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ACRONYMS

ACPC	African Climate Policy Centre
CBL	Central Band of Liberia
CBOs	Community Based Organisations
CCAFS	Cocoa and Coffee Agroforestry Systems
CSOs	Civil Society Organizations
CCAAP	Climate Change Agriculture Adaptation Project
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation
FDA	Forestry Development Authority
FFI	Faun & Flora International
GEF	Global Environmental Fund
GGC	Green Globe Consultancy
GDP	Gross domestic product
GPS	Global Position System
GoL	Government of Liberia
IPCC	Intergovernmental Panel on Climate Change
IWRMP	Integrated Water Resource Management Policy
LASIP	Liberia Agriculture Sector Investment Programme
LDCF	Least Developed Countries Fund
MOA	Ministry of Agriculture
MOT	Ministry of Transport
MDGs	Millennium Development Goals
NAPA	National adaptation programme of action
NAP	National Adaptation Plan
NBSAP	National Biodiversity and Strategy Action Plan
NCCS	National Climate Change Secretariat
NDMC	National Disaster Management Commission
NDC	Nationally determined contribution
NDP	National Development Plans
NFAA	National Fisheries and Aquaculture Authority
NDA	National Designated Authority
NPRSCC	National Policy and Response Strategy on Climate Change
NPRS	National Policy and Response Strategy
NGOs	Non-governmental Organisations
NTFPs	Non-timber Forest Products
NRDP	National Reconstruction and Development Plan
SLM	Sustainable Land Management
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WEAG	Women Empowerment Agriculture Group

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EXECUTIVE SUMMARY

In this report, we assess climate change vulnerability, risks and the impacts on the agriculture, fisheries, and forestry sectors and we propose appropriate adaptation options and action plans for implementation. In conducting this study, we used a combination of methodological approaches and tools including: the IPCC concept of climate vulnerability and risks, the analyses of climate change policy and technical documents, consultations, interviews and group discussions in all the four agroecological zones of Liberia cutting across eight counties, GIS analysis to produce vulnerability maps, stakeholders' multi-criteria analysis to prioritize adaptation options, transect walk and field observations, triangulation of data, as well as the organization of three technical workshops with resource persons.

The findings reveal that climate change and climate variabilities are already negatively impacting the productivity of the agriculture, forestry, and fisheries sectors and their associated supply chains. Climate change and variabilities also have a social impact and a human dimension as it affects the life of the communities with different effects on women, men and children and the elderly, their lifestyle and reveal their abilities to cope with changes. It is posited that the major climate impacts and hazards will be on the agriculture sector through increased crop loss/failure due to extreme weather events, warmer temperatures, droughts, floods, changing rainfall patterns and distributions, increased pests, weeds, and pathogens which will results to food insecurity and loss of livelihoods in some communities. Warmer temperatures in the country have led to a reduction in chill hours potentially reducing yields for some crops like corn, rice, rubber, coffee, cocoa, and cassava. In addition, livestock population in Liberia is below 10% of national requirements and part of the cause is attributed to impacts of climate change.

In the fisheries sector, climate change impacts related to sea level rise, floods, coastal erosions, wind storms and brown tides are affecting fishing, coastal livelihood activities and the coastal ecosystems in Liberia. The forestry sector on the other hand is impacted by increase in temperatures that causes snails to hide and dead of species such as framire. Increase in temperature also leads to an increase in pests and diseases that affect tree species. Increase in the frequency of intense precipitation leads to erosion and runoff leading to decrease in forest cover and forest health, decrease in flowering of plants and less seed-fruits in walnuts, decrease in yields of Xylopia (*aethiopica*-country-spot), *Piptadeniastrum africanum*-Dahoma, rattan and Garcina kola or bitter kola.

Based on the above climate vulnerabilities, impacts and risks in the three sectors, resources persons and stakeholders from the three sectors engaged in a multi-stakeholder process using multicriteria analysis to assess and prioritize appropriate adaptation options. We build on the prioritized adaptation options to prepare and propose an action plan for implementation, composed of four programmes that will benefit the communities at large, as indicated in the table below. The detail action plan provides the estimated cost, proposes organisation and timeline for implementation, men and women beneficiaries, sectors concerned, areas of interest for the Green Climate Fund, activities for male and female and expected result areas among others. Moving forward, we

recommend actions for enhancing the implementation of these four programmes and they are related to: sensitization and promotion of collaborative stakeholder implementation process, monitoring and adaptive management of the action plan.

Programme	Key Activities
Enhancing resilience to climate change in vulnerable coastal communities in Liberia	✓ Promote sustainable fishing practices and supply chain ✓ Integrate fisheries into climate policies ✓ Build a climate resilient jetty ✓ Establish marine protected areas ✓ Promote eco-tourism and ecosystem management ✓ Establish woodlots to produce firewood for drying fish ✓ Promote the use of household energy efficient stoves ✓ Provide electricity using solar panels ✓ Promotion of marine stores to supply fishing equipment
Implementing climate smart agriculture in Liberia	✓ Promote sustainable water and soil management ✓ Integrated Pest management ✓ Farmers field school and develop extension systems ✓ Use improved technologies and adapted varieties ✓ Promote marketing and climate resilient supply chains ✓ Mainstream gender into all farming and livestock activities ✓ Improve agriculture commodity and trade policy ✓ Develop livestock and crops value addition ✓ Strengthen capacities of extension officers
Intensification and diversification of cocoa and coffee agroforestry systems for climate mitigation and adaptation	✓ Develop and implement a comprehensive strategy to reduce the vulnerability of the cocoa and coffee supply chains to climate change and ensure their future viability ✓ Training of farmers on farm renewal techniques and tree domestication and improvement techniques ✓ Promotion of improved germplasm of cocoa, coffee & fruit ✓ Integrate agroforestry systems into policy plans / programmes ✓ Promote marketing and supply chain of cocoa and coffee to impacts of climate change
Climate resilient emission reduction in Liberia forest ecosystems	✓ Alternative livelihoods for forest dependent communities ✓ Sustainable management of NTFPs including supply chains ✓ Reforestation and afforestation of degraded forest lands ✓ Sustainable forest management and protection ✓ Replace charcoal and firewood with energy efficient stoves ✓ Detect, control and manage invasive species ✓ Promote reduce impact logging during logging operations ✓ Identify and address drivers and causes of forest lost ✓ Biodiversity conservation and ecosystem services for climate-resilient development.

1. INTRODUCTION

1.1. Forestry Sector

Overview

Liberia is located in West Africa and holds a vast majority of the Upper Guinean Forest Ecosystem. Liberia was once believed to have been covered entirely by tropical moist forest prior to anthropogenic activities that have impacted the forest (FDA, 2000). However, the country is still known to hold the highest amount of forest blocks in the Upper Guinea rain forests (FDA, 2006). The forest estates of Liberia cover 4.39 million hectares which accounts for 45 percent of the total land area of Liberia (FDA, 2006). Closed dense forest is estimated at 2.42 million hectares and the open dense forest covered 1.02 million hectares while agriculture and degraded forest amount to 0.95 million hectares (USAID, 2015). However, the most updated information about Liberia's forest cover revealed that the dense forest is about 3,572,100 hectares which accounts for 32 percent of Liberia's land area (US Geological Survey, 2014). The vast forest area of Liberia has dwindled to an estimated 14.3% of its original size, driven in Liberia by commercial and chainsaw logging, shifting cultivation, charcoal production and mining (World Bank FCPF 2019). The average annual deforestation rate between 2000 to 2015 is estimated at 0.7%. The country is endowed with natural resources, has well established itself as one of the biodiversity hotspots, and is listed as the 34th global biodiversity hotspots (EPA, 2018). Liberia has recorded a number of threatened and endangered timber species as follows*: Entandrophrama utilis-Sipo, Entandrophrama angolensis-Tiama, Entandrophrama candolei-Kosipo, Entadrophragma cylindricum-Sapele, Heritiera utilis-Niangon, Khaya enthoteca-Khaya, Lovoa trichiodes-Lovoa/dibétou, Tetraberlina tubmaniana-Tet/sikon, Tieghemella heckelli-Makore, Lophira alata-Ekki/iron wood, Triplochiton scleroxylon-Wawa/obeche, Piptadeniastrum Africana-Dahoma, Chlorophora regia-Iroko, Aniegre robusta -Aniegre, and Holea celiata Abura* (USAID, 2015).

Besides, the biodiversity of Liberia includes over 2,900 different vascular plants with 225 tree species, 150 mammal species, and 75 reptile species. Over 60 tree species have been harvested and exported from Liberia in the past. Niangon (*Heriteria ultilis*) is recorded as the most harvested species and account for 50 percent of the industrial roundwood production (FDA, 2006). In 2002, Liberia recorded several concessionaires. Indeed, about 36 forest contracts were awarded to these concessionaires and the estimated value of timber in the contract amounted to about USD 100 million or 60 percent of the country's total export revenues (FDA, 2006). The forestry sector employed about 10,000 people. In the Central Bank of Liberia annual report of 2015, it was recorded that the forestry sector contributed 94.8 million USD, the same amount in of 94.8 USD was captured in 2016. There was a decline in 2017 (87.2 million USD) as well as 2018 (83.7 million USD). On the overall, the forestry sector contribution declined to a negative 8.0 percent from zero (CBL, 2017). Aside the formal contribution of the forestry sector to the national economy, the informal activities such as fuelwood, charcoal production also employed a

good number of people. Also, the harvesting and sale of bushmeat has contributed to the local economy in the form of income and employment (FDA, 2006).

Regulatory Framework (laws, policies guidelines and standards)

Like many institutions in Liberia that came from an original setup, what is known as the Forestry Development Authority (FDA) today originated from the Bureau of Forest and Wildlife Conservation (1953) that was created in the Ministry of Agriculture (FDA, 2006). The FDA which is the custodian of the forestry sector was created by an Act in December 1976. The Act repealed all previous forestry and wildlife laws and granted the FDA the power to issue, amend and rescind forestry and wildlife regulations. "The Act defined the objectives for the sector, which may be grouped into three broad themes: establishing a permanent forest estate made up of National Forests and National Parks; optimizing the contribution of forestry to the national economy; and increasing public involvement in forest conservation and management through the creation of communal forests and agroforestry programmes" (FDA, 2006).

The Forestry Development Authority's functions cover the following: formulating forestry policy; forest resource management; control and management of concessions; collection of revenue from forest activities; research (including market intelligence); and training. The Forestry Development Authority has issued 27 regulations that deal mostly with the administration and management of forestry and wildlife activities (including forest charges, fines and penalties).

In 2000, a New National Forestry Law came into existence. It amended or repealed certain provisions of the existing forest laws. The final version remains controversial, as it transferred powers over the sector from the legislature to the executive. In 2006, "An act adopting the national forestry reform law of 2006" was passed, which amended the National Forestry Law of 2000 and the Act Creating the Forestry Development Authority. The Law recognized the problems of the past and stressed the integration of community, conservation and commercial (3C) forest management for the benefit of all Liberians.

Past and Current Initiatives

Some of the past and current initiatives in the forestry sector include the following:

- The Liberia Forest Programme financed under the $150 million commitment of the Liberia-Norwegian partnership agreement aimed to support the Government's efforts in the forest sector, including the integration of carbon aspects.
- REDD+ programme in Liberia (R-PIN, R-PP, REDD+ strategy, R-Package) funded since 2008 by the World Bank Forest Carbon Partnership Facility (FCPF) and other donors and initiatives.
- USAID Land Rights and Community Forestry Project (LRCFP) from 2007 to 2011 established and demonstrated a framework for community land and forest resource rights that will provide equitable local benefits while safeguarding national and international forest conservation obligations.

- US Forest Service (USFS) Liberia Forestry Support Programme (LFSP) from 2011 to 2012 continued to support the development of community forestry in Liberia. The People, Rules and Organizations Supporting the Protection of Ecosystem Resources (PROSPER) programme from 2012 to 2017. The PROSPER Programme was funded by USAID and implemented by Tetra Tech to support and build on the development of community forestry.
- Establishment of Protected Area Network (EXPAN) project funded by GEF to conserve and sustainably use biodiversity.
- Consolidation of Protected Areas Network (COPAN) project funded by GEF.
- Establishing The Basis for Biodiversity Conservation in Sapo National Park and in South-East Liberia project funded by World Bank-GEF and by Fauna & Flora International and FDA from 2005 to 2010.
- ZiamaWonegizi-Wologizi (ZWW) Landscape, project implemented by FFI. The project's goal in the landscape is to promote collaborative management of the Transboundary Forest between Liberia and Guinea to strengthen forest conservation, protect biodiversity, ensure connectivity between sites, enhance forest governance, and improve the livelihoods of the people in the landscape
- Wonegizi REDD+ Project implemented by FFI.
- Conservation International Sustainable Development Concessions project.
- Capacity Building Initiative for Transparency (CBIT) project aimed at strengthening the Capacity of Institutions in Liberia to comply with the Transparency Requirements of the Paris Agreement. The project is implemented by EPA and CI and funded by GEF.
- CI "Reducing Deforestation from Commodity Production Project" aimed at reducing the impacts of agriculture commodities on GHG emissions and biodiversity by meeting the growing demand of palm oil through supply that does not lead to deforestation and related GHG emissions.
- Liberia Forest Sector Project (LFSP). Some of the gender responsive initiatives implemented by the LFSP included trainings in community resource management, planting of indigenous tree species, promotion of agroforestry, smart-mining practices to reduce deforestation, the establishment of artisanal mining cooperatives, creation of alternative livelihoods such as the rolling out of community forest enterprises in beekeeping and honey production, post-harvest cocoa management and trainings, use of improved climate-resilient cocoa varieties, use of high yielding and drought-resistant rice varieties.

1.2. Fisheries Sector

Overview

The Liberian fishery sector provide about 65 percent of the cheap animal protein needs of the country's population and contribute to about 3.2 percent of the country GDP in 2002. In addition, it creates job opportunities for about 11, 250 people in 2004 and income earning opportunities for both its people and the government through foreign exchange (FAO, 2007). Liberia has a total area of about 111 370 km². Fisheries sector consists of

Freshwater resources that covers 15 050 km² (14%) of the total area of Liberia, comprising rivers, lakes, lagoons, creeks and streams that drain to the Atlantic coast (FAO, 2007), Marine resources form a coastline of 570 km and a continental shelf averaging about 34 km in width extending 200 nautical miles off-shore from the geographical baseline providing an area of about 20, 000 km^2 of fishing grounds (GoL, 2007) and aquaculture.

Liberia records 167 freshwater fish species and 464 saltwater fish with three been listed as endemic to Liberia. 54 fish from the list have been listed in the Red List of IUCN, of that number, 14 are critically endangered, 18 as endangered and 22 as vulnerable (EPA, 2018). Some main fish species in Liberia include *Caranx, Sphyraena, Cybium, Trichiurus, Sardinella spp, Ethmalosa, Chloroscombrus, Vomer spp, Ilisha africana, Pseudotolithus, Dentex, Cyanoglossus, Galeoides decadactylus and Pentanemus quinquarius, Ilisha africana, Ethmalosa fimbriata and Parapenaeus atlantica and Lutjanus spp., Parapenaeopsis atlantica, Pomadasys jubelini, Pseudotolithus senegalensis, P. typus (Sciaenidae) and Lutjanus spp*. (FAO, 2007).

The fisheries resources and practices of Liberia can be classified into four groups namely: marine small-scale, marine industrial scale, inland and recreational fisheries (GoL 2014). The Liberian fisheries are still operating from a very low base and concerted efforts. Previously, it was relatively well equipped and expanded significantly in the decades preceding the 14 - year civil war. Before the civil war in 1970s, the Liberian fisheries used larger vessels, carrying crews of up to ten men and often going to sea for several weeks at a time that landed around 3000 tons of finfish and 2000 tons of shrimp per year. During and after civil – war, the fisheries sector through its production dropped and provided an opportunity for illegal fishing activities. This resulted to negative impacts on the health of the fish stocks and the marine ecosystem. The Bureau of National Fisheries (BNF) under its strong action against illegal fishing in 2012 - 2014 was able to bring over 40 illegal vessels into justice (MoA, 2014).

Today, the Fisheries sector provides revenue to the government from license fees, vessel registration fees, inspection fees, observer fees, import and export charges, and fines totaled US $400,000 in 2011 and rose steeply to nearly US$6.0 million by mid-2013. More than half of the population live along the coast, dependent or partially dependent on fisheries for livelihoods, including many rural communities, women and youth. The fisheries data from 2000 to 2004 ranges from 10300 to 11700 t/year (FAO, 2007). Key challenges and opportunities in the fishery sectors are related to managing access for responsible use, ensuring compliance for maximum benefits, developing infrastructure for new enterprises, and building capacity for growth (GoL 2014).

Regulatory Framework (laws, policies guidelines and standards)

"The National Fisheries and Aquaculture Authority (NaFAA) was established by an Act of National Legislature in 2017. The mandate of NaFAA under the Act is to management all fisheries resources which are the natural habitat of the Republic of Liberia and the natural assets, heritage and sovereign rights of the Liberian people. NaFAA has

jurisdictional and consequential custody of these resources for the benefit of present and future generation".

NaFAA also has responsibilities to ensure that the Fisheries and Aquaculture resources be used sustainably to achieve socio-economic benefits including economic growth, human resources development employment creation and ecological balance and that the standard of optimum utilization of resources shall be applied and adapted to value creation, to promote employment and develop the fisheries and aquaculture sectors of the Republic of Liberia. However, looking back in 2014 at Liberia's Fisheries and Aquaculture Policy and Strategy (GoL 2014) it was within the purview of the Ministry of Agriculture (MOA) through the BNF.

The vision of the Fishery Policy is to achieve a "modern, vibrant and sustainably managed fisheries sector, capable of:

- providing increased profitable fisheries employment opportunities while offering an enabling environment for upgrading technical skills for enhanced value-added fisheries vocations;
- engaging participatory fisheries management institutions based on community and stakeholder structures for the creation of opportunities for socio-economic development;
- contributing to Gross Domestic Product, national food and nutritional security and improving living conditions, by upgrading and adopting appropriate, modern and efficient fisheries capabilities for increased fish production while reducing losses through illegal fishing; and
- deriving net benefits from a vibrant fish trade supported by, value addition systems and fisheries infrastructure for fish landing and export, as well as efficient fishing input supply and distribution systems".

