



# **Liberia's Second National Communication to the United Nations Framework Convention on Climate Change**



2021



Environmental Protection Agency of Liberia (EPA)

With kind support from



## ACKNOWLEDGEMENT

Liberia's Second National Communication (SNC) is an informative report that was prepared in fulfillment of her obligations as required by article 12 of the convention and based on the 8 guidelines of national communications of Non- Annex 1 parties (decision 17cp.8). The project

Title "Liberia's Second National Communication under the United Nations Framework Convention on Climate Change" was executed by the Environmental Protection Agency of Liberia (EPA).

The preparation of this document has demonstrated strong traits of team work and dedication. The technicians came from a range different backgrounds and expertise and their timely and productive support was unwavering for which I remain appreciative.

Representing the project management staff, it is my pleasure to recognize the immerse contributions from all of those who offered their distinguished service towards the development of this report. I am astounded at the level of dedication and hard work from the consultants.

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Special thanks to the former Executive Director of the EPA, Dr. Nathaniel T. Blama, Sr. and former UNFCCC Focal Point/ MEAs Coordinator Mr. Benjamin S. Karmorh, under whose regime the project begun. I am also very grateful to the current Executive Director of the EPA, Prof. Wilson K. Tarpeh who provided all the necessary support in ensuring that the SNC is completed.

This report demonstrates that although Liberia is still battling with many negative environmental malpractices, she is making frantic efforts to combat the devastating effects of an enemy we all fear, climate change.



Jefferson F. Nyandibo

**UNFCCC Focal Point/ Coordinator, Multilateral Environmental Agreements**

## Foreword



On behalf of the Government of Liberia, the Environmental Protection Agency is delighted to submit its Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC). The SNC provides a comprehensive review of the status of climate change issues in the country.

Liberia submitted her first national report in 2013. Much has happened since then: meetings and workshops have been held, data have been collected and consultants have worked tirelessly to yield this updated version of the country's national communication. This effort is a reassurance that Liberia

remains dedicated to her commitment in the quest to combat climate change; ensuring that the worst effects of global warming will never become a reality.

This report was prepared using the 2006 IPCC Guideline, 2000 IPCC Good Practice Guidance (GPG) and other related software. The report gives an account of the major economic sectors of Liberia, paying heed to the national circumstances of the country. Liberia has experienced a significant decrease in its emissions levels. Our intention is to reduce emissions by 15 percent by the year 2030.

Data from this document can be used as a professional source for research and teaching. Teachers, scholars, scientists, students, interest groups, NGOs and private entities can tap into the knowledge provided by this document to help improve the quality of the environment and human lives. It will increase the awareness level of policy makers on climate change issues and their inter-relationship with sustainable development, leading to the integration of climate change concerns into the national socioeconomic planning process. Data from this inventory can also be used to drive investments opportunities. It will also help the general public to become environmentally conscious and identify and track our local climate change trends.

Liberia, still being a vulnerable nation, is visibly seeing the signs of climate change in seasonal variation. The frequency and intensity of precipitation and sunshine has changed drastically. The consequence of this will be devastating for farmers, ranchers, crops, animals etc. Flood occurrences have increased nationwide. Best management practices that can ease the detrimental impacts of seasonal shifts needs to be adopted.

Efforts will be made to align this SNC with the government's national development agenda (Pro-Poor Agenda for Prosperity and Development) to ensure sustainability. This SNC will serve as a model to address our anthropogenic actions that degrades the Earth.

We intend to address some of the existing gaps and constraints in this document to strengthen our inventory as Liberia begins to explore carbon finance opportunities. This, and all other efforts are geared towards ensuring that the global temperature is well below 2 degree Celsius for the good of our future generations.

Prof. Wilson K. Tarpeh  
EXECUTIVE DIRECTOR/CEO

# Contributors

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## COORDINATORS

Jefferson F. Nyandibo

Benjamin S. Karmorh, Jr.

---

## AUTHORS

Dr. Charles Ansumana

Dr. Albert Butare

Christopher B. Kabah

E. Tenesse Wilson

Zinnah Botoe

Arthur R. M. Becker

Richard S. Sambolah

---

## EDITORS

Usman Khan

Othreniel Angel Forte

J. S. Datuama Cammue

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## Acronyms

|         |  |
|---------|--|
| ACE     | Action for Climate Empowerment                                       |
| ACP     | African, Caribbean and Pacific                                       |
| ACTS    | African Christian Theological Seminary                               |
| ADB     | African Development Bank   |
| ADB     | African Development Bank   |
| AF      | Adaptation Fund  |
| AFL     | Armed Forces of Liberia  |
| AFOLU   | Agriculture, Forestry and Other Land Use                             |
| AfT     | Agenda for Transformation  |
| AGR     | African Governance Report  |
| AMCOMET | African Ministerial Conference on Meteorology                        |
| AMESD   | African Monitoring of the Environment for Sustainable<br>Development |
| AMEU    | African Methodist Episcopal University                               |
| AU      | African Union  |
| AUC     | African Union Commission   |
| AWOS    | Automatic Weather Observing Station                                  |
| BC      | Black Carbon   |
| BNF     | Bureau of National Fisheries   |
| BRE     | Buchanan Renewable Energies  |
| BUR-1   | First Biennial Update Report   |
| CAC     | County Agriculture Coordinator                                       |
| CAP     | Coastal Add-On project   |
| CARI    | Central Agricultural Research Institute                              |
| CBEs    | Community-Based Enterprises  |
| CBL     | Central Bank of Liberia  |
| CCAAP   | Climate Change Agriculture Adaptation Project                        |
| CCC     | Carbon Constraint Case –scenario                                     |
| CCCD    | Cross-Cutting Capacity Development                                   |
| CCG     | Carbon Consultative Group  |
| CCKSP   | Climate Change Knowledge Sharing Platform of Liberia                 |
| CDA     | Cooperative Development Agency                                       |

|                 |  |
|-----------------|--|
| CDMS            | Climate Database Management System   |
| CEDAW           | UN Convention on the Elimination of all forms of<br>Discrimination against Women |
| CEMENCO         | Liberia Cement Corporation   |
| CGE             | Consultative Group of Experts  |
| CH <sub>4</sub> | Methane  |
| CIA             | Central Intelligence Agency  |
| CLUS            | Cheesemanburg Landfill Urban Sanitation  |
| CO              | Carbon monoxide  |
| CO <sub>2</sub> | Carbon dioxide   |
| COP             | Conference of Parties  |
| CRC             | Convention on the Rights of Children   |
| DNA             | Designated National Authority  |
| DTIE            | Division of Technology, Industry and Economics                                   |
| DTU             | Technical University of Denmark  |
| ECOWAS          | Economic Community of West African States  |
| ECREE           | Ecowas Centre for Renewable Energy and Energy Efficiency                         |
| EDF             | European Development Fund  |
| EEZ             | Exclusive Economic Zone  |
| EFs             | Emission Factors   |
| EIA             | Environmental Impact Assessment  |
| EKMS            | Environmental Knowledge Management System  |
| EMUS            | Emergency Monrovia Urban Sanitation Project                                      |
| EN              | Earth Network  |
| EPA             | Environmental Protection Agency  |
| EPO             | Equatorial Palm Oil  |
| EST             | Environmentally Sound Technology   |
| EU              | European Union   |
| EWS             | Early Warning System   |
| FAO             | United Nations Food and Agriculture Organization                                 |
| FAOSTAT         | Food and Agriculture Organization Statistical Database                           |
| FAPS            | Fishery and Aquaculture Policy and Strategy                                      |
| LFAPS           | Liberia Food and Agriculture Policy Strategies                                   |
| FDA             | Forestry Development Authority   |
| FM              | Frequency Modulation   |

|       |   |
|-------|---|
| GCMs  | Global Circulation Models   |
| GCOS  | Global Climate Observing System   |
| GDP   | Gross Domestic Product  |
| GEF   | Global Environment Facility   |
| GFCS  | Global Framework for Climate Services                                   |
| GHG   | Greenhouse Gases  |
| GIS   | Geographic Information System   |
| GoL   | Government of Liberia   |
| GPG   | Good Practice Guidance  |
| GSN   | Global Surface Network  |
| GTS   | Global Telecommunication System   |
| GUAN  | Global Upper Air Network  |
| GVL   | Golden Veroleum Liberia   |
| HFCs  | Hydrofluorocarbons  |
| HIPC  | Heavily Indebted Poor Countries   |
| IBCS  | Intergovernmental Board on Climate Services                             |
| ICA   | International Climate Agreement   |
| ICZMU | Integrated Coastal Zone Management Unite                                |
| IEC   | Information, Education and Communication                                |
| IFDC  | International Centre for Soil Fertility and Agricultural<br>Development |
| IIAG  | Ibrahim African Governance Index  |
| IMF   | International Monetary Fund   |
| INC   | Initial National Communication  |
| INDC  | Intended Nationally Determine Contribution                              |
| IPCC  | Inter-Governmental Panel on Climate Change                              |
| IPPU  | Industrial Processes and Product Use                                    |
| ISFM  | Integrated Soil Fertility Management                                    |
| ITCZ  | Intertropical Convergence Zone  |
| ITD   | Intertropical Discontinuity   |
| IUU   | Unreported and Unregulated  |
| KP    | Kimberly Process  |
| LACRA | Liberia Agriculture Commodity Regulatory Authority                      |
| LADA  | Liberia Agribusiness Development Activity                               |
| LAGBC | Liberia Assemblies of God Bible College                                 |



|         |  |
|---------|--|
| LAMCO   | Liberian American Swedish Mining Company                     |
| LATA    | Liberia Agriculture Transformation Agenda                    |
| LccGAP  | Liberia Climate Change Gender Action Plan                    |
| LCD     | Least Developed Countries                                    |
| LD      | Liberian Dollar  |
| LDAA    | Liberia Domestic Airports Agency                             |
| LEC     | Liberia Electricity Corporation                              |
| LESA    | Liberia Endangered Species Association                       |
| LGS     | Liberian Geological Survey                                   |
| LHS     | Liberian Hydrological Service                                |
| LIBA    | Liberia Business Association                                 |
| LISGIS  | Liberia Institute of Statistics and Geo-information Services |
| LLWAS   | Low Level Wind Alert System                                  |
| LNRDS   | Liberia's National Rice Development Strategies               |
| LPG     | Liquefied Petroleum Gas                                      |
| LPMC    | Liberia Produce Marketing Corporation                        |
| LPRC    | Liberia Petroleum Refining Corporation                       |
| LTO     | Landing and take-offs  |
| LULUCF  | Land Use, Land Use Change and Forestry                       |
| LWS     | Liberia Waste Sector   |
| LWSC    | Liberia Water and Sewage Corporation                         |
| MCA     | Multi-Criteria Analysis                                      |
| MCC     | Monrovia City Corporation                                    |
| MCDA    | Multi Criteria Decisions Analysis                            |
| MDAs    | Mineral Development Agreements                               |
| MDTF    | National Multi-Donor Trust Fund                              |
| MEAs    | Multilateral Environmental Agreements                        |
| MESA    | Monitoring for Environment and Security in Africa            |
| METAGRI | Agricultural Meteorology                                     |
| MFPD    | Ministry of Finance Planning Development                     |
| MICAT   | Ministry of Information Culture and Tourism                  |
| MLME    | Ministry of Lands, Mines & Energy                            |
| MME     | Ministry of Mines and Energy                                 |
| MOA     | Ministry of Agriculture                                      |
| MOF     | Ministry of Finance  |

|        |   |
|--------|---|
| MOFA   | Ministry of Foreign Affairs                       |
| MOGCSP | Ministry of Gender, Children & Social Protection  |
| MOGD   | Ministry of Gender and Development                |
| MOH    | Ministry of Health                                |
| MOPP   | Maryland Oil Palm Plantations                     |
| MOT    | Ministry of Transport                             |
| MPW    | Ministry of Public Works                          |
| MRD    | Ministry of Rural Development                     |
| MRU    | Mano River Union                                  |
| MRV    | Measurement, Reporting and Verification           |
| MW     | Megawatt  |
| N2O    | Nitrous oxide                                     |
| NaFAA  | National Fisheries and Aquaculture Authority      |
| NAM    | Non-Aligned Movement                              |
| NAMA   | Nationally Appropriate Mitigation Action          |
| NAP    | National Adaptation Plan                          |
| NAPA   | National Adaptation Programs of Action            |
| NATCOM | National Communication                            |
| NBSAP  | National Biodiversity Strategy and Action Plan    |
| NCC    | National Cultural Center                          |
| NCCS   | National Climate Change Secretariat               |
| NCCSC  | National Climate Change Steering Committee        |
| NCHE   | National Commission of Higher Education           |
| NCSA   | National Capacity Self-Assessment                 |
| NDC    | First Nationally Determined Contribution          |
| NDMA   | National Disaster Management Agency               |
| NDMP   | National Disaster Management Policy of Liberia    |
| NDP    | National Development Plans                        |
| NEP    | National Environmental Policy                     |
| NEP    | National Energy Policy                            |
| NFCS   | National Framework for Climate Services           |
| NGO    | Non-Governmental Organization                     |
| NHRM   | National Human Right Monitor                      |
| NIR    | National Inventory Report                         |
| NMHS   | National Meteorological and Hydrological Services |

|        |   |
|--------|---|
| NMS    | National Meteorological Service   |
| NMVOCs | Non-methane volatile organic compounds                                  |
| NOX    | Oxides of nitrogen  |
| NPHIL  | National Public Health Institute of Liberia                             |
| NPP    | National Petroleum Policy   |
| NPRSCC | National Policy and Response Strategy on Climate Change                 |
| NREAP  | National Renewable Energy Action  |
| NTFPs  | Non-Timber Forest Products  |
| NWP    | Numerical Weather Prediction  |
| NWRI   | National Water Resources Institute                                      |
| OC     | Organic Carbon  |
| ODS    | Ozone-Depleting Substances  |
| ODU    | Oxidized During Use   |
| OECD   | Organization for Economic Co-operation and Development                  |
| PAPD   | Pro-Poor Agenda for Prosperity and Development                          |
| PCC    | Paynesville City Corporation  |
| PET    | Polyethene Terephthalate  |
| PFCs   | Perfluorocarbons  |
| PUMA   | Preparation for the Use of Meteosat in Africa                           |
| QMS    | Quality Management System   |
| REC    | Regional Economic Community   |
| RIA    | Roberts International Airport   |
| RREA   | Rural Renewable Agency of Liberia                                       |
| RTC    | Regional Training Center  |
| SAPEC  | Smallholder Agricultural Productivity Enhancement and Commercialization |
| SBTSTA | Subsidiary Body on Scientific and Technological Advice                  |
| SCCF   | Special Climate Change Fund   |
| SCNL   | Society for the Conservation of Nature Liberia                          |
| SIGI   | Social Institutions and Gender Index                                    |
| SMEs   | Small and Medium Enterprises  |
| SNC    | Second National Communication   |
| SOE    | State of the Environment  |

|        |   |
|--------|---|
| STARP  | Smallholder Agriculture Transformation and Agribusiness<br>Revitalization Project |
| SWGs   | Sectorial Working Groups  |
| TAP    | Technology Action Plan  |
| TNA    | Technology Needs Assessment   |
| TNIMA  | Tubman National Institute of Medical Arts   |
| UL     | University of Liberia   |
| UN     | United Nations  |
| UNEP   | United Nations Environment Programme  |
| UNFCCC | United Nations Framework Convention on Climate Change                             |
| UNMIL  | United Nations Mission in Liberia   |
| USA    | United States of America  |
| USAID  | United States Agency for International Development                                |
| USTC   | United States Trading Company–Coca Cola   |
| WASCAL | West African Science Service Center on Climate Change and Adapted<br>Land Use     |
| WIGOS  | WMO Integrated Global Observing System  |
| WMO    | World Meteorological Organization   |
| WTO    | World Trade Organization  |
| WWW    | World Weather Watch   |

## Executive Summary

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), Liberia is committed to contributing to attaining the ultimate objective of the Convention, "Preventing dangerous human interference with the climate system", in accordance with the principle of common but differentiated responsibilities. Article 12, paragraph 1, item (b) of the Convention provides that a signatory must regularly update the Parties Conference with a general description of steps taken or planned to implement the Convention in the country. The preparation of the Second National Communication under the UN Framework Convention on Climate Change for Liberia is an enabling activity that is expected to enhance general awareness and knowledge on Climate change-related issues in Liberia as required by Article 12 of the Convention and based on COP 8 Guideline for National Communication for Non-Annex 1 Parties (Decision 17/CP.8).

### ES 1. National Circumstances

Liberia is a unitary constitutional republic and representative democracy with the seat of government based in Monrovia, the capital city. The country was initially made up of four provinces and country was later subdivided into nine counties to include the indigenous areas. The Government of Liberia has three branches: the legislative, the executive, and the judiciary. The legislative branch has two chambers – the Senate (the Upper House) and the House of Representatives (the Lower House). Liberia has a functioning local government. The country is subdivided into fifteen administrative divisions (counties), each headed by a superintendent appointed by the President.

The counties are sub-divided into districts headed by commissioners. Besides, mayors head cities. Other levels of local administration are the chiefdoms, headed by paramount and clan chiefs. There is also a traditional system, comprised of "zoes" and "bodios" (traditional healers and priests), etc., which is part of the local administration. Liberia's 2018 estimated population was 4,809,768 (LISGIS, 2018). Liberian landscape is mostly flat to rolling coastal plains containing mangroves and swamps, rising in the northeast rise to a rolling plateau and low mountains. Liberia's climate is determined by the Intertropical Convergence Zone (ITCZ) position or the Intertropical Discontinuity (ITD), better known in West Africa. The equatorial climate is hot year-round with heavy rainfall from May to October, except for a short interlude from mid-July to August. Temperature ranges from 28°C in November to 32°C in June.

### ES 2. National Greenhouse Gas Inventory

Liberia conducted the national Greenhouse Gas (GHG) inventory with the 2006 IPCC Guideline and 2000 IPCC and Good Practice Guidance (GPG) and other relevant tools. The inventory covers the emissions from Energy, IPPU, AFOLU and Waste sectors for 2014. The inventory used data and statistics from the following sources for anthropogenic sources and sinks of GHG emission:

- The Liberian Ministry of Commerce and Industry
- The Liberian Electricity Corporation
- The Liberian Petroleum Refining Company
- The National Port Authority
- Total Liberia – the sole importer of jet fuel in the country
- The Monrovia City Corporation
- Firestone Liberia, Inc.
- Ministry of Public Works
- Ministry of Commerce and Industry
- LISGIS and others

The energy sector is the largest GHG emissions (ES1) source, with 19,160 GgCO<sub>2e</sub> accounting for 97.6% of the total national emissions and Agriculture (2.1%).

ES 1: Sectoral contribution of greenhouse gas emission in 2014

| Sectors      | Greenhouse Gases (Gg) |                 |                  | Total (GgCO <sub>2e</sub> ) |
|--------------|-----------------------|-----------------|------------------|-----------------------------|
|              | CO <sub>2</sub>       | CH <sub>4</sub> | N <sub>2</sub> O |                             |
| Energy       | 4,969                 | 42              | 43               | 19,160                      |
| IPPU         | 0.4228                | -               |                  | 0.4228                      |
| Agriculture  | -                     | 8.4122          | 0.79             | 421.56                      |
| LULUCF       | -20.41                | -               |                  | -20.41                      |
| Waste        | -                     | 3.23            |                  | 67.83                       |
| <b>Total</b> | <b>4,949.01</b>       | <b>50.41</b>    | <b>43.79</b>     | <b>19,629.4</b>             |

Liberia has a weak and dysfunctional GHG inventory management system and poor institutional performance. With these limitations, our country lacks the capacity to fully and timely conduct GHG inventory and ensure the availability of accurate and reliable datasets to inform policymakers. Consequently, this report falls short of providing some historical data and detailed information on the diversity of sources and gases.

### ES 3. Greenhouse Gas Mitigation Assessment

The scope of the assessment - sectors that are drivers for economic growth and major contributors to the national greenhouse gas emissions were considered for this assessment. In uniformity with IPCC categories, the sectors included Energy, Land-Use Land Use Change and Forestry (LULUCF), Industrial Processes and Product Use (IPPU), and Waste.

The baseline scenario was developed for a single Business As Usual (BAU) scenario that aims to represent Liberia's most likely future to 2050 in the absence of actions and policies to reduce greenhouse gas emissions. Using the base year of 2015 from the third National GHG Inventory Report, projections of emissions to 2050 were prepared by making assumptions of how activity related to specific sources of emissions changes over time. Assumptions were based on the dataset extracted from the Third National GHG Inventory compiled under the first Biennial Update Report, Energy Balance 2018, Liberia Institute of Statistics and Geo-Information Services (LISGIS) and the Macroeconomic reports from the Central Bank of Liberia Liberia's baseline emission projections show that if no new climate change mitigation measures are implemented, Liberia's net GHG emissions are projected to increase by 59.3% between 2015 and 2050, reaching (8,536.9 kt CO<sub>2</sub>e) by 2050 (compared to 5357.7 kt CO<sub>2</sub>e in 2015), with land-use change and deforestation remaining the largest contributor to the country's GHG inventory throughout the period (Figure ES 1).

