems that should be addressed for the sustainability and productivity of the coastal zones in Sierra Leone. We organized our recommendations in the following categories:

- **Improve natural environment management practices**

For mangroves:

- Sensitize the populations to the issues of mangrove ecosystem services and dynamics to reach a better understanding of the requirements for sustainable mangrove forest use.
- Working with the communities and building on the existing community-based management systems, design and implement in several locations community-based mangrove management systems that take into account direct and direct ecosystem services.
- Building on the experience gained in the above activity design a national guidance for community-based mangrove management system and national rules for mangrove areas access and use.

For water and sanitation:

- Design and deploy sanitation systems suitable for low-lying and flood-prone villages to insure a healthier environment and decrease water contamination. This should also improve the sanitary quality of fish and shell-fish.

- **Lower exposure and impacts of climate and weather disasters**

- Working with communities and building off existing initiatives such as Red-Cross supported work in Bonthe, design and implement effective fire prevention and combat systems in all the villages.
- Support the Meteorological Agency of Sierra Leone in designing an extreme wind and storm early warning system (EWS) for different sections of the coast. This activity will require additional research into synoptic situations leading to heavy wind/storm events and their predictability and research on the most effective ways of disseminating alerts. Eventually, a flood EWS could also be designed.
- Support or facilitate implementation of locally designed infrastructures such as drainage systems, higher embankments, and wind barriers (tree planting) to lower exposure to weather and climate disasters and their impacts, taking into account and sensitizing populations about future changes in disaster frequency and/or amplitude.

- **Lower the sensibility of the populations to climate related disasters**

- Support livelihood diversification
- Improve food-security and nutritional status; of particular interest might be implementation of raised garden beds that could provide supplementary vegetables and condiments, especially during the hunger season, as well as an activity for women and in particular female-headed households.

Figure 6.4: Raised bed garden in a village a few miles inland in Yawri Bay area. Raised bed gardens have the advantage of being flood- and soil salinization-proof and could be installed in areas where farmland is limited and tended to by women. Photo credit: S. Trzaska, July 2016

- Improve health and sanitation; support design and implementation of sanitation facilities addressing the particular conditions in low-lying, flood-prone villages.
- Support initiatives exploring housing construction approaches that are more suitable for the particular conditions in the coastal areas. For example thatch roofs are most suitable for the sea spray conditions, provide best thermal insulation and rely on local materials and skills, but are flammable and not durable. Zinc has low insulation capacity, is also not very resistant to sea spray and is relatively costly, but resists better to fire (especially for *bandas*).

- **Increase the adaptive capacity of populations**

- Build awareness around climate variability and change to allow populations to better understand and anticipate changes to their livelihoods and prepare autonomous adaptations. In particular create greater awareness around sea level raise and temperature increase.
- Improve access to information on climate and climate change and its understanding for different stakeholders, from local government to individuals.
- Improve access to education, including vocational education and education for girls and women.
- Improve access to and understanding of financial instruments.

- **Improve Sierra Leone's capacity to monitor environmental conditions and project impacts of climate change**

In order to develop national and local climate change adaptation strategies a better understanding of the current and future climate impact on the human and ecosystem is needed. Since adaptations occur at local level, such understanding needs also to be developed at local level and needs to be anchored in local information and data. At this stage little quantitative information about the natural systems is available to decision-makers in Sierra Leone at scales compatible with adaptation. Given the steep climatic and environmental gradients existing in Sierra Leone the reliance on global gridded datasets may not provide information that is detailed enough to capture local differences. As discussed earlier, such datasets also interpolate between existing observational records, which, in areas with little *in situ* information may result in information that is not accurate and reflects rather distant observations. While such datasets are useful at global scale they may not be relevant at local scale. In addition, because of the interpolation, they usually poorly capture extreme events that are most damaging to the populations. It is thus critical for Sierra Leone to develop the capacity to monitor, archive, analyze and extract information relevant to stakeholders in a number of areas such as: rainfall, temperature and wind; sea-level and storm-surge; physical and chemical characteristics of coastal waters; and sedimentation. In addition there is a need to develop the capacity to model coastal dynamics and ecosystems to evaluate impacts of changing climate conditions in the future on the coastal zones. Such models have been developed for other regions but need to be adapted for the local conditions of Sierra Leone.

More concretely we suggest:

- Increasing the capacity of the Meteorological Department of Sierra Leone to provide stake-holders with relevant information on past, current and future climate. This includes digitizing current data holdings and ensuring the automation of future record acquisition, sufficient storage, appropriate software and personnel training. The information that could be provided ranges from the statistics of historical climate, to seasonal climate forecasts, early warning systems, to localized projections of climate, contextualized using historical climate records and tailored to different sectors.
- Development of coastal water monitoring system capturing its level and physical and chemical properties, with relevant data storage capacities as well as strengthening the capacities of relevant institutions to analyze the data.
- Support the capacity of the research institutions to develop ecosystem and sectoral impact models tailored and validated to Sierra Leone enabling the use of information on past and future climate to derive impact of climate change on natural and human systems.

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Annex 1. Details on Data Cleaning for the Household Survey

Data Quality Control

This annex provides information on the data cleaning and de-identification of respondents, in conformity with Columbia University Institutional Review Board (IRB) requirements.

Quality control checks:

- The following answers -9999, 9999, -999, 999, 0.9999, 0.999 were coded as null values (i.e. NA in R).
- Variable names were edited as short names, instead of long, nested names. A data dictionary was created in order to pair each short name with the corresponding raw variable name, and question.
- Checks for duplicate submissions were conducted. Two cases were assessed: 1) either the whole record was submitted more than once (i.e. a system bug); or 2) entries with identical respondent names (i.e. a person may have been interviewed more than once, or the name copied more than once). The first case rendered negative results, which means all observations are unique submissions. In the second case, 42 entries with duplicated respondent names were found, distributed along 19 unique names. Columbia researchers advised that it is possible to find identical names within the study areas, therefore identical names would not necessarily mean duplicate interviews or deliberate copies. A second check was conducted among the 42 entries, dismissing unique variables (i.e. time of submission, or unique identifiers such as UUID strings), in order to assess duplicates among the responses. The results were not conclusive. Among duplicate names there are some identical values for selected categorical questions, and other with different values. It is not possible to discern which entry might be a deliberate copy and which one is a valid entry. Therefore, all these entries were considered for analysis.
- How long did it take for enumerators to fill in a questionnaire? Columbia researchers advised that cut-offs values of 20 and 40 minutes should be implemented since entries completed in those time intervals may be assumed of poor quality. A proxy value for completion time was estimated as the time difference between the starting points of two surveys within the same day (see figure A1 for the distribution of starting times, per enumerator). In order to approximate an average and median time for survey per day, a subset of observations with time differences between start times of less than 10 hours was created (assuming 1 survey completed in 2 hours + 10 hours window in-between surveys, or less, for a working day of 12 hours per day). The average time resulted in 1.42 hours, and the median in 1.17 hours per survey.

- Only 3 interviews were found with time differences of less than 20 minutes, and 24 interviews with time differences of less than 40 minutes[21]. The 3 first cases are non-consent, which makes sense; the last cases are varied. Excluding the non-consents, there is a mix of completed, partly completed, and NA cases for 'survey result'. These entries were only flagged, and no subsequent analysis was conducted at this point.
- Further inspection was conducted to identify entries where the starting time was outside working hours (i.e. before 7 am, or after 6pm, see figure A2). Five entries started an interview after 6pm, none started before 7 am. Columbia researchers advised not to automatically dismiss these entries, but to take a more in-depth look into the answers submitted in all five cases. Given the challenging circumstances in which the fieldwork was conducted, it was possible that some of these interviews indeed started late, and were completed after working hours. A closer look revealed 3 consented and complete interviews, and 2 partially completed entries.