The policy objectives focus on the following areas:

- Sustainable management of fisheries resources and ecosystems
- Development of aquaculture to meet national fish demand deficits and for foreign exchange
- Strengthening of fisheries management and development capacities for sustenance of a vibrant fisheries sector
- Enhancement of value addition, marketing and fish trade for improved foreign exchange earnings and employment opportunities

Past and Current Initiatives

Some of the past and current initiative in the fishery sector include the following:

- European Union of the Sustainable Fisheries Partnership Agreement signed on 24th of May 2016 between the European Union and the Republic of Liberia. The agreement is for 5 years. https://ec.europa.eu/fisheries/cfp/international/agreements/liberia_en
- The Government of Liberia (MEDP and NAFAA) and the Government of Iceland on Friday, December 14, 2018 signed a grant agreement of US$3.1 million. The grant is intended to support and provide micro-credit programme for fishing men and fish

processors or fish sellers in fishing communities in Grand Cape Mount, Montserrado and Grand Bassa counties. https://www.liberianobserver.com/business/iceland-boosts-liberias-fisheries-sector/

- World Bank's West Africa Regional Fisheries Programme (WARFP) – Phase 1 (2009-2016).The objective of WARFP project is to strengthen the capacity of Cape Verde, Liberia, Senegal, and Sierra Leone to govern and manage targeted fisheries, reduce illegal fishing, and increase local value added to fish products. The total project cost is US$ 46.30 million. http://projects.worldbank.org/P106063/west-africa-regional-fisheries-program?lang=en
- The National Fisheries and Aquaculture Authority (NaFAA) has begun a conversation since August 2018 with Yamaha Motor Company Limited for the establishment of a manufacturing plant in Liberia to produce motorized boats for artisanal fishermen as a way of industrializing the sector. https://frontpageafricaonline.com/news/liberia-engages-yamaha-motor-for-manufacturing-fishery-plant/
- The EAF-Nansen Programme "Strengthening the Knowledge Base for and Implementing an Ecosystem Approach to Marine Fisheries in Developing Countries" is the phase 4 (2006-2017) of an initiative to support the implementation of the ecosystem approach in the management of marine fisheries. The programme is funded by NORAD and executed by FAO and the Institute of Marine Research (IMR) of Bergen. http://www.fao.org/in-action/eaf-nansen/en
- In Robersport, a Co-Management Association (CMA) has been established as a pilot project to test options for developing greater community involvement in the management of fisheries.

  The United Nations in Liberia (UNMIL), in partnership with the Government of Liberia through NAFAA and a consortium of private Liberian fishery groups - Faimaba Fisheries Development Inc. (FFDC) and the National Fish Farmers Union of Liberia (NaFFUL), have set up mechanisms to end conflict in the fishery sector of Liberia. It was a US$700,000 project for four-month period: January 17-April, 2018. https://frontpageafricaonline.com/news/2016news/unmil-liberian-fishery-groups-discuss-threats-to-fishery-sector/

1.3. Agriculture Sector

Overview

Since peace returned to Liberia in 2003, the country has been experiencing economic growth with agriculture being one of the major sectors. In 2015, agriculture was worth 38.8% of GDP, employing more than 70 percent of rural households involved in the sector and contributing 23.9% to the real GDP (EPA 2018, USAID 2015). However, the outbreak of the Ebola Virus Disease (EVD) in 2014 temporarily stifled this growth. Abandoned farms, interrupted crop cycles and market shutdown led to weak agricultural outputs. In the same year, the government responded by putting in place the Liberia Economic Stabilization and Recovery plan (LESR). The plan assessed the impacts of EVD, provided guidance and focused on four key sectors including the agricultural sector

(Musinamwana and Togba 2014). Other constraints in the agricultural sector are related to low levels of productivity, inadequate irrigation and inputs of fertilizer, poor quality of seeds and breeding stock, lack of credit, machinery and infrastructure for transport, storage and marketing. Uncertainty of land tenure also discourages investment, adoption of improved techniques, and economies of scale.

Beside the constraints, Liberia generally has a climate favourable to farming, vast forests, and an abundance of water. Liberia principal food crops include rice and cassava. Commercial agricultural activities are almost exclusively cash crop plantation estates of rubber, palm oil, coffee, cocoa and sugar cane. Other crops grown for local consumption include bananas, plantains, citrus, pineapple, sweet potatoes, maize, and vegetables. Rice, cassava and vegetables production accounts for about 87% of cultivated land (MoA 2009). Traditionally, domestic production of Liberia's main staple foods still depend on a traditionally low input/low output, shifting cultivation, mixed crop system. Although agricultural production has increased in recent years yields are still well below the regional average and the post-harvest loss rate very high. Most farmers operate at subsistence level on small family plots growing rice, cassava, pepper, bitter balls, greens, aubergines, okra, pulses and corn (Partel 2013).

The livestock including poultry on the other hand, is a growing agricultural sub-sector and it contributes to household and community economy and employment with sustenance and food security in Liberia. It is one of those sub-sectors degraded due to the civil war. The sub-sector is dominated by traditional systems holdings of cattle, goats and sheep, pigs and guinea fowl (CPF Liberia, 2012). There is a rapid growth in demand for livestock products due to increases in income, rising population numbers and urban growth. In response, smallholder farmers are expanding poultry, goats, sheep and pig production. Challenges faces by farmers are related to the use of local, low productive breeds of animals with inappropriate techniques (MoA 2014). Moreover, farmers have access to few service- delivery inputs, and receive limited public support services. The sub-sector is now focusing on restocking, promoting small ruminants short-cycled animals, reducing production costs and revitalizing the value chains in livestock production.

The three vegetation types defining the farming systems of Liberia are: the coastal plains, the upper highland tropical forest and the lower tropical forest. Coastal plains vegetation comprised of swamp along rivers and creeks, mangroves, scattered patches of both low and high bushes and savannah woodland belt up to 25km inland. Farming activities include upland and lowland rice production, cassava, vegetables, sugarcane, rubber, coffee and cocoa. The upper highland tropical forest is the main agriculture belt of the country composed of semi-deciduous forest and transition zone or secondary forest. The farming system is excellent for cash crops production like cocoa, coffee rubber, citrus and oil palm production mainly in Lofa, Bong and Nimba. Crops also produced in the forest are upland and lowland rice, yams, cocoyam, plantains, potatoes and vegetables. The Lower Tropical Forest is mostly evergreen rainforest in south-eastern part of the Country. Farming activities include cash crops like rubber, cocoa, coffee and sugarcane as well as upland and lowland rice cultivation, yams, cocoyam, plantains, potatoes and vegetables.

The Northern Savannah Vegetation comprised of dense elephant grass of up to 1.5m, scattered trees and patches of forests.

Regulatory Framework

Liberia Agriculture Support Investment Plan (LASIP I and II): LASIP I and II is an initiative intended to develop priority agricultural value chains through private sector investments, adopt innovative financing solutions, promote an export-driven industrial policy, and ensure the appropriate business enabling environment in Liberia.

Liberia Food and Agriculture Policy Strategies (FAPS) 2008: FAPS seeks to address the plethora of problems that have historically bedeviled agriculture and its linkages to the other sectors in a coherent, consistent and forward-looking manner. FAPS articulate three fundamental orientations related to : improving national food and nutrition security, enhancing agricultural productivity, competitiveness and linkages to market and finally to strengthening human and institutional capacities.

Liberia's National Rice Development Strategies (LNRDS) 2012. The LNRDS aims to achieve self-sufficiency by doubling the local rice production by the year 2018. The strategies proposed here aim to achieve this by increasing the rice productivity in both upland and lowland ecosystems and by expanding the land area under rice cultivation in the lowlands.

Liberia National Livestock Policy and Veterinary and Animal Law 2014 (draft)*:* The following options were advocated: (i) provide credible and improved public and private veterinary services; (iii) provide disease diagnostic and investigation facilities; (ii) develop research capacities; (iii) delivery of technology; (iv) promote data collection and analysis (v) strengthen marketing of animal product; (vi) regulate import and export of animals and their products (vii) promote animal welfare; (viii) promote use of environmentally friendly technologies; (ix) promote sustainable livestock production; (x) promote equal access to resources and credit for livestock production, processing and marketing; (xi) improve capability of the livestock subsector in providing affordable animal products and (xii) expand livestock enterprises.

The Liberia Agricultural Transformation Agenda**:** LATA aims to enable Liberia to achieve higher levels of economic resilience through inclusive growth and four guiding principles: developing agricultural value chains, adopting innovative finance solutions, promoting an export-driven industrial policy and ensuring an enabling business environment. The value chains that have been selected are oil palm, rubber, cacao, fisheries, rice, cassava, horticulture and poultry/livestock. The government is seeking strategic investors in agriculture, agro-processing and manufacturing as well as explore possibilities of Public Private Partnerships.

Liberia National Cassava Sector strategy (NCSS) 2008. NCSS is an agreed long term plan of action by Liberian cassava sector stakeholders and the Government of the Republic of Liberia, for the development of the nation's cassava sector. It identifies and articulates specific time bound actions and measures to be taken to enable the sector to

reach its full potential through a coordinated approach that involves all sector stakeholders.

***Cooperative Development Agency (CDA*)**: The Cooperative Development Agency is the main instrument of the government through which support is provided to cooperatives in the country. The civil war mostly destroyed the CDA infrastructure, but work has resumed on rebuilding the infrastructure and other capacities to pre-war levels. CDA is active in the main cocoa producing counties of Bong, Nimba and Lofa.

Liberia Cooperative Development ACT of 2010 and Regulation of 2010: These documents were developed to inform the growth of the agricultural sector. They provide an enabling institutional and legal environment for the development of autonomous, viable and demand driven cooperative organizations.

National Export strategy Together with the International Trade Centre (ITC) Liberia developed this strategy in April of 2014 to democratize the export culture by incorporating Micro, Small and Medium Enterprises (MSME). These enterprises have historically been neglected as Liberia's economic growth was fueled by commodity and extractive sectors which were primarily concessionaire-based activities.

Liberia Agriculture Commodity Regulatory Authority (LACRA)*:* The LACRA Act was passed in 2016 under the LATA. It has been set up to develop functioning value chains and market systems and is an effective regulatory system for the trading of agricultural commodities. It protects value chains from under investment and poor crop quality. Its main focus is the cacao sector, one which is critically constrained by side-selling, but has the mandate to cover other commodities such as coffee as well.

Major Agricultural Concessions in Liberia

Investors are looking favorably into the cash crop and food sub-sector of Liberia not only for domestic markets, but also for regional and international markets. Some of them include:

- **Firestone Liberia** produces natural rubber in Margibi County. The company's business plan calls for US$185 million to be injected into its Liberian operations through 2015; some of this is being spent on a new rubber wood processing facility and increased social expenditure.
- **The Cavalla Rubber Plantation** produces natural rubber in Maryland County and is owned by Belgian and French interests. The government has sold its 50% stake in the company and negotiations are ongoing to convert the land lease into a concession agreement. The company's business plan calls for injection of US$25 million over the next four to five years.
- **The Liberia Company:** The Cocoa plantation produces natural rubber in Nimba County and is owned by the Liberia Company, whose majority shares are owned by American investors. Some investment is being made to improve social services, replant, and expand the plantation.

- **The Sinoe Rubber Corporation** also produces natural rubber in Sinoe County. The plantation is now being managed by the locals and their authorities with plans for a takeover by central government authorities. No new investment has been made aside from attempts to maintain minimum operations.
- **The Guthrie Rubber Plantation** in Bomi County produces rubber, and its concession rights are owned by Sime Darby, a Malaysian company. Sime Darby has renegotiated the concession agreement that has been ratified by the national legislature, and the company plans to make an investment of over US$800 million, mainly in oil palm cultivation and processing.
- **The Salala Rubber Corporation** is in Bong County and it produces rubber. In 2007, Salala merged with Weala, and the International Finance Corporation took an equity stake in the new company. New investment is unknown.
- **African Development Aid** – This Libyan-backed venture plans to spend US$30 million during the first phase of massive rice production in Fora, Lofa County, and Gbeydin, Nimba County. It has obtained a concession agreement from government and initiated activities in Lofa.
- **NOVEL** – An international rice marketing firm with substantial interests in Liberia, this company received a concession agreement to cultivate 5,000 acres of rice in the Garwula Tombe area of Cape Mount County. Very little activity has taken place.
- **Equatorial Biofuels (EBF)/Liberia Incorporated (LIBINC**) – EBF obtained a concession agreement from the GOL for the rehabilitation and expansion of the Butaw Oil Palm Plantation in Sinoe County. It then merged with **LIBINC in Palm Bay**, Grand Bassa County. Initial investment amounts were US$9.0 million for Butaw and US$5.2 million for Palm Bay. Following the ratification of these two agreements by the legislature, LIBINC investors sold their interest to EBF, which now controls both entities.
- **Liberia Agricultural Company**: The GoL is currently engaged in renegotiating the concession agreement with the Liberia Agricultural Company, a producer and exporter of natural rubber located in Grand Bassa County and is far along in the competitive bidding process for management of the Decoris oil palm plantation in Maryland County.

Past and Current Initiatives

Some of the past and current initiative in the agriculture sector include the following:
- Liberia Agricultural Sector Investment Plan. LASIP I : 2011 - 2015 and LASIP II: 2018 – 2022. LASIP will be a public-private partnership (PPPs) in which investment growth for the export sectors will be spearheaded by the private sector, while the public sector will concentrate in promoting small farmer growth and development.
- Commercial Farming Project in Foyah Lofa County.
- The African Development Bank -funded Liberia "Agriculture sector rehabilitation project" 2010-2017 (ASRP) aimed at increasing the income of smallholder farmers and rural entrepreneurs including women, on a sustainable basis, as part of the country's efforts to provide food security and reduce poverty.
- The Smallholder Agricultural Productivity Enhancement and Commercialization (SAPEC) Project is a $52M project that seeks to reduce rural poverty and household

food insecurity by increasing income for smallholder farmers and rural entrepreneurs particularly women, youths and the physically-challenged.

- West Africa Agricultural Productivity Project (WAAPP-Liberia)—a regional project supported by the World Bank and Japanese Government—has helped fund the resuscitation of the Central Agricultural Research Institute (CARI), Liberia's only agricultural research institute, which was badly damaged during the country's civil wars. WAAPP supported 32 young Liberian scientists, some of whom earned Masters' degrees or PhDs at African universities, and all of whom completed their studies. Now they serve in Liberia's Ministry of Agriculture and at CARI.
- Smallholder Agriculture Transformation and Agribusiness Revitalization Project (STAR-P) of Liberia. A 25 million $ project funded by the World Bank.
- Liberia Agribusiness Development Activity 2015-2020 (LADA), an initiative by USAID's Feed-the-Future programme. Started in December 2015, LADA aims to increase incomes of smallholder farmers and entrepreneurs throughout Liberia. The project aims to expanded access to and use of agricultural inputs, improved post-harvest activities, and streamlined high-potential agricultural value chains.
- The Food and Enterprise Development (FED) Programme will be implemented to achieve the following objectives: increase agricultural productivity and profitability and improve human nutrition; stimulate private enterprise growth and investment; and build local technical and managerial human resources. Special emphasis will focus on women food producers and micro-entrepreneurs as key actors in the sector. Funded by USAID $80M.

1.4. Vision 2030 and the Pro-Poor Agenda

One of Liberia's Vision 2030 long term outcome core aspiration is to prioritize agriculture for food self-sufficiency and income security. The two recent development strategy documents of Liberia: the Agenda for Transformation (AfT: 2012-2017) and the Pro-Poor Agenda for Prosperity and Development (PAPD: 2018 to 2023) are contributing towards Vision 2030 and agriculture is at the centre.

The Agenda for Transformation 2012-2017 (AfT): Agriculture was central to Liberia's vision of economic transformation for wealth creation and poverty reduction. The intent of this strategy was to achieve sustainable agricultural growth, in the small-holder and plantation parts of the sector, and to improve nutrition for the population, with special attention to low-income households. During the period of this strategy, food crops such as rice, cassava corn, peanuts, pineapples, bananas and pulses were targeted for increased production as well as animal production— sheep, goats, and poultry. Other crops were being targeted for production and research, including fruits, nuts and vegetables and high value crops, like cocoa and coffee, consistent with Liberia's competitiveness. With regard to commercialization, an increased number of smallholder farmers were to be integrated into commercial production through cooperatives or as individuals. By 2017 rice yields increased from 1.5mt /ha to 3.5mt/ha (2011-2015), cassava production increased from 5.0mt/ha to 8.0mt/ha; while illegal fishing reduced from 83 percent to 30 percent (2009 - 2014). Rubber, cocoa, and oil palm are major cash crops. Cocoa yields increased from

200kg to 800kg per ha from 2010 to 2017, while rubber yields reach 0.8mt/ha in 2013 (GoL 2018).

The Pro-Poor Agenda for Prosperity and Development from 2018 to 2023 (PAPD) is the current document guiding the development strategy of the Government of Liberia. One of the two goals of the PAPD is to provide greater income security to an additional one million Liberians and reduce absolute poverty by 23 percent across 5 out of 6 regions--through sustained and inclusive economic growth driven by scaled-up investments in agriculture, in infrastructure, in human resource development, and in social protection. The agriculture sector is seen as a driver of food self-sufficiency, income security and economic transformation at the regional and national level. It is expected that by 2013, the PAPD will achieve a more competitive, productive and diversified agricultural sector in Liberia that promotes value chains, agricultural processing and marketing for food self-sufficiency, increased exports, job creation, and livelihood opportunities (GoL 2018). More specifically, the PAPD will promote the production of rice, cassava and vegetables using new and appropriate technologies to boost the agricultural sector as a major source of foreign exchange and livelihood of Liberians.