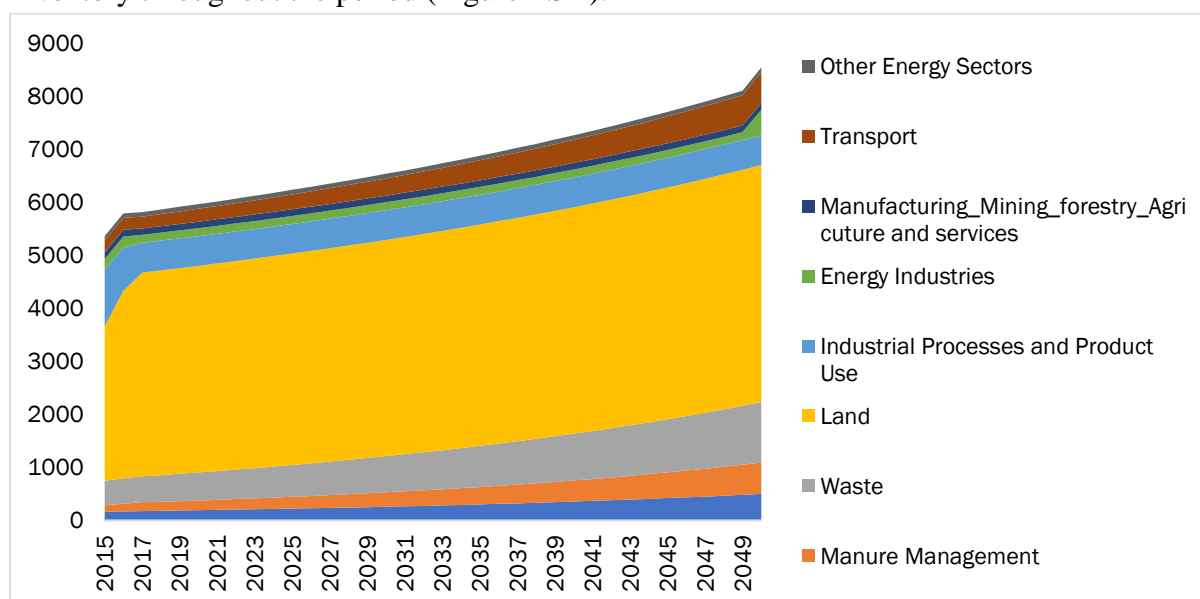


Figure ES.1 Sectoral baseline emission trajectory (2015-2050)

Eight mitigation measures we prioritized in the energy, transport, forestry, land-use and waste sectors from a long list of mitigation measures were identified from the country's existing policies and national plans. These mitigation measures can reduce Liberia's GHG emissions by 24.9% and 41% from baseline in 2030 and 2050, respectively, as shown in the Figure ES 2. The trajectory is based on these reductions can be termed the mitigation scenario.

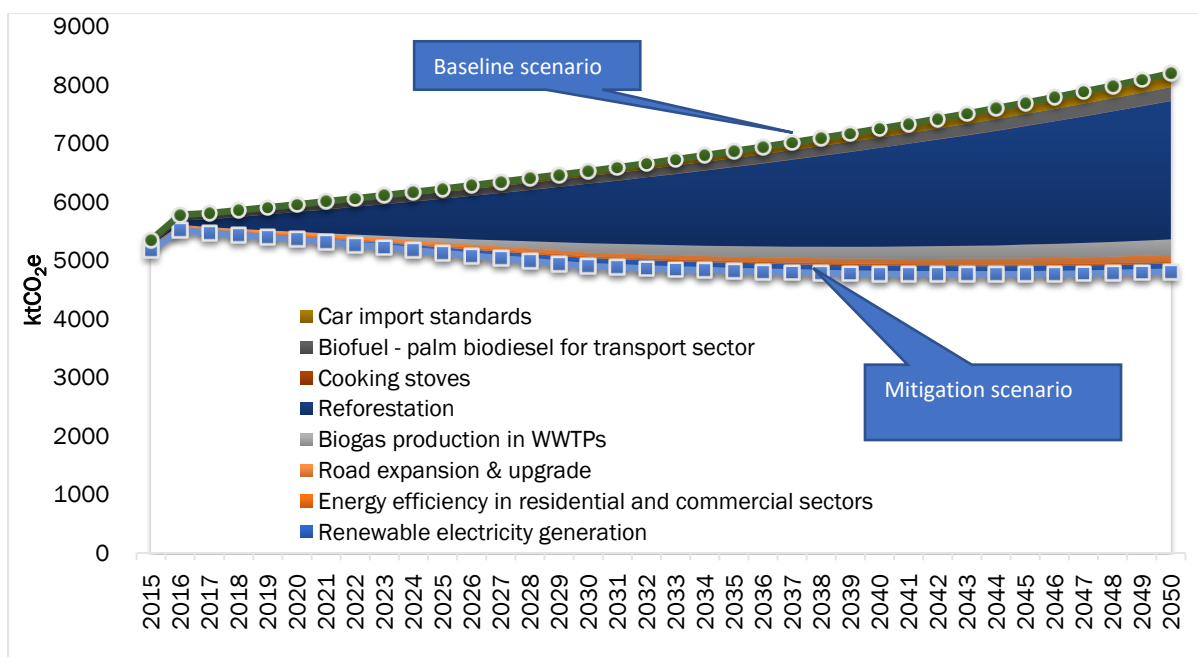


Figure ES.2 Prioritized mitigation options and the projected benefits

The total cumulative impact of the mitigation scenario for the entire period amounts to 64,588 ktCO<sub>2</sub>e. Reforestation is the highest contributor at 66%, followed by biogas production in Waste Water Treatment Plants (WWTPs) at 8.2%. The least contributor is the introduction of efficient cookstoves. Implementation of these activities can contribute significantly towards Liberia's long-term goal of achieving carbon neutrality by 2050.

To achieve this, Liberia requires sustainable funding for the implementation of the identified mitigation actions and technical support to build capacity around tracking of mitigation policies and measures. Moreover, effort needs to improve the country's data collection, generation and archiving to have consistent, reliable, and complete datasets.

## ES 4. Climate Change Vulnerability and Adaptation Assessment

Liberia's projected climate from 2010 – 2050 is based on an ensemble of Regional Climate Models (RCMs). The mean air temperature is unanimously projected to increase from 0.4°C to 1.3°C. The average increase in temperature for the year 2020 was estimated at 0.6°C. With the scenarios and the trends, it appears that temperature will increase by 1.3°C in the middle of the 21st century. It has been estimated that future climate scenarios will exacerbate the already experienced reduced productivity on agriculture, forestry, fisheries, and water resources. The sectors already experience the impacts of climate change.

### Agriculture sector adaptation options

- 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 the farming calendar.
- Building capacity and skills through the farmers' field school.
- Use of fertilizers to improve soil nutrients: materials, equipment for work and finance to pay for labor.
- Planting a mix of early maturing seedlings and the late-maturing seedlings; and
- Strong cooperative capacities and management.

### **Adaptation options for the Forestry Sector**

- Park management - Wonegizi Nature Reserve, Sapo National Park, Gola Forest, Grebo-Krahn and East Nimba Nature Reserve (five 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).
- Practice conservation agriculture – brush and farm allowing grass to cover the soil and provide moisture (traditional slash and burn – brush and burn before planting, and convention farming used as a control by brushing and taking away the grass before planting).
- Introduce innovations such as the Farmers feeding school, where new agricultural innovation is practiced.

### **Adaptation options for the fisheries sector**

- 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 to have easy access and be able to purchase fishing gears.
- Oven dryers to avoid too much fire and smoke.
- Move from 15 to 40 horsepower 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, two-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 a 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 a marine store to enable easy access to fishing gears.
- Storage facilities enable fishermen to preserve their catches and reduce losses.

### **Proposed adaptation options for coastal protection**

- Develop an integrated coastal zone management plan.
- Reduce the vulnerability of urban coastal areas to erosion, floods, siltation, and degradation.
- Control coastal development, and build infrastructure to protect coastal zones, including:
  - The construction of groin systems using trunks of rheum palm trees which are jetted into the beach and tied together with timber to stabilize the beaches;
  - The construction of a breakwater system is another shoreline stabilization technique that could be useful in protecting the sandy beaches.
  - Construction of revetment system to reduce erosion;
  - Construction of seawalls or bulkhead.
- Creation of public awareness and outreach activities.
- Increasing the height of coastal infrastructure and urban growth planning;
- Wetland preservation and mitigation.
- Development and implementation of coastal zone management plan.

### **Proposed adaptation options for the health sector**

- Identifying and disinfecting stagnant water sources that are breeding grounds for insects;
- Promoting hygiene and sanitation education and awareness, including clinical interventions and community health education programs;
- Strengthening the Roll Back Malaria program and providing a range of herbal treatments.

## **ES 5. Technology Transfer and Development**

Liberia, like most countries in West African region is experiencing the effects of climate change as a result of rising sea level, increased intensity in rainfall, and soaring temperatures. As the country grapples with challenges posed by climate change, its economic, social, political and environment development remain threatens. Liberia is one of 23 countries participating in Phase III of the Technology Needs Assessment (TNA) within the framework of the United Nations Framework Convention on Climate Change (UNFCCC).

The aim of the TNA process is to assist Liberia identify and analyse priority technology needs, which can form the basis for a portfolio of Environmentally Sound Technology (EST) projects and programmes to facilitate the transfer of, and access to the ESTs and know-how in the implementation of Article 4.5 of the UNFCCC which states that developed country Parties and other developed Parties included in Annex II “shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention” (UN, 1992). Hence TNAs are central to the work of Liberia on technology transfer and present an opportunity to track an evolving need for new equipment, techniques, practical knowledge and skills, which are necessary to adapt and mitigate greenhouse gas (GHG) emissions and/or reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change.

The national TNA team of Liberia consist of the core group of persons engaged in the TNA project and it includes the National Climate Change Steering Committee (NCSSC), the National TNA Coordinator, the National Consultants for Mitigation and Adaptation, and three (3) Sectoral Working Groups (SWGs) (one for mitigation and two for adaptation). Stakeholder consultations took place during each stage of the TNA process. Throughout the TNA process, it was ensured that a gender sensitive approach be considered to make the process participatory, inclusive and gender responsive. This approach was carried out with respect to the composition of the adaptation and mitigation sectoral working group, identifying and prioritizing technologies, and developing scoring criteria for the various identified technologies. The groups have a 40% female membership. Key stakeholders drawn from government ministries, departments and agencies, non-government organizations (NGOs), the private sector, technical experts and academics were involved identifying two sectors for adaptation and one sector for mitigation; reviewing technology factsheets and recommending other adaptation and mitigation technologies applicable in the local context; developing scoring criteria for the identified technologies; and participating in the multi-criteria exercise.

In addition to the formal workshops, the National Consultants also conducted sectorial working sessions, informal meetings with experts and resource persons from various ministries, institutions and NGOs who could not attend the workshops. After a lengthy deliberation where stakeholders presented their views and opinions, stakeholders of the sectors’ working group finally agreed that the criteria for selection be categorized as cost, economic, social, and environmental and climate related. The MCA exercise enables the selection of priority technologies for Liberia in an objective way and based on consensus.

The MCA selected the following technologies in the mitigation Sector:

- Solar Home PV System
- Solar PV Grid-tied System
- Small Hydropower
- Improved clean cook stove
- Solar dryer
- Briquette Production

- Solar Lantern
- Biodiesel
- Biogas Digester
- Methane Capture from Landfill

The following technologies were also peritonised in the adaptation sectors:

- Agriculture
  - Value addition to agriculture products
  - Improve storage (drying and freezing of agriculture products)
  - Integrated Soil Fertility Management
  - Crop Diversification and new varieties
  - Irrigation
  - Ecological pest management
  - Mixed farming
- Coastal Zone
  - Integrated Coastal Zone Management (ICZM)
  - Flood early Warning System (FWS)
  - Rock/ Armour Revetment
  - Groynes
  - Sea-wall
  - Beach Nourishment
  - Coastal Wetland Protection & Restoration
  - Restoration of coastal vegetation (Coconut trees, Almond trees, Mangroves & etc.)

## **ES 6. Research, Systematic Observation and Early Warning Systems**

The study reviewed current information on climate change research and systematic observation and participation and contribution to activities and programs at national, regional and global research networks and observing systems. The study also provided information on the following: status of the national program for research and systematic observation, hydrological observing systems, atmospheric and oceanographic research and observations, needs and priorities for climate change research and systematic observations, and needs, constraints and gaps in climate change research and systematic observation.

## **ES 7. Education, Training and Public Awareness**

According to the World Bank, 2016 report, Liberia, one of the poorest nations in south of the hemisphere has with very limited knowledge on climate change awareness, no modern laboratories and no weather or climate change forecast equipment to predict and plan ahead of disasters. The country faces significant risks as a result of climate change owing to the fact that there is a high level of dependence on climate-sensitive activities from other nations or institutions (EPA, 2013). Since Liberia is far behind in statistic and equipment collection, civil awareness and education are the best options Liberia needs in reducing the high risks of climate change.

Education, public awareness and training of every citizen, community and county must be seen as a major priority of the government of Liberia through the Environmental Protection Agency. The UNFCCC, through its Article 6, and the Kyoto Protocol, through its Article 10(e), mandate all governments to educate, empower, and engage all stakeholders (students, political leaders, community heads, school heads, and religious leaders) on policies relating to climate change. In particular, Article 6 of the convention, the Lima Ministerial Declaration, Doha Working Groups address the issue of climate change-related education, training, and public awareness and the strategies through which institutions can apply in the execution of education and awareness.

In this document, we have touched on the following issues: which is the introductory focus on the limitation of climate change awareness and lack of preparedness within the country and the acts/laws that bind the Government of Liberia on climate change. Chapter; focus on the importance of Education, Research and the need for public awareness in all schools, communities and the country at large; touched on the Government of Liberia Policy and Engagement on Climate Change. It touches on some of government policies documents that have contributed to the reduction or fight against climate change; gives some highlight on the Role of National and International institutions have played and still contributing in the country; lists the number of NGOs working in the country on climate change; analyze the Lima Ministerial and the Doha work programme; and concluded with gave some recommendations that hope to reduce to high risk on climate change in the country. These two strategies are the guides that every country needs to use in order to implement its awareness and education on climate change.

## **ES 8. Constraints, Gaps and related Financial, Technical and Capacity**

### **Needs**

Liberia is presently gearing up to address its capacity gaps during the reporting process of this Second National Communication (SNC) to the UNFCCC. The capacity gap assessment has thrown up areas of improvement including a suitable institutional arrangement that ensures sustainability of the process; activities that need to be covered for a comprehensive assessment of national GHG inventories by sources and sinks; capacitated sectoral experts who can map and gather relevant activity data and estimate GHG emissions by sources and sinks, manage uncertainties and undertake quality assurance and quality control of the GHG inventory the need for a standard operating procedure to comprehensively complete preparation of GHG inventory by sources and sinks in a timely manner.

The EPA responsible for implementation of REDD+ programme, has decided to apply a portion of the grant received on developing the capacity of the Government of Liberian GHG inventory team towards GHG accounting and reporting procedures, consistent with the IPCC guidelines and requirements of the UNFCCC.

The absence of a dedicated climate change committee or task force means that at the beginning of any activity on climate change, the EPA struggles to assemble a body of capable experts.

Technical experts who have been trained in the development of national inventories, assessment of technologies, and assessment of vulnerability to climate change in previous activities may be available from their parent institutions, but in most cases fresh technicians are nominated to participate in the implementation of the activity. The rate of turnover is high, as is the number of fresh members with no previous knowledge of climate change issues. Generally, these new members have no hard exposure to or training on issues related to climate change. This is a constraint. Most of the technicians that participate in the implementation of climate change activities and gain knowledge and expertise in climate change are from the central government. This is an important constraint, especially when it comes to using the services of contractors and consultants who cannot be employed by the government. There is hardly any individual in the private sector who has been or is currently engaged in climate change activities. On the other hand, the membership of a dedicated climate change committee or task force is relatively stable. These technicians are involved in the implementation of most of the climate change activities and thus continuously receive knowledge and develop their expertise.

Liberia faces challenges in the implementation of its climate change programmes. Chief among them is inadequate access to resources to meet prioritized financial, technical and capacity needs.

The current levels of the GEF funding for in country climate assessment and reporting purpose are not adequate while the government support is stated to be in kind. So, Liberia is exploring other options including considering GEF's medium-size proposal window to mobilize additional funding.

Some of the identified financial constraints and gaps are captured below:

- **Inadequate funding in the national budget** – funding for climate change activities in the country is largely donor driven and project-based. Domestic financing of climate change activities is difficult to estimate over a given time frame. This is because in the national budget, there are no clear differentiation of climate expenditure items and this leads to challenges in tracking actual government expenditures on climate change.
- **Duplication of activities and funding** – weak institutional coordination within government and among donors leads to duplication of activities and in most cases resources are not directed to where they are needed most.
- **Insufficient transparency on non-financial support for training and technical assistance**– there are cases where Liberian institutions have received training and technical assistance support without much financial disclosure from the donor because most of this support are tapped from global projects that might have different financial contributors. In such situations, reporting is constrained because the recipient countries do not have full access to the funding and accounting information.

- **Gaps in tracking capacity and technical assistance** Most of the climate change activities take place at different levels so it is difficult to track them. This means that information on capacity may not be complete to inform future capacity planning.

## ES 9. Networking, Knowledge, and Information Sharing

It is anticipated that climate change will impact Liberia due to its geographic location and economic condition. Science predicts that the impacts of climate change will strain many aspects of the country, including the socio economic aspect, which includes employment, revenue generation and other environmental services. Several factors contributes to the limited level of climate change knowledge and information sharing in the country. The knowledge management gap is glaring, thus the need of knowledge management systems that can strengthen institutional memory, improve people's understanding of climate change adaptation, and more experts in the areas of climate change cannot be overemphasized.

With the help of partners, the government of Liberia was able to develop the following national networks, platforms, programs and groups in an attempt to increase awareness levels and communities resilience towards the impacts of climate change:

- Climate Change Knowledge Sharing Platform of Liberia (CCKSP)
- Environmental Knowledge Management System (EKMS)
- Environmental Studies Master's Degree Programs at the University of Liberia (UL)
- Other and information sharing groups, networks & programs (Talk the Environment, Knowing your environment, EPA Intersectoral Department

Awareness Campaign, Climate Saturday)

It is undebatable that there is a demand for networking, knowledge management and information sharing in climate change in Liberia, but there are challenges in the supply chain. Many of the challenges are fixable, and many of the identified strategies were broadly relevant. If these challenges are addressed, it will improve government's effort and support the development of sustainable management plans. These strategies rests on the pillars of action, collaboration, coordination, innovation and learning and sharing.

The threats posed by climate change especially in vulnerable nations calls for countries like Liberia to recognize the value of "knowledge in climate change" as an integral part of enhancing communities' resilience to climate change. The adoption and practical implications of the suggested measures is a key aspect of ensuring sustainability.

## **ES 10. Capacity Building**

The Capacity Building Framework (CBF), which stemmed from the 1995 Conference of Parties (COP) in Berlin aims to build capacity in developing countries thus promoting sustainable development while meeting the objective of the convention and its Kyoto Protocol. CBF has a large scope which seeks to cultivate good results by allowing developing countries to identify their own needs while being supported and backed by bilateral and multilateral financial sources. The EPA has been building experts' capacity through a range of knowledge dissemination activities from projects capacity building components at international and national levels.

In order to properly reduce greenhouse gases emissions nationwide, the expertise of Liberians have to be enhanced beyond theoretical knowledge mediums (trainings, workshops) which will yield the implementation of successful adaptation practices. There is an urgent need for Liberians to catch up with the rest of the world and understand what climate change really is. This will be easily achieved when climate change is mainstreamed into the national development agenda of the country.

It is costly to implement the Kyoto Protocol at national level, but the latter is far worse. The climate is changing rapidly worldwide and adaptation measures needs to be adopted to ensure long term integrity and successful operation of the environment. Liberians have high dependence on livelihood practices that are climate sensitive and a change in the climate will have devastating effects on farmers, crops, animals etc... Systematic updates, training and research needs to be conducted to obtain a wide range of updated precise data. Modern technologies needs to be adopted to help address the existing gaps as we strive to protect and ensure the continuation of life on earth.



# 1. National Circumstances

## 1.1. Political Geography of Liberia

### 1.1.1. Location

Liberia is situated on the West Coast of Africa and is bounded by longitude 7° 18' to 11° 30' West and latitude 4° 20' to 8° 30' North. The country covers an area of 111,370 square km with a coastal belt 563 km long extending 149 km inland. It is bordered by Sierra Leone on the West, Guinea on the North, and Côte d'Ivoire on the East (Figure 1.1).



Figure 1.1 Geographic location of Liberia

### 1.1.2. Government of Liberia

Liberia gained its independence in 1847 and has had two written constitutions. The 1847 constitution was written by Professor Simon Greenleaf of Harvard University (USA) following the Declaration of Independence. This historic document existed for 133 years (1847–1980) and was abrogated by the military take-over (coup d'état) of April 12, 1980. The existing constitution of Liberia was written in 1986. The constitution guarantees the dignity of humankind, freedom of the press, freedom of association, freedom of religion, and freedom of speech. Liberia is currently governed by a multiparty, republican democracy. It is a secular state.