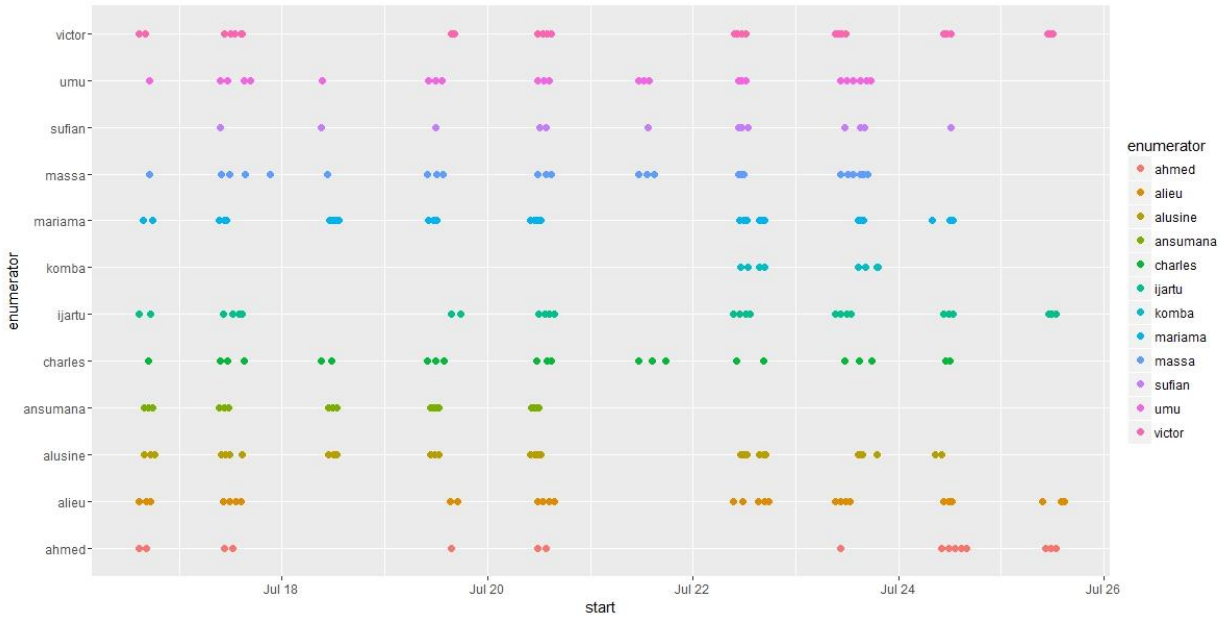


Figure A1. Interviews start times by enumerator and by day. Each point represents a new interview initiated during the day.

[21] The analysis with a cut-off value of 1 hour or less was not conducted, based on results for average and median completion times.

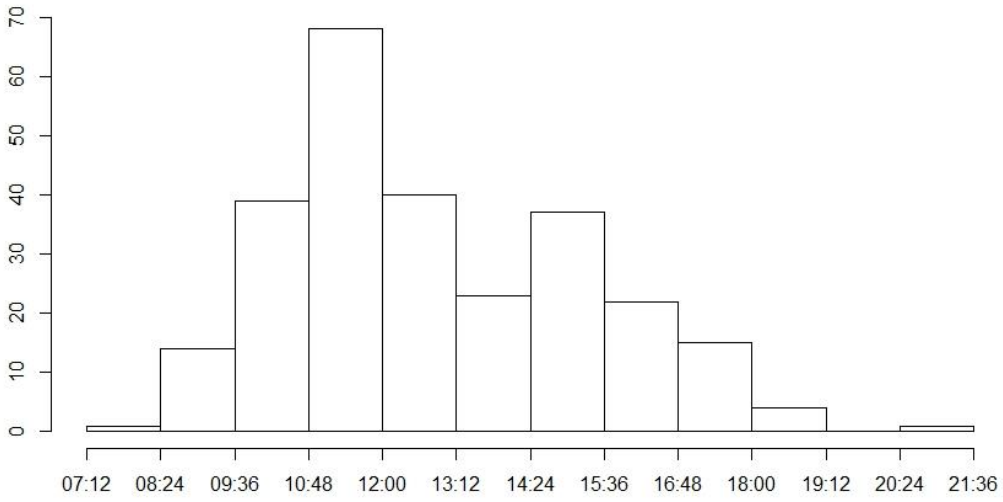


Figure A2. Histogram of start times of interviews.

- Recoding of variable 'survey result' for NA values (i.e. nothing selected by the enumerator for this question) was conducted based on: 1) starting times after 6pm; and 2) having less than +/- 50% of the survey answered (based on visual inspection, not actual quantification of variables). Table 2.1 shows the breakdown of the variable 'survey result'.
- Checks for the household roster were conducted. The most common mistakes found were:
    1) Respondent's info was entered twice (i.e. as a respondent, and as part of the roster), which could have led to a double-counting for household size. Since all enumerators but one incurred in this mistake, respondent's info was left within the roster, and the household size count was edited. The household roster was also completed including the records from the one enumerator who followed the instructions correctly. Therefore, the household roster includes all members in the household. A consistency check was also performed between the respondent's data, and its duplicate record within the roster, so that both instances contained the same value. All edits are documented.
    2) In some cases, the question 'relationship to the head of household' was likely to be misunderstood –possibly interpreted as 'relationship to the respondent'. In some cases we were able to identify errors, and corrected them. In other cases, the information was too ambiguous and was left as is. All edits are documented.
    3) One enumerator did not enter any information on the household roster for any household member, for all the households that he/she interviewed. There were 21 consented and completed cases in this circumstance, from a total of 23 (2 households did not consent to be interviewed).
    4) Moreover, Columbia researchers found instances where no household head was recorded in the roster. In sum, there are 31 households without household head (21 from case #3, and the rest from non-recorded cases).

- Respondent's economic activities section was edited to classify selling fish-related responses entered as 'other' economic activities. Columbia researchers advised that when 'other' respondent's activity was reported as "selling fish", and the household owned a boat, then the respondent's activity was recoded as "subsistence". Alternatively, when 'other' respondent's activity was related to "selling fish", and the household did not own a boat or the answer was null, then the respondent's activity was recoded as "wages". Twenty-eight responses were edited in this regard; all changes are documented.
- Respondent's livelihood strategies were also edited to include 2 new categories: 1) "buy and sell fish", and 2) "trades". A person who buys and sells fish is not necessarily a fisherman. Likewise, buying and selling fish does not imply the person is processing it (i.e. buying raw fish and selling smoked fish). Therefore, a new category is pertinent in order to differentiate this niche. The livelihood strategies classified as "trades" include all construction-related activities such as building contractor, carpentry, and construction work. It also includes tailoring. Other responses listed as "other" livelihood strategies (i.e. palm wine tapper, driver, charge phones) were recoded to their corresponding category (i.e. food preparation, transportation, small business, respectively). Twenty- seven responses were edited in this respect, and all edits are documented.
- In regards to total pebbles count for livelihood strategies, 10 entries recorded answers different than 20 pebbles (all answers were supposed to sum 20). There were 4 entries that recorded zero pebbles, though they did not report any livelihood strategy, therefore it is not possible to infer a potential mistake. Columbia researchers advised that, for instances where the count of pebbles did not sum 20, a prorated number among the activities selected using the same proportion, should be allocated.
- Additional recoding edits were conducted for the options selected as 'other' when the 'other responses' correspond to categories listed in the previous question; or creating new categories based on the frequency of text responses. Approximately 15% of the variables (n ~ 150) were edited. When the 'other responses' were too ambiguous or required clarification from the field team (i.e. public/ government toilets, thrift societies mentioned as part of the savings strategies, and others) they were left as is. Moreover, open-ended questions were not touched, as well as questions from the KAB questionnaire.

De-identification:

- Respondents and household members' names and last names were formatted to remove unnecessary white spaces, and all in uppercase. This step allowed editing an entry that, probably, the auto-spell check edited what the enumerator entered it (recoded as "NA"); and another instance where twins were captured as one household members instead of two (one for each child).

- The variable HHID (household ID number) was created in order to remove individuals' names from the dataset. The cleaned dataset used for analysis do not contain personally identifiable information (PII).