Sustainable Development goals and principles

It is important to note that any initiative that is related to economic growth and development planning also promotes the implementation of the SDGs (13, 17, 1 5 etc.) and follows the principles of leaving no one behind, the principles of youth empowerment, gender equality and social inclusion. Climate actions and initiatives should therefore take into consideration the aspirations of men, women and youth for sustainable development. This explains the construct of many gender-responsive initiatives by FDA, national NGOs like RICCE and related research in Liberia with the intention to include all, especially women in mitigation and adaptation actions.

1.5. Climate Projections and Potential Impacts

Climate change has caused impacts on natural and human systems on all continents and across the oceans. Africa is the most vulnerable continent to climate change due to limited adaptive capacity (IPCC, 2004) including researchers and policy makers. Among the affected countries is Liberia that has become vulnerable to the adverse effects of climate change. Indeed, The Republic of Liberia's economy, population, and environment are highly vulnerable to climate variability and change. A range of studies, including the Republic of Liberia's Initial National Communication under the United Nations Framework Convention on Climate Change (UNFCCC) notes that the impacts of climate change are expected to intensify as changes in temperature and precipitation will affect the forestry, agricultural, and the fisheries sector (GoL 2013).

Despite Liberia's effort of immense change as it makes the transition towards stability from widespread poverty, high inequality and unemployment, and limited access to basic services (water, sanitation, energy) since 1989 - 2003 of civil war, it has also experienced

climate change scenarios that had been ranked 7th in terms of climate change vulnerability by ND GAIN (2013). The historical climate change scenarios include increased average annual temperatures of 0.8°C throughout the country, a 15.7% increase of hot nights, decline in mean annual rainfall, increased frequency and unpredictability of intense rainfall events and rising sea-level. These scenarios are projected to 0.9°–2.6°C increase in temperature by 2060 (USAID, 2012), substantial increase in the frequency of "hot" days and nights, increase in frequency and intensity of extreme weather events by 2050 and 0.13–0.56 m increase in sea levels by 2100. It is also projected that by 2100 sea level will rise between 0.13-0.56m in the country (USAID, 2017).

According to Stanturf, et al., (2013) expected changes in temperature by 2050 and 2080 for Monrovia, Nimba, and Sapo National Park are based on an ensemble of 16 models. The general trends are for a warmer climate in most of the country. The most conservative estimates on temperature change have Monrovia warming by an estimated average of 1.54°C by 2050 and 1.90°C by 2080 during the dry season (1.30°C by 2050 and 1.85°C by 2080 for the wet season). In the interior, Nimba is estimated to warm by an average of 1.50°C by 2050 and 2.13°C by 2080 during the dry season (1.38°C by 2050 and 1.82°C by 2080 for the wet season). In the southeast, Sapo National Park is projected to warm slightly less, by an estimated average of 1.44°C by 2050 and 1.95°C by 2080 during the dry season (1.29°C by 2050 and 1.73°C by 2080 for the wet season – see Figure 1).

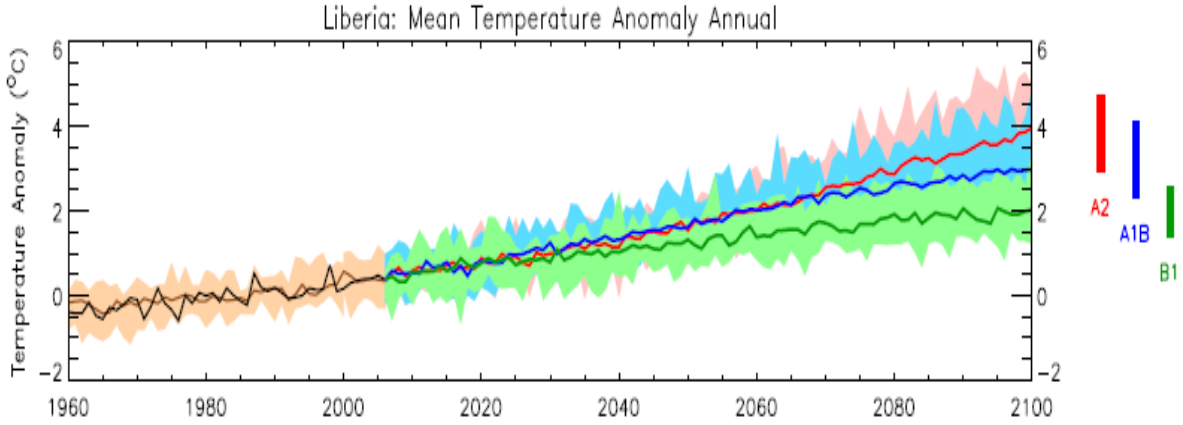

Figure 1. Trends in annual mean temperature for the recent past and projected future. (Source: Stanturf, et al., 2013)

With regards to precipitation, McSweeney et al., 2008 established that the overall ensemble prediction across Monrovia emission scenarios gives a slight increase in wet season with rainfall of 1.54 ± 11.09% by 2050 and 1.92 ± 13.21% by 2080. The overall ensemble prediction at Sapo National Park across emission scenarios gives a slight increase in wet season rainfall of 3.54 ± 11.55% by 2050 and 5.25 ± 16.26% by 2080 (McSweeney et al., 2008). Finally, in summation, the overall ensemble prediction in Liberia across emission scenarios gives a negligible change in wet season rainfall of 0.35 ± 10.28% by 2050 and 0.40 ± 13.67% by 2080 (see Figure 2).

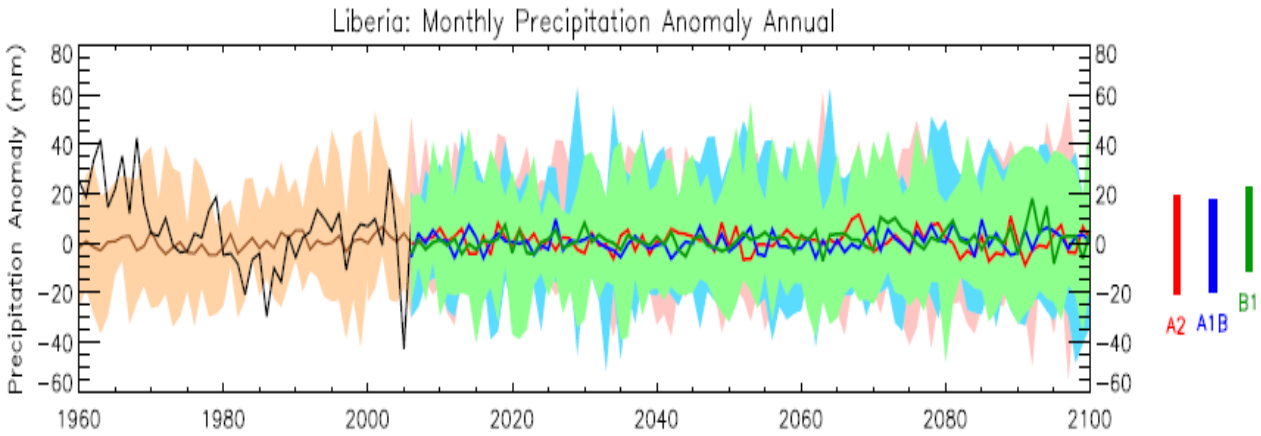

Figure 2. Annual trends in monthly precipitation for the recent past and projected future. (Source: McSweeney et al., 2008)

These future climate scenarios will exacerbate the already experienced reduced productivity on agriculture, forestry, water resources, and fisheries. The major consequences will be experienced in agriculture sector through increased crop loss/failure due to extreme weather events, increased pests, weeds, pathogens and reduced fish yield through shift in distribution of species and biodiversity loss which will both result in loss of livelihoods. Honorable Minister Tweah of the Ministry of Finance and Development Planning said at the launch of the National Policy and Response Strategy (NPRS) on Climate Change in Monrovia on Wednesday August 15, 2018 that future climate change projections in the country may likely have deleterious impacts on agriculture, forestry and fisheries sector (EPA 2018). A USAID (2013) report also notes that, the change in aridity indicates the forest in eastern Liberia is the most likely area that will be impacted by the "drier" climate in 2050.

1.6. Development Context and Socio–Economic Vulnerability

Socio – economic consequences from climate change vulnerability fall particularly on rural populations in their different genders, whose livelihoods depend on natural resources and for whom prevalent poverty persists. Socio – economic vulnerability is the exposure of individuals or collective groups to livelihood stress resulting from climate change impacts. Its understanding is therefore important in guiding to socio – economic adaptations and coping mechanism to climate change. Once socioeconomic vulnerability has been assessed from a gender perspective, the information will be relevant in designing the relevant adaptation measures that can be associated to economic costs and social benefits for all. Although social vulnerability can be to an individual or a collective group, it can be differentiated by institutional and economic position between or within the group from the existing practices such as in agriculture, forestry, fisheries and resources management (Adger, 1999). Social vulnerability to climate change including rapid population growth, poverty and hunger, poor health, low levels of education, social status, age, gender inequality, fragile and hazardous location, and lack of access to resources and services, including knowledge and technological means in addition to lack political voice by the people (Fischer et al., 2002). On the other hand,

economic vulnerability consists overall national economy, trade and foreign-exchange earnings, aid and investments, international prices of commodities and inputs, and production and consumption patterns particularly in countries that are poor and have agriculture-based economies like Liberia.

1.7. Objective and Scope

The report identifies climate vulnerability and risks in the agriculture, fishery and forestry sectors in Liberia. It intends to provide decision makers and stakeholders with sufficient information to justify sustainable and viable sector interventions under climate change. It also provides the basis for guiding subsequent coping strategies, which will ensure that the sectors are managed in consideration of any climate-related risks and adaptation differentiated needs and options.

The remaining part of this report is presented as follows. Section 2 of this report outlines the methodological approach used in preparing this report. Sections 3, 4 and 5 present the state of vulnerability and risk assessment as well as adaptation options respectively for the fishery, agriculture and forestry sectors. Concrete action plans in the form of project idea notes are elaborated for the three sectors in section 6, while concluding remarks and recommendations are presented in section 7.

2. METHODOLOGY

We used a three-phased approach to conduct this study: inception phase, data collection and analysis phase and close out phase. In the inception phase, we delineated the boundaries of the study, defined the scientific and conceptual approach, outlined the data collection and analysis approach and tools, identified the range of stakeholders to be consulted, prepared guiding questions for different stakeholder groups, agreed on the specific sites to be visited. In the data collection and analysis phase, we engaged in the collection of secondary and primary data across Liberia; while the close out phase was used to analyse the collected data and write up the report for climate vulnerability and risk assessment in the fisheries, agriculture and forestry sectors.

All along, we built on existing work that has already been done in Liberia on climate change in general and climate vulnerability in particular. In addition to the terms of references for this study, we consulted with the UNDP and the EPA for further orientation which led to the identification of three cores aspects that guided this entire study. One - vulnerability assessment of the three sectors; two - identification and prioritization of adaptation options and strategies; and three - costed action plan for implementation.

2.1. Conceptual Approach: Climate Vulnerability and Risk

The scientific premise of this study is based on the climate change vulnerability and risk concept as defined by the fifth assessment report (5AR) of the International Panel on Climate Change (IPCC) (IPCC 2014). Figure 3 below illustrates the interaction of both the climate system and the socioeconomic processes including adaptation and mitigation, which are drivers of climate hazards, exposure and vulnerability.

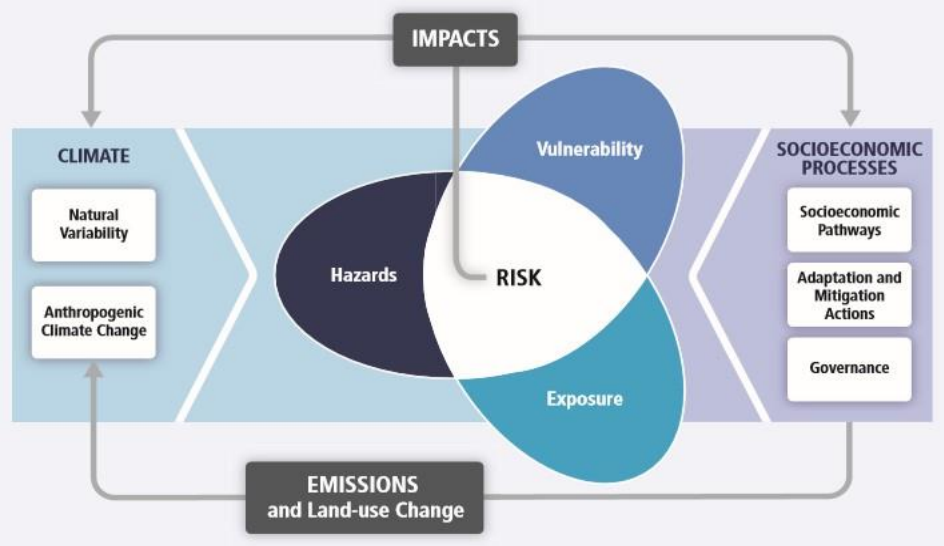

Figure 3. Illustration of the risk of climate-related impacts resulting from the interaction of climate hazards with the vulnerability and exposure of human and natural systems.

The box below further provides definition of the key terms central for understanding the conceptual approach used in this study.

Definition of key terms used in this report (IPCC 2014)

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

UNFCCC Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.

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

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

Sensitivity: The degree to which a system will respond, either positively or negatively, to a change in climate.

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

Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard (see Figure above). In this report, the term risk is used primarily to refer to the risks of climate-change impacts.

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

Adaptive capacity: The degree to which adjustments in practices, processes, or structures can moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate.

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

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

2.2. Data Collection and Analysis

This study used both primary and secondary data. The study was conducted using:

- ✓ A document review and analysis of past studies and reports;
- ✓ Face-to-face interviews with key informants from the different sectors;
- ✓ Focus group discussions with farmers and resource persons from the three sectors;
- ✓ Interviews and discussions with technical and financial partners in the three sectors.

Secondary data collection: The team reviewed and analysed policy and technical documents that are of relevance to the study. Some of the key policy documents consulted and reviewed included among others:

- Liberia's initial national communications to the UNFCCC;
- Liberia's national policy and response strategy on climate change;
- Nationally determined contribution of Liberia (NDC);
- Liberia national adaptation programme of action (NAPA),
- Methods for assessing the vulnerability of agriculture, fisheries, and forestry sectors to climate change;
- Liberia climate change assessment report (USAID 2013);

- Policies, plans, and programmes as well as other legal texts related to the forestry, agriculture, and fisheries sectors;
- Relevant peer-reviewed scientific publications, reports and other grey literature.

An extended list of all the documents consulted can be found in the reference section.

Primary data collection: Field visits were made to different parts of Liberia and stakeholders from the 3 sectors were consultations through interviews, group and focus group discussions as indicated in the table below.

Table 1. Types of stakeholders consulted

Sector	Key stakeholder consulted
Agriculture	Ministry of Agriculture (MoA) FAO Central for Agriculture and research Insttute (CARI) Farmers Feed School (FFS) Farming Communities Individual resource persons
Fishery	National Fishery and Aquaculture Authority (NFAA) Collaborative Management Association (CMA) Community Science Monitoring group Bureau of National Fisheries, World Bank Fishing Communities Individual resource persons
Forestry	Forestry Develoment Authority (FDA + REDD) Flora and Fauna International (FFI) Conservation International (CI) World Resource Institute (WRI) Forestry Communities Individual resource persons
Cross cutting institutions	EPA UNDP University of Liberia Ministry of Transport Liberia National Department of Meteorology Ministry of Finance and Development Planning Ministry of Mines & Energy National Disaster Management Commission, Liberia Institute of Statistics & Geo-Information Services

Given that climate change will affect each country, society and individuals in various forms as per their geographical positions (Seo et al., 2008; Godfray et al., 2010), we decided to conduct field visits in all the four agroclimatic zones of Liberia: Coastal Plains, Upper Highland Tropical Forest, Lower Tropical Forest, and the Northern Savannah. Out of the fifteen counties of Liberia, the population from eight counties

engaged in agriculture, forestry and fisheries were consulted for the assessment of climate change vulnerability and risk in the three sectors. The counties were selected based on the agro-climatic regions, their livelihood activities that are climate sensitive, level of vulnerability and the degree of exposure. These eight counties include:

- ✓ Montserrado County (Monrovia City)
- ✓ Grand Cape County (Robersport City);
- ✓ Grand Bassa County (Buchanan City);
- ✓ Lofa County (Ziggida- Konia District);
- ✓ Nimba County (Gbedyin, Camp 3);
- ✓ Bong County (Foekuelleh town, Kpanta District);
- ✓ Grand Gedeh (Zleh Town);
- ✓ Sinoe (Greenville and Chelus Town around the Sapo National Park).

During the field visits, semistructured questionnaires were used to conduct interviews, consultations and discussions with the above mentioned stakeholders. The focus was on past and future climate impacts, risks and hazards in the agriculture, forestry and fishery sectors and the identification and implementation of appropriate adaptation options to reduce vulnerabilities of natural and human systems. Some of the guiding questions used in the field included the following:

- Have there been the occurrence of climate hazards within the last 10 years (examples included: temperature increase, flooding, erratic rains, change in precipitation, sea level rise, brown tides, droughts, forest fires, climate related pest, invasive species, wind storms, etc.)? If yes, indicate its impact on the sector.
- What is the likelihood of the climate hazards to occur in the future and its likely impacts on the sector? Here, a scale of probability/likelihood of occurrence and likely impacts were provided to guide the discussions.
- What response measures exist to deal with climate variability and hazards in the agricultural / fisheries / forestry sector?
- Have the response measures specifically addressed climate variability and hazards in the agriculture / fisheries / forestry sector?
- What are the needed resources by men and women respectively to effectively reduce the impacts of climate variability and hazards in the sector?

Data Analysis: The data obtained from literture review and stakeholder consultations was transcribed, coded, cleaned and then analyzed using document content analysis, simple descriptive statistics as well as GIS-based analysis.