The Government of Liberia, modelled on the government of the United States, is a unitary constitutional republic and representative democracy with the seat of government based in Monrovia, the capital city of Liberia. The country was initially made up of four provinces that were mainly along the coastal belt where the settlers were based. Later the country was subdivided into nine counties to include the indigenous areas. Between 1980 and 2000 the country was again subdivided into fifteen counties (Figure 1.2)

The Government of Liberia has three branches: the legislative, the executive, and the judiciary. The legislative branch has two chambers – the Senate (the Upper House) and the House of Representatives (the Lower House). Members of the Senate are elected for nine- and six-year terms for senior and junior senators, respectively. Members of the House of Representatives are elected for a six-year term. Representatives of both houses can be re-elected as many times as their constituencies wish. The constitutional responsibilities of the legislative branch are, among other things, the enactment of laws, minting of currency, creation of national armies, impeachment, etc.



Figure 1.2 Political map of Liberia

The second branch of the Liberian government is the executive, headed by the president, who is the chief foreign policy formulator and commander-in-chief of the Armed Forces of Liberia (AFL). With the consent and advice of the Senate, the president appoints cabinet ministers to form the cabinet which assists in the day-to-day running of the government. The president also appoints local superintendents, ambassadors, and other officials. The executive branch is charged with enforcing the laws enacted by the legislative branch.

The third branch of government, the judiciary, is headed by the chief justice, who is assisted by four associate justices of the Supreme Court. The constitutional responsibility of the judiciary is to interpret the laws. The Supreme Court serves as the final arbiter of justice in the country. Under the Supreme Court are several lower courts such as the circuit court, criminal court, tax court, debt court, traffic court, juvenile court, magistrate court, Justice of the Peace courts, etc.

In addition to the central government administration, the country also has a functioning local government. The country is subdivided into fifteen administrative divisions (counties), each of which is headed by a superintendent appointed by the president. The counties are further subdivided into districts headed by commissioners. In addition, cities are headed by mayors. Other levels of local administration are the chiefdoms, headed by paramount and clan chiefs. There is also a traditional system, comprised of “zoes” and “bodios” (traditional healers and priests), etc., which is part of the local administration.

Liberia traditionally has maintained cordial relations with the West. China and Libya have been prominent international partners in Liberia's reconstruction since the end of the civil war. Liberia also maintains diplomatic relations with Cuba. The country is a founding member of the United Nations (UN) and its specialized agencies, and is a member of the African Union (AU), the Economic Community of West African States (ECOWAS), the African Development Bank (ADB), the Mano River Union (MRU), and the Non-Aligned Movement (NAM).

### 1.1.3. Population growth rate, Distribution and Density

The results of five major censuses show that the population of Liberia was 1.02 million in 1962, 1.5 million in 1974 (GOL, 2008), 2.1 million in 1984 (LISGIS, 2009), 3.48 million in 2008 (LISGIS, 2009) and 3.5 million in 2010. Liberia's 2018 estimated population was 4,809,768 (LISGIS, 2018). The 1999/2000 Liberia Demographic Survey showed a total fertility rate of 5.06, an average life expectancy of 62.5 years, an infant mortality rate of 37.9 per 1,000 live births, and a maternal mortality rate of 725 per 100,000 live births. As of 2018, Liberia had the highest population growth rate in the world (2.6% per annum) (LISGIS, 2014). The 2008 census indicated a population growth rate of 2.1% and 5.8 total fertility rates, but as of 2018, it is 2.5%. The 2008 census results show that the average expectation of life at birth for Liberia was 62.50 years, i.e., 61.52 years for males and 63.50 years for females (Table 1).

Table 1-1 Summary of some key demographic indicators from the 2016 census report

| Demographic indicators                | Values |      |      |      |
|---------------------------------------|--------|------|------|------|
| Total fertility rate (TFR)            | 5.06   | 4.9  | 3.5  | 3.1  |
| Life expectancy at birth (males)      | 62.50  | 54.0 | 58.6 | 63.4 |
| Life expectancy at birth (females)    | 63.50  | 66.2 | 60.9 | 65.5 |
| Life expectancy at birth (both sexes) | 63.7   | 55.0 | 59.7 | 64.4 |
| Dependency ratio                      | 0.97   | 0.74 | 0.6  | 0.56 |

As shown in Figure 3, 43.8% of the population are 0-14 years, 15-24 years account for 19.6%, 25-54 representing 30.33%, and only 6.3% are 55 years and above. Christianity is the major with religion with 85.6%, Muslim 12.2%, Traditional 0.6%, Other 0.2%, and None 1.4%. The recognized ethnic groups include the Gio (or Dan), Mano, Bassa, Kpelle, Grebo, Vai, Gola, Kru, Krahn, Kissi, Gbandi, Mandingo (or Mandinka), Dei (or Dewoin), Bella, Mende and Lorma. According to LISGIS, the largest group is the Kpelle, concentrated in central and

western Liberia. Americo-Liberians are descendants of African American and West Indian people and account for 2.5% of the population. The Congou people are descendants of repatriated Congou and Afro-Caribbean slaves and makeup 2.5% of the population. Liberia also has a sizable population of Lebanese, Indians, and West Africans. According to the World Bank Development Indicators published in 2016, the life expectancy at birth among the general population is 62.5 years. The infant mortality rate stands at 52.2 death/ 1000 live birth. Liberia has a youthful population with a median age of 17.8 years.

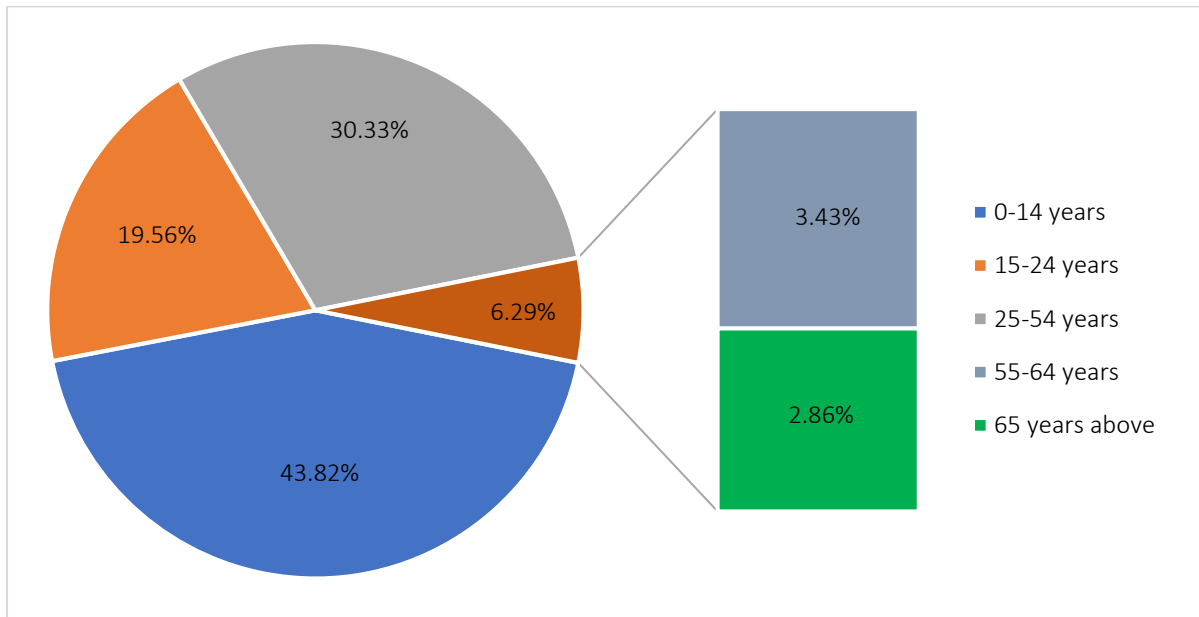


Figure 1.3 Age distribution of Liberia's population

Thirty-one indigenous languages are spoken within Liberia, none of which is the first language to more than a small percentage of the population ([www.ethnologue.com](http://www.ethnologue.com)). English is the official language and serves as the country's lingua franca (Moore, 2009). Liberians speak a variety of dialects collectively known as Liberian English (Moore, 2009). By the year 2058, the expectation of life at birth in Liberia will increase to 64.4 years for both sexes, 63.4 years for males and 65.5 years for females. Similarly, the total fertility rate will decrease from 5.8 in 2008 to 3.1 by 2058, while the total population will increase to 10.3 million.

## 1.2. Physical Geography of Liberia

The Liberian landscape is mostly flat to rolling coastal plains containing mangroves and swamps, rising in the northeast rise to a rolling plateau and low mountains (Bateman et al., 2000). The relief system of Liberia is subdivided into the following four belts:

- The coastal belt extends upland to 32 to 40 km and comprises gently undulating hills or low plains with an altitude not exceeding 15 m. This belt has three promontories:

Cape Mount, Cape Montserrado, and Cape Palmas. The highest of these promontories is Cape Mount on the Sierra Leonean border, with over 350 m.

- The second belt comprises hills, discontinuous ranges, and occasional escarpments that constitute the larger parts of Liberia's hinterland.
- The third belt is composed of plateaus that are about 200 to 300 m above sea level.
- The fourth belt comprises mountains located in the northern highlands and includes the Nimba and Wologisi range along the Guinean border.

The highest point wholly within Liberia is Mount Wuteve at 1,440 m above sea level in the northwestern Liberia range of the West Africa Mountains and the Guinea Highlands (Bateman et al., 2000). However, Mount Nimba near Yekepa is higher at 1,752 m above sea level but is not wholly within Liberia as Nimba shares a border with Guinea and Côte d'Ivoire. Liberia's watershed tends to move in a southwestern pattern towards the sea. Table 1-2 shows the six principal river basins, which empty into the South Atlantic Ocean.

The country's main northwestern boundary is traversed by the Mano River, while its southeastern limits are bounded by the Cavalla River (Bateman et al., 2000). The largest of these rivers is the Cavalla, found along the eastern side of the country. The river reaches east of the city of Tappita and forms the boundary between Liberia and Côte d'Ivoire, emptying into the South Atlantic Ocean about 25 km east of Cape Palms. The river is also navigable from its mouth for about 80 km inland to its first rapids.

Table 1-2 Principal river basins of Liberia

| River Basin | Total area (sq km) | Area in Liberia (sq km) |
|-------------|--------------------|-------------------------|
| Cavalla     | 11,670             | 5,300                   |
| Cestos      | 4,850              | 3,900                   |
| St. John    | 6,650              | 5,700                   |
| St. Paul    | 8,460              | 4,950                   |
| Lofa        | 4,100              | 3,550                   |
| Mano        | 3,200              | 2,440                   |

### 1.3. Liberia's Climate

Like any other country in West Africa, Liberia's climate is determined by the Intertropical Convergence Zone (ITCZ) position or the Intertropical Discontinuity (ITD) as it is better known in West Africa. The ITD moves north and south during the year, with areas north of its surface position experiencing dry seasons and areas south of its surface position experiencing wet seasons. The position of the ITD and the climate of Liberia are further influenced by the positions and strengths of the subtropical high-pressure belts located on average at about 45° North and South of the equator and by the series of low-pressure areas and wave action between these high-pressure belts.

Climate Change is a critical function of the Environmental Protection Agency (EPA) of Liberia to pursue its developmental and sustainable goals. The Agency seeks adaptive capacity in different sectors, such as human and institutional capacities, technology, infrastructure, economy, etc. The impact exerted by climate change is severe; hence impacted sectors identified as priority sectors through stakeholders' consultation and document review include: Economic, Forestry and Wildlife, Agriculture, Coastal Area, Water, Fishery, Energy, Mining, Industry, Transport and Tourism; Infrastructure; Urbanization; and Social as well as Health and Settlement. These sectors have experienced severe climate change impacts over the past few decades. The impacts have also translated to negatively affect developmental growth, degradation of the human and physical environment (EPA, 2018).

For instance, in forest-dependent communities, climate change-induced extreme events are 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, lack of access to clean water, medicinal products, and fuelwood among other things, which they get from the forest. The disruption to the agricultural system resulting from climate change-induced changes in patterns of rainfall. The temperature has direct consequences for the country, where more than 70% (Republic of Liberia 2010). The population engages in agriculture as their main livelihood activity, with rice (which is the nation's staple) covering most of the area under production (rubber and cassava coming in at a second and third place, respectively). Intense precipitation could affect the water infrastructure, leading to an increase in runoff into rivers and lakes, washing sediment, nutrients, pollutants, trash, animal waste, and other materials into water supplies (EPA, 2018). The national climate change sector is significantly improving under the EPA of Liberia.

### 1.3.1. Precipitation

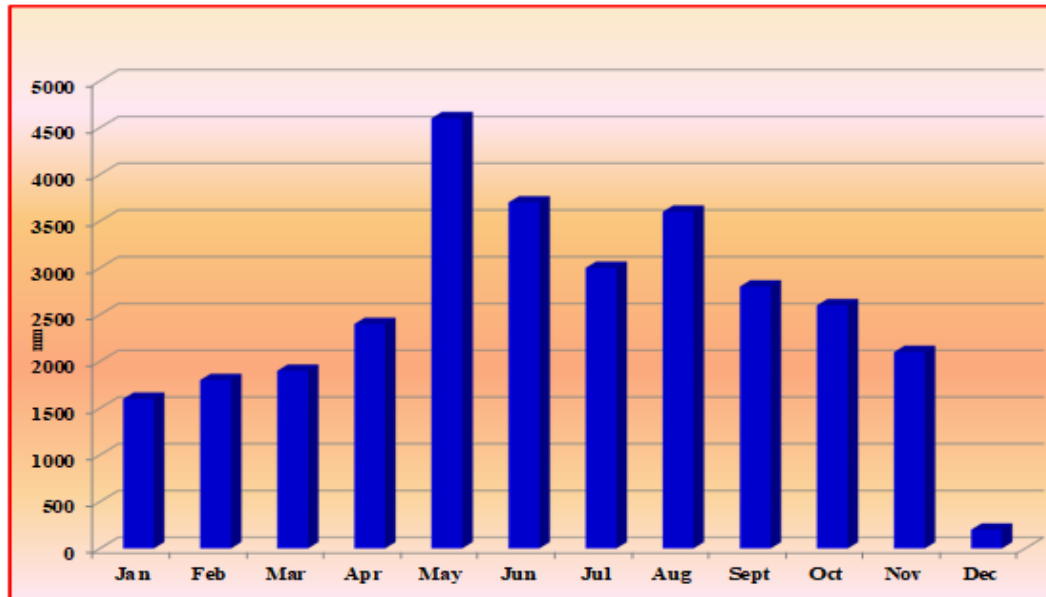


Figure 1.4 Mean monthly rainfall (mm) in Liberia (1953-1982)

The equatorial climate is hot year-round with heavy rainfall from May to October, except for a short interlude from mid-July to August (Bateman et al., 2000) (Figure 1.4). The dry season extends from November to April, although there has been a gradual change in both seasons over the last 30 years. However, there is hardly any month without rainfall. The heaviest rainfall is recorded in June, while the lightest rainfall is recorded in December. The main type of precipitation experienced in Liberia is convection rainfall.

The coastal areas are wetter, and except for highland areas where the air is forced to rise, causing aerographic rains, reduced moisture in the atmosphere causes rainfall to decrease toward the interior. The relative humidity is about 90–100% during the rainy season and 60–90% during the dry season.

### 1.3.2. Temperature

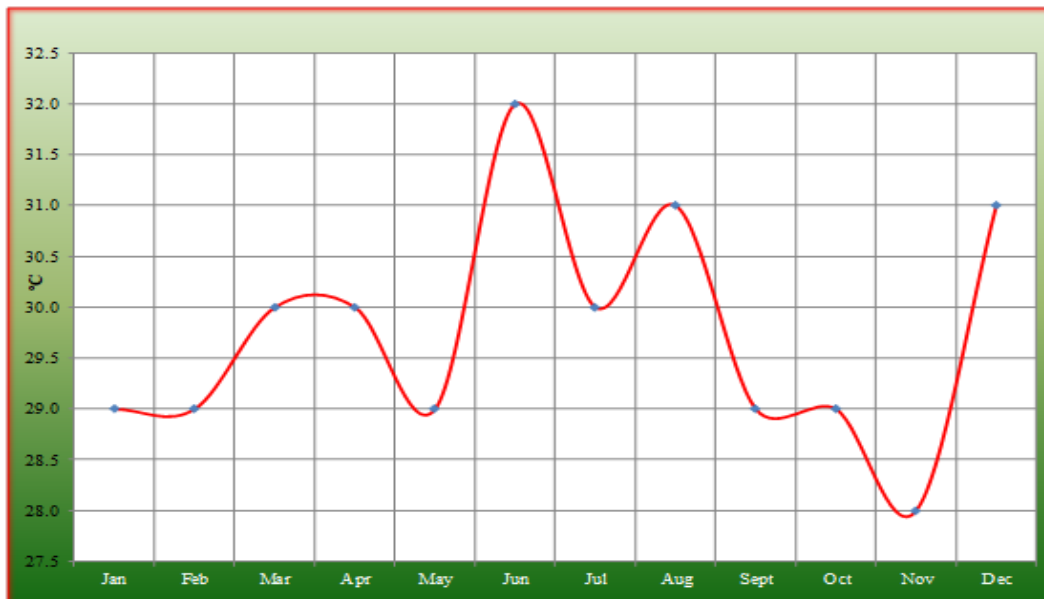


Figure 1.5 Mean monthly temperature (°C) in Liberia (1953-1982)

Liberia's geographic location means that the sun is overhead at noon throughout the year because of the country's proximity to the equator. Insolation is very intensive in all parts of the country. As shown in Figure 1.5, temperature ranges from 28°C in November to 32°C in June.

### 1.3.3. Sunshine

In Figure 1.6, the average length of bright sunshine in Liberia is about 7.7 hours/day with a maximum length of about 9 hours in January and February in the dry season and a minimum length of about 7 hours in August, September, and October, the peak of the rainy season.

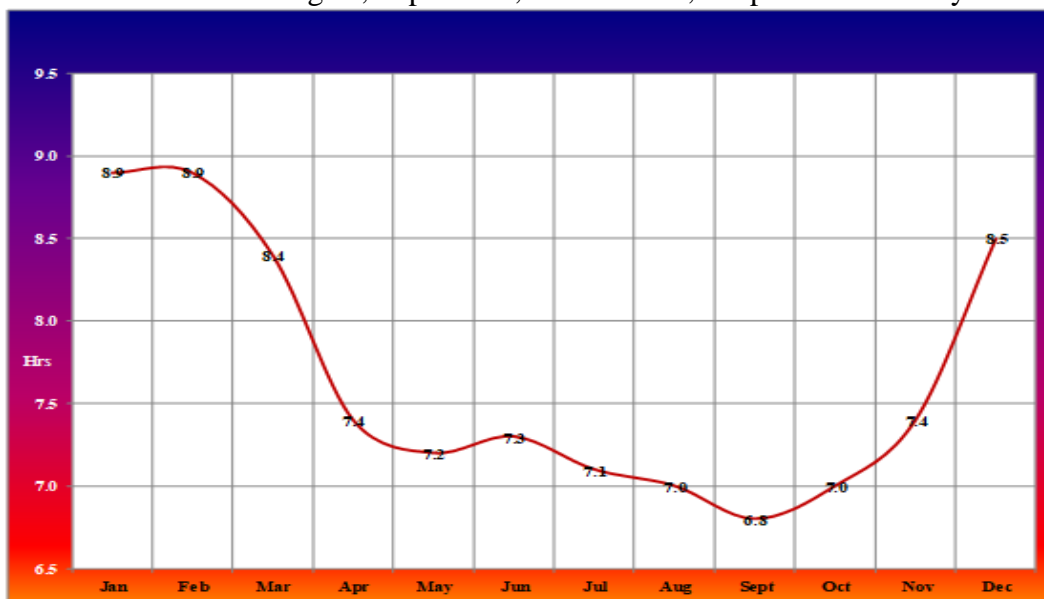


Figure 1.6 Mean monthly sunshine (hours) in Liberia



## 1.4. Economic Indicators

According to the Bureau of African Affairs, 2011 report, Liberia is one of the world's poorest countries, with a formal employment rate of only 15% (Bureau of African Affairs, 2011). GDP per capita peaked in 1980 at US\$496. But as of 2018, it is now US\$698 (WB, 2018). In 2010 the country's nominal GDP was US\$974 million, but it is now \$728.019 as of 2018 (World Bank, 2018), while nominal GDP per capita stood at US\$226. The nominal GDP per capita now stands at \$360.00 as of 2019 (Trading Economic, 2019), which remains the third-lowest in the world. Historically, the Liberian economy has depended heavily on foreign aid, foreign direct investment, and exports of natural resources such as iron ore, rubber, and timber (Bateman et al., 2000).