Annex 2. PRA Adaptation Solutions by Locality

Tables 1-4 below summarizes adaptation solution responses by category and includes village name and group for each region.

Table 1. Adaptation solution responses for SLRE region.

Adaptation Solutions	Village name	Group	Responses
ask government for assistance	York Island	men ages 30 above	report to council for help
ask government for assistance	York Island	women ages 18-30	ask for help from municipal council to pay community health workers
banking of river, sea, or homes	Mange Koya	women ages 18-39	banking of the river
construction of drainage systems	Mange Koya	men ages 40 above	drainage construction
	Waterloo	men ages 18-30	community self-help by building drainages to divert water
construction of homes with local materials	Mange Koya	women ages 40 above	use grass for roofing
construction of schools with local materials	White Stone	men ages 18-35	construction of local building for school
cutting of wood	Rogbaray	women ages 30 above	wood cutting
increase access to wells and taps	White Stone	women all ages	construction of wells-high temp
increase awareness	Rogbaray	men ages 40 above	awareness
	Waterloo	women all ages	awareness
	Waterloo	women all ages	awareness (thunder and lightning)
	White Stone	women all ages	awareness-heavy rainfall

Adaptation Solutions	Village name	Group	Responses
increase farming activities	Rogbaray	men ages 18-30	increase farm size and create employment
	White Stone	men ages 18-30	farming
	White Stone	men ages 18-33	backyard garden
	Tissana	women all ages	improved farming and external support-high temp
	Rogbaray	men ages 18-30	provide materials to make fishing net
increase number of health facilities, workers, and access to medicine	White Stone	women all ages	medicine-high temp
osusu money contribution system	York Island	men ages 30 above	forming womens group to contribute money
	Rogbaray	women ages 30 above	osusu to generate fund
	Rogbaray	men ages 40 above	osusu
	Rogbaray	men ages 40 above	by loan
	Rogbaray	men ages 18-30	community contribution
	Rogbaray	men ages 18-30	osusu
reforestation	Mange Koya	women ages 40 above	plant trees
	Mange Koya	women ages 18-39	planting of tree
	Mange Koya	men ages 40 above	stop deforestation

Adaptation Solutions	Village name	Group	Responses
	Mange Koya	men ages 40 above	replant mangrove
	Robakka	women all ages	afforestation
	Robakka	women all ages	replantation
	Robakka	women all ages	stop timber production
	Robakka	women all ages	stop wood cutting
	Robakka	men all ages	afforestation of different trees
	Robakka	men all ages	afforestation
	Rogbaray	women ages 30 above	mangrove wood cutting
	Rogbaray	men ages 40 above	wood cutting
	Waterloo	women all ages	stop deforestation (heavy wind)
	Waterloo	men ages 18-30	tree planting
	White Stone	women all ages	planting of trees-high wind
road maintenance	Waterloo	men ages 18-30	road maintenance
road maintenance	White Stone	women all ages	construction of roads-high rainfall
salt extraction/making	Rogbaray	women ages 30 above	salt making
	Rogbaray	men ages 40 above	salt making
trading	White Stone	men ages 18-31	trading

Table 2. Adaptation solution responses for Yawri region

Adaptation Solutions	Village name	Group	Responses
banking of river, sea, or homes	Samu	women all ages	banking locally-flooding
	Shingebull	women all ages	banking-flooding
	Shingebull	men all ages	banking of coastal area with sticks/planting tree
	Katta	women ages 18-39	banking/supporting the foundation with sticks to prevent the house from falling
	Katta	men ages 40 older	do banking-flooding
	Katta	men ages 18-39	banking-flooding
	Katta	women ages 40 older	in house banking with sand and grass
	Tombo	women ages 40 older	sea banking
construction of drainage systems	Samu	men all ages	construct drainage
	Samu	women all ages	construct drainage-flooding
	Shingebull	women all ages	construct drainages-flooding
	Katta	men ages 40 older	construct drainages-flooding
	Katta	men ages 18-39	construct drainages-flooding
	Seaport	men all ages	construct local drainage
	Tombo	women ages 18 older	construct drainage
	Tombo	women ages 40 older	drainage construction
construction of homes with local materials	Shingebull	men all ages	use palm thatch for roofing
	Katta	women ages 18-39	roof house with grass to avoid leakage
	Katta	women ages 18-39	using palm thatch to protect the house from heavy wind
	Katta	men ages 18-39	use palm trunks-heavy storm
	Seaport	women mixed	use palm fronds on houses-heavy rains

Adaptation Solutions	Village name	Group	Responses
		youth and adult	
construction of sturdier homes	Samu	men all ages	change the method of building
	Tissana	women all ages	construction of mud houses-high temp
	Katta	men ages 40 older	hang stones on top of houses/on roof-storm
	Katta	men ages 18-39	cover homes with rice bags-heavy storm
	Seaport	women mixed youth and adult	use heavy stones on top of thatch-heavy storm
fencing for protection	Samu	women all ages	palm tree fencing-flooding
	Shingebull	women all ages	fencing using palm trees-flooding
	Katta	men ages 40 older	use palm trunks to fence houses-floodings
	Seaport	women mixed youth and adult	construction of palm fronds-flooding
increase access to wells and taps	Katta	women ages 40 older	construct taps/wells
	Katta	women ages 40 older	dig wells near farmland
increase awareness	Tombo	men ages 40 older	awareness raising & sensitization
increase fishing activities	Tissana	women all ages	support on fishing activities-high temp
reforestation	Samu	men all ages	tree planting
	Samu	women all ages	afforestation-heavy storm
	Shingebull	women all ages	afforestation-high temp
	Shingebull	men all ages	tree planting
	Tissana	women all ages	afforestation-heavy rainfall

Adaptation Solutions	Village name	Group	Responses
	Tissana	women all ages	afforestation-storm
	Tissana	women all ages	afforestation-high temp
	Katta	men ages 18-39	afforestation-heavy storm
	Katta	women ages 40 older	tree planting
	Seaport	women mixed youth and adult	afforestation-high temp
	Tombo	men ages 40 older	stop deforestation
	Tombo	women ages 18 older	tree planting
	Tombo	women ages 40 older	stop deforestation

Table 3. Adaptation solution responses for Sherbro region

Adaptation Solutions	Village name	Group	Responses
ask government for assistance	Bonthe	men ages 30 above	beg for help to council to buy fishing materials
banking of river, sea, or homes	Bonthe	men all ages	construction of the sea-face (heavy rainfall)
collection of rain water	Yangasai	men ages 18-30	rain water collected
	Bonthe	women ages 18-30	rain water collected
	Mopala	women ages 18-30	water from the rain
construction of bridges with local materials	Mosam	men ages 18-30	make bridge with local materials
construction of drainage	Mosam	men ages 18-30	build drainage

Adaptation Solutions	Village name	Group	Responses
systems	Bonthe	men all ages	construction of drainages
construction of homes with local materials	Yangasai	women ages 30 above	construction of hosues with mud
	Bonthe	men ages 30 above	construction of houses with local materials
	Gayahun	women ages 18-30	construction of houses with local materials like grass, mangroves, and sticks
construction of schools with local materials	Mosam	men ages 18-30	build school with local materials
	Yangasai	men ages 18-30	build school with local materials
construction of schools with local materials	Mopala	women ages 18-30	construction of local building as school
construction of sturdier homes	Mosam	women all ages	good and strong houses
	Yangasai	women ages 18-30	construction of strong and permanent houses (high wind)
	Bonthe	men all ages	construction of strong houses
	Bonthe	women all ages	construction of permanent houses (high temp)
	Gayahun	men all ages	construction of strong and permanent houses (heavy rainfall)
	Gayahun	men all ages	roofing of the houses
	Mopala	men all ages	construction of good houses
	York Island	men all ages	construction of good houses (heavy wind)
cutting of wood	Yangasai	men ages 18-30	cut wood and sell to make money
	York Island	men ages 30 above	cutting of woods for sale
increase access to wells and	Mosam	women all ages	pump (tap water)