2.3. Data Collection Tools and Methods

Rapid Rural Appraisal (RRA): We used RRA participatory methodology to quickly learn from the people we consulted across the four agro-ecological zones and eight counties about their realities and challenges related to climate change vulnerability and adaptation in the forestry, fisheries and agriculture sectors of Liberia. RRA focused more strongly on facilitation, empowerment, behaviour change, local knowledge and sustainable action (IDS 2018). RRA was selected in response to the disadvantages of other vulnerability

assessment frameworks (CVCA) and tools (CRiSTAL) that were time consuming and needed more resources.

Multi-Criteira Analysis (MCA): In this study, we used MCA to assess and prioritize the identitifed adaptation options in the three sectors against a set of decision criteria. This was done during a workshop organised in November 2018 that invloved 53 participants from: relevant line ministries and agencies of government, NGOs, universities and local community leaders including; farmers, fishermen and foresters. The list of participants and the adaptation options prioritized are found in annex 4 and 7. MCA consisted of several steps including: vulnerablity assessment, identification of adaptation options, identification of relevant criteria to assess the options, weighting and ranking of adaptation options etc. Examples of the decision criteria included: vulnerability reduction, cost, gender mainstreaming, indigenous knowledge, public and political acceptance, employment generation, institutional and technical capacities, achievement of sustainable development goals etc. MCA brings the most advantages because it allows a participatory process where all the stakeholders can participate at different stages of the assessment. Other commonly used techniques for assessing adaptation are Cost Benefit Analysis (CBA) and Cost Effectiveness Analysis (CEA). CBA is used when efficiency is the only criterion while CEA is used to identify the adaptation option which is least costly for meeting specific goals (UNFCCC 2011). CBA relies on only one criterion and it can only assess if all are expressed in monetary terms while CEA cannot consider other dimensions such as co-benefits, equity, feasibility (Gianoli et al. 2016).

Geographic Information System (GIS): We used GIS-based analysis to prepare vulnerability maps for the forestry and agriculture sectors. The maps were based on existing environmental and climate data, including land cover/vegetation cover, slopes, hazards, and precipitation distribution, etc. We could not produce a vulnerability map for the fisheries sector due to inadequate data.

Transect walk and field observation: Together with the local people, we had a transect walk in most of the sites we visited to explore and appreciate the climate change situation by observing, asking, listening, looking and making sense of what we have learned in the literature and during dicussions with the local prople. The information collected during the walk is used to traingulate other sources of information.

Inclusiveness and parrticipatory approaches: In each of the field sites visited, we made sure the views of all segments of the populations (men, women, young and old, disabled, etc. were captured. This was done through special focus group discussions (FGD): some FGD involved only women or youth.

2.4. Challenges and Limitations

Limited time and resources for field work: Initially, we planned to use the Community-Based Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL food security and CRiSTAL Forest) and the Climate Vulnerability and Capacity Analysis (CVCA)

framework where relevant to engage in group discussions with communities identified in selected vulnerable hotspots across the counties. This was not possible due to the limited time and resources so we adapted our vulnerability assessment and data collection method into RRA. We also focused the vulnerability and risk assessment in the field mainly on the production side of the three sectors. With enough time and resources, we could have done a more detail assessment that included both the production side as well as the climate vulnerability of the value chain in the three sectors. The vulnerability of the agriculture sector for instance could have been looked from a food secusity perspective along the different value chains of selected produce like rice, cassava and cocoa and cofee.

Incomplet data. We could not complete the vulnerability map of the fishery sector due to inadequate data.

3. COUNTRY CONTEXT

3.1. Liberia's Agro-Ecological Zones

Based on the key characteristics of climate, soils and topography, four main agro-ecological zones (AEZ) can be classified in Liberia (FAO 2012, Schroth et al. 2015). The Coastal Plains, Upper Highland Tropical Forest, Lower Tropical Forest, and Northern Savannah. This study covers all the four AEZ. Details about each zone is presented in Table 2 below – but first let us look at the topography, soil and climate of Liberia.

Topography: The topography of Liberia ranges from the coastal plains, lagoons and mangroves marshlands, to rain forests and plateaus moving towards the interior to the northern highlands that is rated to be the highest elevation and include Mount Wutivi (1335 meters). There are six major rivers and the known longest river is Cavalla with a total length of 515 km. Besides the rivers, Liberia have two natural Lakes; Lake Shepperd in Maryland and Lake Piso in Grand Cape Mount. Liberia has a tropical climate with heavy rainfall from May to October and a period of short rainfall in mid-July to August with a dry season lasting from November to April.

Soil: About 70% of the area of Liberia is covered by Haplic and Xanthic Ferralsols soils. These soils are acidic, low in nutrients and are typically associated with tropical conditions, high rainfall and very old (Tertiary) land surfaces. As a consequence of intense weathering over prolonged time periods, they have lost nearly all of the weatherable minerals they had inherited from their parent rock and are now dominated by stable products such as aluminum oxides, iron oxides and kaolinite. On the positive side, these soils are deep and have a favorable structure that poses few obstacles to water infiltration and root development (van Wambeke 1992).

Climate: The climate of Liberia is divided into two separate regimes; the equatorial climate regime restricted to the southernmost part of Liberia, where rainfall occurs throughout the year, and the tropical regime dominated by the interaction of the Inter-tropical convergence zone (ITCZ) and the West African Monsoon (Stanturf, et al., 2013). Climate change is already being experienced in Liberia (EPA, 2018). The sensitivity of climate change to the biophysical features of Liberia and level of vulnerability of each sector are being felt and observed (EPA, 2018).

Table 2. Agro-ecological zones (AEZ) of Liberia with their main characteristics.

AEZ	Land Coverage	Counties	Agro-Climate	Vegetation and Livelihood Activities
Coastal Plains	From sea level to a height of 30 m.a.s.l., reaching up to 25 km into the interior of the country	Cape Mount, Grand Bassa, Sinoe	Very high rainfall (4450–4550 mm), high humidity (85–95%), long sunshine hours with high temperatures and wide temperature ranges	**Vegetation**: swampy along rivers and creeks, mangroves, scattered patches of both low and high bush and savannah woodland belt up to 25 km inland **Livelihood activities**: fishing, upland and lowland rice, cassava intercropped with vegetables and sugarcane; forest hunting, rubber, coffee and cocoa; grasslands are a potential pasture resource.
Upper Highland Tropical Forest	Plateau (tablelands) about 30 m.a.s.l. and mountain ranges (600 m) behind rolling hills	Lofa, Bong, Nimba	Bi-modal rainfall (sub-divided by short dry spell of 2 weeks) more evenly spread from 1265 mm in Bong, 2900 mm in Lofa to Nimba, to 3200 mm (overall maximum); temperature variation is 5 °C	**Vegetation:** closed semi-deciduous forest and transition zone or secondary forest ("farmbush") **Livelihood activities**: cocoa and coffee typical of Lofa, Bong and Nimba, rubber, citrus and oil palm as main cash crops; food crops are upland and lowland rice, yams, cocoyam, plantains, potatoes and vegetables, forest hunting, livestock
Lower Tropical Forest	Mid-altitude rolling hills composed of valleys, hills and numerous water courses	Grand Gedeh	Average rainfall from 3000 mm in Maryland to 4100 mm in Sinoe; long dry spell and two distinct peaks of rainy season	**Vegetation:** mostly evergreen rainforest in south-eastern part of the counties **Livelihood activities**: upland and lowland rice, yams, cocoyam, forest hunting, plantains, potatoes and vegetables; rubber, cocoa, coffee and sugarcane are the major cash crops
Northern Savannah		Northern Lofa and Northern Nimba	High elevation with average rainfall between 700 and 1750 mm	**Vegetation:** dense elephant grass (*Pennisetum purpureum*) of up to 1.5 m, scattered trees and patches of forest; it consists of the derived and Guinea savannahs, which in addition to the coastal savannah are the main pastoral resources **Livelihood activities:** cassava, rice, woodlots, non-timber forest products, livestock

Adapted from FAO (2012).

3.2. Profile of the Study Counties

Bong County

Bong county is located in central Liberia with the total population of 520,000 people. It is bordered by Lofa County on Northwest, Gbarpolu County on the West, Margibi County on the Southwest, Grand Bassa County on the South and South-East, and Nimba County on the East and the North-East. On the North, Bong County is bordered by the Republic of Guinea. The capital is called Garnga city and is located about 200 kn NE of Monrovia (Gol, 2012). Bong county is one of the known richest counties in Liberia. The resources available there are; gold, diamonds, iron ore and timber. It is also known as one of the areas that have adopted agriculture as a way of life and one of Liberia's bread baskets. The main agricultural crops produced are Rice, vegetables, cassava and rubber. Due to its richness, it has attracted many investments and development programmes such as, China Union that has a contract to mine iron ore, Central of Agriculture Research Institute (CARI), the Phebe Hospital and School of Nursing, Rubber Corporation of Liberia (RCI), Liberia Telecommunication Corporation (LTC), Liberia Electricity Corporation (LEC), Cuttington University College (CUC) and the Bong County Community College.

Climate

The climate of Bong County is tropical, hot and humid. The temperature generally ranges from 65F to 85F. Based on the prevailing precipitation, two seasons are differentiated: rainy and dry. The rainy season lasts from mid-April to mid-October. The dry season begins in November and ends in April. However, with the planet experiencing climate change, a slight fluctuation in the timing of the seasons has been noticed. Generally, the wind blows from the Northeast during the dry season and from the Southwest during the rainy season. Wind mileage is normally greatest in the rainy season, sometimes bringing violent storms capable of destroying houses and crops. Bong County has a conventional type of rainfall of around 70 to 80 inches. Toward the interior, the rainfall decreases because the air loses moisture except for high areas where the air forces rise causing some relief rain.

Topography

The County is said to be well watered by six principal rivers and a number of small streams. The St. John River runs through Bong County and rises in Guinea where it is known as Mano River, north-west of the Nimba Mountains. The Mano River receives much water from Naye River, the Zoi and Yja Creeks.

Geology

The soils of Bong County are mostly latosols, which occurs on undulating and rolling land and occupies about 18% of the total land area in Liberia. This soil is heavily leached and silica nutrients and humus are readily washed out.

Vegetation

Bong County is part of the high forest belt, which can be divided into an evergreen rain forest zone and the moist semi-deciduous forest zone. The evergreen forest receives an

annual rainfall of 80 inches and consists of species that do not have a marked period of leaf fall. The tallest trees reach 200 feet. The semi-deciduous forest is a transition to the deciduous forest type found in the Ivory Coast. The long dry season (4.5 – 5.5 months) forces many species to drop their leaves during part of this period to minimize evaporation. The occurrence of this vegetation in Bong County is based on soil conditions.

Grand Bassa County

The County is located in the area from latitude 6°45' to latitude 5°30' North, and from longitude 10°30' to longitude 9°00' West. On the Southwest of the County there is the Atlantic Ocean. Grand Bassa borders with four counties: Margibi on the Northwest, Bong on the North, Nimba on the East, and River Cess on the Southeast. The total land area the County is approximately 3,382 square miles (8,759 square kilometers). The major livelihood activities include; fishing, agriculture meanly cassava production and rice. Bassa has a sea port that makes one of the engines of economic growth in Liberia.

Climate

The equatorial position and the distribution of high and low-pressure belts over the African continent and the Atlantic Ocean influence the climate of Liberia. The zone, north of the Intertropical front, where the continental air masses prevail from mid-December to end of January show arid conditions (humidity may drop to below 50% in the harmattan period, November to March). As the maritime air reaches the coast, it is forced to rise, its cooling resulting in rain falls. The shift of the Inter-tropical convergence zone from the northern hemisphere over the Sahara Desert and the cool air mass over the south Atlantic Ocean in the southern hemisphere results in the replacement of dry continental air mass and moist south-equatorial maritime air mass at six-month intervals. The rainy season is from mid-April to late October, and the dry season from mid-November to mid-April. Average annual rainfall along the coastal belt is over mm 4,000 and declines to mm 1,300 at the forest-savannah boundary in the north. Two-thirds of the rain along the coast falls during the night, most of the other in the afternoon. Rainfall is caused by the South Atlantic subtropical monsoon. Under the influence of the low pressure from the Sahara Desert, low humidity prevails usually from the end of December to January, and sometimes till February. Relative humidity along the coastal belt does not drop below 80% in the day but during the dry season, in the interior it may fall to below 20% during the harmattan period. In the night it is regularly 90- 100% regardless of the season. Temperature ranges from 27-320 C during the day and from 21-240 C at night and has little monthly variations, cloud cover and rainfall reducing its impact at the soil level. The highest temperature occurs between January and March and the lowest is between August and September. Total wind speed is greatest in the rainy season and lowest in the dry season, being lower in the interior, where high vegetation cover serves as a windbreak. Along the coast, the average annual wind speed was km/h 30.

Grand Cape Mount

Grand Cape Mount county is one of the historical places in Liberia that has hosted Pedro De Sintra in 1461, a Portuguese Navigator. Like many other counties in Liberia, it was not spared from the devastating effects of the war and Ebola, in fact, it was one of the counties heavily hit by Ebola and was among the last to recover from the deadly virus (GoL, 2012; WHO, 2016). The capital is Robersport and is situated near the Wakolor Mountain and close to the shores of the Atlantic Ocean and is watered by lagoons and the famous Lake Piso with a natural forest just at its back inland. The forest contains mixed species of animals and plants that makes it one of the biodiversity hotspots and an attractive tourist area (Gol, 2012). Fishery is a major livelihood activity coupled with inland agriculture practices that focus on cassava, rice, vegetables and domesticated animal raring mainly goats and sheep.

Geography

Grand Cape Mount is a border County found in the Western Region, specifically the south-western corner of Liberia along the coastal belt. Located on coordinates 7º 15! N, 11˚ 00'W, it is bounded in the Northeast by Gbarpolu County, in the East by Bomi and Lake Piso, in the South by the Atlantic Ocean and in the West by Sierra Leone, with a total land area of 5,827 square kilometers. The County is sparsely populated with concentrations in commercial, mining and fishing areas (Gol, 2012).

Climate

The climate of the County is humid and tropical with two distinct seasons: the wet season and the dry season. The wet season begins in April and ends in October with an average rainfall of 400 cm and temperatures ranging from 28 degrees and 34 degrees Celsius, while humidity goes as high as 90 to 100 percent. The dry season is from November to March. Cape Mount, being a coastal County, has high annual average rainfall because the coastline runs approximately from South-east to Northwest and at right angles to the prevailing south-western rain-bearing winds.

Topography

Grand Cape Mount has a large natural lake called Lake Piso, which forms a confluence with the Atlantic Ocean with beautiful shores that attract tourists. The County is also endowed with mountains such as the Bie Mountains in Porkpa and Gola Konneh Districts, which contains a large deposit of iron ore. Cape Mount County is served with a good network of rivers such as Maffa, Mani, Konja, and Lofa, which separates Bomi from Cape Mount, and the Congo Mano River, separating Sierra Leone and Liberia. These rivers contain rich deposits of gold and diamonds and provide food and livelihoods for many communities.

Geology

The County is richly endowed with natural resources, mainly iron ore in Porkpa and Gola Konneh Districts, and diamonds and gold in Porkpa, Gola Konneh and Tewor District. It was reported during the CDA consultations that there may be valuable deposits of oil around Bobojah in Garwular District, though a geological survey has yet to confirm this claim.

Vegetation
The County's coastal belt is rich with coastal mangrove, farmland, coastal savannah and secondary forest. Tewor, Porkpa and Gola Konneh Districts are mostly covered with semideciduous and rainforest. A portion of the Gola Forest runs through the County, with a variety of wildlife species such as elephants, monkeys, chimpanzees, pottos, genets, pigmy hippopotamus, zebra duiker, leopards, egrets and owls, among others.

Grand Gedeh

Grand Gedeh is the third largest County in Liberia and is located in the South-East bordering Ivory Coast. The capital is Zwedru and the county has a total population of 140934 people. The natural resources of Grand Gedeh include; virgin forest that has not been logged for many years. The soil is rich and capable of producing any kind of food crops, and the streams and rivers are filled with various fish species. The County is also known to be rich in deposits of gold, iron ore and many others natural resources that have not been widely exploited (Grand Gedeh CDA, 2012).

Geography
Grand Gedeh is located in southeastern Liberia, bounded on the Northwest through the North by Nimba, on the Northwest through the East by the Cavalla River forming the boundary with Cote d'Ivoire, on the South by River Gee County, and on the Southwest by Sinoe County. The total land area of Grand Gedeh County is 10,276 km", which is about 9.22% of the total land area of Liberia.

Climate
The climate of Grand Gedeh County, like many parts of Liberia, is determined by the Country's geographic position near the equator and Atlantic Ocean. Temperatures are warm throughout the year with extremely high humidity. The climate is characterized by little seasonal change of temperature and humidity, but by changes between day and night. There are basically two seasons, rainy and dry, which are marked by variation in precipitation. These seasonal patterns result from the movement of high and low-pressure belts caused by the changing angle of the sun. The rainy season runs from April to October, while the dry season runs from October to April. The average annual rainfall of Grand Gedeh County ranges from 76 inches in the upper or northern part to 107 inches in the lower or southern part. Average temperature is 77.5º F (25.5ºC).

Topography
Grand Gedeh is categorized under the highlands of Liberia, which is generally characterized by plateau and mountain ranges up to 1,000 ft (300 M). Important mountain ranges are the Puto and Tiempo. The hilly terrain is an impediment to road construction; gradients are steep and irregular, and the river valleys are V-shaped and narrow in their upper reaches.

Geology
The soils are not unlike those of the rest of the country, generally amenable to a variety of agricultural uses. The rock of the County forms part of the West African croton,

recognized by its stability and general absence of tectonic activity during the last 2,500 million years.

Vegetation
The vegetation of Grand Gedeh County is typical of the tropical rain forest, characterized by evergreen and semi-deciduous forest.

Lofa County

Lofa county is known to be one of the biggest counties in Liberia with a total population of 416173 people. Historically, the county was known as "Breadbasket of Liberia". The capital is Voinjama and agriculture is the major livelihood activity. The main agriculture crops are; rice, vegetables, cocoa, coffee, etc.