Following a peak in growth in 1979, the Liberian economy began a steady decline due to economic mismanagement following the 1980 coup. According to a 2011 report from the IMF, this decline was accelerated by the outbreak of civil war in 1989. An estimated 90% reduced GDP between 1989 and 1995, one of the fastest declines in history. With the end of the war in 2003, GDP growth began to accelerate, reaching 9.4% in 2007. The global financial crisis slowed GDP growth to 4.6% in 2009 (IMF, 2011).

The African Governance Initiative stated that strengthening agricultural and forestry sectors led by rubber and timber exports increased 5.1% in 2010 and an expected 7.3% in 2011, making the economy one of the 20 fastest-growing in the world. Current impediments to growth include a small domestic market, lack of adequate infrastructure, high transportation costs, poor trade links with neighboring countries, and the economy's high dollarization. Liberia used the US dollar as its currency from 1943 until 1982 and continues to use the US dollar alongside the Liberian dollar (Africa Governance Initiative, 2011).

Following a decrease in inflation beginning in 2003, inflation spiked in 2008 due to the worldwide food and energy crises (Ministry of Finance, 2011), reaching 17.5% before declining to 7.4% in 2009 (IMF, 2011). Liberia's external debt was estimated in 2006 at approximately \$4.5 billion, 800% of GDP (GOL, 2011). As a result of bilateral, multilateral, and commercial debt relief from 2007–2010, its external debt fell to \$222.9 million by 2011 (MOF, 2011). Worth noting about the downward trend of Liberia's economy was the Ebola epidemic outbreak in 2014 and 2015. The country is recovering, had its devastating impact.

Table 1-3 Estimated economic indicators of Liberia (US\$)

| <b>Economic indicators</b>         | <b>2017</b> | <b>2016</b> | <b>2015</b> | <b>2017<br/>Ranking</b> |
|------------------------------------|-------------|-------------|-------------|-------------------------|
| GDP – PPP (US\$ billion)           | 6.112       | 5.965       | 6.064       | 173                     |
| GDP – Exchange rate (US\$ billion) |             |             | 2.4         |                         |

|                                    |  |        |        |     |
|------------------------------------|--|--------|--------|-----|
| GDP – Real Growth Rate (%)         | 2.20   | -1.6   | 0.0    | 127 |
| GDP/Capita – PPP (US\$)            | 456.05   | 455.37 | 360.00 | 37  |
| GDP – Composition by sector        | Agriculture (34%), industry (13.8%), services (52.2 (2017.))   |        |        |     |
| Labor force                        | 1.677 million (2017), world ranking 184  |        |        |     |
| Labor force – by occupation        | Agriculture (70%), industry (8%) and services (22%) (2017 est.)  |        |        |     |
| Unemployment rate (%)              | 85%, world ranking 128 (2017 est.)   |        |        |     |
| Population below poverty line (%)  | 54.1% (2017.)  |        |        |     |
| Household income (%)               | 2.4% for lowest 10%, 30.1% for highest 10% (2007 est.)   |        |        |     |
| Distribution of family income      | Gini index 38.2 (2007 est.), world ranking 184   |        |        |     |
| Budget (US\$ million)              | Revenues: 570, expenditures: 562.2   |        |        |     |
| Taxes and other revenues           | 16.9 GDP (CIA, 2017), world ranking 174  |        |        |     |
| Budget surplus (+) or deficit (-)  | -4.3% of GDP (CIA, 2017 est.), world ranking 161   |        |        |     |
| Inflation rate (consumer price)    | 12.4 % (CIA, 201207.), 8.8% (2016 est.), world ranking 207   |        |        |     |
| Commercial bank prime lending rate | 13.3% (Dec. 31, 2017 est.), 13.59% (31 Dec. 2018 est.)   |        |        |     |
| Agriculture – products             | Rubber, coffee, cocoa, rice, cassava (tapioca), palm oil, sugarcane, bananas, sheep, goats, and timber   |        |        |     |
| Industries                         | Rubber processing, palm oil processing, timber, and diamonds   |        |        |     |
| Electricity                        | Production = 300 million kWh (2017), world ranking 165<br>Consumption = 270 million kWh (2017), world ranking 184  |        |        |     |
| Oil                                | Production 0 bbl/day (2017), world ranking 162<br>Consumption 8,000 bbl/day (2016), world ranking 164<br>Exports = 0 bbl/day (2015), world ranking 172<br>Imports = 8.18 bbl/day (2015), world ranking 152 |        |        |     |
| Current account balance            | - 0.754 .2 million (2019 est.), world ranking 111  |        |        |     |
| Exports                            | \$260.6 million (2017est.), world ranking 186<br>\$169.8 million (2017 est.)<br>Commodities: rubber, timber, iron, diamonds, cocoa, and coffee   |        |        |     |

|                                       |   |
|---------------------------------------|---|
|                                       | Partners: South Africa 26.9%, US 18.1%, Spain 7.8%, Denmark 5.4%, Venezuela 4.8%, Malaysia 4.3% (2010)  |
| Imports                               | \$1.166 billion (2017 est.), world ranking 178<br>\$1.296 billion (2016 est.)<br>Commodities: fuels, chemicals, machinery, transportation equipment, manufactured goods, and foodstuffs<br>Partners: South Korea 37.2%, China 26.3%, Singapore 17.3%, Japan 11.5% (2010), South Korea 37.2%, China 26.3%, Singapore 17.3%, Japan 11.5% (2010) |
| Reserves of foreign exchange and gold | \$529727175<br>529.727 million (2019 est.), world ranking 149<br>\$399.8 million (December 31, 2011 est.)   |
| Debt – external                       | \$1.036 billion (2017 est.), world ranking 165<br>\$938.0 million (2016 est.)   |
| Exchange rates – Liberian\$ per US\$  | 196 (2017est.)<br>165 (2016 est.)   |

Table 1-3 presents an overview of Liberia's macro-economic trends relevant to sustainable development and climate change.

While official commodity exports declined during the 1990s as many investors fled the civil war, Liberia's wartime economy featured the exploitation of the region's diamond wealth (BBC News, 2000). Due largely to foreign aid and investment inflow following the end of the war, Liberia maintains a large account deficit, which peaked at nearly 60% in 2008 (IMF, 2010). Liberia gained observer status with the World Trade Organization (WTO) in 2010 and acquired full member status (Star Radio Liberia, 2010). Liberia has the highest ratio of foreign direct investment to GDP in the world, with US\$16 billion in investment since 2006 (Africa Governance Initiative, 2011). Following the Sirleaf administration's inauguration in 2006, the country signed several multi-billion-dollar concession agreements in the iron ore and palm oil industries with numerous multinational corporations, including BHP Billiton ArcelorMittal and Sime Darby (AllAfrica.com, 2010).

The Firestone Tire and Rubber Company, now Firestone Natural Rubber Company, has operated the world's largest rubber plantation in Liberia since 1926. Liberia has also begun exploring offshore oil: unproven oil reserves may be over one billion barrels (Reuters Africa, 2009). The government divided its offshore waters into 17 blocks and began auctioning off exploration licenses for the blocks in 2004, with further auctions in 2007 and 2009 (Business Wire, 2004; Pearson, 2007; Deloitte Petroleum Services, 2009). An additional 13 ultra-deep

offshore blocks were demarcated in 2011 and planned for auction. Among the companies that have won licenses are Repsol, Chevron, Anadarko, and Woodside Petroleum.

Due to its status as a flag of convenience, the country has the second-largest maritime registry in the world (behind Panama), with 3,500 vessels registered under its flag, accounting for 11% of ships worldwide. The Liberian economy grew by 6.3% in 2010. The main sectors of the economy are mining, agriculture, and forestry, while the main natural resources are iron ore, rubber, timber, diamonds, and gold.

Richly endowed with water, mineral resources, forests, and a climate favorable to agriculture, Liberia was a producer and exporter of basic products, primarily raw timber and rubber, and revived those sectors. Local manufacturing, mainly foreign-owned, had been small in scope. The country reached its Heavily Indebted Poor Countries (HIPC) initiative completion point in 2010, and nearly US\$5 billion of international debt was weaved. This has enabled Liberia to establish a sovereign credit rating and issue bonds. Liberia's Paris Club creditors agreed to cancel Liberia's debt as well. The International Monetary Fund (IMF) has completed the sixth review of Liberia's extended credit facility, bringing total disbursements to over US\$379 million.

The African Development Bank (ADB) approved a grant of US\$48 million in 2011 to finance economic governance and support for competitiveness. Rebuilding infrastructure and raising incomes will depend on generous financial and technical assistance from donor countries and foreign investment in key sectors, such as infrastructure and power generation. Based on the 2012 Social Institutions and Gender Index (SIGI), the Development Centre of the Organization for Economic Co-operation and Development (OECD) ranks Liberia 62 out of 86 non-OECD countries assessed (OECD, 2012). The maternal mortality rate from the 2008 census was 890 per 100,000 live births. The Human Development Index of Liberia was 0.300 in 2010. The country's latest overall ranking using the Ibrahim African Governance Index (IIAG) was 36 in 2011. Liberia's overall ranking in the African Governance Report (AGR) was 45 in 2011, while Liberia's ranking was 3.2 on Transparency International's 2011 Corruption Perception Index, placing Liberia at 91 out of 183 countries.

## **1.5. Development Priorities**

National and regional development priorities, objectives, and circumstances in relation to climate change impacts

Liberia is implementing the following national priority programmes to address climate change impacts in the country. Table 1-4 provides an overview of the policy and supporting programme Liberia is implementing to achieve its climate protection objectives.

Table 1-4 Priority climate change programmes and supporting policies

| Policy scale          | Policy   | Supporting Programmes  |
|-----------------------|--|--|
| National level        | Pro-poor Agenda for Prosperity and Development (PAPD)    | Agenda for Transformation (AFT) to integrate climate change considerations and build resilience into Liberia's national planning and budgeting processes   |
|                       |  | Ten Core Forest Harvesting practices   |
|                       |  | National Environmental Action Plan   |
|                       |  | National Forestry Reform Laws of 2006  |
|                       |  | Wildlife and Protected Area Management Law   |
|                       |  | Wetland and Climate Change Policies,   |
|                       |  | Environmental Statement Impact Assessment procedural guidelines and Fees regime  |
|                       |  | Noise and Asbestos regulations   |
|                       |  | Water quality guidelines and a dispersant policy   |
|                       | National Energy Policy                                   | Construction of a 35 MW biomass power plant  |
|                       | National Forest Policy of Liberia                        | Liberia's REDD+ strategy   |
|                       |  | Voluntary Partnership Agreement  |
|                       |  | Forest Plantation Development Strategy   |
| Climate Change Policy | National Adaptation Programme of Action (NAPA, 2008)     |  |
|                       | Nationally Determined Contributions                      |  |
|                       | Develop an integrated coastal zone management plan       |  |
| Regional level        | West African South-South Network on MRV and Transparency | South-South exchanges of knowledge, experiences, and good practices on appropriate institutional arrangements for MRV, support capacity development activities, and create awareness within national institutions. |
|                       | West Africa Power Pool                                   | Establish a reliable power grid for the region and a common electricity market.  |
|                       | SERVIR-West Africa                                       | Support national environmental management and disaster response.   |
|                       | Power Africa   | Undertake ambitious measures to rebuild its electricity infrastructure.  |

## 1.6. National Climate Change Governance

The institutional arrangement is an important step in addressing climate change impacts in Liberia through adaptive or mitigative actions. This involves having a functioning institutional structure to coordinate climate change initiatives across all sectors at the national and sub-

national levels. The structure reflects the roles various institutions play in the planning and implementing climate change in the country as envisaged in the National Climate Change Steering Committee (NCCSC).

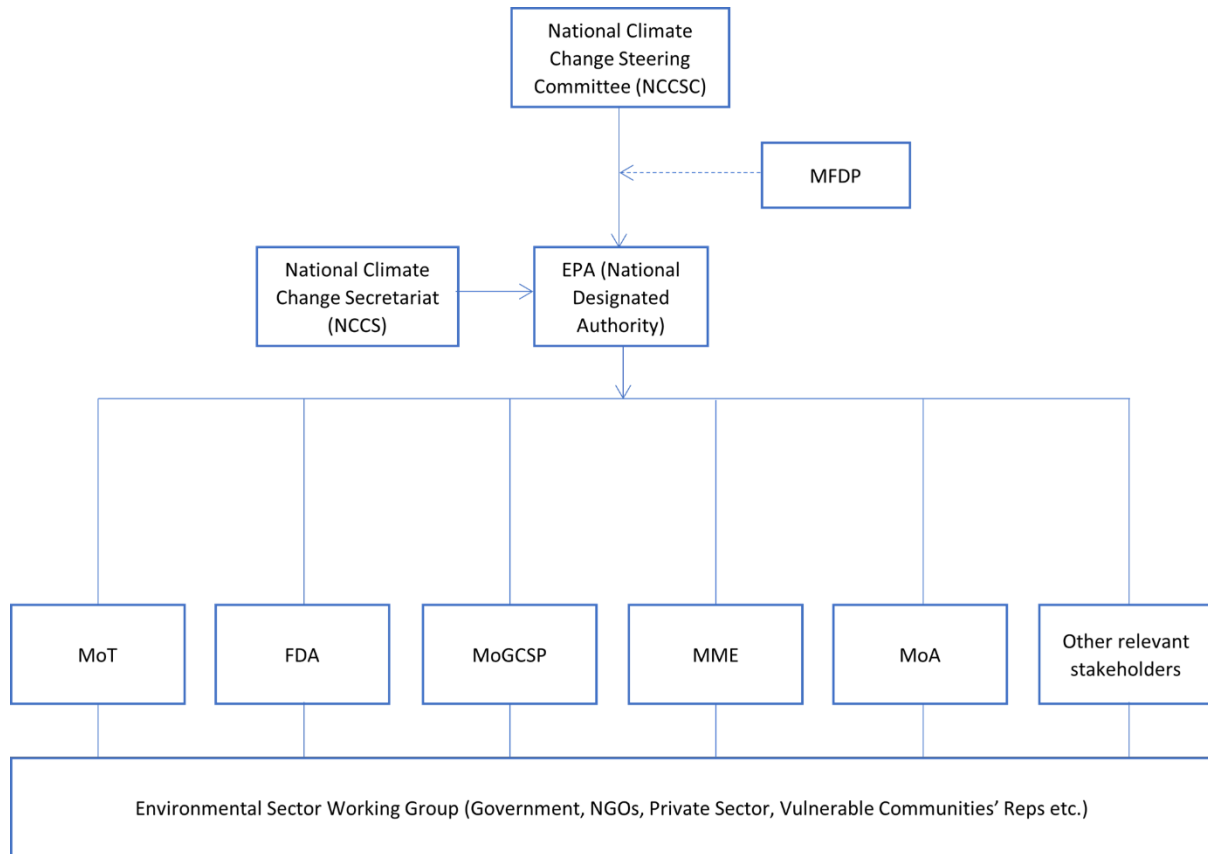


Figure 1.7 Institutional arrangement for climate change in Liberia

### 1.6.1. National Climate Change Steering Committee (NCCSC)

The NCCSC, as the overarching institutional structure, has the mandate for coordinating and supervising the implementation of the climate change policy. Established by the President in October 2010, the NCCSC comprises a 16-member high-level policy coordination and oversight committee and is responsible for overall climate change activities in Liberia. H.E. the President of the Republic of Liberia is an ex officio of the NCCSC. The NCCSC, chaired by the Minister of Finance and Development Planning, relies on expert advice from its technical working groups.

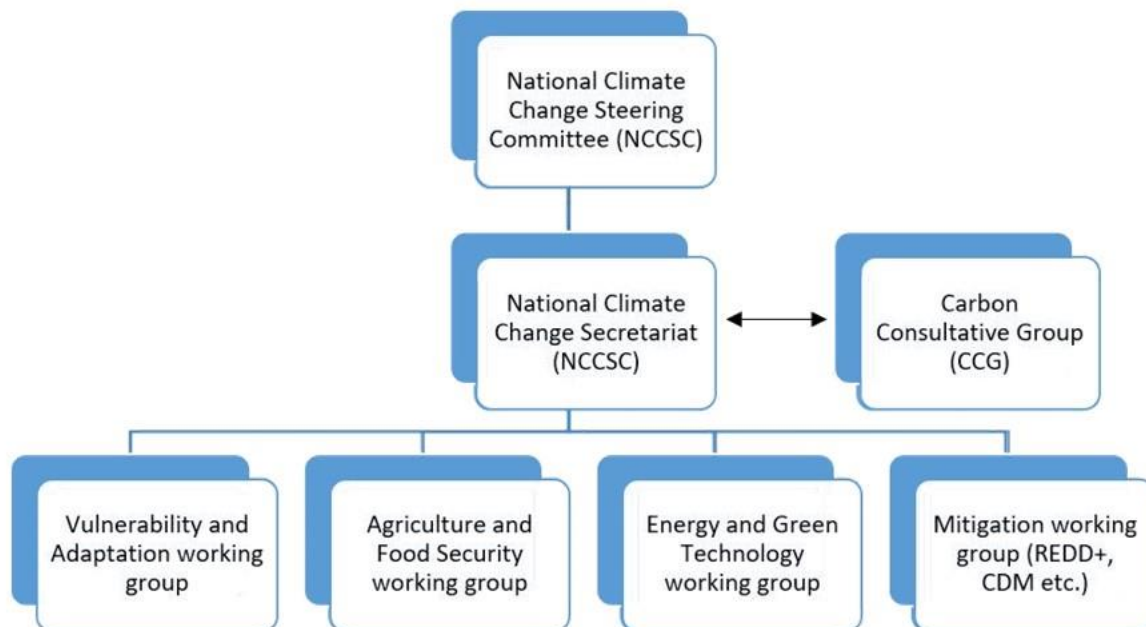


Figure 1.8 Organisational structure of the NCCSC

The primary roles of the NCCSC are as follows:

- Validate and secure government support for the implementation of the climate change policy.
- Supervise and provide leadership for the overall coordination and programs of activities, which accelerates the policy implementation;
- Strengthen the capacity of the National Secretariat (NCCS) to be responsible for carrying out and coordinating the daily operations of the NCCSC;
- Adopt measures and take appropriate actions necessary for achieving the mandate and goals of the policy;
- Report annually on progress made towards implementation of the climate change policy;
- To authorize and/or approve the solicitation of external assistance for activities under the policy; and
- Engage cabinet and the Legislature to secure adequate and accessible funding for the implementation of the policy.

The current composition of the NCCSC includes:

1. Minister of MFDP (Chair)
2. Executive Director of EPA (Co-Chair 1)
3. Managing Director of FDA (Co-Chair 2)
4. National Coordinator of NCCS (Secretary)
5. Minister of MME (Member)
6. Minister of MoGCSP (Member)

7. Minister of MoT (Member)
8. Minister of MoA (Member)
9. Chairman of Senate Committee on Lands, Mines, Energy, Natural Resources & Environment (Member)
10. Chairman of House Committee on Lands, Mines, Energy, Natural Resources & Environment (Member)
11. Chairman of NIC (Member)
12. Commissioner of LiMA (Member)
13. Country Manager of WBG (Member)
14. President of UL (Member)
15. Co-Chairman of NCSCL (Member)
16. Country Director of FFI (Member)

### 1.6.2. National Climate Change Secretariat (NCCS)

The NCCS serves as the operational arm of the NCCSC and provides coordination, monitoring, and evaluation. It is housed at the EPA to better coordinate climate change-related activities, access information, monitor key programs and activities, and promote inter-agency cooperation. The roles of the NCCS are to:

- Track progress on implementation and align international climate change programs and policies with the national climate change policy;
- Serve as liaison between the NCCSC, EPA, technical working groups, and other relevant national stakeholders on climate change;
- Engage in appropriate programs to strengthen national capacity in addressing climate change;
- Cooperate with international organizations, regional centers, institutions, and experts to develop action programs to mitigate and adapt to climate change in the region;
- Collate, document and store data, record and disseminate climate change information to the public and media; and
- Maintain full records of NCCSC proceedings, issue citations, serve as a clearing house on climate change and inform all stakeholders regularly on the policy implementation progress.

### 1.6.3. Environmental Protection Agency

The EPA is the Republic's regulatory Agency charged with the responsibility to ensure the sustainable use, management and protection of the environment and its natural resources. The Agency is also clothed with the statutory authority to integrate, harmonize, and monitor the implementation of the Policy Council's environmental policies and decisions by line ministries and agencies. Based on its mandate, the Agency will coordinate, along with other ministries and agencies, the full implementation of major activities under the policy. The EPA is also the Designated National Authority (DNA) for the United Nations Framework Convention on Climate Change (UNFCCC), the Global Environment Facility (GEF) Operational Focal Point



and the National Designated Authority (NDA) for the Green Climate Fund (GCF). and has the mandate as the national regulatory Agency for sustainable environmental management, including climate change.

As a key member of the NCCSC, the EPA will serve as the implementing Agency of the policy in consultation with the Ministry of Transport (MoT), and Forestry Development Authority (FDA), Ministry of Gender, Children and Social Protection (MoGCSP), Ministry of Mines and Energy (MoME), Ministry of Agriculture (MoA), Ministry of Finance and Development Planning (MFDP) and other relevant Sectoral institutions indicated in the Action Plan through the NCCSC.