Adaptation Solutions	Village name	Group	Responses
taps	Bonthe	women ages 18-30	council built a tap for us
	Bonthe	men all ages	cleaning of water wells (high temperature)
	Bonthe	women all ages	cleaning of water wells
	Mopala	women ages 18-30	dig bore holes to get water
increase awareness	Yangasai	women ages 18-30	awareness
	Bonthe	men all ages	awareness
	Mopala	men all ages	awareness
increase farming activities	Yangasai	women ages 30 above	farming to get money & food
	Bonthe	women ages 18-30	farming or backyard garden
	Rogbaray	women ages 30 above	vegetable growing
increase fishing activities	Mosam	men ages 18-30	fish to get money
	Yangasai	men ages 18-30	fishing activities
	Bonthe	men ages 30 above	we get fishing materials through dept.
	Bonthe	men ages 30 above	we fish and sell the fish to get money to pay for our children's education
	Mopala	women ages 18-30	selling fish and fish processing
	York Island	men ages 30 above	fishing activities
	York Island	women ages 18-30	fishing activities to sell and buy fish
increase number of	Mosam	women all ages	health centre

Adaptation Solutions	Village name	Group	Responses
health facilities, workers, and access to medicine	Bonthe	men all ages	a resident surgical doctor
	Bonthe	women all ages	medical facility (high temp)
	Gayahun	men all ages	medicine
	Mopala	men all ages	medicines and health workers
increase number of toilets and accessibility	Bonthe	women ages 18-30	council built a public toilet for us
	Bonthe	women ages 18-30	we will go to our neighbors toilet
obtain water from neighboring village	Gayahun	women ages 18-30	we fetch water in neighboring villages
	Mopala	women ages 18-30	we go to neighboring villages to get water
	Yangasai	men ages 18-30	fetch water from neighboring villages
osusu money contribution system	Yangasai	women ages 30 above	contributing money among ourselves to get money
	Bonthe	women ages 18-30	we contribute money among ourselves to help each other
	Mopala	women ages 18-30	we form group that contribute money (osusu)
reforestation	Bonthe	men all ages	planting of trees
	Bonthe	women all ages	planting of trees
road maintenance	Mosam	men ages 18-30	road maintenance
	Mopala	men all ages	construction of good roads
salt extraction/making	Mosam	men ages 18-30	salt extraction
support teachers	Mosam	men ages 18-30	contribute money to pay volunteer teachers

Adaptation Solutions	Village name	Group	Responses
	Mopala	women ages 18-30	volunteer teacher from the community
trading	Mosam	men ages 18-30	trading with farm product
	Yangasai	men ages 18-30	trading and farming
	Yangasai	women ages 30 above	petty trading
	Bonthe	women ages 18-30	we also do petty trading and going to public markets
	Gayahun	women ages 18-30	Trading. We remove oysters and fish from water to sell and get money
	York Island	women ages 18-30	petty trading
transportation to neighboring village	Yangasai	men ages 18-30	transportation of people through the sea to another village

Annex 3. Household Survey Instrument and PRA Guide

Structure of the household survey

Section 1: Introduction (general Information and consent) - Questions 100-106

Section 2: Demographic information (general Information and consent) - Questions 107-126

Section 3: Literacy - Questions 127-130

Section 4: Economic activities - Questions 130-134

Fishing Questions 130-135

Fishing gear Questions 136-140

Fishing practices Questions 141-144

Fishing species Questions 145-146

Fishing sales Questions 147-152

Fishing perception Questions 153-156

Smoking fish Questions 157-170

Production and fuel use Questions 157-170

Sales Questions 171-174

Improved smoking fish banda Questions 175-183

Crop cultivation

Land cultivated Questions 184-189

Sales Questions 190-193

Section 5: Business development - Questions 194-197

Section 6: Mangroves

Mangrove wood use Questions 198-207

Mangrove wood sales Questions 208-223

Mangrove forest perception Questions 224-230

Section 7: Household assets Questions 231 - 233

Section 8: Livestock Questions 234 - 235

Section 9: Water and sanitation

Drinking water Questions 236-238

Sanitation and hygiene Questions 239-245

Section 10: Household's needs Question 246

Section 11: Lost days at work Questions 247-248

Section 12: Food access

Prevalence Questions 249-257

Seasonality Questions 258-259

Section 13: Climate impacts

Flooding Questions 260-266

Coastal erosion Questions 267-271

Droughts Questions 272-277

Strong winds Questions 278-283

High temperatures Questions 284-289

Ranking Question 290

Section 14: Social networks

Groups and associations Question 291

Social solidarity Questions 292

NGO involvement Questions 293-294

Giving Questions 295-296

Section 15: Customary and formal regulatory frameworks Questions 297-304

Section 16: Accessibility Questions 305-316

Section 17: Media access/exposure Questions 317-333

Section 18: Knowledge questions Questions 334-339

Section 19/20: Attitude questions Questions 340-366

Section 21: Interpersonal communication questions Questions 367-375

Section 22: Behavior questions Questions 376-387

Section 23: Survey result Questions 388-390

Section 24: Smoking house materials Question 391

Section 25: Housing materials Question 392-394

Guide to the Participatory Rural appraisal

Methodology – 15 July 2016

• Introduction

The purpose of the focus group discussions and participatory rural appraisal (hereafter referred to as "PRA") is to get a broader picture of coastal climate impacts, community resilience, coping/adaptation mechanisms, and the role of mangrove ecosystems in promoting resilience. It will also explore gender issues in terms of differences in perception of major problems/stresses or available solutions to climate-related problems, as well as gender differences in access to resources. The PRA are intended to complement the household survey and field research being conducted along the research transects. The PRA will be conducted in the same villages as the household surveys but will include a broader group of respondents.

Key questions to be answered by these activities (though not necessarily in the order that they appear here) are as follows:

- What are the primary climate-related shocks and their impacts?
- How would local actors rank climate-related shocks compared to other daily stressors?
- What are the coping strategies adaptation mechanisms available (or potentially available) to communities in view of climate related shocks?
- What are the primary factors underlying community resilience to climate-related shocks?
- What are key natural resources (and related governance systems) upon which villagers depend?

All PRA exercises will be conducted with groups of 8-12 participants (min. 5 max. 15, absolute max. 20), and will last 2-3 hours. One facilitator and one note taker/ assistant facilitators will be needed. There are five exercises, roughly in order of priority. If exercise 5 cannot be accommodated within the time constraints, then either reduce the discussion time or drop it. **It is important to facilitate the PRA in such a way that participants do not get hung up on minor points or disagreements, and to work towards completion of each exercise within 30-45 minutes maximum**. Where disagreements arise, assure the participants that these differences of opinion are being recorded and that all views will be taken into account in preparing the final report.

For small villages, holding separate focus groups for men and women is sufficient. For large villages and towns, we recommend two groups per gender targeting different demographic groups: men and women aged 18-30 (youth) and men and women over 30 years of age. A number of gender-specific and inclusion questions are included in the additional discussion questions in the forms for each exercise.

Note that in some cases, these exercises were originally designed in a way that individuals could record their answers on index cards, and results would be ranked. But,

given low literacy rates, all questions will be posed of the group, and the group will decide on the answers. It will be important, nonetheless, to record major differences of opinion related to ranks or scores assigned to different items during the exercises. Throughout this document, *instructions for facilitators are included in brackets with italicized text*.

• Supplies List

The following supplies will be required for the PRA exercises:

1. Fat tipped sharpies / magic markers – black ink (5 per team)
2. Fat tipped sharpies / magic markers – assorted colors (2 colors each per team)
3. Standard ball point pens
4. Package of sharpened pencils
5. Flip charts (two flip charts per team)
6. Masking tape (1 rolls/team needed to tape flip charts together and to tape index cards to flip charts)
7. Clip boards
8. Sealable plastic bags (to protect notes from water damage)
9. Larger plastic trash bags (to protect the flip charts and other materials from water damage)
10. Sheets of small circle or star stickers (15 sheets per village)
11. Printouts of Annex tables (at least four per village)
12. Index cards (200 per team)
13. Post-it notes (100 per team)

A supply of cash will be needed to pay for meal preparation for the PRA participants.