Geography
Lying in the north-western corner of the country, Lofa is bounded on the east and north by Guinea, west by Sierra Leone and on the south by Gbarpolu and Bong counties. Lofa County is now the second largest County in Liberia. It is bounded on the east and the north by Guinea, on the west by Sierra Leone and on the south by Gbarpolu and Bong Counties.

Climate
The climate in Lofa County is tropical, hot and humid. Based on the prevailing precipitation, two seasons are differentiated. The rainy season lasts from mid-April to mid-October. The dry season begins in November and ends in April. The temperature normally ranges annually from 24C to 30C (75F to 85F). Data on winds in Lofa County is incomplete, but wind generally blows from the Northeast during the dry season and from the Southwest during the rainy season. The total wind mileage is greatest in the rainy season from July to September and lowest in the dry season during December and January.

Lofa County has an average rainfall of around 115 inches (2,900mm). Three principal types of rainfall can be distinguished. First, heavy downpours occur at the beginning and at the end of the rainy season. Second, longer periods of precipitation with less turbulence occur, covering larger areas. The intensity of this kind of rainfall is increased through the drop of temperature during the afternoon and the night hours. Third, "Relief Rains" are produced by the friction between the topography and air masses which reach the county from the sea. Relief rains occur at mountain ranges and other relief features.

Topography
The plateaus and mountain ranges lie behind rolling hills. Table lands reach heights of up to 1000 ft-2000 ft (609.6 m) and mountain ranges are found up to 2000 ft. (600 m). Important ranges are the Wologisie, Wutivi and Wanigisi. The greatest width of this zone is 80 miles (130 km) between the Lofa and St. Paul Rivers. The belt of rolling hills parallel to the east zone has elevation in the order of 300ft (90 m). There are numerous hills, valleys and water courses in this zone.

Geology
All three kinds of soil produced by different conditions of climate and vegetation in Liberia are found in Lofa: clay loam, sandy clay loam, and loam.

Vegetation
Vegetation in Lofa is composed of tropical rain forest including high forest, broken forest and low bush. The type of forest most common to Lofa County is known as Moist Semi-Deciduous Forest. Some of the most common trees are the nesogordonia papaverifera, the limba (or terminalia superb), and the obechi (or triplochiton scleroxylon).

Nimba County

Nimba is generally rural-based with most of its population living as subsistence farmers. The county is named after its tallest and largest mountain, Neinbaa Tohn. The population of Nimba is 732195 people (Nimba CDA, 2012). The capital is Sanniquellie.

Geography
Nimba County is situated in the Northeastern part of Liberia and shares borders with the Republic of Cote d' Ivoire in the East, and the Republic of Guinea in the Northwest. Nimba is bordered by the counties of Bong, River Cess, Sinoe, and Nimba. The total geographic area (of land and water) of Nimba is 2,300 square kilometers; from North to South, the County stretches 230 kilometers and East to West, 100 kilometers. It has a distance of 298 kilometers from Monrovia to Sanniquellie.

Climate
Nimba has a tropical climate. There are two seasons: wet and dry. According to the New Geography of Liberia, average rainfall in Nimba is recorded between 12.5 – 25mm in January; between 100-150mm in the West and 150-200mm in the North, East and South of the County in April; and in October average rainfall is recorded between 200-250mm in the south-eastern portion and 250-300mm in the northwestern portion. Prevailing wind is generally south-easterly or monsoonal.

Topography
There are three principal topographic areas: the northern part of the County is dominated by mountains, hills and deep valleys. Prominent among the mountains is Mount Nimba. The highlands of Nimba form part of the Bleetro-Nimba Block in the Central Region of Liberia, one of three large mountain blocks of Liberia, the other two being the Kpo-Wologisi Block in the western region and the TienpoPutu Block in the Eastern region. The Northern Highlands of Liberia are primarily found in Nimba and Lofa counties and form part of the Guinea Highlands also known as the Futa Jallon Mountains. Two relief features are characteristics of this region: long ranges and doomed-shaped hills. The Nimba Range rises north of Sanniquellie and after twenty miles extends into the Republic of Guinea, where it reaches an altitude of 6,083 feet.

Geology

All three kinds of soil produced by different conditions of climate and vegetation in Liberia are found in Nimba: lateritic soil or latosols or upland soil, clay or swamp soil, and sandy soil. Generally, lateritic soils cover about 75% of Liberia according to W E. Reed. They are the most typical soils of the humid tropics, where there are alternating wet and dry seasons. This soil type is predominant in Nimba. According to soil scientists, latosols have only 0.24% nitrogen (plant food) and are very acidic. Their continuous farming requires the constant use of fertilizers, an input that nearly all farming households are too poor to afford, and this may explain the situation of annual bush fallowing by subsistence farmers in the County. Nevertheless, latosols are more productive than the other soil types and they provide valuable material for road building due to their hardness. Vegetation Nimba's natural vegetation is composed of tropical rainforest, specifically high forest, broken forest and low bush. As in the other northern counties of Liberia the most prominent forest type is moist semi-deciduous. Trees of this forest type are the nesogordonia papaverifera, limba (terminalia superba), and obechi (triplochiton scleroxylon). Low bush establishes itself in the areas of land rotation where trees are cut and burnt as a result of the shifting or bush fallowing method of farming. Typical trees of this vegetation type are the umbrella or corkwood tree (mussanga cecropioides) and the oil palm. Swamps are common in the County, and there is a small portion of the vegetation covered with scattered trees and dense elephant grass (pennisetum purpureum). There are, however no natural grass fields except those created by human activities through farming, habitation or the development of football fields. The original vegetation of the County would have consisted of tropical rainforest, which was cut down primarily for farming purposes and the cultivation of other cash crops such as cocoa, coffee, oil palm and rubber. The land abandoned after farming is occupied by elephant grass that slows the regeneration of forest trees.

Sinoe County

Sinoe was discovered by the Portuguese in the 15th Century as part of what they called the Grain Coast. Its capital is Greenville where major fishing activities occurred. The population of Sinoe county is 76224 people (Sinoe CDA, 2012).

Geography

Sinoe is found in the South-eastern region of the Republic of Liberia, which is on the West Coast of Africa. Sinoe is bordered by Grand Gedeh County on the North, by River Cess County on the West, by Grand Kru and River Gee Counties on the East, and by the Atlantic Ocean on the South. Sinoe covers a land area of about 3,861 Square miles (10,000 square kilometers) and has a total coastline of 86 km.

Climate

The climatic condition in Sinoe County is typical of the equatorial tropics, with a high temperature and high humidity. The County has two seasons, rainy and dry, which show distinction in the temperature according to the seasons. The average annual temperature during the dry season (the hot period) is December to March and exceeds 79 degrees Fahrenheit (26 degrees Celsius). At its peak in February, the temperature rises above 80

degrees Fahrenheit. The County experiences westerly wind and heavy storms during the rainy season, and moist winds during the dry season. Annual rainfall is over 80 inches in the County as is typical of of the Republic of Liberia.

Topography

The physical features of Sinoe County are about sixty percent lowland with somewhat increasing elevation from the coast. It has some high hills and few mountains and valleys, mainly in Jaedae, Jedepo and Dugbe River Districts on the left bank of the Sinoe River. The County has six major rivers including the Sinoe River, Dugbe River, Sanquin River, Tarsue River, Baffu River, and Plason River. Sinoe has a number of natural falls that may be suitable for the construction of hydroelectric plants. Some of these natural falls are: Sinoe River Fall in Wehjah District, Dugbe River Fall in the Dugbe River District, Sanquin River Fall in the Troh Chiefdom/Sanquin Statutory District and the Hamgbe River Fall, situated in the upper region of BOPC and Tumata.

Geology

Sinoe soils are typical for the country, comprising sedimentary rocks, loamy clay, sandy clay loam, and marshland/swampy soil.

Vegetation

Sinoe has an evergreen rain forest, which receives an annual rainfall of 80–85 inches. The Sinoe National Park is composed of virgin forest reserved for eco-tourist activities and biomedical research as well as wildlife preservation. The height of the tallest trees is approximately 200ft. Due to shifting cultivation, most of the evergreen forests have been converted into farmland or secondary forest. The coastal area is noted for savanna and mangrove with some grassland.

4. FISHERIES SECTOR

4.1 Current Vulnerability and Risk Assessment

There is no doubt that the fishery sector of Liberia has huge potentials for lifting the poor out of poverty and over the years has provided employment and livelihoods for more than 11250 people (FAO, 2006). However, climate change stands as a major driving force to the decline in fish species in the fishery sector in Liberia (EPA, 2018). Indeed, climate change has impacted the fishery sector by the shift in the distribution of species, biodiversity loss and loss of livelihoods (USAID, 2017). The USAID (2017) report opines that increase in temperature is causing disruption to production patterns and migration of fish species and has reduced aquatic biodiversity and the overall productive capacity. While on the other hand, increased frequency of intense precipitation has led to more frequent loss of fishing days caused by bad weather, loss of income and livelihoods and reduced protein intake.

Inland fisheries, particularly important for small-scale artisanal fishers in Liberia and an integral part of Liberian rural livelihood and food security systems could be severely impacted by climate change (USAID, 2013). Nearly the entire inland fishery lies in the Southern Upper Guinea Aquatic Ecoregion. About 20% of the 151 fishes from the ecoregion are endemic. Nevertheless, so little is known about the inland fishery in terms of rates of exploitation, diversity and status of fishes exploited, number of fishers, and state of the aquatic ecosystem that projections of climate change impacts on this important national resource are virtually impossible beyond broad generalizations. Precipitation and evapotranspiration changes, including an increase in extreme events (e.g., exacerbated floods, extreme drought), is affecting inland waters causing changes in magnitude and timing of high and low river flows (USAID, 2013). These kinds of hydrological variability could adversely affect fish habitats, reproduction, growth, recruitment, and mortality (USAID, 2017).

From our field data collection with relevant stakeholders, we gathered from 116 respondents from three coastal fishing counties (Grand Cape Mount-Robersport, Grand Bassa- Buchanan, Sinoe-Greenville) that the current risks and climate vulnerabilities in the fishery sector are sea level rise, flooding and coastal erosion being experienced on an annual basis that eats up the coast as observed in Buchanan and Greenville. Brown tides due to temperature increase has also destroyed fishing nets so badly to the extend that debris were seen on the beaches in Robersport. In addition, most respondents from our interviews revealed that sea storms as a result increase precipitation have resulted in reduced fish catch which has impacted the activities of the women involved in drying fish. The vulnerability of the fishery sector to climate change in Liberia is presented in figure 3.

4.2. Past Vulnerability and Risk Assessment

Climate induced changes in the biophysical characteristics in Liberia, along with extreme events, have had significant effects on the ecosystems which support fish (especially inland). This has affected food security in multiple ways. These include loss of some fish species due to extinction and low productivity to support local consumption, migration of many fish species to aquatic environments with optimal climatic condition beyond Liberian waters (those that are inaccessible to fishers), lower earnings from fish export due to reduced fish production, consequently reduced capacity to import food and exacerbation of food insecurity locally, and fisheries productivity and supplies (Barange et al., 2014). Hence, with the predicted increase in the demand for fish products, efforts to support food and livelihood security need to be informed by predictions of climate change impact in fish production and its associated social and economic consequences

4.3. Past, Current and Future Adaptation Options

According to UNFCCC 2018, adaptation addresses climate impacts that are observed today and prepares us for impacts occurring in the future. Given that Liberia is already experiencing the impacts of climate change, the solution is not to stop it but to adapt to the past and current impacts and be ready to take similar or progressive measures for future climate change. In this report, we have gathered adaptation options from key national reports as well as from our field visits in three coastal economic zones (Grand Cape Mount-Robersport, Grand Bassa-Buchanan, and Sinoe-Greenville) and from a one-day workshop with key sectoral stakeholders. The USAID report in 2012 outlined the following adaptation options:

- ✓ Promote sustainable fishing practices;
- ✓ Reduce number of fishing licenses issued to foreign vessels;
- ✓ Regulate fishing practices to prevent overexploitation and fishing in restricted areas.

Also, the National Policy and Response Strategy document (EPA 2018) drew a list of adaptation options which are as follow:

- ✓ Investment and support for artisanal fishery communities including training and alternative livelihood;
- ✓ Set up a robust monitoring, reporting and verification system that captures and reports in a timely and accurate manner changes in the stock, productivity, and pressure on fisheries;
- ✓ Use the precautionary principle as a cue, use information from monitoring to implement adaptive management practices that set catch limits based on changes in recruitment, growth, survival and reproductive success;
- ✓ Conduct research to fully understand fishing pressures and adjust quotas to sustainable levels, as well as predicting where fish populations will move; finding species resistance to salinity and temperature fluctuations for aquaculture and, where necessary, support selective breeding for increased resilience in aquaculture;

- ✓ Support the protection and restoration of mangroves, recognizing their role as an important habitat for aquatic species, which contributes to biodiversity and increased food product;
- ✓ Availability for household consumption and resources for local markets, as well as providing water filtration services that are key for good health hygiene and sanitation;
- ✓ Identify and protect areas valuable for fisheries (e.g. deep pools in river systems that serve as spawning areas), including the setting up of marine protected areas and encouraging native aquaculture species to reduce impacts;
- ✓ Put in place or strengthen a system to reduce external stressors on fisheries by instituting changes in vessel or gear types in order to reduce pressure on fishery and to contribute to their sustainable harvesting, as well as instituting actions and regulatory measures to reduce land-based sources of pollution (e.g. agricultural and urban runoff) and destructive fishing practices (e.g. fishing with explosives and poisons);
- ✓ Integrate fisheries fully into climate change adaptation and food security policies at the national level (draft and enact where non-existent) to ensure incorporation into broader development planning;
- ✓ Support the diversification of the livelihood portfolio of communities that are fishery dependent;
- ✓ Establish improved information and communication networks for decision making and planning, as well as between fishing communities, to support information sharing about potential shocks in the system.

Adaptation options gathered from the fishery stakeholders working group during a national workshop included the followings:

- ✓ Capacity building of fishermen (local & industrial)
- ✓ Capacity building of women involved in drying and marketing fish;
- ✓ Effective and early warning system;
- ✓ Replacement of non-motorized boats with motorized boats;
- ✓ Build a climate resilient jetty;
- ✓ Development of training programmes for fishermen and women;
- ✓ Conduct research on ecosystem degradation;
- ✓ Improve regulation and enforcement;
- ✓ Create marine protected areas;
- ✓ Create alternative livelihood (aquaculture, animal husbandry); and
- ✓ Establishment of more co-management.

Adaptation options gathered during the focus group discussions and individual interviews included the following:

- ✓ Provision of early warning system through community science monitoring – very far from being perfect in providing reliable weather information. System being piloted under the Collaborative Management Association (CMA);
- ✓ Access to market, access to loans or support to acquire bigger boats/machines better and stronger fishing nets;
- ✓ Training to acquire specific skills in the fishing value chain;

- ✓ Availability of marine store to enable fishermen have easy access and be able to purchase fishing gears;
- ✓ Oven dryers to avoid too much fire and smoke;
- ✓ Move from 15 to 40 horse power engine costing about 4200 USD. This can be done by buying the machine at once with one's own money or get a guarantor like the Fanti Governor to stand as a guarantor to the Toyota garage in Monrovia;
- ✓ Operate as a registered company with a group of 15 to 30 people involving the investor and workers. Sometimes it works as a family business;
- ✓ Access to different kinds of fishing nets depending on individual businesses. Most common nets are 1.5, 2 miles, 2 finger, 1.78 net and some may cost up to 340 $;
- ✓ Establish woodlots to provide firewood for drying the fish. Fishermen are willing to participate in the planting of the trees;
- ✓ Access to credit to buy fishing materials/equipment;
- ✓ Build and manage storage facility for fresh fish;
- ✓ Provide compasses for fishermen to enable proper navigation at sea;
- ✓ Provide specialize gasoline for fishermen to reduce some of the heavy costs and competitions with different users;
- ✓ Establish marine store to enable easy access to fishing gears
- ✓ Storage facilities to enable fishermen preserve their catches and reduce losses;
- ✓ Drying and other facilities for women involved in fishery sector.

5. AGRICULTURAL SECTOR

5.1. Current Vulnerability and Risk Assessment

Climate patterns play a fundamental role in shaping national ecosystems and the human economies and cultures that depend on them. This is true of many sectors including agriculture. Studies have shown that the manifestations of climate change are difficult to distinguish from those of natural disasters such as floods, wind, storm and heat waves. These phenomena are being experienced in Liberia in the absence of hydrological and meteorological data. These conditions therefore, are being catered for by many local and uncoordinated actions to manage such events. Similarly, development decisions that are dependent on climate variables and information are very difficult to make. This challenge has adversely threatened sustainable agricultural production and development including socio-economic growth.

The effect of temperature changes on plants depends on local conditions and the types of crops grown. It was revealed during interviews with key stakeholders that agriculture in Nimba and Grand Gedeh Counties is being affected by warmer temperatures which have led to a reduction in chill hours potentially reducing yields for some crops like maize, rice, rubber, and cassava. Indeed, maize that is a common staple and constitutes a dietary base in Liberia is highly sensitive to temperature increase. It is reported that for every $1^{o}C$ increase above $30^{o}C$ temperature per day during maize growing season, there is a corresponding 1% reduction in yield each day under optimal rain fed condition (ACPC, 2014). Furthermore, compounded climate factors are decreasing plant productivity resulting in price increases for many important agricultural crops in Liberia (EPA 2018)**.** The net effect of climate change on Liberian agriculture is negative. Upland rice, the predominant cropping system in Liberia is being impacted by changes in seasonality of precipitation (USAID, 2013). The Liberia climate assessment report of 2013 found that most rural households are food insecure, meaning that they lack access always in the year to sufficient, safe, and nutritious food to meet their dietary needs; nationally, 80% of the rural population was either moderately vulnerable (41%) or highly vulnerable (40%) to food insecurity (USAID, 2013).