#### 1.6.4. Environmental Sector Working Group

The Environmental Sector Working Group encompasses all sectors that are said to have a stake in the policy implementation, including but not limited to the sectors identified under Table 5 and civil societies, the private sector, and community representatives. The Environmental Sector Working Group will serve as a multi-stakeholder forum to exchange ideas, including updates on ongoing and planned climate change initiatives. Issues proposed to be discussed by the working group will focus broadly on issues directly related to the environment and natural resources management, such as forestry, agriculture, biodiversity conservation, land and marine resources. The working group will also address the cross-cutting aspects of climate change that impact livelihoods, food security, health, shelter, water, education, and gender. To facilitate the smooth operations of the working groups, a sub-working group focusing on the issues listed above should be created, as not every member of the working group will have the expertise or interest in all the issues falling within the purview of the working group.

Climate Change is a critical functionary of the Environmental Protection Agency (EPA) of Liberia to the developmental and sustainable goals of the nation. In so doing, the Agency seeks adaptive capacity in different sectors, such as human and institutional capacities, technology, infrastructure, economy, etc. The impact exerted by climate change is severe, hence impacted sectors identified as priority sectors through stakeholders' consultation and document review include but not limited to: Economic, Forestry and Wildlife, Agriculture, Coastal Area, Water, Fishery, Energy, Mining, Industry, Transport and Tourism; Infrastructure; Urbanization; and Social as well as Health and Settlement. These sectors have been impacted by climate change seriously over the past few decades with severe impact to developmental growth and financial paralysis and degradation the human and physical environment (EPA, 2018). For instance, in forest dependent communities, climate change induced extreme events are 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, lack of access to clean water, medicinal products, and fuel wood among other things, which they get from the forest. The disruption to the agricultural system resulting from climate change induced changes in patterns of rainfall. The temperature has direct consequences for the country, where more than 70% (Republic of Liberia 2010). The population engage in agriculture as their main livelihood activity, with rice

(which is the nation’s staple) covering a majority of the area under production (rubber and cassava coming in at second and third place respectively). Intense precipitation could affect the water infrastructure, which could also lead to an increase in the amount of runoff into rivers and lakes, washing sediment, nutrients, pollutants, trash, animal waste, and other materials into water supplies (EPA, 2018). The national climate change sector, is significantly improving under the EPA of Liberia.

### 1.6.5. National Communication Institutional Arrangements

The Liberia EPA is responsible for the implementation of international environment treaties. Within the EPA, the Climate Change Enabling Unit (CCEU) is responsible for preparing National Communications, Biennial Update Reports; and National Inventory Reports to the UNFCCC. The CCEU is also responsible for monitoring climate change-related activities/projects and their execution across the country. The Unit serves as Executing Agency for the preparation of the BUR and SNC. The project management team and reconstituted technical expert groups in consultation with other government ministries, agencies, and civil society organizations used the best available scientific approaches to prepare the SNC. The Climate Change Enabling Unit was responsible for the day to day running of the project.

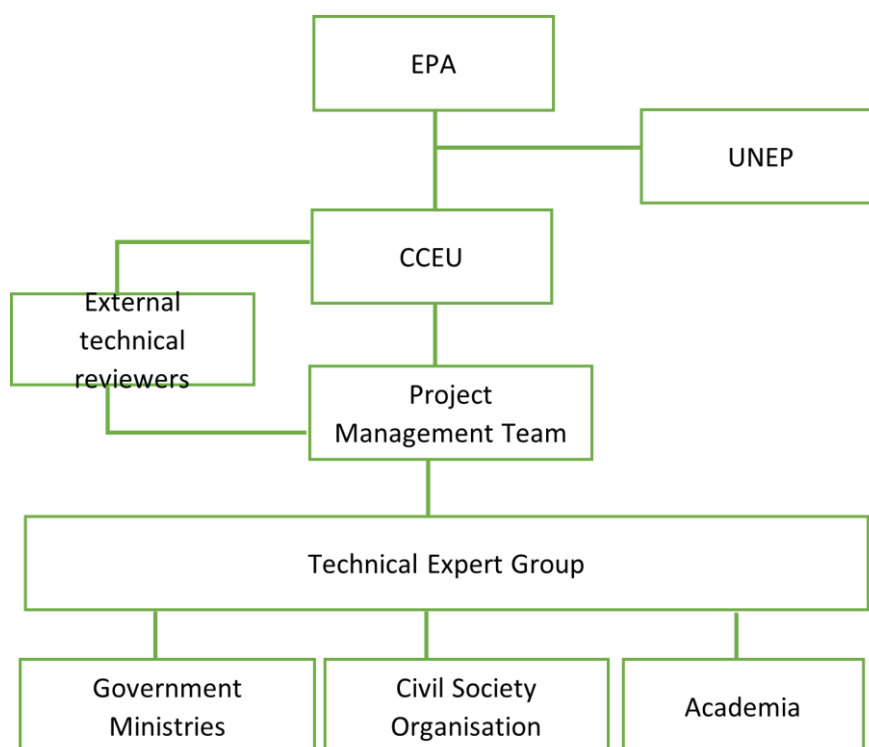


Figure 1.9 Institutional arrangement for the preparation of the SNC

## 1.7. Major Sectoral Policies and Programs

### 1.7.1. Energy

The objective of the National Energy Policy (NEP) of Liberia is “to ensure availability of modern energy services for all Liberians, in both the urban and rural areas.” According to NEP (2009), Access to modern energy services is recognized as one of the essential requirements for sustaining people’s livelihoods and propelling communities living at subsistence levels to higher levels of prosperity (GEA, 2008).

With appropriate technology, Liberia’s post-war social and economic development can be largely achieved with a sustainable energy supply from extensive use of increasingly efficient and decentralized renewable sources such as hydro, solar, wind, geothermal, biomass and dung. The provision of adequate, efficient, and affordable energy services is essential for reducing poverty, raising the standard of living, and enhancing sustainable development in post-war Liberia.

Table 1-5 below shows valuable statistics of the energy sector of Liberia. Liberia imports all its petroleum products, which make up not less than 95% of the primary energy supply of the country. The yearly volumetric import of petroleum products is approximately 175,000 metric tons (NEP, 2009). This consists predominantly of gasoline, diesel fuel, and to a lesser extent, jet fuel and kerosene. In 2004 it was estimated that over 95% of the population relied on firewood, charcoal, and palm oil for their energy needs (NEP, 2009).

Liberia has great potential for solar energy because it falls in the equatorial belt (which lies between latitudes 15°S and 15°N) and receives the second highest annual solar radiation on earth. Despite this enormous solar energy potential, not much has been done to generate electricity from solar. About 85% of the current annual energy consumption in the coastal regions is charcoal and 5% is wood fuel, while the hinterland uses 85% wood fuel and 5% charcoal. A relatively small quantity of LPG is being used for cooking by a very limited number of households and commercial establishments.

About 10% of the population of Liberia has access to electricity; 17% of urban areas have access to electricity, while about 3% in rural areas have access to electricity (CIA, 2013). About 4.5% of household Liberians use Liberia Electricity Corporation (LEC) power. About 4.9% use community generator, 4.4% have their own generator, 3.9% use vehicle batteries, and 0.8% uses other sources of electricity. About 81.3% have no access to electricity. LEC accounts for roughly 70.07 million kWh (CIA, 2018). To strengthen this sector, the Liberia Government is working with development partners undertaking ambitious steps to building its electricity infrastructural through Power Africa in Liberia (USAID, 2018). According to USAID, *Liberia* has one of the lowest *electricity* access rates in the world at less than 2%. The Mount Coffee hydropower plan that was rehabilitated to meet most of the electricity needs of central

Monrovia and its environs, is faced yet another problem rendering it incapable to meet its commitment of fully operational by 2018.

Table 1-5 Statistics for the energy sector in Liberia

| Indicator   | Value        | Source      |
|---|--------------|-------------|
| Energy sector share of national GDP (%)                 | 0.8          | CBL, 2008   |
| Annual petroleum product consumption (m <sup>3</sup> )  | 247,111      | LPRC, 2008  |
| Current power generation from the national grid         | 9.6 MW       | LEC, 2008   |
| Urban population with access to electricity (%)         | 10           | NEP, 2008   |
| Current electricity tariff                              | 0.3 US\$/kWh | LEC, 2008   |
| Rural areas electrified by the national grid (%)        | 0            | LEC, 2008   |
| Rural population with private access to electricity (%) | <2           | NEP, 2008   |
| Rural population with access to the national grid (%)   | 1            | LEC, 2008   |
| Annual charcoal consumption                             | ~36,500      | NACUL, 2005 |
| Annual firewood consumption (m <sup>3</sup> )           | 10.8 Million | CSET, 2004  |

Figure 1.10 shows the trend in consumption of petroleum products from 1991 to 2008 according to data collected and processed by the energy sector GHG emissions inventory team and the Liberia Petroleum Refining Corporation (LPRC) annual reports. While the supply patterns show a decline between 2000 and 2003, the graph illustrates a take-off and very rapid growth rate in the consumption of petroleum products between 2003 and 2008, with an almost linear curve of 14.5% during the last four years (2005–2008). In general, changes in consumption patterns reflect a low quality of data but also a probably erratic supply constraint.

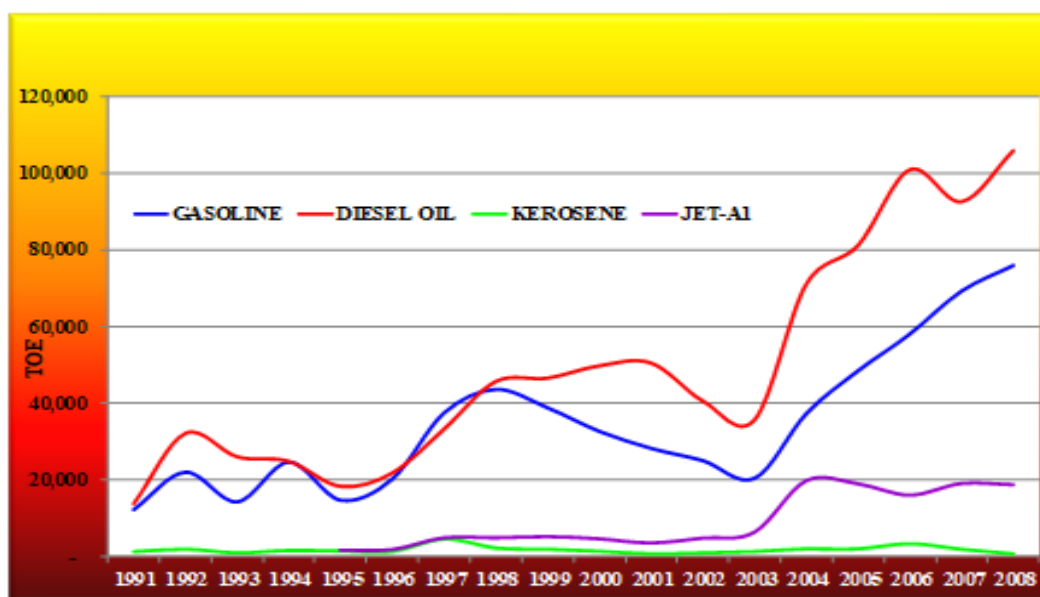


Figure 1.10 Current petroleum supply 1991-2008 by fuel type in Liberia (TOE)

Gasoline and diesel oil together represent almost 90% of the total petroleum products consumed since the 1980s. Table 6 shows the share of petroleum products consumed by transport, electricity generation, and other subsectors of the energy sector. Data from the 2000–2008 periods describe a similar situation.

Table 1-6 Estimating energy subsector shares of consumption of petroleum products (1986 and 1999)

| Subsectors               | 1999 (TOE) | 1986 (%) | 1999 (%) |
|--------------------------|------------|----------|----------|
| Transport                | 71,204     | 36       | 61.37    |
| Mining                   | 2,500      | 1.5      | 1.94     |
| Industrial               | 833        | 0.5      | 0.65     |
| Residential              | 833        | 1        | 0.65     |
| Commercial               | 3,000      | 1        | 2.33     |
| Government               | 2,333      | 2        | 1.81     |
| Electricity generation   | 37,568     | 56       | 29.18    |
| Agriculture and forestry | 2,667      | 2        | 2.07     |
| TOTAL                    | 120,938    | 100      | 100      |

The disaggregation in **Error! Reference source not found.** below shows the proportion of various products, particularly those used in the transport sector and public and private electricity generation (gasoline, diesel oil) and household lighting energy (kerosene). The yearly average consumption during the period 2000–2008 has been 127,665 TOE.

Table 1-7 Consumption of petroleum products by energy subsectors (1999 and 2008)

| Subsectors               | 1999 (TOE) | 2008 (TOE) |
|--------------------------|------------|------------|
| Transport                | 71,204     | 123,572    |
| Mining                   | 2,500      | 3,906      |
| Industrial               | 833        | 1,309      |
| Residential              | 833        | 1,309      |
| Commercial               | 3,000      | 4,692      |
| Government               | 2,333      | 3,645      |
| Electricity generation   | 37,568     | 58,755     |
| Agriculture and forestry | 2,667      | 4,168      |
| TOTAL                    | 120,938    | 201,356    |

Using the 2008 figures for petroleum product consumption among subsectors in Table 1.7 above, we can see that from a total of 201,356 TOE consumed, transport absorbed 123,572 TOE while electricity generation consumed 58,755 TOE. The remainder (<10%) was shared among the agriculture and forestry, mining, industrial, residential, government, and commercial subsectors. This assessment is also an indication that:

- The industrial and commercial sectors are still very weak.
- Agriculture and forestry are restarting very slowly.
- Households (residential sector) are still using traditional, more affordable fuels than petroleum products for most end-uses like lighting and cooking.

As the quantities of petroleum products consumed overall are relatively low, this may be an opportunity to introduce non-traditional, non-fossil fuels by implementing programs, projects, and policies to overcome barriers in adopting new end-use technologies. The very slow shift in the consumption share of petroleum products can estimate the quantities per end-use sectors. This picture can considerably change if mining and industry sectors start the significant economic activity, thus distorting which calculations are made.

#### 1.7.1.1. Electricity

A national legislature created the Liberia Electricity Corporation (LEC) on July 12 1973, as a power parastatal with a mandate to plan, generate, transmit, distribute, and sell electricity at reasonable rates. In October 1976, the LEC began operation. Of the total petroleum products available, electricity generation consumed 56% in 1986 (pre-war) and 29.18% in 1999. Before the war, Liberia's total installed generation capacity was 412.7 MW, of which the LEC owned 195 MW (182 MW in Monrovia and 13 MW in rural areas). The Mount Coffee Hydroelectric Power Plant accounted for about 64MW of electric power out of a total installed capacity of 22

182 MW generated by the LEC Monrovia grid. The hydroelectric power plant in Harbel, Margibi County, operated by the Firestone Natural Rubber Company, produces 4MW. As of 2020, the installed generation capacity of LEC is 126MW. The private sector produces the rest.

The electricity-generating capacity of LEC in 2009 was based on 9.6-MW diesel generators, 80 km of transmission and distribution network, with about 1,000 street lights and over 2,500 customers in Monrovia. The GOL signed a 25-year Power Purchase Agreement (PPA) with Buchanan Renewable Energies (BRE), which was expected to construct a 35 MW biomass power plant to supply electricity for Monrovia and its surrounding communities. The power plant would be fueled with wood chips from Liberian rubber trees beyond their useful life, and that must be removed to make way for new, productive rubber trees. The electricity provided from renewable sources would be sold at a much lower price than current electricity prices and transmitted by the LEC's grid. There is about 30 km of a distribution network in Liberia, compared with 400 km of transmission lines and 860 km of distribution network before the 1989 war. However, the average power demand for 743 LEC customers in Monrovia during June 2001 was rated at 1.6 MW compared to 199.3 MW for a little over 3,000 Monrovia customers before the conflict. Liberia's current generating capacity is 151.000 kW (CIA, 2016).

### 1.7.2. Transport

The conflict in Liberia has reduced the capacity of the transportation sector. The road network is in a devastating condition with very limited road construction, which logging companies largely funded during the 15-year civil war. Only 6.2% of the total network of 10,600 km is paved. Most roads are impassable during the rainy season from April to October (Figure 8). Vehicle statistics for 2001 to 2004 from the Bureau of Land Transport of the Ministry of Transport (MOT) indicate that the total number of vehicles (sedans, Jeeps, trailers, trucks, and buses) plying the streets and roads of Liberia in 2001 was 8,225. The number of vehicles declined to 5,665 in 2002 and 5,660 in 2003 due to the civil war. In 2005 the number of vehicles increased dramatically to 10,150. Most of these vehicles use low-grade diesel and mixed petroleum and have a high potential to emit large GHG quantities.



Figure 1.11 Sample of good and bad roads in Liberia



Figure 1.12 Deserted train tracks of the former Bong Mines Company

Liberia has only one international airport, the Roberts International Airport (RIA), located 45 km south of the nation's capital of Monrovia. There are a few gravel-surfaced runways and paved runways in the country (Figure 1.11). The civil war paralyzed the 490 km of rail lines in Liberia. Currently, only the Bong Mines rails are functional after being rehabilitated for private and informal rail transport services from Monrovia to the old Bong Mining premises in Lower Bong County. The railway network was not developed to transport passengers within and outside the country but to transport iron ore from the Bong and LAMCO mines to Monrovia and Buchanan's ports. This rail network has not been maintained since iron ore mining companies ceased operation due to civil unrest, thus exposing these rails to looting and destruction.



In the 1980s, four seaports (Buchanan, Greenville, Harper, and Freeport of Monrovia) handled approximately 200,000 tons of general cargo and 400,000 tons of imported petroleum products per year. All the seaports were used for timber export, while Buchanan and Freeport of Monrovia were used to export iron ore, cocoa, coffee, and rubber. The three ports of Monrovia, Greenville, and Harper are generally engaged in rubber and logs' transshipment (timber). Rubber is also exported from the ports of Harper and Monrovia. In the Freeport of Monrovia harbor, some sunken vessels and boats cause extensive pollution around the fuel storage installations. Liberia currently has the world's second-largest fleet in shipping cargo. This is mainly a result of Liberia's status as an "open registry" or "flag of convenience." In 2001 a total of 1,566 ships with a combined gross tonnage of about 52 million were registered in Liberia, and the majority were foreign-owned. Annual revenues from shipping were reported to be more than US\$20 million, which is lower than fees charged by other registries. The country's six major rivers are not navigable by boats or large canoes due to the many stems and debris found in these rivers. Rivers are not frequently used as a means of transportation in Liberia.

### 1.7.3. Agriculture

The agriculture system of Liberia is 80% subsistence involving shifting cultivation. Major food crops produced are rice, a primary staple food, with some of it imported (Figure 10); cassava (a secondary staple), potatoes, palm for oil, coconut, kola nuts, fruits, etc. Liberia's Ministry of Gender and Development (MOGD) highlighted in 2009 that women provide about 80% of the country's agricultural labor force. According to estimates (UNFAO, 2003), the subsistence food production system's weakness, less than 10% of the 4.6 million ha of arable land is cultivated. Also affected by the war was the production of major cash crops such as coconut, coffee, rubber, and timber. This situation has had a serious impact on the economy of Liberia.

The major agricultural exports of Liberia (cocoa, rubber, and coffee) were also impacted by the war, further damaging efforts to ensure food security in urban and rural Liberia. When fully utilized, the agricultural sector is one of those areas from which the nation stands to benefit immensely in self-reliance. Liberia especially lags in the production of its staple food – rice. In addition to the lack of basic tools and seeds for food and non-food crops, the inactivity of the Liberia Produce Marketing Corporation (LPMC), the sole buyer of wholesale agricultural products, has further weakened the food security system of Liberia. The rice paddy production in 2001 was estimated at 219,040 metric tons. This estimate is 73% of its pre-war (1988) level of 298,760 metric tons. The current level of paddy production was achieved, with 83% of agricultural households reporting rice growing during 2001. The average paddy production per rice farm and rice household were estimated in 2001 at 1.52 metric tons and 1.75 metric tons, respectively.

In 2001, the land area cultivated for paddy production was estimated at 170,480 ha with an average yield of 1,285 kg/ha. This 2001 cultivated land estimate was about 28% below the 1988 pre-war level of 235,760 ha. Cassava production in 2001 was estimated at 373,390 metric tons, which was about 91% of its 1998 level of 410,030 metric tons. The average production of fresh cassava per cassava farm and cassava household was estimated at 3.76 metric tons and 4.12 metric tons, respectively. There were few company plantations and private farms that produced cash crops and livestock. The country's biggest plantation is the Firestone Rubber Plantation, the world's leading rubber producer in the 1960s. Due to the high cost of rehabilitating cocoa and coffee farms affected by the war, 61% of the cocoa farms and 71% of the coffee farms have not been rehabilitated. This has hampered cocoa and coffee production. Between 1998 and 2001, the quantity of cocoa exported totaled 7,457.65 metric tons, while that of coffee was 2,110.80 metric tons. Both the 1998 and 2001 levels are far lower than the 1989 pre-war levels.