• Planning for the PRA

Before the PRA starts

- The team leader will make the contact with the village authorities and selected local facilitators 2 days before arrival. Local facilitators will asked to organize the meetings, indicating that they will last 2.5-3 ours and that people should plan their participation accordingly. He will make sure that the times for the PRA are set in a way that is convenient for men and women.
- The team leader will ask how many men and women could be gathered and determine how many groups should be formed, i.e. whether there will be one group/ per gender or two, with the minimum of 5 participants. He will also ask the facilitator to make sure food will be provided to the number of people who will participate (cooked locally, budget has been planned).
- If two groups per gender are planned it is preferable to run the groups for the same gender at the same time to avoid 'leakages' from one age group to another (older men monitoring what the younger men are saying, younger men listening to what older men are saying or starting arguments). If one group per gender is run, the team leader should make sure that both age groups are present.

- The team-leader will ask that a group of no more than 12-15 people be invited to the discussion to keep the discussions manageable. The local facilitator should remain present at the discussion for some time to manage the flow and ask extra participants to leave. It is recommended that there be no people observing the meeting without participating, in order to guarantee privacy and confidentiality.
- DO NOT FORGET to bring the flip charts and stands, tape and markers, cards and stickers with you.
- Before the start of the discussions the consent should be obtained from each participant and participation agreement signed by one of the facilitators. This could be done by explaining the terms of the consent to the group than asking each participant individually if they understand the purpose of the research and agree. A consent agreement (the last page of it) should be signed by the RA facilitator for each participant. At the same time participants should be encouraged not to discuss the specifics of the discussions ('she/he said…') outside of the group, although the discussion of the topics and general conclusions is allowed.
- In each pair of facilitators the roles should be defined, so that there is not doubts about who should be doing what, although changes during the discussions can happen. Facilitators are encouraged to plan very precisely who is doing what at what time and managed the time to ensure that all the exercises can be completed. If needed the additional discussion questions not related to gender/inclusion can be skipped.
- It is important to fill the top page of each sheet, either before or after the meeting, so if a form gets separated from the file it can be identified. Make sure that you include the number of participants and monitor it during the meeting eventually allowing substitution (in some questions only the count will be reported while the proportion, ie count/total number of participants will be needed).

During the PRA

- Monitor time to be able to finish in time. If necessary interrupt arguments etc.
- But prompt people to explain their choices where indicated or when they are counterintuitive. Record if there is room or on the back of the page indicated which issue it relates to.
- Prompt passive/shy participants to respond.
- If possible fill the forms as you finish each section. Capture the discussion points as you go even if they are no on the chart. If not possible…

After the meeting

- Fill the forms and answers to the questions immediately after the end of the discussion.

- Review all the forms and answers for consistency and clarity. Make sure that the headre (village, date, # participants and gender/age group) are filled on all forms.
- Indicate village and group (gender and age range) at the top of the charts and take pictures.
- Roll the charts and take them with you
- Review the forms in the evening.

• Methods

Participatory risk ranking and scoring

The intent of this exercise is to elicit experienced and perceived problems among community members. The underlying rationale is to highlight problems that are most relevant for enhancing resilience/adaptive capacity, and to understand how important climate stress is compared to other livelihood hazards. As pointed out by Reid and Vogel (2006), climate stressors are rarely the only concern or stress that constrain 'quality of life' in rural, resource-poor communities in Africa. The terms concern, worry, stress, stressor, hazard, and threat are used here interchangeably as they all reflect "threats to people and the things they value" (Kates and Kasperson, 1983).

The ranking and scoring will capture four components:

- the importance: weighted average of the counts in each of the 4 ranks
- the incidence: total count a given worry was listed
- severity: how much the daily life/activities are impacted by the worry (if possible, this part was difficult to implement in Sierra Leone and was dropped after testing)
- frequency

Importance and incidence

The facilitator will describe in broad outline what the purpose of the exercise is, and how participants will be asked to rank the most important worries/stressors in their lives. Examples could include "health problems", "lack of clean water supply", "lack of money", "inadequate food supply", "assets" etc. But more detailed answers are also accepted, such as 'malaria', 'leaking roof', 'not enough food', 'television'. Participants are asked to think of the four most important worries/stressors they have experienced during the past year. When they've had a chance to think of the worries, they should keep them in mind. They should also not change their list based on other people's responses. The facilitator will go around the circle and ask the first person to provide out-loud their list of four items. The facilitator will write the worries with their ranks on a card or sticker and **hand it to the responded who will keep it**. **At the same time** the note taker will write the worry on the flipchart and/or add one mark in the appropriate rank. The next person then lists their items and they are recorded on the stickers.

The facilitators should ask the village chief and any of the people who seem to be holding leadership roles in the village to speak the last, not to influence people's answers. For example the facilitator could start going around starting with the person sitting next to the chief and not being a leader then finish with the chief. However, this process should be clearly explained to the group not to offend the chief and other leaders.

Once all the responded have had a chance to list their worries, the note taker will perform the total count for each worry and rank them. Record the count and rank on the chart, then report the results on the form 1.1.

Chart 1: Example of a sticker

Rank	WORRY
1	health
2	food
3	job
4	shelter

Chart 2: Example of the chart.

Facilitators are encouraged to use the 5 tick convention, where four ticks are written and a fifth strikes across 𝍸 or a square is attempted and as soon as the four sides are complete a  fifth is stricken across. In each case the completed shape should be counted as 5 to facilitate the total count.

WORRY	Rank1	Rank2	Rank3	Rank4	Total count	Rank
health	𝍸 III	III	I	I	12	2
shelter	III	II	II	I	8	4
job	II	I	𝍸	II	9	3
education	II	II	I	II	7	5
food	𝍸 II	III	II	II	13	1

By the time the whole group has finished with their lists, there may be a list of 15-20 items, with different numbers in different ranks.

If there is time add pictograms to represent the stressors. [Take a picture of the **chart after having written the name of the village and the age group**.]

Frequency

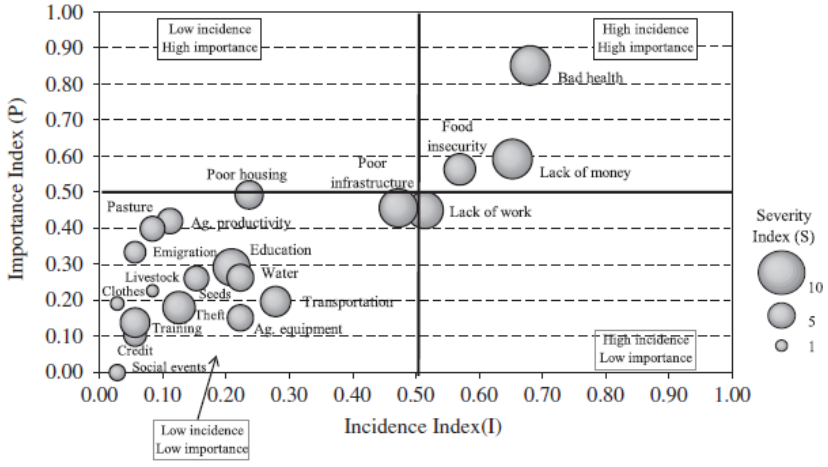
Next ask participants how often they worry about each stressor they listed. Propose the frequencies: every day, once a week, once a month, seasonally, less often. Record in similar way.

[Record the responses in the form1.3. Take a picture of the chart after having written the name of the village and the group.]

STRESSOR	Every day	Once a week	Once a month	season ally	Less often
Health	I		~~IIII~~	~~IIII~~ III	I
Food security	II	I	~~IIII~~ II	III	II
Sanitation		I	II	~~IIII~~ I	I

In the final report, the results of this exercise will be presented in a manner similar to that devised by Tschakert (2007) (Figure 1).

Figure 1. Summary of significance of stress conditions at the individual, household, and community level. The severity index ranges from 1 (barely noticeable) to 10 (life threatening).