There is no doubt that climate change is having an impact on livestock performance. Currently, livestock population is below 10% of national requirements due to the impacts of climate change. The difficulty facing livestock is weather extremes, e.g: Climate intense heat waves, floods and droughts. In addition to production losses, extreme events also result in livestock death (Gaughan and Cawsell-Smith, 2015*)*. Furthermore, the livestock sector which contributes 14% of food and agricultural GDP (*MoA, 2006*), adverse impacts are expected as climate change hazards as well as animal disease and vectors have affected the productivity of the sub-sector.

Results obtained from field visits with local stakeholders also establish that farmers are impacted negatively due to fluctuation in rain patterns. Observations have shown that May and June are wetter than expected and this carries implication for farm productivity. May and June are predominant planting periods for farmers especially those engaged in upland agriculture in Liberia. Excessive rain during this time of the year washes away plant seeds and sprouting plants thereby causing low productivity.

Farmers are vulnerable to shifts in Climate variables when considering the fact that majority of the households are living below the poverty line. Similarly, the fact that temperature shifts are particularly intense in mid dry season carries implications for farming during the dry season. Furthermore, the rain being intense during the early stage of the rainy season affect farmers decision to plant which in turn have serious impact on their survival. The vulnerability of the agricultural sector to climate change in Liberia is presented in figure 4.

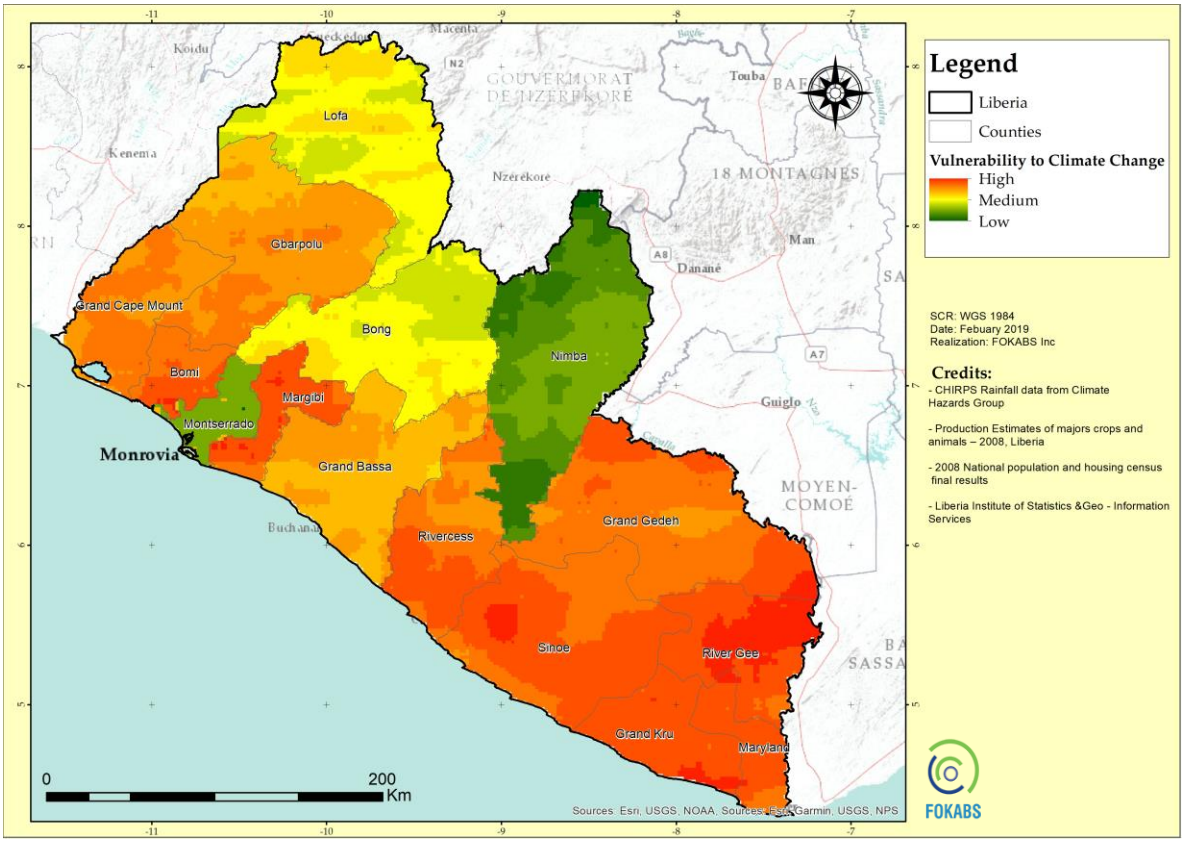

Figure 4. Map showing the vulnerability of the agricultural sector to climate change (source: Fokabs)

5.2. Past Vulnerability and Risk Assessment

The production system of agriculture in Liberia is nature dependent as the production activity that transforms inputs into agricultural outputs involves direct use of weather inputs (precipitation, temperature, and solar radiation available to the plant.), with various

studies of the impacts of climate change on agriculture reporting substantial differences in outcomes such as prices and production (EPA, 2018). The increasing tendency of temperature and the high variability, but increasing tendency for rainfall pattern, show that climate change continuous to exert significant pressure on the agriculture sector in Liberia. Similarly, the livestock sector, which contributes 14% of food and agricultural GDP, has experience climate change hazards, and animal diseases and vectors (resulting from climate hazards) has affected the productivity of the sub-sector.

5.3. Past, Current and Future Adaptation Options

Many studies have been done to assess the impacts of climatic warming on crop yields. Results from these studies indicate that relative to current technologies or management practices, the yields of major crops in Liberia may diminish because of climatic warming. However, by employing rigorous techniques to illicit and utilize the opinions of experts, particularly in the aggregation of differing projections, expert opinions could be an effective and inexpensive means for estimating effects of climatic change on crop yields. National leaders as well as non-state actors at all levels are confronted with the question of how to address the alarming impacts of climate change on development.

In Liberia, addressing climate change vulnerability impact is constrained by a number of factors, including a limited observational network (e.g. Automatic weather stations, hydrological gauges, satellite imagery, radars, etc), which limits observations and the ability to monitor and evaluate the impact of climate related hazards or risks such as incorporating advisories information in extension services e.g. on selection of crop varieties, drought resistance, short season, crop harvesting, fertilizer/commodity prices and flood vulnerability maps, as well as communication through different media (e.g. public notice boards, TV, radio, internet) and institutions (e.g. disaster management agencies and NGOs) required an effective Early Warning System. The ability thus for decision-makers to understand the likely impacts of climate change in the short and long-term is of critical importance when planning strategies for sustainable development.

In 2008 a three-year Sustainable Land Management (SLM) initiative was started with funding from the Global Environmental Fund (GEF), the United Nations Development Programme (UNDP) and the Government of the Republic of Liberia (GoL). The project was designed to contribute to the mitigation of land degradation and to promote ecosystem integrity and stability with enhanced ecological functions and services. The project sought to strengthen the enabling environment for SLM through mainstreaming and capacity development for sustainable agriculture through a broad-based participatory process. The project was completed in 2013. It achieved the following outcomes in terms of climate change adaptations strategies in the agricultural sector: integration of SLM into the curriculum of the University and into the extension training systems of the Ministry of Agriculture and the NGOs sector, and establishing a knowledge management system for facilitating information and experience sharing among stakeholders (EPA, 2013).

Adaptation to climate variability and extreme events serves as the basis for reducing vulnerability to long-term climate change. It was gathered during stakeholder

consultations that simple adaptation practices such as using climate-ready crops or thermal stress-tolerant varieties, adjusting planting dates, improving water conservation and management practices, using efficient irrigation and fertilizer management, diversifying crops, and improving pest management could help reduce the impacts of climate change. Apart from those, reliable local weather information and early warning systems for farmers will be useful in minimizing risks of climatic threats. Adaptation will further require cost-effective investments in water infrastructure, emergency preparation for and response to extreme weather events, development of resilient crop varieties that tolerate temperature and precipitation stresses, and new or improved land use and management practices (Collier et al. 2012*).*

In 2008, Liberia completed its National Adaptation Programme of Action (NAPA) with technical support and funding from the GEF and UNDP (GoL 2008). The preparation of NAPA was guided by existing national development plans such as the National Reconstruction and Development Plan (NRDP), National Biodiversity and Strategy Action Plan (NBSAP) and the Millennium Development Goals (MDGs). Several adaptation measures were formulated by the stakeholders as adaptation measures to reduce the impact of climate change variability and extreme climate events in Liberia. The NAPA process identified several projects and urgent adaptation needs using multi-criteria analysis, which were validated at a stakeholder's forum. Based on multi-criteria analysis, three projects were selected as the most urgent priority needs of the country. These projects, given by priority rank within the NAPA, are described hereinafter:

- ✓ Agriculture adaptation: enhancing resilience to increasing rainfall variability through the diversification of crop cultivation and small ruminants rearing;
- ✓ A National Meteorological and Hydrological Monitoring System: enhance adaptive capacity through the rebuilding of the national hydro-meteorological monitoring system and improved networking for the measurement of climate parameters;
- ✓ Coastal Defence: reducing the vulnerability of coastal areas especially in Monrovia, Buchanan, and Robersport to erosion, floods, siltation, and degraded landscapes.

The Climate Change Agriculture Adaptation Project (CCAAP), with the intention of introducing climate smart agriculture was executed by the Ministry of Agriculture from September 2011- 2015 with support and funding from the GEF, UNDP, and Government of Liberia in-kind contribution. The project was intended to increase resilience and enhance adaptive capacity to address the additional risks posed by climate change in the agriculture sector; providing the conduit through which agriculture adaptation, can be implemented in Liberia.

The Government of Liberia also developed the Liberia Agriculture Sector Investment Programme (LASIP), which expresses Liberia's strategic choices for the growth and development of agricultural in an environmentally friendly and sustainable manner over a period of 10 years (beginning 2011). LASIP is geared toward food security, public and private sector investment in the agriculture sector, promoting the use of technology and innovation by local farmers.

The National Meteorological Monitoring System (Early Warning System) project of Liberia is being executed by the Ministry of Transport with funding from the GEF, under the Least Developed Countries Fund (LDCF). This system will provide farmers and extension officers in the pilot project sites with real time climate information (rainfall, temperature, sunshine etc.) that can assist them in planning agriculture activities and measures intended to adapt to climate variability and extreme events like flooding or drought.

The coastal defence project, executed by the Ministry of Land, Mines & Energy was designed with the objective to strengthen national capacities in reducing the incidence of floods, erosion, siltation and degraded landscape in the cities of Monrovia and Buchanan. The project was given priority due to the increasing threat of sea erosion to the shorelines of coastal cities. It was implemented with funding from the GEF, under the Least Developed Countries Fund. For the Construction of a Break Water System in Buchanan (Walvis Bay, Robert Street and Port of Buchanan) in January 2012 the project was launched. At the moment the project has realize the consolidation of 500m of coastline in the coastal city of Buchanan and put in place a mechanism for the establishment of an Integrated Coastal Zone.

A National Adaptation Plan (NAP) was developed as a means of identifying Liberia's medium and long-term adaptation needs. Additionally, the Government of Liberia (GoL) through the Environmental Protection Agency is working in collaboration with the UNDP to develop a climate change adaptation Project proposal. A team comprising of staff from UNDP, GoL and experts, are leading the project formulation process. This proposal aims to build/strengthen national and communities level structures in the Greater Monrovia Metropolitan Area capacities for Disaster Risk and climate change impacts in the wake of the potential threat of increasingly intense extreme events like drought, windstorm, flooding and heavy rainfall etc.; plus determine the social and economic costs of these impacts and its impediments to the country's development now and in the future.

Moreover, the government also developed an Integrated Water Resource Management Policy (IWRMP) developed in 2007, to ensure the supply of adequate quantity and quality of water for domestic water use, food production and other uses. *(*Climate Change Adaptation and mitigation in Tourism Sector, UNEP 2008*)*

With regards to future adaptation measures in the agricultural sector, the government should consider developing a farmer's vulnerability index that will isolate farmers/communities that are vulnerable to climate change and ensure that such farmers and farming communities are well targeted. Any fiscal and financial interventions to alleviate the impact from climate change should consider the differential vulnerabilities of rural communities and aim to support their autonomous adaptation responses. The scope of the adaptation programme should be broadened to include mechanisms that will improve the resilience and adaptation of farmers that are vulnerable to climate change. The Ministry of Agriculture should support the development of a sustainable and resilient multi-purpose production system in rural areas, especially mechanisms that improve the

asset base of rural communities such as providing support towards strengthening livestock production; training for pasture-land management, disease control and crop-livestock husbandry and support strategies increase access to inputs, markets and financial resources, improved agricultural extension services and access to climate and weather forecast information. In addition, there is a need to promote multi- purpose crop production, small grains (Sorghum and millet), and drought and water stress tolerant crop varieties, improved agronomic practices (in-field water harvesting, and application of appropriate fertilizer amounts, proper timing of sowing dates, conservation agriculture, etc.). The Ministry of Agriculture needs to strengthen the extension service and capacitate extension workers with knowledge on climate change risks and climate smart agriculture. Moreover, it should support farmers by ensuring that a value chain of drought resistant crops are encouraged.

Some key adaptations strategies that were obtained from interviews with stakeholders (men, women, youth, etc.) included the following:

- ✓ Access to road, transportation and storage facilities
- ✓ Adapt to new technology and use of improved and adapted rice seeds
- ✓ Irrigation to reduce impacts of flood events. Diversification of both livelihood and cash crops to improve resilience
- ✓ Use of equipment for early land preparation; watering machines for vegetable farmers; Start planting oil palm in May to June to receive enough rains for growth
- ✓ Integrated pest management and control; Adjust farming calendar
- ✓ Building capacity and skills through the farmers feed school; Use of fertilizers to improve soil nutrients: materials, equipment for work and finance to pay for labor; a mix of early maturing seedlings and the late maturing seedlings; strong cooperative capacities and management.

6. FORESTRY SECTOR

6.1. Current Vulnerability and Risk Assessment

Over the years, Liberia has managed to maintained 40 percent of the Upper Guinea rain forest which serves as sources of revenue generation for the government and a source of livelihoods in the form of Non-timber Forest Products (NTFPs) for the communities in close proximity to it (FDA, 2000). As climate change is not discriminatory, the forest sector stands to get its shares of the impacts of climate change. The current vulnerability and risk of the forest sector were gathered both from literature review and the field work conducted by the team. According to the USAID 2017 report about climate risk profile of Liberia, increased in temperatures is causing increase in pests and diseases and increase in the frequency of intense precipitation has led to decrease in forest cover and health due to increase rainfall and erosion and runoff because of root loss. From our field data collected from stakeholders, we gathered the current or prevailing vulnerability of the forest sector from respondents from Lofa-Zigidda, Bong county- Foekoleh, Nimba-Gbedyin Camp 3, Sinoe-Cherue's town, and Grand Gedeh-Zleh town. This included: increase temperatures which (i) causes snails to hide, (ii) causes lots of Framire to die, (iii) leads low flowering of plants and less seed-fruits in walnuts, (iv) leads to reduced yield of Garcina kola or bitter kola, and (v) reduction in yield of Xylopia (aethiopica-country-spot), *Piptadeniastrum africanum-Dahoma,* and Rattan. The vulnerability of the forestry sector to climate change in Liberia is presented in figure 5.

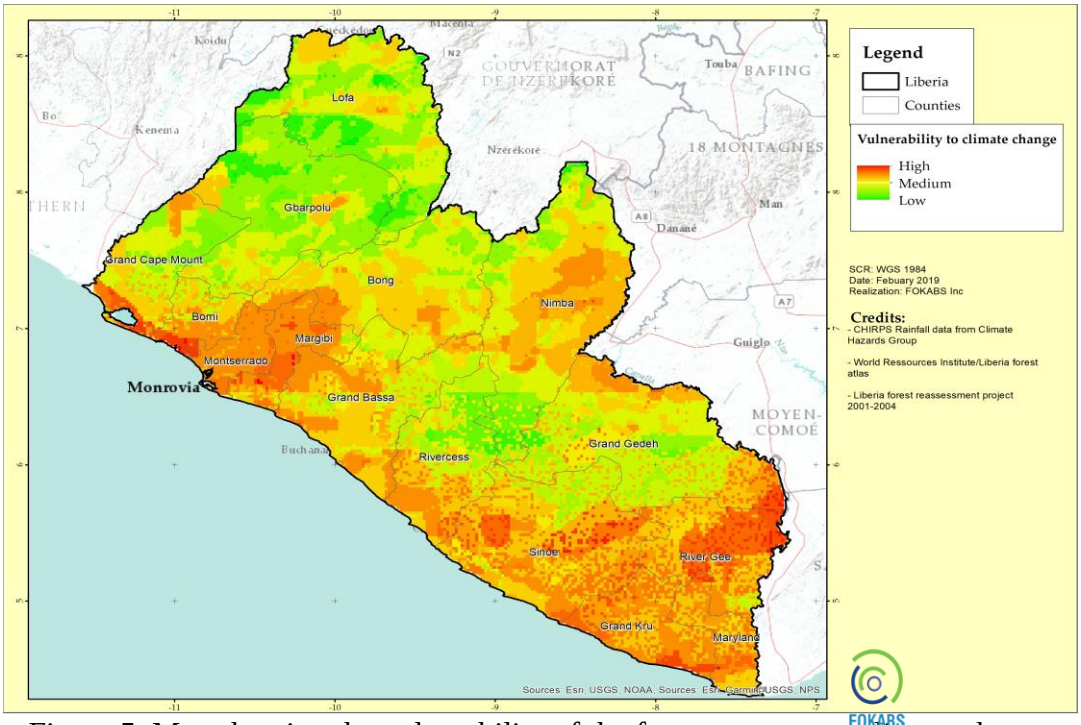

Figure 5. Map showing the vulnerability of the forestry sector to climate change (source: Fokabs)

6.2. Past Vulnerability and Risk Assessment

A changing climate influences the structure and function of forest ecosystems and plays an essential role in forest health. It may worsen many of the threats to forests, such as pest outbreaks, fires, human development, and drought. Evidence also suggests that climate-induced changes on the ability of forest ecosystem to provide basic goods and services will impact negatively the economic and social well-being of forest-dependent communities. This might include limiting the ability of communities to meet their basic requirements for food due to a reduction in the amount of productive land and pest infestation of crops, access to safe water, medicinal products, wildlife products, and fuel wood among other things which they get from the forest. In fact, increased temperature as a result of climate change has expanded the ranges and to enhance the survival rates of forest pests; such as the case of the armyworm caterpillars outbreak which occurred in rural Liberia in 2009 (EPA, 2018). The FAO speculated the abnormal behaviour of the armyworms to reach in the foliage of the tall Dahoma trees where they tend to congregate due to climate change (EPA, 2018). Moreover, higher temperatures pose various problems to Liberian forestry by facilitating the spread of a variety of forest pest such as the pine caterpillar, Dendrolmus punctatu, impede the growth of certain plant and tree species such as the Tetra berlinatubmanan of southeastern Liberia.