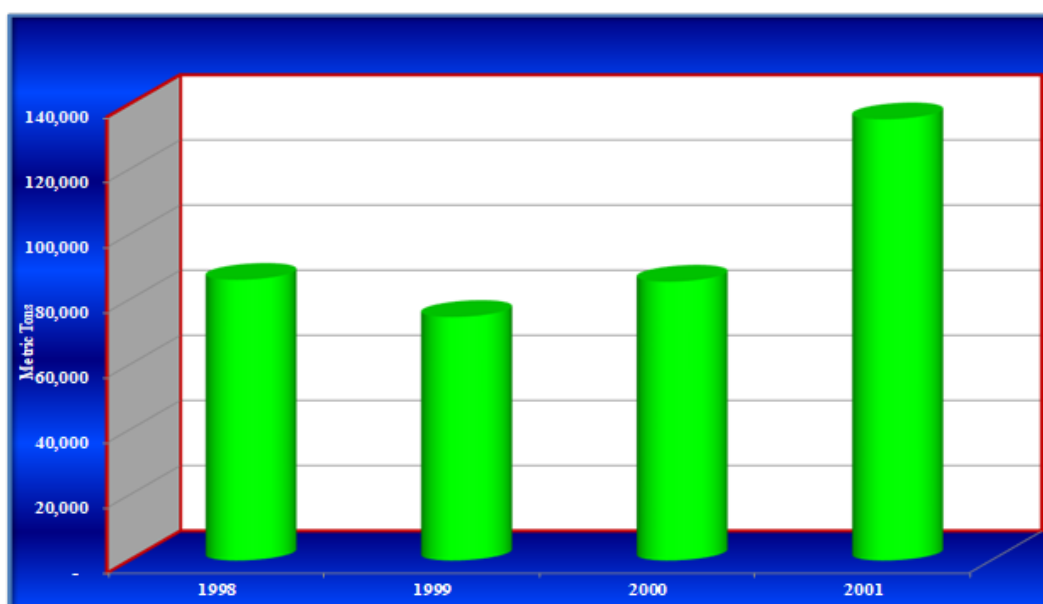


Figure 1.13 Quantity of rice imported in Liberia between 1998 and 2001

Of recent report in 2017, agriculture still is the primary livelihood for more than 60% of Liberia's population and provides sustenance for many households engaging in cassava, rubber, rice, oil palm, cocoa, or sugarcane production. More farmers engage in cassava production than any other crop. Notwithstanding, overall agricultural productivity is low, resulting in Liberia importing more than 80% of its rice. Cassava and rice are the primary staple food crops. The main cash crops and foreign-exchange earners are rubber, cocoa, timber, and palm oil.

According to the Central Bank of Liberia report, rubber is one of the dominant generators of state revenues, accounting for 17.5 per cent of the total export receipts in 2017. Commercial rubber farms employ an estimated 30,000 people, and up to 60,000 smallholder households are involved in growing rubber trees. Recently, there has been considerable interest from both smallholders and large investors in expanding export production. However, uncertainty about land tenure is a significant challenge for potential oil palm farmers and investors. Stakeholders

in the oil palm sector include smallholder farmer cooperatives, individual farmers, large multinational corporations and concessionaires, and individuals playing various intermediation roles and support services. Another obstacle to investment in the sector is the lack of capital and professional expertise to increase farm productivity (CBL, 2017).

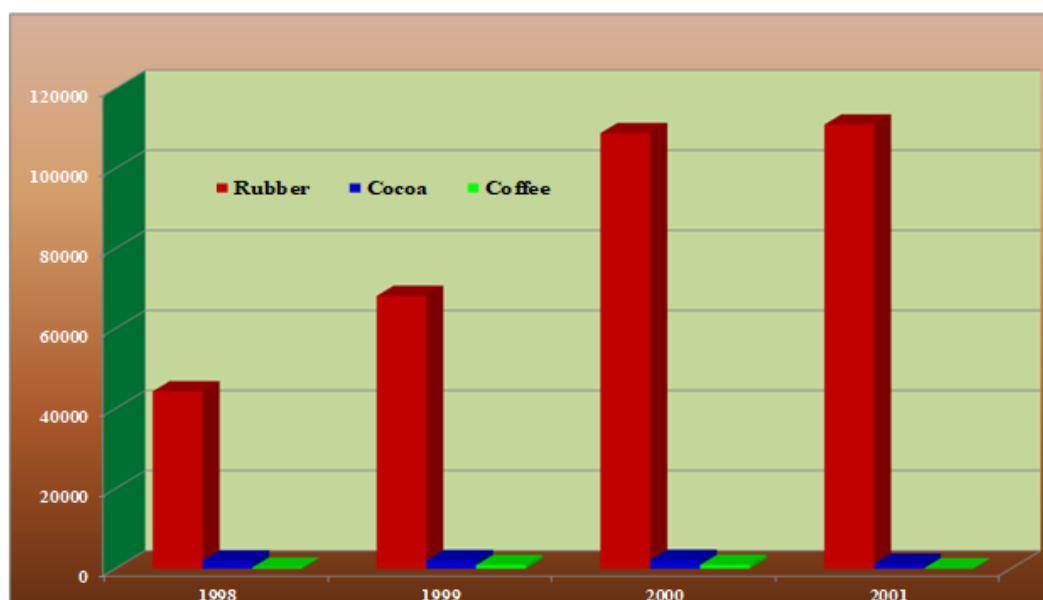


Figure 1.14 Quantity of rubber, cocoa and coffee exported from Liberia between 1998 and 2001

Table 1-8 Market size as determined from the Central Bank of Liberia's reports (in millions of USD)

| Export parameters              | 2015     | 2016     | 2017     | 2018 (Estimated) |
|--------------------------------|----------|----------|----------|------------------|
| Total Local Production         | 896.40   | 882.10   | 904.10   | 939.40           |
| Total Exports                  | 283.30   | 279.30   | 388.80   | unknown          |
| Total Imports                  | 1,551.40 | 1,201.20 | 1,018.20 | unknown          |
| Imports from the United States | 136.60   | 87.90    | 81.60    | unknown          |
| Total Market Size              | 2,164.50 | 1,804.00 | 1,533.50 | unknown          |

#### 1.7.4. Fisheries and Livestock

The fisheries, which are a component of agriculture, are underdeveloped in Liberia. The continental shelf of Liberia has an area of 14,894 km<sup>2</sup> and produces annually 7,616 metric tons of fish and 126 metric tons of mollusks and crustaceans. Livestock production is very limited in Liberia due to the heavy cost associated with such ventures. There are, however, private livestock farms in Liberia where domestic animals such as cattle, goats, pigs, chickens, ducks, and other livestock are raised. Due to the country's underdevelopment of the fisheries and livestock sectors, livestock and fish are imported. The total quantity of fish imported between the period 1998 to 2001 was 6,776 (1998), 10,799 (1999), 7,243 (2000) and 7,498 (2001) metric

tons, respectively (**Error! Reference source not found.** 12). The total quantity of livestock imported for slaughter during the same period was 6,000 metric tons of cattle, 1,136 metric tons of goats, 36 metric tons of pigs, and 619 metric tons of sheep (Figure 13). However, recently, the National Fisheries and Aquaculture Authority (NaFAA), under the current leadership of the Government of Liberia, has some success story regarding the industry, such as the arrival of fisheries patrol vessels from wales which will result in regular patrol by the Coast Guard across the nine coastal counties of Liberia and lead to increase revenue collection from the fisheries sector and at the same time reduce illegal, unreported and unregulated fishing particularly in the Southeastern part of Liberia which is hosting five of the coastal counties. Hence, NaFAA has resulted in collecting more resources from the fisheries sector (NAFAA, 2018).

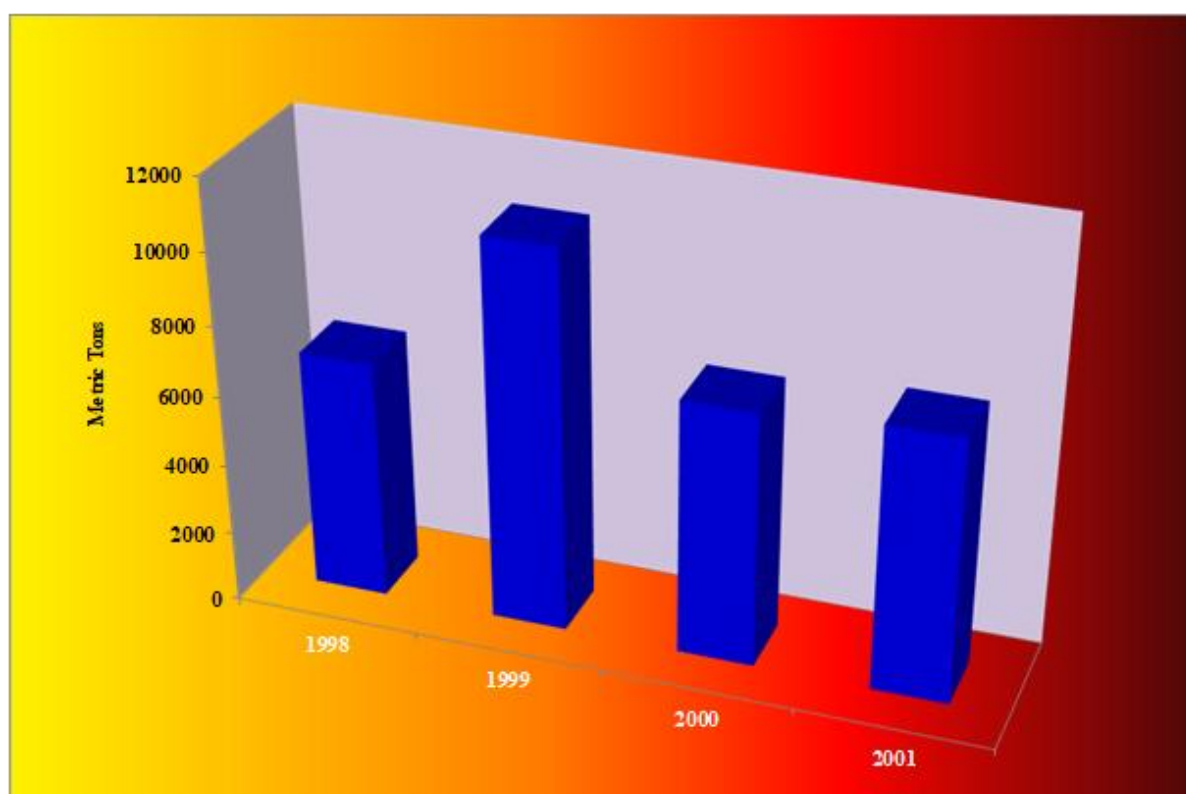


Figure 1.15 Quantity of fish imported between 1998 and 2001

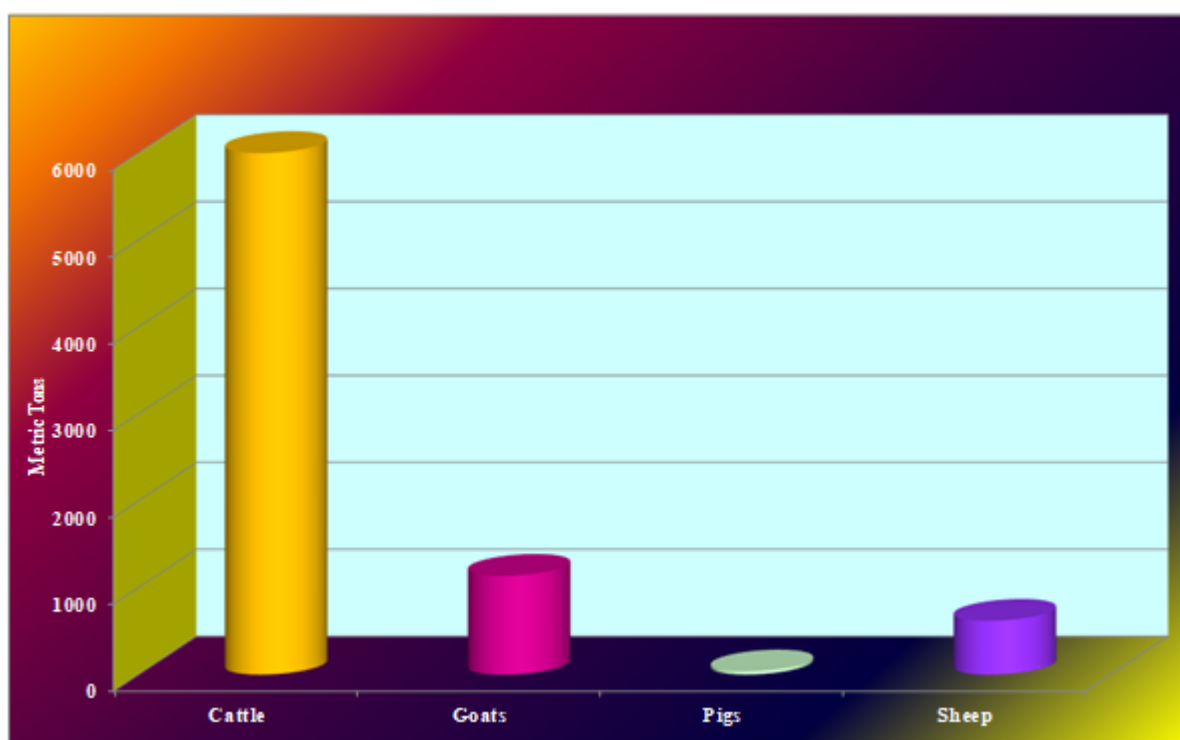


Figure 1.16 Quantity and types of livestock imported into Liberia between 1998 and 2001

### 1.7.5. Information, Culture and Tourism

The Ministry of Information, Culture, and Tourism (MICAT) was established in 1965 by an act of the Legislature granted the authority to direct and supervise all aspects of internal and external information programs about Liberia. The successful implementation of MICAT's mandate has increased the number of newspapers from less than five in pre-war Liberia to fifteen in 2005. There are also community radios in each of the fifteen counties, which help to relay programs from the Monrovia-based radio stations, especially those stations that air only on frequency modulation (FM). Television stations have also increased from two in 2003 to four in 2005. These mass-media institutions' existence creates opportunities and a wide range of enabling environments for development-oriented Information, Education and Communication (IEC)-advocacy in rural and urban localities. MICAT also monitors, guides, and catalyzes promoting cultural activities in Liberia. It is empowered to control, regulate, and coordinate the annual registration of information concerning video centers, clubs, cinemas, culture troupes, arts and crafts, antiquities, and cultural and tourism institutions such as hotels and other activities.

The major institutions that help train, guide, develop, and protect the Liberian cultural heritage are the National Museum and the national cultural centers (Kendeja in Montserrado and Basao Cultural Village in Bomi). Located in Monrovia, the National Museum of Liberia was the archive of the country's cultural artifacts from all parts of Liberia. However, the 5,000 artifacts in the museum collection in 1989 were reduced to about 100 by the end 2005. Efforts by

cultural authorities to recollect looted artifacts have not been successful to date; most of the works were sold or damaged. Today local crafts and artisanal objects are stored and exhibited at the museum. The National Cultural Center (NCC) at Kendeja was established in 1964 to promote Liberia's cultural heritage. In collaboration with the Basao Cultural Village, the NCC has trained cultural artists, craftsmen, dancers, and singers. The centers also organize performing programs for Liberian guests and major celebrations.

The MICAT designs policies aimed at promoting the tourism sector of the Liberian economy. It also coordinates, supervises, and controls tourism programs in the 50 government-recognized tourism institutions. These include hotels, guest houses, beaches, motels, restaurants, and islands (mostly located in or around Monrovia). The government-owned tourism institutions, particularly Hotels Africa and Ducor and Providence Island, have yet to be resuscitated to their pre-war status. However, two of the damaged structures on Providence Island have been renovated. Both the Amphibian and performing theatres are now open to tourists. In fact, about 25 tourists visited the island for sight-seeing in 2005.

Tourism is a critical and important mean through which most countries generate capital for a lifeline. Liberia's tourism industry is underdeveloped, in part because of the country's insufficient transportation networks, electricity connectivity, telecommunications systems, and accommodation facilities. Only a few attractions have facilities that cater to international visitors. The infrastructure deficit is one of the critical factors discouraging entrepreneurs from investing in this sector. As infrastructure improvements are undertaken, prospects are emerging for the sector to contribute to the economy. Liberia is endowed with rich natural resources that provide a potential tourism and hospitality market, including forests, rivers, seas, waterfalls, hills, mountains, lagoons, lakes, wetlands, and deltas.

The country's biodiversity, landscape, and beaches are natural attractions for tourists and international visitors seeking new adventures. As a result of these challenges, the most important tourist sites are underused as the Sapo National Forest, the beaches at Robertsport along the Atlantic Ocean, the Kpatawee Waterfalls in central Liberia, Lake Piso Nimba Natural Reserve, Providence Island, among others.

#### 1.7.6. Industry

Industries in Liberia are privately owned except for a few government manufacturing companies. Since Liberia's independence in 1847, foreign investors, especially Americans and Asians, have monopolized businesses and industries and dominate the industrial sector of the economy. Industrial Production in the country is on a low scale and normally of poor quality and is unable to compete on the international market. There are a few factories in Liberia, such as Monrovia Breweries Inc, the United States Trading Company–Coca Cola (USTC) factory, CEMENCO, NICOM distillery, etc., that produce commodities for the Liberian market. These factories started production as far back as the early 1970s. The manufacturing industries in Liberia do not have the capacity to produce motor vehicles, simple machines, or high

technology machines such as computers, electronic devices, etc. Goods produced in Liberian industries are food stuff, alcoholic beverages, vegetable drinks, furniture, household utensils, nails, zinc, etc.

### 1.7.7. Land Use and Forestry

Liberia has one of the world's oldest forests, filled with endangered animal and tree species. Liberia's natural forest covers 4.8 million ha, with disturbed productive (unprotected productive forest) forest constituting 45% of the total ha available. An analysis of land use in 2001 shows that 3.95% of Liberia's land was arable, while another 2.28% was used for permanent crops (Figure 1.17).

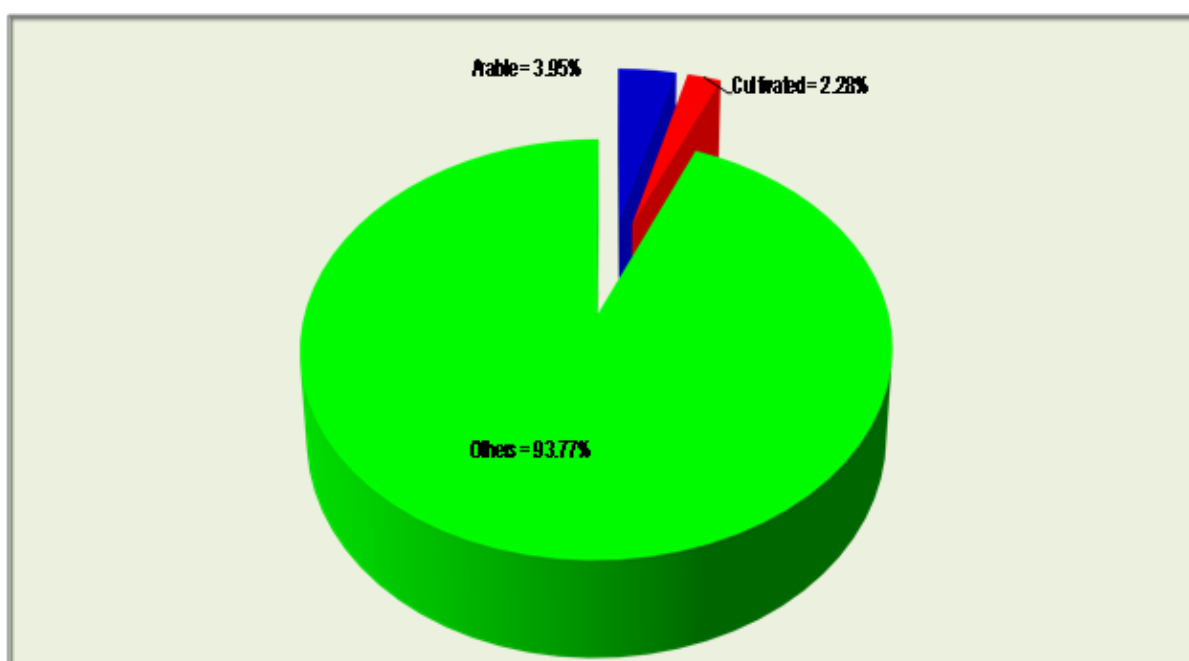


Figure 1.17 Distribution of land use in Liberia (2001)

The reforestation efforts initiated prior to the 14-year civil conflict have produced an artificial forest that occupies 10,158 ha in Liberia. The largest of these man-made forests is the Bomi Hills in Bomi County with 3,521 ha. This is followed by the Trial Industrial Plantation and the Foya Afforestation with 1,416 ha each. The purpose of the artificial forest is to complement the natural forest that is being depleted by the rampant illegal logging and farming activities in the country. The level of deforestation emanating from logging intensified during the period 1997–2002. For example, in 1998 the 26 logging companies operating in Liberia produced 157,134 m<sup>3</sup> of logs.