Source: Tschakert, 2007

Solution

Finally, if the time allows, for the three top-ranked problems, ask the group to describe the various strategies they have undertaken to reduce or solve each problem and their

rate of success. Capture maximum three/worry. Record the results in the form 1.4 (additional space is added in case the group insists on discussing more worries).

Inclusion aspects:

1. there are groups who would have more difficulties than others accessing/implementing any of the solutions (women, youth, ebola survivors, minorities). *[Capture in form 1.4]*
2. there are any solutions that the other gender/age group would implement that would adversely affect tis group. *[Capture as comments, eventually using the back of the form 1.4]*.

[Take a picture of the chart after having written the name of the village and the group.]

Climate-related stressors and mental mapping

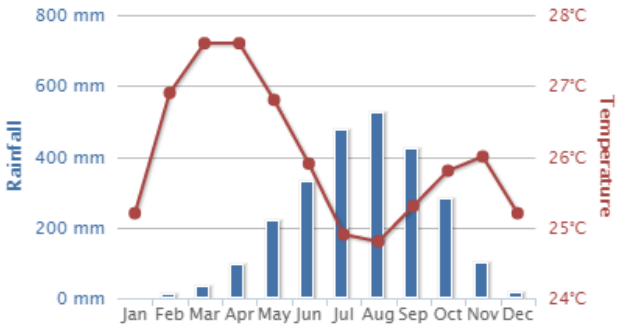
Participants in focus group discussions are asked to propose definitions of the term **climate**. These definitions should be recorded as described by participants, without passing judgment on the accuracy of the definitions. [*Record all responses in Form2.1 .*]

Climate and perceived climate change

1. After this first step, the facilitator should provide a definition of climate as the "long term average conditions of temperature, rainfall, winds, and humidity that villagers would normally expect during different seasons of the year. Weather is what you get on any given day, whereas climate is what you expect to happen during the season." Use examples such as the seasonality of therain, expected dates of the start and end of the season, differences in temperature during the rainy and the dry season. The facilitator should also define **climate extremes** as "unexpected" events of various intensities and durations – such as extreme rainfall or winds, which may occur over periods of one or more days, or prolonged flood or drought events, which may endure over a matter of weeks to months.

2. Discuss the issue of climate variability vs climate change. For example, ask the participants when is the usual date of the start of the rains and discuss the fact that sometimes they start earlier, sometimes later; similarly the number of heavy storms is not the same each year. As long as sometimes the season starts earlier and later than exoected or there is more or less storms this is climate variability. Climate change is when the start of the rains data start oscillating permanently around another date (e.g 10 days later). Or the number of storms is permanently larger. This needs to be recorded over a period of time (e.g. 10 years) nt just in one year. The facilitator should then ask if respondents perceive the climate has changed over the past 10 years – first in terms of average conditions, and then in terms of variability (greater, less, or the same predictability), and lastly in terms of the severity or duration of extremes. [*Record all responses in Form 2.2..*]

Figure 2. Average Monthly Temperature and Precipitation for Sierra Leone, 1960-1990



Source:
http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Africa&ThisCCode=SLE

Conceptual model of current climate impacts

After this, the facilitator will use conceptual mapping (also known as mental models). Mental models are psychological representations of real or hypothesized situations, generally in the form of individual conceptual maps of ideas. Respondents are asked about the positive and negative consequences of climate change and variability, for both people and the environment, organizing their thoughts with the help of index cards and arrows. **This exercise is aimed at current climate impacts/stressors.**

Create a large blank area by taping four flip chart pages together. Create the mental map following these steps:

1. Start with a box in the center indicating 'Climate and Climate Variability'.
2. Record climate events or weather extreme affecting the village (heavy rain, drought, winds etc). If necessary ask villagers to list events that they have observed in the past 10 years. Tape those around the climate box. Make sure you are differentiating the climate events from the impacts. **Drawings / pictograms may be used** in addition to verbal descriptions on the index cards.
3. Record the impacts of these events. Example: house flooded, road flooded, trees down, houses damaged, crop lost, animals sick). **Record human-related effects on pink cards, and nature-related effects on green cards.** Tape them. Draw arrows between climate, events and impacts.

Note that the objective here is not to impose expert knowledge or to correct misinterpretations or far-fetched causal relationships, but to accurately record the causal relationships as perceived by respondents and to stimulate discussion around these relationships.

For each impact index card (outer circle), indicate in the lower left hand corner the **frequency** of the impact in terms of the approximate number of times said impact occurred **over a ten year period**, and on the lower right hand corner indicate the perceived **importance or severity** of the impact on a 1-5 scale following:

Level 1: mild, did not influence my daily routine or prevented me from doing my daily tasks (e.g. road flooded but could go around, tree fallen but could go around, minor repairs)

Level 2: impacted some of the activities but not most (could not go to the weekly market or visit family)

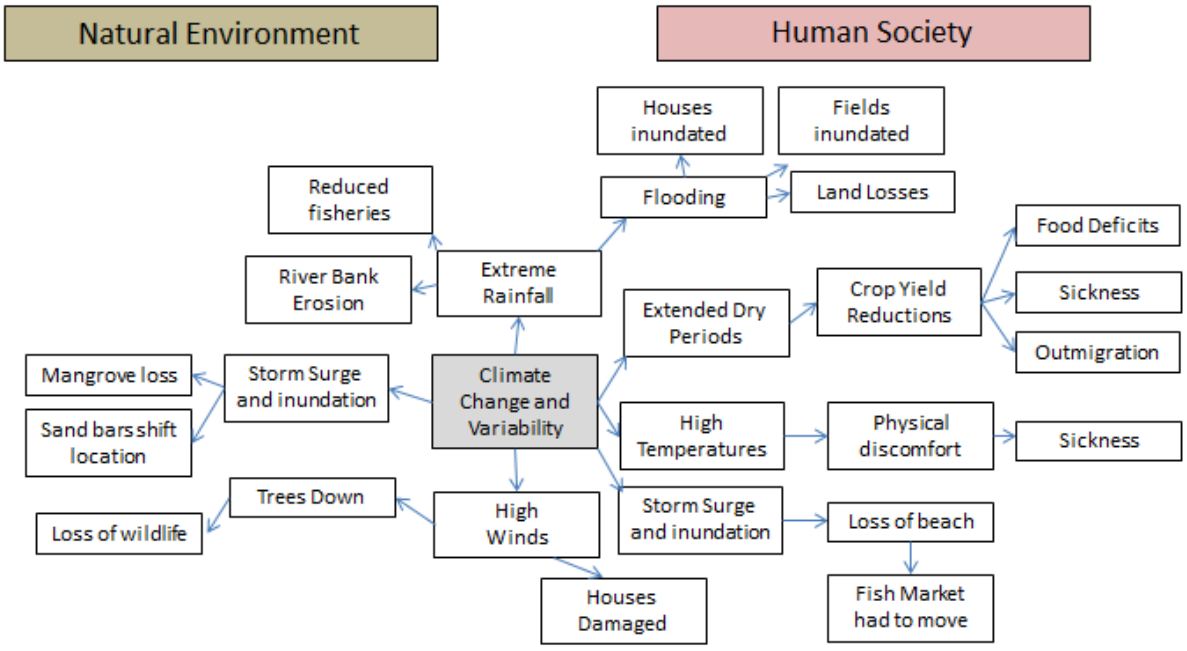
Level 3: impacted most of the activities (e.g. could not go fising, could not access supplies needed for my economic activity, major repairs in the house)

Level 4: impacted ny ativities/life severely (eeded to relocate temporarily, lost my boat, loast all harvest etc.)

Level 5: life threatening; impacts all my activities, could have led to death (access to health facility cut, lot all harvest no food, house collapsed when sleeping, flood came quickly we could have drowned etc)

[Once the mental map is filled out, take some photos of the mental map, and also transcribe the information in Form2.2.]