6.3. Past, Current and Future Adaptation Options

The past, current and future adaptation options in the forestry sector were gathered from literature review, a workshop held in Gbarnga, and from field interviews. According to USAID (2012) adaptation strategies in the forestry sector included:

- ✓ Finalize forest- and wetlands-related legislation currently in progress; and
- ✓ Maintain fast growing nitrogen-fixing tree species to improve soil fertility and use multipurpose tree species on farmlands in order to maintain forest cover.

The National Policy and Response Strategy on Climate Change (NPRSCC) document outlined the following adaptation strategies for the forestry sector;

- ✓ Implement sustainable and where applicable, alternative livelihood initiatives for forest-dependent communities, to enable them to become less reliant on forest resources or to be able to use them in a sustainable way;
- ✓ Promote community forests activities beyond timber extraction as a management tool for sustainable forest management, using indigenous species and knowledge;
- ✓ Establish a comprehensive monitoring system for forest resources by building on existing system (including non-timber forest products) to detect changes in the conditions of the ecosystem that might affect these resources and other ecosystem services provided by forests;
- ✓ Implement reforestation and afforestation activities to increase vegetation cover, to improve ecosystem services in degraded areas, to increase rural income, and to improve biodiversity richness including wild fauna,
- ✓ Enhance the management and conservation of forest biodiversity, focused on preventing perturbations such as fire, invasive species, insects and diseases

through including the adoption of a strategic approach to communication that clearly outlines the cost and benefits of various actions affecting forests,

- ✓ Identify and map for proper management water catchment areas valuable to forest-dependent communities,
- ✓ Promote consolidation of the protected area network by considering landscape approach and ensuring that it consists of a large spectrum of forest types across various environmental gradients to enhance connectivity between habitats and support species migration.
- ✓ Establish and/or strengthen coordination mechanisms with other line ministries and agencies that might be implementing activities that affect forest and wildlife and to ensure that the principle of sustainable forest and wildlife management is mainstreamed in national and sectorial policies and programmes,
- ✓ Enforce regulations related to illicit hunting, eliminate poaching and developing and implementing an environmental 'Code of Ethics' in the wildlife sector,
- ✓ Put in place health facilities for wildlife in hotspot areas,
- ✓ Develop/harmonize and implement a communication strategy to increase the awareness of relevant stakeholders, particularly forest dependent communities, about the impact of climate change and how they can take action to adapt to these changes.

During interviews with the forestry working group in Gbarnga, we gathered the followings adaptation strategies;

- ✓ Awareness raising and strengthen capacity of forest dependent communities;
- ✓ Strengthen forestry policies including enforcement and compliance;
- ✓ Improve alternative livelihoods for forest-dependent communities; and
- ✓ Promote climate smart agriculture practices.

During our field visits, we gathered the followings adaptation options from focus group discussions and individual interviews:

- ✓ Park management - Wonegizi nature reserve, Sapo National Park, Gola Forest, Grebo-Krahn and East Nimba Nature Reserve (the 5 existing protected areas)
- ✓ Forest protection through regular forest patrol
- ✓ Conduct research to improve forest management practices
- ✓ Awareness raising on forest protection and sustainable access to ecosystem services e.g Non timber forest products (NTFPs), water
- ✓ Practice conservation agriculture – brush and farm allowing grass to cover soil and provide moisture (traditional slash and burn – brush and burn before planting, and convention farming used as control by brushing and taking away the grass before planting.)
- ✓ Introduce new innovations such as the Farmers feeding school where new agricultural innovation is practiced.

7. ACTION PLAN (FLAGSHIP PROGRAMMES)

Based on the vulnerability assessment of the fishery, agriculture, and forestry sectors of Liberia to climate change and the adaptation options identified and prioritized by stakeholders using multi-criteria analysis (MCA), this section of the report draws from the Green Climate Fund (GCF) format and presents four programme idea notes (PINs). The PINs provide an overview and key operational elements and aspects required to take actions towards reducing the vulnerability and increasing the resilience of the fishery, agriculture, and forestry sectors and actors (both men and women) of Liberia to climate change impacts. Each programme is presented and analysed in turn.

Further details and development of these PINs can be done in the form of a GCF concept note, a GCF simplified approval process (SAP) or a GCF full proposal (FP). While going through the PINs, it is however important to note that the GCF concept note, SAP or FP have completely different templates and sections that can not be mixed up with a GCF PIN provided under this section.

7.1. Action Plan in the Fisheries Sector

Table 2. Summary description of the Coastal community programme

Title	Enhancing Resilience to Climate Change in Vulnerable Coastal Communities in Liberia
Sector	Fisheries, ecotourism, forestry sectors
Focus	Adaptation - Most vulnerable people and communities - Health and well-being, and food and water security - Ecosystems and ecosystem services
Beneficiaries	Fantie and Kruh fishing communities in Roberspot, Burchana, Monrovia and other coastal communities and actors in ecotourism value chains.
Interest for the Green Climate Fund	**Potential impact:** Climate change impacts related to sea level rise, floods and coastal erosions, wind storms and brown tides are affecting fishing, coastal livelihood activities and the related ecosystems in Liberia. This project intends to build the adaptive capacity and resilience of vulnerable coastal community livelihoods and ecosystems to the climate impacts by supporting best fishing practices, ecotourism, reforestation in coastal communities across Liberia. **Paradigm shift potentials:** Best practices in fisheries, forestry, agroforestry, ecotourism, agriculture, and solar energy in Liberia will be supported to increase adaptive capacities and reduce vulnerabilities to climate impacts on humans and natural systems along the coastal cities of Liberia. The proposed programme will also establish a knowledge base and raise awareness to support large-scale implementation of climate smart

	practices in the fishery, agriculture, ecotourism and forestry sectors while bringing about a change in behaviour and mindset across coastal communities. **Sustainable development potentials:** The proposed programme will contribute to Liberia's Vision 2030 in the long term and to the Pro-poor Agenda for Prosperity and Development in the short term. It will promote sustainability in the fisheries sector by upgrading all the national Fish Landing Points in the country, as well as develop the fisheries value chain in the country. The programme will equally contribute to the Sustainable Development Goals number 1 (no poverty), 2 (zero hunger), 7 (affordable and clean energy), 13 (climate action), 14 (life below water), 15 (life on land), 5 (gender equality). **Country ownership:** The proposed programme will be led and implemented by the Government of Liberia through the EPA in collaboration with NaFAA and other stakeholders, relevant government Ministries, Community-Based Organizations (CBOs); NGOs; and the Association of Industrial Fishing Companies. **Effectiveness and efficiency:** The proposed programme addresses all aspects of climate smart fishing including support for aquaculture, upgrading fishing landing points in the country, development of the fisheries value chain, and support for the development of policies, plans, and programmes that promote fisheries value chain, use of eco-friendly devices for fish transformation. In addition best practices for climate change from the forestry, ecotourism and agriculture will be adopted, implemented and upscaled with the most cost effectiveness
Proposed submission date	To be determined with the National Designated Authority (NDA)
TECHNICAL DESCRIPTION	
Needs of recipients:	Fishes are important part of the dietary intake, supplying a substantial amount of the total animal protein consumed in Liberia. The fisheries, agriculture and forestry sectors play a relatively significant role in the national economy as they contribute to food security, employment, poverty reduction, and even foreign exchange earnings. Thus, it is hoped that the proposed programme will contribute enormously in boosting the Liberia's economy and most importantly improve the needs of men and women in communities who depend on fishing, ecotourism and agriculture for their livelihoods.
Activities	✓ Promote sustainable and adaptive fishing practices ✓ Regulate fishing practices to prevent overexploitation and fishing in restricted areas ✓ Integrate fisheries fully into climate change adaptation and food security

	policies at the national level to ensure incorporation into broader development planning ✓ Build a climate resilient jetty ✓ Establish marine protected areas or mangrove conservation zones ✓ Conduct research to fully understand fishing pressures and adjust quotas to sustainable levels, as well as into predicting where fish populations will move; finding species resistance to salinity and temperature fluctuations for aquaculture and, where necessary, support selective breeding for increased climate resilience in aquaculture. ✓ Eco-tourism and ecosystem management: Key areas include the natural reserved forest, coastal areas (beach) for surfing, Lake Piso. Develop tracks and walk over like in Kankum national park in Ghana, animal and bird watching, surfing destination and capitalise on the rich historical and cultural landmarks of Robersport. This will be accompanied by the development and management of supporting infrastructure mainly (1) hotels with modern conference centres of different capacities, (2) fuel station, (3) tarring of the road by the government, (4) training centre for empowering women, men and youth economically. ✓ Woodlots: Establish woodlots in degraded savannah areas to produce eco-charcoal and firewood, eco-ovens - for drying fish, household heating / cooking and to supply the Monrovia market. Build and promote the use of household energy efficient stoves. ✓ Provide electricity using solar panels at the household level and as a solar farms with mobile payment options for households and businesses. ✓ Develop eco-tourism and boat-driven urban transportation system in Monrovia. ✓ Promotion of marine stores to supply fishing gears and equipment
Expected results	**Expected results** ✓ Outcome: Improved and resilient livelihoods of coastal communities to climate impacts ✓ Mainstream sustainable and resilient fishing practices into policies, plans, and programmes and activities. ✓ Vibrant ecotourism business in Robersport and Monrovia based on a public private partnership ✓ Installation of solar energy for households and local businesses ✓ Marketing and value chain development (including road construction in Robersport) ✓ Woodlot to supply firewood for fish drying ✓ Strengthened capacities of fishermen, communities and institutions ✓ Businesses related to the fisheries and ecotourism sectors
INSTITUTIONAL ARRANGEMENT	
Accredited entity	To be determined
Institutions responsible	EPA in collaboration with other relevant institutions

for execution			
FINANCIAL ARRANGEMENTS			
Estimated total cost	100 Million USD		
Green climate fund (amount and financial instruments)	To be determined		
Others (amount and financial instrument)	To be determined		
PREPARATION PLAN			
Action	**Potential responsibilities**	**Planning**	**Budget and potential financial source**
Elaboration of the concept note	EPA, National Fisheries and Aquaculture Authority (NaFAA), UNDP	2nd Semester 2019	To be determined
Elaboration of the financial proposal	EPA, NaFAA, UNDP	1st Semester 2020	To be determined

7.2. Action Plan in the Agricultural Sector

Table 3. Summary description of agriculture programme

Title	Implementing climate-smart agriculture in Liberia
Sector	Agricultural sector including livestock
Focus	Adaptation - Most vulnerable people and communities - Health and well-being, and food and water security - Ecosystems and ecosystem services
Beneficiaries	Agricultural and livestock communities especially farmers in Lofa, Bong, Nimba, Grand Kru, Maryland, Sinoe and Upper Montserrado
Interest for the Green Climate Fund	**Potential impact:** The proposed programme will have a positive impact on communities engaged in the cultivation of food crops like rice, cassava, vegetables and maize in that it will provide drought and pest resistant seeds to farmers engaged in the cultivation of these crops. Value addition of these

	crops while minimizing the use of chemical fertilizers, climate smart irrigation practices, eco-friendly practices, farmers to farmers learning, and improvement in extension services will also constitute important components of this programme. **Paradigm shift potentials:** The proposed programme is transformational in that it promotes sustainable agricultural practices that increases productivity and enables farmers involved in agriculture to adapt to the impacts of climate change. **Sustainable development potentials:** The proposed programme will support climate-smart agricultural practice, livestock practices and value chains thereby contributing to ecological sustainability, creation of employment and promotion of the Government's Pro-Poor Agenda and gender-sensitive approach. Productivity of the food crops will be increased and this will contribute in improving the income of farmers (men and women) thus leading to economic sustainability. **Country ownership:** The proposed programme will be led and implemented by EPA and the Ministry of Agriculture whose vision is to transform agriculture into a sustainable, modernized, increased production and export-oriented sector which contributes to improved food security, farmers' livelihood and overall economic growth. **Effectiveness and efficiency:** Most aspects of climate smart agriculture practices including the provision of drought and pest resistant seeds to farmers engaged in the cultivation of food crops, livestock, value addition, climate smart irrigation practices, farmers to farmers learning, and improvement in extension services.
Proposed submission date	To be determined with the National Designated Authority (NDA)
TECHNICAL DESCRIPTION	
Needs of recipients	Most people in Liberia depend on agriculture for their livelihoods and the agricultural sector contributes enormously to the country's GDP. That said, the agricultural sector in The Gambia is vulnerable to climate change. Thus, this proposed programme will address vulnerability in the agricultural sector through climate smart agricultural practices.
Activities	- Promote sustainable water and soil management - Integrated Pest management - Promote farmers field school and develop appropriate extension systems and farmer-to-farmer learning. - Use of improved technologies, adapted seeds and crop and livestock varieties - Promote marketing and climate resilient value chains for rice, cassava, maize, vegetables and livestock products.

	- Mainstream gender into all farming and livestock activities - Support communities in livestock and crop sectors through inventory and dissemination of indigenous knowledge, establishing and/or strengthening insurance scheme, early warning and early action system, vaccination campaign, disease control, etc., to cope with the stress based on climate variability - Adjustment in commodity and trade policy - Provide financial incentives for the development of value addition of rice, cassava, vegetables, other food crops and livestock - Provide agricultural financing (loans facilities) to farmers - Build and strengthen the capacity of extension officers in new sustainable farming and livestock raising technologies, in order to enhance their support for farmers.
Expected results	- Best practices and technologies in rice, cassava and vegetable cultivation, livestock rearing, and marketing for food security and income generation - Appropriate systems of extension and farmer-to-farmer learning is developed - Financial incentives for the development of value addition of food crops and livestock products are provided to farmers and livestock owners - Training schemes to farmers on climate smart irrigation practices are provided to farmers engaged in the cultivation of food crops - Drought and pest resistant varieties to farmers and livestock owners is provided - Marketing and resilient value chain for rice, cassava, vegetables and livestock products
INSTITUTIONAL ARRANGEMENT	
Accredited entity	To be determined
Institutions responsible for execution	EPA in collaboration with Ministry of Agriculture
FINANCIAL ARRANGEMENT	
Estimated total cost	25 Million USD
Green climate fund (amount and financial instruments)	To be determined
Others (amount and financial instrument)	To be determined

PREPARATION PLAN			
Action	**Potential responsibilities**	**Planning**	**Budget and potential financial source**
Elaboration of the concept note	EPA, Ministry of Agriculture, UNDP	2nd semester 2019	To be determined
Elaboration of the financial proposal	EPA, MoA, UNDP	1ST Semester 20220	To be determined