An analysis of port operation and market in 1998 shows that the Freeport of Monrovia shipped 39.3% (31,707 m<sup>3</sup>) of the log consignment, while the Port of Greenville exported 34.7 % (27,960 m<sup>3</sup>). The harvesting and exportation of logs by month shows a sharp decline during the peak of the rainy season (July–December), when most of the roads are impassible in the

hinterland where most of the timber harvesting takes place. The logging industry generates enormous revenue in Liberia. For example, in 1998 the total revenue received was about US\$3 million. The high level of revenue from logging, particularly in the past 14 years, increases the probability of depletion of the forest in Liberia.

Charcoal made of wood is used as fuel for cooking and heating tea and bathwater in households, restaurants, and other facilities. Close to 95% of the 1.5 million people in Monrovia use charcoal for cooking and heating, particularly following public electricity outages from 1990 to the present. The widespread use of charcoal is thus a major accelerator of the deforestation that Liberia is experiencing. The illicit destruction of forest for charcoal production has even extended into rubber plantations, where charcoal miners illegally destroy rubber trees to make charcoal. As a consequence of high demand, charcoal's price increased 6,000% between 1989 and 2005, from LD\$2.50 to LD\$150. The huge price increase prompted the rampant destruction of the forest around Monrovia and nearby counties. Another form of forest destruction for energy generation is the use of firewood for cooking and heating. Outside of Monrovia, some 70–80% of the population in urban centers and large rural localities use firewood. In the rest of Liberia, i.e., the rural areas, towns, and villages, firewood for cooking are universal.

#### 1.7.8. Biodiversity (Flora and Fauna)

Current estimates of flora and fauna show that there are over 2,000 species of flowering plants in Liberia, of which 240 are valuable timber trees. The fauna also consists of 125 species of reptiles and other amphibians and more than 1000 insect species. There are multiple species of birds and mammals such as hawks, eagles, rats, monkeys, leopards, elephants, etc. Liberia's southeastern region has the largest forest park: the Krahn-Bassa National Forest, which covers an area of 513,962 ha or 37.1% of the area of all the national parks combined. The overall size of the ten national forest parks in Liberia in the southeast is 66,969 ha. Of these ten parks, five are in Lofa County, two in Grand Gedeh County and three in Nimba County. The largest of the national forest and nature reserves in Liberia is the Lofa/Mano Forest, with 37.3% (208,120 ha) of the forestland, followed by Cestos/Sehnwen, 25.9% (144,800 ha), and the Sapo Forest, 23.4% (130,747 ha). The Lofa/ Mano Forest is in Lofa County, while the Cestos/ Sehnwen and the Sapo Parks are located in Sinoe and Rivercess counties.

#### 1.7.9. Waste

Before the 1989 civil crisis, the Liberia Water and Sewage Corporation (LWSC) and the Monrovia City Corporation (MCC) were responsible for managing the disposal of household and material waste within major settlements in Liberia. The period 1989–2005 has been marked by a poor waste-management system in Liberia. There was no institutional mechanism to ensure the proper disposal of rubbish and human feces in both urban and rural localities. As of 2019, waste management remains a challenge to the Monrovia City Corporation (MCC) and Paynesville City Corporation (PCC) and its environs (Figure 1.18). The destruction of the water



plant and electricity facilities has increased the improper waste disposal experienced in Liberia, particularly in Monrovia and other urban centers.

The most common method of disposing of the waste is throwing it on private and public heaps and in freshwater bodies, which affects the environment and human and animal health. Some of the rubbishes (metallic substances, chemical fluids, plastic bags, and other indissoluble substances) are difficult to dissolve or rot, thereby posing serious environmental and human/animal health problems. In addition to household rubbish disposal, industrial waste management is a problem in Liberia. This is because of the lack of institutional mechanisms to strengthen regulation and monitor industrial waste products' discharge into the ocean and freshwater bodies and on the land, common practices that require rigorous monitoring. However, efforts are being made to address the improper disposal of waste.



Figure 1.18 Solid waste disposal site in Monrovia

#### 1.7.10. Mining

Liberia has rich mineral deposits. Iron, gold, and diamonds are the leading export commodities for Liberia. The minerals are mainly exported in a raw or semi-finished form. In addition to large iron ore deposits, there are substantial diamond and gold deposits and indications of manganese, bauxite, uranium, zinc, and lead deposits. Diamond deposits, primarily exploited via alluvial and artisanal diamond mining, are widespread in most parts of Liberia. The government issues Kimberly Process (KP) Origin Certificates, which enable the legal export of rough diamonds to other KP member countries. The iron ore industry contributed significantly to the Liberian economy and accounted for 16% of total export earnings in 2017.

Several large-scale international companies hold Mineral Development Agreements (MDAs) for iron ore mining operations in Liberia, but the largest such operations are owned by

ArcelorMittal, which has invested heavily into the sector. This world's leading steel and mining company has iron ore and metallurgical coal reserves in the Mount Nimba range in northern Liberia. Their multi-billion-dollar mineral investments include building railways, roads, ports, electrical plants, housing facilities for workers, and other critical physical infrastructure. Low global iron ore prices have dropped on the global market reduced which has impacted Liberia's Production and exports over the last few years as multinational iron ore companies worldwide scaled down their operations (export.gov, 2019).

Table 8 shows the total gold production in Liberia, including exports volume and total export values (million USD) between 2015 and 2017. From the table, gold production has been on the increase since 2015. In 2016, there was an approximate 1500% increase in the amount of gold produced in Liberia. This value also contributed to an increase in revenue during this time. Table 9 provides the quantity of iron ore produced between 2015 and 2017. **Error! Reference source not found.** 1.11 shows the total production of diamonds in Liberia, including export between 2015 and 2017.

Table 1-9 Gold production

| <b>Gold</b>                       | <b>2015</b> | <b>2016+</b> | <b>2017*</b> |
|-----------------------------------|-------------|--------------|--------------|
| Total Local Production (Ounce)    | 9,466       | 151,224      | 204,355      |
| Total Exports Volume (000/Ounce)  | 29.1        | 129.6        | 202.2        |
| Total Exports Value (Million USD) | 26.6        | 116.4        | 187.5        |

Table 1-10 Iron Ore production and exports (metric tons and constant prices in millions USD)

| <b>Iron Ore</b>                   | <b>2015</b> | <b>2016+</b> | <b>2017*</b> |
|-----------------------------------|-------------|--------------|--------------|
| Total Local Production (Mt.)      | 4,529,531   | 1,405,195    | 1,934,193    |
| Total Exports Volume (000/Mt)     | 5,553       | 1,405.20     | 2,024.40     |
| Total Exports Value (Million USD) | 141.8       | 48.2         | 63.3         |

Table 1-11 Diamond production and exports (metric tons and constant prices in millions USD)

| <b>Diamond</b>                    | <b>2015</b> | <b>2016+</b> | <b>2017*</b> |
|-----------------------------------|-------------|--------------|--------------|
| Total Local Production (Carat)    | 65,996      | 60,367       | 59,951       |
| Total Exports Volume (000/Crt)    | 61.1        | 60.9         | 58.6         |
| Total Exports Value (Million USD) | 26.8        | 28.7         | 32.8         |

### 1.7.11. Health

Since the outbreak of the deadly Ebola epidemic, Liberia's healthcare system was devastated and remained a grave challenge. However, the current administration claims an upward trend of progress. The current GDP in healthcare is approximately 10%. Physician density is about 0.04 to every 1000 population; 0.8 bed to every 1000 population (CIA, 2018). Liberia's healthcare system is a challenge, but significant progress has been made in the post-Ebola era (Health data, 2017; WHO, 2018). By comparison, it is ranked 25 on the world scale.

### 1.7.12. Education

Liberia's educational system is faced with many challenges, such as poor infrastructure, poor management, brain drain, and low budgetary support remains stagnated in such condition. 3.8% of the country's GDP is allotted. There is a need for more funding for the educational system, especially when the government has declared free tuition for public colleges and universities for all undergraduates. On the tertiary educational levels, scientific and technical research is an integral part of learning, but that essential component of learning is extremely limited if not nonexistence at public colleges. The University of Liberia, William V.S. Tubman University in Harper, Maryland County, Liberia, and other public colleges should be adequately funded for research capacity.

### 1.7.13. Telecommunications

Telephone services in Liberia are relatively stable with coverage in most part, particularly in Monrovia. There are two privately owned telephones service providers; orange Liberia and MTN Liberia, while Liberia Telecommunication Corporation (LIBTELCO) is a public service provider. It has been efficient and effective of communication other than landlines which are almost obsolete.

### 1.7.14. Disaster Management

The National Disaster Management Agency (NDMA) of Liberia was established in 2017 to management disasters (NDMA, 2018). According to the Agency, disaster loss is on the rise with grave consequences for individuals' survival, dignity, and livelihood, particularly the poor. Risks are compounded by an increasing vulnerability related to climate variabilities, and among others, that provoke disaster. Climate change has a direct impact on weathering change in Liberia during the rainy season. The frequency and intensity of rain have increased significantly in the past fifteen years, thereby causing heavy floods and disasters to Liberia's most vulnerable communities – farming, transports, and other activities are interrupted (Koffa, 2018). An early warning system is one of the mechanisms used to forecast especially weather conditions. Flooding is now a severe annual event in most communities in Liberia that is associated with climate change.



Figure 1.19 Floods in parts of Monrovia

## 2. National Greenhouse Gas Inventory

### 2.1. Overview of National greenhouse gas inventory

The Greenhouse Gas (GHG) emission estimates have been compiled based on the Intergovernmental Panel methodologies on Climate Change (IPCC Guidelines for National Greenhouse Gas Inventories IPCC 2006). The use of the 2006 IPCC guidelines was to enhance the quality of the GHG emission estimates on, Transparency, Completeness, Consistency, Comparability and Accuracy (TCCCA) over the 1990-2016 period. The inventory estimates cover direct anthropogenic GHG emissions by sources and removals by sinks and include CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs and PFCs. The emissions/removals from the following four economic sectors have been estimated; following the 2006 IPCC guidelines

- Energy
- Industrial processes and product use (IPPU)
- Agriculture, Forestry, and Other Land Use (AFOLU)
- Waste

The GHG inventory estimates are expressed in mass units and carbon dioxide equivalents (CO<sub>2</sub>e) terms using the 100-year Global Warming Potentials (GWPs) contained in the 1995 IPCC Second Assessment Report (IPCC 1996).

### 2.2. Institutional arrangements for the GHG inventory

The Liberia EPA is responsible for preparing the national gas inventory. EPA outsourced the preparation of the two previous inventories but decided to produce current inventory in-house, under the BUR1 and SNC. Despite the decision to prepare the inventory in-house, it is important to highlight that the GHG inventory preparation is a challenge to Liberia due to the severe lack of resources and human capacities. Within the EPA, the Environmental Assessment Unit serves as the inventory compiler. The Unit accordingly works closely with four sector working groups and consultants to plan, prepare and report the inventory estimates.

### 2.3. Inventory methodology

The 2006 IPCC Guidelines has been supplemented with the European Monitoring and Evaluation Program/ European Environment Agency (EMEP/EEA) air pollutant emission inventory guidebook for compiling estimates for nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and Sulphur dioxide (SO<sub>2</sub>). Generally, the method adopted to compute emissions involved multiplying Activity Data (AD) by the appropriate Emission Factor (EF) as indicated in Equation 1.

$$\text{Emissions (E)} = \text{Activity Data (AD)} \times \text{Emission Factor (EF)} \quad \text{Equation (1)}$$

All the methodologies and tools recommended by IPCC have been followed according to the 2000 IPCC Good Practice Guidelines. Generally, the inventory has been compiled using tier 1 methodology except for the solid waste category tier 2 was applied. As recommended by the IPCC, Global Warming Potentials (GWP) were used to convert non-CO<sub>2</sub> emissions into carbon dioxide equivalent. As per the requirements from decision 17/CP.8, the values adopted were those from the IPCC Second Assessment Report for the four main GHGs, namely: Carbon dioxide, Methane (21), Nitrous Oxide (310) and HFC - 134a (1,300).

## 2.4. Activity Data

Activity Data (AD) for the inventory come from several national and international sources (Table 12). Consistent with good practice in the 2006 IPCC guidelines, as much as possible, Liberia has used available official national statistics for the inventory. Where country-specific AD is not available, data from recognized international organizations (FAO, AU, ITTO, IEA) has been used to fill the gap. Some data gaps were filled through personal contacts and surveys, scientific studies, and statistical modelling. Local experts' knowledge was resorted to as the last option.

Thus, data collected at the national level from numerous public and private institutions, organizations and companies, and archived by the EPA/LISGIS provided the basis and starting point. In a few isolated cases, due to the restricted timeframe and the inexistence of a declared national framework for data collection and archiving to meet the requirements for preparing GHG inventories, derived data and estimates were made to fill in the gaps. These were considered reliable and sound since they were based on scientific findings and other observations. Not all the AD required to compile an exhaustive GHG inventory could be collected due to the short timeframe or absence of a proper data collection and archiving system, and some categories could not be assessed due to the civil conflict. Nevertheless, the data collected was used to make estimates that are of good quality.

Table 2-1 Description of activity data and sources

| Sub-sector            | Category                        | Data type             | Data source                            | Remarks   |
|-----------------------|---------------------------------|-----------------------|--|---|
| 1. Energy sector      |                                 |                       |  |   |
| 1A: Fuel Combustion   |                                 |                       |  |   |
| Energy Industry (1A1) | Electricity generation (1A1.ai) | Crude Oil, Diesel Oil | Liberia National Energy Balance (LNEB) | The Ministry of Energy and Liberia compiles LNEB. |

|   |   |                                 |   |  |
|---|---|---------------------------------|---|--|
|   | Petroleum Refinery (1A1.b)                    | Petroleum Products              | Not Applicable  | All petroleum products are imported from the international market.   |
|   | Manufacture of Solid Fuel (1A1.ci)            | Woodfuel                        | Liberia National Energy Balance (LNEB) by the Ministry of Energy and Liberia. | The fraction of woodfuel as input into charcoal production.  |
|   | Other Energy Industries (1A1.cii)             | Diesel                          | Not Estimated (NE)  | Fuel consumption data unavailable for own use for thermal power producers.   |
| Manufacturing Industry & Construction (1A2) | Iron and Steel (1A2.a)                        | Diesel                          | Liberia National Energy Balance (LNEB), Africa Energy Commission              | The Ministry of Energy and Liberia compiles LNEB.<br><br><a href="https://afrec-energy.org/En/administration/bilan.php">https://afrec-energy.org/En/administration/bilan.php</a><br>Accessed on 15/08/2020 |
|   | Chemicals (1A2.c)                             | Diesel                          |   |  |
|   | Food processing, Beverage and Tobacco (1A2.e) | Diesel, firewood, Charcoal, LPG |   |  |
|   | Mining and Quarrying (1A2.i)                  | Diesel                          |   |  |
|   | Construction (1A2.k)                          | Diesel, Gasoline                |   |  |
|   | Machinery (1A2.l)                             | Diesel                          |   |  |
|   | Non-specified (1A2.m)                         | Diesel                          |   |  |
| Transport (1A3)                             | International aviation (1A3.ai)               | ATK                             | Liberia National Energy Balance (LNEB)  | The Ministry of Energy and Liberia compiles LNEB   |
|   | Domestic aviation (1A3.aii)                   | ATK                             | Not Estimated   | ATK for Domestic Airline unavailable   |
|   | Road Transportation (1A3b)                    | Gasoline Diesel                 | Liberia National Energy   | The Ministry of Energy and Liberia compiles LNEB   |

|                               |   |                                     |  |  |
|-------------------------------|---|-------------------------------------|--|--|
|                               |   | LPG                                 | Balance (LNEB)                         |  |
|                               | Railways (1A3c)                                 | Diesel                              | Not Estimated                          | Rail operation limited. Diesel consumption data not available.   |
|                               | International water-borne navigation (1A3.di)   | Diesel                              | Not Estimated                          | Unavailable data on diesel consumption.  |
|                               | Domestic water-borne navigation (1A3.dii)       | Diesel                              | Not Estimated                          | Unavailable data on diesel consumption.  |
|                               | Other transport (1A3e)                          | Not Applicable                      | Not Applicable                         | All forms of transports have been covered under 1A3a to 1A3d)  |
| Other sectors (A14)           | Commercial/Institutional (1A4.a)                | LPG, Diesel Charcoal and Firewood   | Liberia National Energy Balance (LNEB) | The Ministry of Energy and Liberia compiles LNEB   |
|                               | Residential (1A4.b)                             | LPG, Kerosene Charcoal and Firewood | Liberia National Energy Balance (LNEB) | The Ministry of Energy and Liberia compiles LNEB   |
|                               | Agriculture/Forestry/Fishing/Fish Farms (1A4.c) | Diesel, Gasoline                    | Liberia National Energy Balance (LNEB) | The Ministry of Energy and Liberia compiles LNEB   |
| <b>1B: Fugitive Emissions</b> |   |                                     |  |  |
| Oil and Gas (1B2)             | Oil (1B2.a)                                     | Not Estimated                       | Not Estimated                          | Liberia is not a commercial producer of oil. Oil exploration is underway. Data for exploration related is unavailable. |
|                               | Gas (1B2.)                                      | Not Occurring                       | Not Applicable                         | Liberia is not a commercial producer of natural gas.   |



|  |  |                                     |  |  |
|--|--|-------------------------------------|--|--|
| Carbon Transport and Storage (1C)                                | Transport of CO <sub>2</sub> (1C.1)      | Not Occurring                       | Not Applicable   |  |
|  | Injection and storage (1C.2)             | Not Occurring                       | Not Applicable   |  |
| 2. IPPU  |  |                                     |  |  |
| Mineral Industry (2A)  |  | Not Occurring                       | Not Applicable   | Liberia has no primary metal producing industry  |
| Chemical Industry (2B)   |  | Not Occurring                       | Not Applicable   | Liberia has no primary chemical industry   |
| Metal Industry (2C)  | Iron and steel production (2C.1)         | Annual Production of Iron and Steel | Annual Reports of Central Bank of Liberia                              | The Central Bank of Liberia produce Annual Report  |
| Non-energy Products from Fuels and Solvent Use (2D)              | Lubricant use (2D1)                      | Annual consumption of Lubricants    | Annual Reports of Central Bank of Liberia                              | The Central Bank of Liberia produce Annual Report  |
|  | Paraffin Wax Use (2D2)                   | Annual consumption of Lubricants    | Annual Reports of Central Bank of Liberia                              | The Central Bank of Liberia produce Annual Report  |
| 2.F - Product Uses as Substitutes for Ozone Depleting Substances | Refrigeration and Air Conditioning (2F1) | HFC (134) consumption               | HFC Consumption data was prepared by the Ozone Unit of the Liberia EPA | Data was sourced from <a href="https://ozone.unep.org/countries/profile/lbr">https://ozone.unep.org/countries/profile/lbr</a> on 1/10/2020 |
| 3. AFOLU   |  |                                     |  |  |
| Livestock (3A)   | Enteric Fermentation (3A.1)              | Head of Animals                     | FAOSTA T,  | FAO published data   |

|           |                          |   |   |  |
|-----------|--------------------------|---|---|--|
|           |                          | (Cattle, Sheep, Goat & Swine)                         | Comprehensive Assessment of the Agriculture Sector,           | Central Agricultural Research Institute and the Ministry of Agriculture                    |
|           | Manure management (3A.2) | Head of Animals (Cattle, Sheep, Goat & Swine Poultry) | FAOSTA T, Comprehensive Assessment of the Agriculture Sector, | FAO published data Central Agricultural Research Institute and the Ministry of Agriculture |
|           |                          | System for manure management                          | Expert judgement by the national consultants                  | Non-existing country-specific data   |
| Land (3B) | Forest land (3B.1)       | Forest land remaining forest land.                    | FAOSTA TS Liberia FRA 2020 Liberia REDD+ FREL to UNFCCC       | FAO Liberia Forest Development Authority   |
|           |                          | Lands converted to Forest land                        | Not Estimated   | Unavailable land use matrix showing land converted to forest land.                         |
|           | Cropland (3B.2)          | Cropland remaining Cropland                           | FAOSTA TS   | FAO  |

|                   |  |                                    |               |   |
|-------------------|--|------------------------------------|---------------|---|
|                   |  | Lands converted to Cropland        | Not Estimated | Unavailable land use matrix showing land converted to Cropland.         |
| Grassland (3B.3)  |  | Grassland remaining Grassland      | FAOSTATS      | FAO   |
|                   |  | Forest land converted to grassland | FAOSTATS      | FAO   |
|                   |  | Other land converted to grassland  | Not Estimated | Unavailable land use matrix showing other land converted to grassland.  |
|                   |  |                                    |               |   |
| Wetland (3B.4)    |  | Wetland remaining wetland          | Not Estimated | Unavailable land use matrix showing wetland remaining wetland areas.    |
|                   |  | Lands converted to wetland         | Not Estimated | Unavailable land use matrix showing other land converted to a wetland.  |
| Settlement (3B.5) |  | Settlement remaining settlement    | Not Estimated | Unavailable land use matrix showing wetland remaining wetland areas.    |
|                   |  | Lands converted to                 | Not Estimated | Unavailable land use matrix showing other land converted to settlement. |

|    |  |   |   |  |
|----|--|---|---|--|
|    |  | settleme<br>nt                                |   |  |
|    | Other lands (3B.6)                     | Other<br>land<br>remaini<br>ng other<br>lands | Not<br>Estimated  | Unavailable land use matrix<br>showing other land<br>remaining other lands.    |
|    |  | Lands<br>converte<br>d to<br>other<br>lands   | Not<br>Estimated  | Unavailable land use matrix<br>showing other land<br>converted to other lands. |
| 3C | Emission from<br>biomass burning (3C1) | Forest<br>areas<br>affected<br>by a fire      | FAOSTA<br>T   | FAO  |
|    | Rice Cultivation (3C7)                 | Cultivat<br>ed rice<br>areas                  | FAOSTA<br>T<br>Liberia<br>Food<br>Productio<br>n Survey | National Rice Development<br>Strategy for Liberia                              |

### 2.4.1. Emission Factors

The default IPCC Emission Factors (EFs) have been for the inventory.