Figure 3. Mental Map of Causal Relations Stemming from Climate Change and Variability



Inclusion questions:

- What do climate impacts mean specifically for women and men or marginalized groups in terms of their livelihoods and household activities? For example, do food deficits mean that women conserve their food for other members of the household other than themselves?
- If migration is mostly an adult male activity, what does that mean for women's roles and responsibilities? Or for the young adults?

Solutions discussion

In this exercise facilitators will use the mental mapping exercise as an input to a discussion on solutions. Sticky notes will be affixed to the problems listed around the periphery. Each sticky note will represent actual or potential solutions to the impacts/problems. For example, Physical Discomfort from high temperatures might include sticky notes such as "sit in the shade" or "grow trees in the village", or Houses Inundated might include "evacuate quickly", "move houses to higher ground", or "build houses on stilts". Some solutions will be coping mechanisms that villagers already employ (e.g., evacuate quickly or sit in shade), but others will imply adaptive responses. Table 1 provides definitions of coping versus adaptation; it is important to recognize that this represents more of a continuum then a dichotomy, and that adaptation could imply things like migration, which are individual responses that may relatively little capital compared to sea walls or moving a village.

Table 1. Coping versus adaptation

COPING	ADAPTATION
Short-term and immediate	Practices and results are sustained
Oriented towards survival	Oriented towards longer-term livelihood security
Not continuous	A continuous process
Motivated by crisis; reactive	Involves planning
Often degrades the resource base	Uses resources efficiently and sustainably
Prompted by a lack of alternatives	Focused on finding alternatives
	Combines old and new strategies and knowledge

Source: weADAPT, https://www.weadapt.org/knowledge-base/adaptation-decision-making/adaptation-versus-coping

Only for solutions that imply **adaptation responses**,[22] list the solutions in the left-hand column of a flip chart with five columns. Then ask participants to collectively rate adaptation responses on a scale from 1 (very low) to 10 (very high) along the following four dimensions:

5. Degree of preference for this adaptation response
6. Difficulty/level of effort required
7. Ability for community to organize to respond, and
8. Dependence on outside funding / technical assistance / institutions

[22] Try to err on the side of an *inclusive* definition rather than applying narrow criteria to what is an "adaptation" response. It may be possible to convert some coping strategies into adaptation responses. For example, the facilitator might suggest that "sitting in the shade" could become "plant more trees" as an adaptation response.

An approach to ranking could be to ask participants in response to the following questions:

1. How many of you find this solution very good/highly desirable
2. How many of you find it very difficult to implement (for whatever reason, if there are important reasons, capture in comments.)
3. How many think the community is able/ready/willing to implement it (or how many would participate in implementation)
4. How many of you think that this solution requires external assistance (technical , funding, institutions)

Capture the number of hands raised and recount the number of participants to be able to calculate the proportions. For example if 16/20 raise their hands, the proportion is 80% and the rank 8.The final result could be : "move the village", preference=8, difficulty=10, ability=6, dependence=8.

[At the end of the exercise, transcribe the flip charts to the table in Annex 2.4. Where contingencies exist, such as villagers would self-organize if materials are provided, note these down in the notes section of Annex 2. 4.[23] Similarly, where community members cannot think of any viable solutions to certain impacts/problems, note those down.]

Additional discussion questions:

- Where do the participants get their information on climate variability and risks? Do all groups have equal access to such information?
- Are there groups/organizations in the community working on disaster mitigation? And if so, are all genders allowed access to such groups?
- For the adaptation responses suggested, who would be responsible for deciding which solution should be enacted on and who would be responsible for its implementation?
    - Are there equal opportunities for women and men to participate in local decision-making around the issue of climate change? In what ways do women and men participate or make sure their interests are represented in local decision-making?
- What training opportunities or technologies do the participants think should be created to improve the resiliency of their communities?
- Are there any indirect impacts of the strategies the other emplys (e.g. migration impact on women or youth)

[23] Explore under which circumstances the community is willing to self-organize and how. Try to identify what villagers are willing to address themselves if assistance were provided from the outside. The outside aid could include materials but could also be training (e.g. mangrove planting) also if there are already community structures in place through which some of the actions could be channeled (women's associations, professional associations, neighbourhood councils, etc.)

Coping/Adapting to climate change

In this exercise you will revisit both the **coping** and **adaptation strategies** explored in Exercise 3. Go through each of the proposed coping and adaptation strategies, and then ask the villagers to imagine a possible future in which a given climatic extreme was **greater in magnitude** or were to occur **twice as often** or **last much longer**. Ask them to explore which coping and adaptation strategies would still be viable in this context. Discuss with the group which ones will still work and which ones would not be enough/become too costly or possibly maladapative (meaning that instead of increasing resilience, they would decrease the ability of the village to withstand the event). For the adaptation options, discuss how the options and their preferences would change in a more extreme future climate. Would some of the more difficult and more costly options become preferable? [*Note down changes in preferences in Annex 5.]*

Resource and risk mapping

[This exercise is best done as a map but if time does not allow it, record the responses without the spatial component, in the form 1..]

With the participants, use four flip charts taped together to map the community in a generalized way. Provide different colored magic markers. Begin with the main route and households of the settlement in **black** pen. Be sure to map at a scale that will provide enough room around the settlement to map things that may be 1-2 kilometers away. Please emphasize that the point of this exercise is *not* to produce an accurate map, so do not get hung up on the cartography. If a map proves to be less useful or distracts from the discussion, then feel free to simply create a list of natural resources that are important to the community.

Ask the villagers to first map resources that are important to them in **green**. For example, water sources, farmlands, pasture areas, near-shore fishing areas, mangrove forests, or other forests. If the resource falls outside the boundaries of the map, have them draw an arrow that points to those resources (e.g., market town, fisheries, etc.). For each resource on the map, indicate why it is of value (e.g., wood for construction, nuts, medicinal herbs, etc.). In **blue** pen, use different symbols to indicate any access agreements or restrictions. Use "O" for "open access" (no restrictions, anyone inside or outside the community can access), "C' for "customary restrictions or agreements" (community use only, or by permission of the local chief), and "G" for "government restrictions" (e.g., government regulation of access to a forest, or water sources associated with a school or clinic). Note where differences in rights or access are gender-specific. Where customary or government restrictions apply, use this opportunity to elicit from the community what those agreements or restrictions are, who has access (and who does not), to what kinds of resources (for example, in a forest tree cutting might be restricted but non-timber forest products or game hunting might be permitted), and whether surrounding communities acknowledge the customary rights of the villagers in that community.

Next, use a **red** pen to draw on the map where different hazards or risks exist. Examples might include zones susceptible to periodic flooding, areas that have suffered erosion, or lands / soil types that are susceptible to drought. Explore with the villagers the frequency of events that affect those areas – are they annual, once every five years, or only once a generation? [*Record responses*]

Additional discussion questions:

- Which resources are the most important for the major livelihoods in the area? How is this differentiated by gender/age?
- Which resources, livelihoods and household responsibilities are most vulnerable to climate variability? How is this differentiated by gender/age?
- What resources are women and men most dependent on and how is this affected by climate variability?
- When asking about access and restriction to resources, how does this differ by gender? [Use sticky notes to distinguish which resources women only can access, which ones men only can access, and which ones are accessible by all genders.]
- Who decides access (or restrictionto) and management of particular resources and how is this defined by gender, age or other criterion?
    - Are there groups excluded from the decisions abut access/ management etc.
- Are there different perceptions of hazards or risks depending on gender?

[Take one or more photographs of the map to clearly capture all the details and note down given resources and any restrictions in Form 5.1.]

References

Kates, R.W., Kasperson, J.X. 1983. Comparative risk analysis of technological hazards. *Proceedings of the National Academy of Sciences*, 80, 7027–7038

Reid, P., Vogel, C. 2006. Living and responding to multiple stressors in South Africa—glimpses from KwaZulu-Natal. *Global Environmental Change* 16: 195–206.