Table 4. Summary description of the agroforestry programme

Title	Intensification and diversification of Cocoa and Coffee Agroforestry Systems (CCAFS) as a climate change mitigation and adaptation strategy
Sector	Agriculture
Focus	Adaptation - Most vulnerable people and communities - Health and well-being, and food and water security - Ecosystems and ecosystem services Mitigation - Forestry and land use
Beneficiaries	Cocoa and coffee farmers
Interest for the GCF climate fund	**Potential impact:** The cocoa and coffee agroforestry systems of Liberia are vulnerable to climate changes especially to changes in temperature maxima, rainfall distribution, length of dry season, low soil fertility interacting with climate, as well as non-climatic drivers related to land degradation and poor infrastructure (Schroth et al. 2015). Intensification and diversification of cocoa and coffee agroforestry systems can therefore contribute in enhancing multi-functionality within these systems by providing climate change mitigation and adaptation benefits. For instance, Gockowski and Sonwa (2011) showed that if intensification of cocoa agroforestry systems in Central and West Africa (Cote D'Ivoire, Ghana, Nigeria, Cameroon) through the use of farm inputs and the incorporation of timber and fruit producing trees was done in the late 1960s, about 21,000 km^2 of forests would have been preserved, thus contributing to a reduction in emissions of about 1.4 billion tons of CO_2. **Paradigm shift potentials:** Intensification and diversification of cocoa and coffee agroforestry systems is innovative in that it is both a climate change mitigation and adaptations strategy. According to the land sparing concept posited by Borlaug (2007), first, investments are made in agroforestry that

	lead to an increase in productivity on a given piece of land through the use of inputs and better technology. Once these interventions permit an adequate supply of food, fuel and fiber, this leads to a decrease in deforestation rates resulting from agroforestry thereby sparing more forest lands. On another note, the incorporation of timber and fruit producing trees into cocoa and coffee agroforestry systems as well as the use of farm inputs within these systems can increase productivity; the farmer thus has several income streams and can remain on the same land and in so doing reducing deforestation (Minang et al. 2014). It is also posited that intensification and diversification of cocoa and coffee agroforestry systems with different tree species could also be a means by which farmers can adapt or resist climatic shocks (Gockowski and Sonwa 2011). This is deeply rooted in the fact that if an epidemic eradicates the cocoa and coffee plants which are the principal sources of income, a farmer with an intensified and diversified cocoa and coffee agroforestry system has other alternative outputs which can be economically beneficial for the farmer e.g. timber and fruits for sale. **Sustainable development potentials:** Through sustainable intensification and diversification of cocoa and coffee agroforestry systems coupled with reducing the use of fertilizers and chemicals, the proposed programme will restore degraded ecosystems within these agroforestry systems thereby contribution to ecological sustainability. This will underpin economic growth within the agroforestry sector and promote stakeholder participation (especially women, indigenous people) in climate change mitigation and adaptation practices. **Country ownership:** The proposed programme strongly aligns with existing initiatives and country priorities like the promotion of practices that increases productivity and enables farmers involved in agroforestry to mitigate and adapt to the impacts of climate change. **Effectiveness and efficiency:** The proposed programme is efficient and effective in that it promotes climate change mitigation and adaptation practices within cocoa and coffee agroforestry systems though intensification and diversification of these agroforestry systems.
Proposed submission date	To be determined with the National Designated Authority (NDA)
TECHNICAL DESCRIPTION	
Needs of recipients	Liberia's lowland humid climate and land-use history suggest a potential to increase the production of cocoa (*Theobroma cacao*) and coffee (*Coffea spp.*) to generate income and employment for smallholder farmers (Schroth et al. 2015). Intensification and diversification of cocoa and coffee agroforestry system with fruit and timber producing trees can greatly improve the fertility of the soil and provide the soil with organic matter via

	litter and wastes emanating from wild animals that use these trees as their natural habitat (Hartemink 2005). These roles can enhance soil quality thereby improving cocoa and timber production.
Activities	- Training of cocoa and coffee farmers on farm renewal techniques as an intensification and diversification strategy within cocoa and coffee agroforestry systems. - Training of cocoa and coffee farmers on tree domestication and improvement techniques (like marcotting, grafting, and cutting) as an intensification and diversification strategy within cocoa and coffee agroforestry systems. - Provision of improved germplasm of cocoa, coffee, fruit and timber producing trees to farmers as an intensification and diversification strategy within cocoa and coffee agroforestry systems. - Provide technical backstopping to the government of Liberia on how to integrate intensification and diversification of cocoa and coffee agroforestry systems into its policy plans, and programmes. - Develop and implement a comprehensive strategy to reduce the vulnerability of the cocoa and coffee supply chains to climate change and ensure their future viability. - Knowledge sharing across government and linking to private sector - Promote marketing of improve resilience of cocoa and coffee value chains to impacts of climate change.
Expected results	- Training is provided to cocoa and coffee farmers on farm renewal techniques as an intensification and diversification strategy within cocoa and coffee agroforestry systems. - Cocoa and coffee farmers received training on tree domestication and improvement techniques (like marcotting, grafting, and cutting) as an intensification and diversification strategy within cocoa and coffee agroforestry systems. - Improved germplasm of cocoa, coffee, fruit and timber producing trees is provided to farmers as an intensification and diversification strategy within cocoa and coffee agroforestry systems. - Technical backstopping is provided to the government of Liberia on how to integrate intensification and diversification of cocoa and coffee agroforestry systems into its policy plans, and programmes. - Marketing of and climate resilient cocoa and coffee supply chain - Comprehensive strategy to reduce vulnerability of cocoa and coffee supply chain.
INSTITUTIONAL ARRANGEMENT	
Accredited entity	To be determined
Institutions responsible for	Ministry of Agriculture, Forestry Department Authority (FDA)

execution			
FINANCIAL ARRANGEMENT			
Estimated total cost	150 Million USD		
Green climate fund (amount and financial instruments)	To be determined		
Others (amount and financial instrument)	To be determined		
PREPARATION PLAN			
Action	**Potential responsibilities**	**Planning**	**Budget and potential financial source**
Elaboration of the concept note	EPA, MoA, UNDP	2nd Semester 2019	To be determined
Elaboration of the financial proposal	EPA, MoA, UNDP	1st semester 2020	To be determined

7.3. Action Plan in the Forestry Sector

Table 4. Summary description of the forestry programme

Title	Climate-resilient emission reduction in the forest ecosystems of Liberia
Sector	Forestry
Focus	Adaptation - Most vulnerable people and communities - Ecosystems and ecosystem services Mitigation - Forestry and land use
Beneficiaries	The government, forest-dependent communities, Civil Society Organizations (CSOs)
Interest for the Green climate fund	**Potential impact:** At the end of the proposed programme, degraded and deforested lands and water catchments in Liberia will be restored (through afforestation and reforestation) and their associated carbon sequestration benefits will be enhanced. Similarly, at the end of the programme, non-carbon benefits which include but not limited to livelihood improvement,

	economic opportunities, adaptation to climate change, good forest governance, biodiversity conservation, improved water quality and quantity and other ecosystem services will be generated. Additionally, the provision of ecosystem services within the proposed programme will strengthen the medium to long term adaptive capacities of forest-dependent communities and their effective participation in forest landscape restoration will favor emissions reductions and guarantee additionality and permanence of the programme. **Paradigm shift potentials:** The programme actions will contribute to meeting the commitment of the government of Liberia under the Paris Climate Accord. It will further support their national development visions of reducing poverty, increasing prosperity, promoting national unity and peace, while conserving biodiversity, protected area management, protecting the environment and achieving green growth. Furthermore, the proposed program will contribute to actions that will shift the development paradigm to a green growth trajectory and will also enable Liberia to fully execute its mandate in the arena of forest landscape restoration. **Sustainable development potentials:** The proposed programme will contribute to sustainable economic, social, and ecological development and gender in the following ways: Economic sustainability: Ecosystems restoration underpin economic growth. By restoring degraded and deforested ecosystems, the economic prosperity of forest-dependent communities will be positively impacted as they will be able to depend on the restored ecosystems for timber, fuelwood as well as non-timber forest products such as honey production, vegetables, legal bush meet for household protein, medicinal plants and food products. Social sustainability: The proposed programme is expected to promote stakeholder participation (especially women, indigenous people, local forest-dependent communities) in ecosystems restoration and integrated forest resource management. Environmental sustainability: By restoring deforested and degraded ecosystems, critical habitats, ecosystems and their associated ecosystem services like carbon, biodiversity, and water will be safeguarded (landscape approach). Gender-sensitive development impact: Proportion of men and women in jobs created. **Country ownership:** The proposed programme will be led and implemented by EPA and the Forest Development Authority (FDA) which are the government institutions that promote environmental protection,

	forest conservation and manages most of the land under forest cover for environmental and socio-economic development in Liberia. **Effectiveness and efficiency:** The proposed programme will advance forest landscape restoration, identify the drivers of forest lost and development of strategies to overcome these drivers, raise awareness at national and community level on the importance of biodiversity and ecosystem services for climate-resilient development.
Proposed submission date	To be determined with the National Designated Authority (NDA)
TECHNICAL DESCRIPTION	
Needs of recipients:	Most people in Liberia depend on the forest for their livelihoods and the forstry sector contributes enormously to the country's GDP. That said, the forestry sector in Liberia is vulnerable to climate change. Thus, this proposed programme will address vulnerability in the forestry sector through forest landscape restoration and integrated forest resource management.
Activities	- Promote alternative livelihoods for forest dependent communities and households - Promote sustainable management of NTFPs including supply chains and small and medium size enterprises - Promote reforestation and afforestation of degraded forest landscapes - Promote sustainable forest management and protection - Promote energy efficient stoves and renewable energy sources to replace the use of charcoal and firewood. - Detect, control and manage invasive species linked to changes in climatic conditions - Promote reduce impact logging during logging operations - Training of forest-dependent communities, civil society and community cooperative groups, and the private sector on forest landscape restoration techniques for achieving multiple benefits and restoring resource base. - Development of effective policies on integrated forest resources management. - Identification of drivers of forest lost and development of strategies to overcome these drivers. - Raise awareness at national and community level on the importance of biodiversity and ecosystem services for climate-resilient development
Expected results	- Degraded, deforested and vulnerable ecosystems and ecosystem services will be restored. - The resilience of forest-dependent communities to climate change will be enhanced - There will be a reduction in deforestation and forest degradation in the country. - More people at national and local level will be aware of the importance of biodiversity and ecosystem services for climate-resilient development.

	- Effective policies for integrated forest resource management will be developed - Emissions from deforestation and degradation will be reduced and sequestration of forest carbon increased - Forest supply chains and operations will be resilient to climate change and will reduce their emissions		
INSTITUTIONAL ARRANGEMENT			
Accredited entity	To be determined		
Institutions responsible for execution	EPA and Forest Department Authority (FDA)		
FINANCIAL ARRANGEMENT			
Estimated total cost	150 Million USD		
Green climate fund (amount and financial instruments)	To be determined		
Others (amount and financial instrument)	To be determined		
PREPARATION PLAN			
Action	**Potential responsibilities**	**Planning**	**Budget and potential financial source**
Elaboration of the concept note	EPA, FDA, UNDP	2nd semester 2019	To be determined
Elaboration of the financial proposal	EPA, FDA, UNDP	1st semester 2020	To be determined

8. CONCLUSION AND RECOMMENDATIONS

The analysis presented in this report highlights the degree to which the agriculture, the forestry and the fisheries sectors of Liberia are vulnerable to climate change. The current climate change risks and climate vulnerabilities in the fishery sector are sea level rise, flooding and coastal erosion and destruction of fishing assets and infrastructures. The results indicate that climate change stands as a major driving force in limiting the potentials of the fishery sector to support livelihoods and contribute to the national economy of Liberia.

With regards to the agriculture sector, our analysis revealed that climate change is already impacting the agricultural sector and this is manifested through the reduction of crop yields both cash crops and subsistence especially maize, rice, rubber, coffee, cocoa, cassava and vegetables. The forestry sector is also vulnerable to clime change impacts even though it is not as visible as in the agricultural sector.

Some of the main adaptation strategies in the various sectors (fisheries, agriculture, and forestry) identified included the following:

- ✓ Promotion of sustainable fishing practices;
- ✓ Reduction of the number of fishing licenses issued to foreign vessels;
- ✓ Regulation of fishing practices to prevent overexploitation and fishing in restricted areas;
- ✓ Integration of Sustainable Land Management (SLM) into the curriculum of the University and into the extension training systems of the Ministry of Agriculture and the NGOs sector;
- ✓ Establishment of a knowledge management system for facilitating information and experience sharing among stakeholders in the agricultural sector;
- ✓ Use of climate-ready crops or thermal stress-tolerant varieties;
- ✓ Adjusting planting dates;
- ✓ Improvement of water conservation and management practices;
- ✓ Use of efficient irrigation and fertilizer management;
- ✓ Crop diversification;
- ✓ Awareness raising and strengthen capacity of forest dependent communities;
- ✓ Strengthening of forestry policies including enforcement and compliance; improvement in alternative livelihoods for forest-dependent communities; and
- ✓ Promotion of climate smart agriculture practices.

Given the vulnerability of the fishery, agriculture, and forestry sector of Liberia to climate change and the various adaptation options of the various sectors, the report has proposed an action plan in the form of four programme idea notes that can be used to address the vulnerability of the three sectors to climate change. Moving forward, we recommend actions for enhancing the implementation of these programmes. They include:

- Sensitisation, information sharing, communication and education with regards to these programmes as this is necessary to ensure that the proposed programmes are disseminated and understood by all the various stakeholders;
- Inclusive and participatory country-driven process to promote a more collaborative process and platform where stakeholders can share their views on effective and efficient ways to implement the four programmes;
- Coordination with other climate change initiatives in Liberia is also key as well engaging other actors, CSOs and international NGOs operating in the thematic area;
- EPA and UNDP should monitor the implementation of the action plan to ensure that hurdles that could affect effective and efficient implementation are identified and solutions for overcoming them are proffered. Additionally, EPA should organise and provide technical backup and capacity building on the monitoring process. EPA should also prepare aggregate quarterly and annual national summary reports on the achievements obtained and submit them to the Ministry responsible for National Planning and the higher body assigned by the President's office.

REFERENCES

ACPC, 2014. Moving against the tide: Africa Rising to Seize Climate Change Opportunities for Water, Food and Energy Security. African Climate Policy Centre (ACPC)/ United Nations Economic Commission for Africa (UNECA). The Climate for Development in Africa (ClimDev-Africa)

Adger, W. N. (1999). Social vulnerability to climate change and extremes in coastal Vietnam.*World Development*, *27*(2), 249 – 269.

Adaptation Decision Making Global exposure and vulnerability to multi-sector development and climate change hotspots Published: 28th June 2018 9:57 Last Updated**:** 29th June 2018 10.

Barange, M., Merino, G., Blanchard, J. L., Scholtens, J., Harle, J., Allison, E. H., and Jennings, S. (2014). Impacts of climate change on marine ecosystem production in societies dependent on fisheries. Nature Climate Change, 4(3), 211-216.

Borlaug, N. 2007. Sixty-two years of fighting hunger: personal recollections. *Euphytica* 157:287-297

Collier, R. J., Gebremedhin, K., Macko, A. R., & Roy, K. S. 2012. Genes Involved in the thermal tolerance of livestock. In Environmental Stress and Amelioration in Livestock Production (pp. 379-410). Springer, Berlin, Heidelberg.

EPA, 2013. Liberia Initial National Communication to the UNFCCC. Environmental Protection Agency of Liberia EPA.

Environmental Protection Agency (EPA) 2018. National Policy and Response Strategy (NPRS) on Climate Change. Government of the Republic of Liberia.

Framework for Climate Change Vulnerability Assessments, 2014. Published**:** 4th December 2014 Last Updated**:** 10th December 2014 9:55.

FA0, 2007. The Republic of Liberia general economic data. Food and Agricultural Organisation, Rome, Italy.

FDA 2006, The National Forest Reform Law of Liberia

FDA, 2018. Strategic Management Plan. FDA.

Fischer G., Shah M. and Velthuizen H. (2002) Climate Change and Agricultural Vulnerability. International Institute for Applied Systems Analysis under United Nations Institutional Contract Agreement No. 1113 as a contribution to the World Summit on Sustainable Development, Johannesburg.

Forestry Development Authority (FDA), 2000. Annual Report, Monrovia.

Gianoli, A., Grafakos, S., Olivotto, V., Hague, A.N. 2016. Application of Multi-Criteria Analysis on Climate Adaptation Assessment in the Context of Least Developed Countries Journal of Multi-Criteria Decision Analaysis: DOI: 10.1002/mcda.1571.

GoL 2012, Bong County Development Agenda.

Grand Gedeh county CDA, 2012, Government of Liberia.

Gockowski, J and D. Sonwa .2011. Cocoa intensification scenarios and their predicted impacts on CO_2 emissions, biodiversity conservation and rural livelihoods in the Guinea rainforest of West Africa. *Environmental management* 48: 307-321.

Government of Liberia (GoL) 2008. National Adaptation Programme of Action (NAPA). Monrovia, Liberia. GoL, GEF and UNEP.

Government of Liberia (GoL) 2013. Liberia Initial National Communication to the UNFCCC. GoL, GEF and UNEP.

Harmon W. Q. (2018). Liberia Remains Vulnerable to Climate Change, Daily Observer updated on August 16th 2018 retrieved on 30th November 2018 at: https://www.liberianobserver.com/news/liberia-remains-vulnerable-to-climate-change/

IDS 2018. Participatory Methods. Institute of Development studies. Access online 2018 https://www.participatorymethods.org/glossary/rapid-rural-appraisal-rra

IPCC, 2014: Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y .O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P .R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY

Lofa County Development Agenda 2012, Government of Liberia.

Malone, E.L. and E.L. La Rovere, (2005), Assessing current and changing socio-economic conditions. *Adaptation Policy Frameworks for Climate Change: Developing Strategies,* 12 *Policies and Measures*, B. Lim, E. Spanger-Siegfried, I. Burton, E. Malone and S. Huq, Eds. pp. 145-163 Cambridge University Press, Cambridge and New York.

McSweeney, C., New, M. and Lizcan, G, 2008. UNDP Climate Change Country Profiles for Liberia. Bulletin of the American Meteorological Society 91, 157-166. http://country-profiles.geog.ox.ac.uk

Minang, P.A., L.A. Duguma, F. Bernard, O. Mertz, and M. van Noordwijk. 2014. Prospect for agroforestry in REDD+ landscapes in Africa. *Current Opinion in Environmental Sustainability* 6: 78-82.

Ministry of Agriculture of the Republic of Liberia, 2009. Food and Agricultural Policy and Strategy: From Subsistence to Sufficiency. Ministry of Agriculture of the Republic of Liberia, Monrovia, Liberia.

MoA 2010. Liberia Food and Agriculture Policy

ND GAIN (2013). Available at 20th June 2014; http://index.gain.org/ranking USAID 2012, liberia_adaptation_fact_sheet_jan2012.pdf__2017_USAID%20ATLAS_Climate Risk Profile_Liberia.pdf New GIZ publication on vulnerability assessments

Nimba County Development Agenda 2012, Government of Liberia.

Sinoe County Development Agenda, 2012, Government of Liberia.

Schroth G, Läderach P, Martínez-Valle AI, Bunn C. 2015. Climate vulnerability and adaptation of the smallholder cocoa and coffee value chains in Liberia. Working Paper No. 134. Copenhagen, Denmark: CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS); International Fund for Agricultural Development (IFAD).

Stanturf, J,A., Goodrick, S., Stegall, S., Williams, M., 2013. Liberia climate change assessement.

UNEP, 2004. Desk study on the environment in Liberia. United Nations Environment Programme, Nairobi, Kenya. Available online at:
http://postconflict.unep.ch/publications/Liberia_DS.pdf

UNFCCC 2011. Assessing the costs and benefits of adaptation options: an overview of approaches.

United States Department of State, 2004. Country background notes, Background Note: Liberia. Available online at http://www.state.gov/r/pa/ei/bgn/6618.htm

USAID, 2012. Climate change adaptation plan.

USAID, 2013. Liberia climate change asessment. A report prepard by USAID For the government of Liberia.

USAID 2015, Gap Analysis of Targeted Domestic Natural Resource Markets in Liberia Report

USAID, 2017. Climate change risk profile Liberia.

US Geological Survey, 2014

WHO 2016. Liberia Annual Report.