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Annex 4: Forest Inventory Forms

Mangrove Inventory Field Form 0

General Assessment

Region:……
Transect Line No:……

Date:……
Vilages:……
GPS Coordinate:……
Altitude:……

Assessment along the ride to the transect*

Human Activity

Human Activity Observed: Cutting…… Clearing…… Cultivation…… Sand Mining…… Salt Mining……

Brief Summary of observations:_____

_____

_____

_____

_____

Bird Life

	Species Name
1	
2	
3	
4	
5	

Crusteceans Species

	Species Name
1	
2	
3	
4	
5	

Mammal Species

	Species Name
1	
2	
3	
4	
5	

Fish Species

	Species Name
1	
2	
3	
4	
5	

Amphibian Species

	Species Name
1	
2	
3	
4	
5	

Reptile Species

	Species Name
1	
2	
3	
4	
5	

* FAO 1994 - The Mangrove forest can be categorized into six vegetation types:
i. RHF = Rhizophora High Forest
ii. AHF = Acicennia High Forest
iii. R/AHF = Rhizophora/Avicennia High Forest
iv. RHB = Rhizophora High Bush
v. R/AHB = Rhizophora/Avicennia High Bush
vi. PF = Poor Forest (species)

Categorization carries an inevitable element of subjectivity but can follow the following guidelines:
i. The crop is classified as being pure if greater than 80% on one species are present
ii. High Forest refers to an area which contains or has previously supported trees of 20-30m tree height
iii. High Bush refers to an area which contains or has previously supported trees of 10-20m tree height
iv. Poor Forest refers to an area supporting a shrub-like crop of poor form and minimal productive potential

Adult Tree Count

Region:……

Transect Line No:……

Sample Plot No:……

Date:……

Viiages: ……

Coordinates:……

Altitude:……

Tree I	Species	Live/Dead	Stand/Fall	DBH(cm)	Height(m)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

Indicate L = Live; D = Dead; S = Stand; F = Fall

Data Entry by: ……

Signed: ……

* FAO 1994 - The Mangrove forest types:

i. RHF = Rhizophora High Forest

ii. AHF = Acicennia High Forest

iii. R/AHF = Rhizophora/Avicennia High Forest

iv. RHB = Rhizophora High Bush

v. R/AHB = Rhizophora/Avicennia High Bush

Mangrove Inventory Field Form 1

Stand Assessment

Region:……

Transect Line No:……

Sample Plot No:……

Date:……

Viiages:……

Coordinates:……

Altitude:……

Human Activity

Human Activity Observed: **Cutting……** **Clearing……** **Cultivation……** **Sand Mining……** **Salt Mining……**

Bird Life

	Species Name	Count
1		
2		
3		
4		
5		

Amphibians

	Species Name	Count
1		
2		
3		
4		
5		

Mammal Count

	Species Name	Count
1		
2		
3		
4		
5		
6		

Reptiles

	Species Name	Count
1		
2		
3		
4		
5		

Crusteceans Count

	Species Name	Count
1		
2		
3		
4		
5		

Evidence of Regeneration:

Height of tide on roots/stem (in cm/m):

Fish Count

	Species Name	Count
1		
2		
3		
4		
5		

Additional Comments:

Mangrove Inventory Field Form 2
Adult Tree Count

Region:……

Transect Line No:……

Sample Plot No:……

Date:……

Viiages: ……

Coordinates:……

Altitude:……

Tree I	Species	Live/Dead	Stand/Fall	DBH(cm)	Height(m)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

Indicate L = Live; D = Dead; S = Stand; F = Fall

Data Entry by: ……

Signed: ……

* FAO 1994 - The Mangrove forest types:

i. RHF = Rhizophora High Forest

ii. AHF = Acicennia High Forest

iii. R/AHF = Rhizophora/Avicennia High Forest

iv. RHB = Rhizophora High Bush

v. R/AHB = Rhizophora/Avicennia High Bush

vi. PF = Poor Forest (species)

Mangrove Inventory Field Form 3

Regeneration Count

Region:……

Transect Line No:……

Sample Plot No:……

Date:……

Viiages:……

Coordinates:.....

Altitude:.....

Tree No.	Species	DBH(cm)	Height(cm)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			

***Note: measure dbh for seedlings ≤5cm or below the height of 1.37m**

Data Entry by: ……

Signed: ……

Annex 5: Staffing for the Vulnerability Assessment

The following table provides staff names, roles, and affiliations. Consult the acronym list in the front matter to identify the institution.

	Name	Role	Level of participation	Institution
1	Sylwia Trzaska	VA Lead	Training and Field work	CIESIN
2	George Ganda	In-country VA Coordinator	Training and Field work	WA BiCC
3	Tom Menjor	Yawri Bay area Team leader	Training and Field work	WA BiCC
4	Rob Merritt	Scarcies area Team Leader	Training and Field work	WA BiCC
5	Augustine Amedzi	Sherbro area Team Leader	Training and Field work	WA BiCC
6	Eslon Nduwawo	WA BIC	Training only	WA BiCC
7	Namalie Tayasinghe	GESI Consultant	Training and Field work	WA BiCC
SOCIOECONOMIC SURVEYS				
8	Samuel Weekes	Consultant	Training and Field work	Fac. Social Sc. FBC.
Household Surveys				
9	Komba Konoyima	Survey Supervisor	Training and Field work	FBC
10	Sufian Carew	Survey Supervisor	Training and Field work	FBC
11	Ahmed N Khan	Survey Supervisor	Training and Field work	FBC
12	Assana Dumbuya	Surveyor	Training and Field work	FBC
13	Massa Amara	Surveyor	Training and Field work	FBC
14	Ansumana Bawoh	Surveyor	Training and Field work	FBC
15	Mariama Kargbo	Surveyor	Training and Field work	FBC
16	Victor Thuray	Surveyor	Training and Field work	FBC
17	Allieu Bakarr Kamara	Surveyor	Training and Field work	FBC
18	Charles Showers	Surveyor	Training and Field work	CSSL
19	Foday Rogers	Surveyor	Training and Field work	FBC
20	Umu Turay	Household surveyor	Training and Field work	FBC
21	Ijartu Feika	Household surveyor (training only)	Training only	FBC
Participatory Rural Appraisal (PRA)				
22	Brima B Bangura	PRA enumerator	Training and Field work	NPAA
23	Samuel M Kamara	PRA enumerator	Training and Field work	EPA SL
24	John Darvi Brima	PRA enumerator	Training and Field work	MAFFS Forestry Department
25	Nancy Saffa	PRA enumerator	Training and Field work	FBC
26	Zainab Jah-Bangura	PRA enumerator	Training and Field work	MLCPE
27	Sibella Swarray	PRA enumerator	Training and Field work	YMCA
28	Bai Bai Sesay	PRA enumerator	Training and Field work	MAFFS
29	Mariama Conteh	PRA enumerator	Training and Field work	NPAA
30	Sahr Sandi	PRA enumerator	Training and Field work	MFMR

	Name	Role	Level of participation	Institution
31	Immah Conteh	PRA enumerator	Training and Field work	NU SL
32	Adama Kargbo		Training and Field work	
MANGROVE ECOSYSTEM SURVEYS				
33	Dr Aiah Lebbie	Consultant	Training and Field work	Fac Env. Science, NU. SL
34	Abdulai Feika	Snr. Surveyor	Training and Field work	NU
35	Jonathan Johnny	Snr. Surveyor	Training and Field work	NU
36	Ibrahim Abu-Bakarr	Snr. Surveyor	Training and Field work	NU
37	Samuel Okoni Sokpo	Surveyor	Training and Field work	NU
38	Joseph Momoh	Surveyor	Training and Field work	NU
39	Jonathan Aruna Musa	Surveyor	Training and Field work	NU
40	Francis Lemon	Surveyor (Standby)	Training and Field work	FBC. SL
41	Abdoulaye Doumbia	Mano River Union Partner (Training only)	Training only	
42	Kouami Kra	Mano River Union Partner (Training only)	Training only	
43	Emmanuel Logueh	Society for Conservation of Nature Liberia- SCNL	Training only	
44	Konikay A Nimley	Forestry Development Authority-FDA	Training only	