## 2.5. Sector emission results

### 2.5.1. Energy sector

The primary national energy objectives can be placed in two categories, namely: short-term and long-term priorities.

The short-term priorities include:

- Provide essential social services in healthcare institutions, education, training facilities, shelter, water, food, roads, and communication facilities.
- Contribute to rural development, secure rural energy, water supply, and improve living standards in rural and urban areas.
- Provide basic utilities such as electricity and water for Monrovia and supply essential services to urban centres throughout the country.

- Promote foreign direct investment in extractive and refining industries (mining, energy, hydrocarbon exploration, forestry, agriculture and housing, rubber processing, etc.)

The long-term priorities are:

- Providing reliable energy services at reasonable prices throughout Liberia.
- Reducing the nation's dependence on imported oil through the development of domestic energy resources.
- Encouraging the development of institutions that provide efficient management of energy activities; and,
- Liberalizing the electric utility sector of Liberia.

The Energy Sector of Liberia is divided into the following sub-sectors, as per the 2006 IPCC methodology:

- Energy industries
- Manufacturing industries and construction
- Transports (including national and international bunkers)
- Commercial and institutional sector
- Residential Sector
- Agriculture/Forestry/Fishery

### **Fuel combustion activities**

GHG emissions in Liberia originate primarily from the combustion of:

- Liquid fuels - comprise gasoline, diesel fuel, liquefied petroleum gas (LPG) and lubricants.
- Solid fuels - include fuelwood and charcoal fuels.

In the 2006 IPCC Guidelines, the main gases follow below:

- Direct GHG - Carbon dioxide (CO<sub>2</sub>), Methane (CH<sub>4</sub>) and Nitrous oxide (N<sub>2</sub>O).
- Indirect GHG - Carbon monoxide (CO), Oxides of nitrogen (NOX) and Non-methane volatile organic compounds (NMVOCs).

### **Fugitive emissions**

Fugitive emissions associated with the Liberian energy sector originate from alluvial mining, transportation, and subsistence agriculture activities. These emissions can be considered negligible to Liberia; hence, default 2006 IPCC values have been used to estimate them.

## **Emissions from biomass and burning**

In 2004, it was estimated that over 95% of the population depends on firewood and charcoal for cooking and heating needs and palm oil for lighting (LISGIS, 2009). The most recent Census (2008 data, published in 2009) shows that 70% of the urban population use charcoal for cooking and 5% of the rural population; 91% of the rural population use firewood for cooking and 21% of the urban population. In Monrovia, the percentage of households using charcoal is even higher, 85%.

### **2.5.1.1. Data sources for the energy sector inventory**

Sources of data of the Liberian energy sector are obtainable through

- The Liberia Electricity Corporation (LEC)
- The Liberia Petroleum Refining Company (LPRC)
- The Rural and Renewable Energy Agency
- The Ministry of Mines and Energy

The LEC furnished data on power generation; the LPRC supplies data on petroleum importation and distribution, while the rural and renewable energy agency provides data on the renewable energy sector. The Ministry of Mines and Energy serves as oversight of the sector. A consistent energy database remains a challenge.

Other data sources include:

- Ministry of Commerce and Industry
- Ministry of Finance and Development Planning
- Ministry of Transport
- National Port Authority
- Liberia Maritime Authority
- Ministry of Agriculture
- Forestry Development Authority

### **2.5.1.2. Data collection challenges**

During data collection, the following problems were noted:

- Generally, data collection has not been forthcoming due to the lack of official information in some government sectors. In the 1980s, Liberia's data availability and reliability were assured, facilitating systematic data collection and statistical reports.
- There is still limited support for research in government institutions for roughly three decades.
- There is a lack of systematic updates of information on the energy sector.

- Liberia continues to experience poor institutional capacity and loss of historical data due to the civil crisis.
- Inconsistency of data obtained from government institutions has been observed. For example:
  - Petroleum products data obtained from the LPRC fuel sales to the power company differed from the LEC power generation department's information and energy assessment data from the National Energy Committee.
  - Biomass energy estimates provided by the World Bank Energy Assistant Study did not corroborate those from the USAID-funded National Energy Committee Assessment report.
- The data lacks some details on the sectoral distribution.
- Data gaps were filled out with the most recent available studies on energy and the environment undertaken by UNDP Liberia and the EPA.

In providing a general picture of data and performance in Liberia's Energy Sector for 2003–2014, it must be noted that the war in Liberia between 2002 and 2004 drastically eroded some vital data. Therefore, these are considered "World Wars" in Liberia. Data collected from the sources have some gaps, but some of them are based on experienced estimates given the activities of the economy.

### 2.5.1.3. Types of petroleum products

For the period under review (2003–2014), the total consumption of petroleum products amounted to 1,632,756.00 TOE averaging 136,063.00 TOE per annum. Gasoline (48.01%) and gas oil (43.26%) accounted for most of the petroleum products imported in the country. Jet fuel and kerosene consisted of less than 10% of imported petroleum products. The data is tabulated in Table 2-2.

Table 2-2 Annual supply of petroleum products by fuel type (TOE)

| <b>Year/Product</b> | <b>Gasoline</b> | <b>Gas Oil</b> | <b>Kerosene</b> | <b>Jet fuel</b> | <b>Total (Product)</b> |
|---------------------|-----------------|----------------|-----------------|-----------------|------------------------|
| 2003                | 40,875          | 48,239         | 3,255           | 6,232           | 98,601                 |
| 2004                | 40,560          | 44,56          | 4,916           | 5,789           | 95,832                 |
| 2005                | 50,852          | 44,756         | 4,423           | 5,058           | 105,089                |
| 2006                | 54,058          | 42,586         | 3,100           | 7,520           | 107,264                |
| 2007                | 53,402          | 60,234         | 3,078           | 8,943           | 125,657                |
| 2008                | 61,932          | 59,598         | 2,824           | 9,356           | 133,710                |
| 2009                | 68,003          | 55,003         | 2,599           | 9,004           | 134,609                |
| 2010                | 73,992          | 63,855         | 2,305           | 9,897           | 150,049                |
| 2011                | 78,142          | 71,045         | 2,145           | 10,451          | 161,783                |
| 2012                | 82,010          | 70,687         | 1,214           | 11,945          | 165,856                |

|                     |                |                |               |                |                  |
|---------------------|----------------|----------------|---------------|----------------|------------------|
| 2013                | 88,678         | 72,043         | 956           | 13,483         | 175,160          |
| 2014                | 91,442         | 73,789         | 914           | 13,001         | 179,146          |
| <b>Total (year)</b> | <b>783,946</b> | <b>706,402</b> | <b>31,729</b> | <b>110,679</b> | <b>1,632,756</b> |
| <b>% Total</b>      | 48.01%         | 43.26%         | 1.94%         | 6.78%          | 99.99%           |

Figure 2.1 shows the petroleum products consumption between 2003 – 2014. From 2003, gas oil was consumed more than any other petroleum product was overturned in mid- 2004 when gasoline became the most consumed gasoline product. Since the beginning of 2008, gasoline has been highly consumed in Liberia as compared to other products. Similarly, kerosene is the least consumed petroleum product, followed by Jet fuel for the entire reporting period.

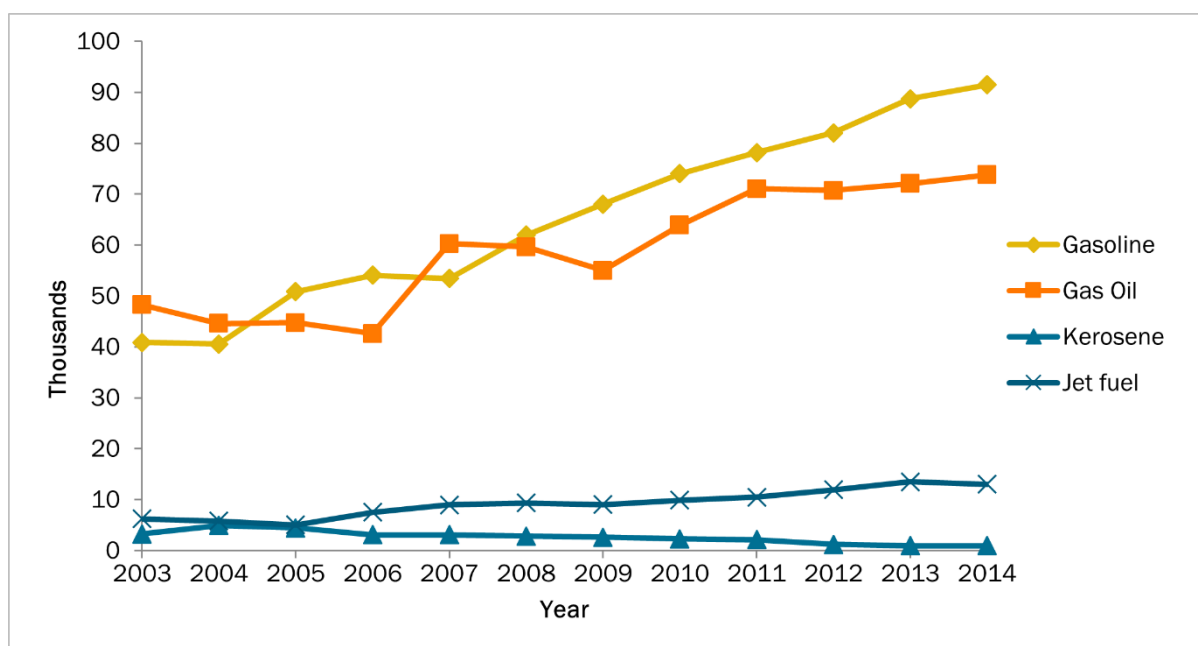


Figure 2.1 Petroleum products consumption by-product per year (TOE), 2003-2014

Table 2-3 lists the average annual energy (in TOE/year) from petroleum products for 2003– 2014. It can be seen that the average petroleum supply reached 136,062.79 in total.

Table 2-3 Average supply of petroleum products from 2003 to 2014

| Product  | Average Energy/Year (TOE/yr.) |
|----------|-------------------------------|
| Gasoline | 65,328.83                     |
| Gas Oil  | 58,866.63                     |
| Kerosene | 2,644.08                      |
| Jet Fuel | 9,223.25                      |



|              |                   |
|--------------|-------------------|
| <b>Total</b> | <b>136,062.79</b> |
|--------------|-------------------|

#### 2.5.1.4. Distribution of energy sector emissions by category

The distribution of energy sector emissions for 2014 is shown in Tables 2-4 and 2-5.

Table 2-4 Fuel combustion emissions in the energy sector (2014)

| Categories   | Emissions<br>(Gg) |                 |                  |                 |     |        |                 |
|--|-------------------|-----------------|------------------|-----------------|-----|--------|-----------------|
|  | CO <sub>2</sub>   | CH <sub>4</sub> | N <sub>2</sub> O | NO <sub>x</sub> | CO  | NMVOCs | SO <sub>2</sub> |
| <b>1 - Energy</b>  | 4,969             | 42              | 43               | 55              | 181 | 36     |                 |
| <b>1.A - Fuel Combustion Activities</b>                          | 4969              | 42              | 43               | 55              | 181 | 36     |                 |
| <b>1.A.1 - Energy Industries</b>                                 | 2502              | -               | 5                | 5               | -   | -      | -               |
| 1.A.1.a - Main Activity Electricity and Heat Production          | -                 | -               | -                | -               | -   | -      | -               |
| 1.A.1.a.i - Electricity Generation                               |                   |                 |                  | -               | -   | -      | -               |
| 1.A.1.a.ii - Combined Heat and Power Generation (CHP)            |                   |                 |                  | -               | -   | -      | -               |
| 1.A.1.a.iii - Heat Plants  |                   |                 |                  | -               | -   | -      | -               |
| 1.A.1.b - Petroleum Refining                                     |                   |                 |                  | -               | -   | -      | -               |
| 1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries | -                 | -               | -                | -               | -   | -      | -               |
| 1.A.1.c.i - Manufacture of Solid Fuels                           |                   |                 |                  | -               | -   | -      | -               |
| 1.A.1.c.ii - Other Energy Industries                             |                   |                 |                  | -               | -   | -      | -               |
| <b>1.A.2 - Manufacturing Industries and Construction</b>         | 209               | -               | -                | -               | -   | -      | -               |
| 1.A.2.a - Iron and Steel   |                   |                 |                  | -               | -   | -      | -               |
| 1.A.2.b - Non-Ferrous Metals                                     |                   |                 |                  | -               | -   | -      | -               |
| 1.A.2.c - Chemicals  |                   |                 |                  | -               | -   | -      | -               |
| 1.A.2.d - Pulp, Paper and Print                                  |                   |                 |                  | -               | -   | -      | -               |
| 1.A.2.e - Food Processing, Beverages and Tobacco                 |                   |                 |                  | -               | -   | -      | -               |
| 1.A.2.f - Non-Metallic Minerals                                  |                   |                 |                  | -               | -   | -      | -               |
| 1.A.2.g - Transport Equipment                                    |                   |                 |                  | -               | -   | -      | -               |
| 1.A.2.h - Machinery  |                   |                 |                  | -               | -   | -      | -               |

|  |       |   |    |    |     |    |   |
|--|-------|---|----|----|-----|----|---|
| 1.A.2.i - Mining (excluding fuels) and Quarrying                             |       |   |    | -  | -   | -  | - |
| 1.A.2.j - Wood and wood products   |       |   |    | -  | -   | -  | - |
| 1.A.2.k - Construction   |       |   |    | -  | -   | -  | - |
| 1.A.2.l - Textile and Leather  |       |   |    | -  | -   | -  | - |
| 1.A.2.m - Non-specified Industry   |       |   |    | -  | -   | -  | - |
| <b>1.A.3 - Transport</b>   | 4147  | - | 43 | 43 | 194 | 54 | - |
| 1.A.3.a - Civil Aviation   | 91    | - | -  | -  | -   | -  | - |
| 1.A.3.a.i - International Aviation (International Bunkers) (1)               |       |   |    |    |     |    |   |
| 1.A.3.a.ii - Domestic Aviation   |       |   |    | -  | -   | -  | - |
| 1.A.3.b - Road Transportation  | 4,056 | - | 43 | 43 | 194 | 54 | - |
| 1.A.3.b.i - Cars   |       |   |    | -  | -   | -  | - |
| 1.A.3.b.i.1 - Passenger cars with 3-way catalysts                            |       |   |    | -  | -   | -  | - |
| 1.A.3.b.i.2 - Passenger cars without 3-way catalysts                         |       |   |    | -  | -   | -  | - |
| 1.A.3.b.ii - Light-duty trucks   |       |   |    | -  | -   | -  | - |
| 1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts                        |       |   |    | -  | -   | -  | - |
| 1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts                     |       |   |    | -  | -   | -  | - |
| 1.A.3.b.iii - Heavy-duty trucks and buses                                    |       |   |    | -  | -   | -  | - |
| 1.A.3.b.iv - Motorcycles   |       |   |    | -  | -   | -  | - |
| 1.A.3.b.v - Evaporative emissions from vehicles                              |       |   |    | -  | -   | -  | - |
| 1.A.3.b.vi - Urea-based catalysts  |       |   |    | -  | -   | -  | - |
| 1.A.3.c - Railways   |       |   |    | -  | -   | -  | - |
| 1.A.3.d - Water-borne Navigation   |       |   |    | -  | -   | -  | - |
| 1.A.3.d.i - International water-borne navigation (International bunkers) (1) |       |   |    |    |     |    |   |
| 1.A.3.d.ii - Domestic Water-borne Navigation                                 |       |   |    | -  | -   | -  | - |
| 1.A.3.e - Other Transportation   |       |   |    | -  | -   | -  | - |

|  |     |    |    |    |   |   |   |
|--|-----|----|----|----|---|---|---|
| 1.A.3.e.i - Pipeline Transport                     |     |    |    | -  | - | - | - |
| 1.A.3.e.ii - Off-road                              |     |    |    | -  | - | - | - |
| <b>1.A.4 - Other Sectors</b>                       | 450 | 78 | 23 | 45 | 5 | - | - |
| 1.A.4.a - Commercial/Institutional                 | 298 | -  | -  | -  | - | - | - |
| 1.A.4.b - Residential                              | 63  | 78 | 23 | 40 | - | - | - |
| 1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms  | 89  | -  | -  | 5  | 5 | - | - |
| 1.A.4.c.i - Stationary                             |     |    |    | -  | - | - | - |
| 1.A.4.c.ii - Off-road Vehicles and Other Machinery |     |    |    | -  | - | - | - |
| 1.A.4.c.iii - Fishing (mobile combustion)          |     |    |    | -  | - | - | - |
| <b>1.A.5 - Non-Specified</b>                       |     |    |    | -  | - | - | - |
| 1.A.5.a - Stationary                               |     |    |    | -  | - | - | - |
| 1.A.5.b - Mobile                                   |     |    |    | -  | - | - | - |
| 1.A.5.b.i - Mobile (aviation component)            |     |    |    | -  | - | - | - |
| 1.A.5.b.ii - Mobile (water-borne component)        |     |    |    | -  | - | - | - |
| 1.A.5.b.iii - Mobile (Other)                       |     |    |    | -  | - | - | - |
| 1.A.5.c - Multilateral Operations (1)(2)           |     |    |    |    |   |   |   |
| <b>1.A.4 - Other Sectors</b>                       | 450 | 78 | 23 | 45 | 5 | - | - |
| 1.A.4.a - Commercial/Institutional                 | 298 | -  | -  | -  | - | - | - |

Table 2-5 Sectoral report for energy sector (2014)

| Categories                                   | Emissions<br>(Gg) |    |                |    |   |      |    |
|--|-------------------|----|----------------|----|---|------|----|
|  | CO                | CH | N <sub>2</sub> | NO | C | NMVO | SO |
|  | 2                 | 4  | O              | x  | O | Cs   | 2  |
| <b>1.B - Fugitive emissions from fuels</b>   | -                 | -  | -              | -  | - | -    | -  |
| <b>1.B.1 - Solid Fuels</b>                   | -                 | -  | -              | -  | - | -    | -  |
| 1.B.1.a - Coal mining and handling           | -                 | -  | -              | -  | - | -    | -  |
| 1.B.1.a.i - Underground mines                | -                 | -  | -              | -  | - | -    | -  |
| 1.B.1.a.i.1 - Mining                         | -                 | -  | -              | -  | - | -    | -  |
| 1.B.1.a.i.2 - Post-mining seam gas emissions | -                 | -  | -              | -  | - | -    | -  |

|  |   |   |   |   |   |   |   |
|--|---|---|---|---|---|---|---|
| 1.B.1.a.i.3 - Abandoned underground mines                                | - | - | - | - | - | - | - |
| 1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2 | - | - | - | - | - | - | - |
| 1.B.1.a.ii - Surface mines   | - | - | - | - | - | - | - |
| 1.B.1.a.ii.1 - Mining  | - | - | - | - | - | - | - |
| 1.B.1.a.ii.2 - Post-mining seam gas emissions                            | - | - | - | - | - | - | - |
| 1.B.1.b - Uncontrolled combustion and burning coal dumps                 | - | - | - | - | - | - | - |
| 1.B.1.c - Solid fuel transformation                                      | - | - | - | - | - | - | - |
| <b>1.B.2 - Oil and Natural Gas</b>                                       | - | - | - | - | - | - | - |
| 1.B.2.a - Oil  | - | - | - | - | - | - | - |
| 1.B.2.a.i - Venting  | - | - | - | - | - | - | - |
| 1.B.2.a.ii - Flaring   | - | - | - | - | - | - | - |
| 1.B.2.a.iii - All Other  | - | - | - | - | - | - | - |
| 1.B.2.a.iii.1 - Exploration  | - | - | - | - | - | - | - |
| 1.B.2.a.iii.2 - Production and Upgrading                                 | - | - | - | - | - | - | - |
| 1.B.2.a.iii.3 - Transport  | - | - | - | - | - | - | - |
| 1.B.2.a.iii.4 - Refining   | - | - | - | - | - | - | - |
| 1.B.2.a.iii.5 - Distribution of oil products                             | - | - | - | - | - | - | - |
| 1.B.2.a.iii.6 - Other  | - | - | - | - | - | - | - |
| 1.B.2.b - Natural Gas  | - | - | - | - | - | - | - |
| 1.B.2.b.i - Venting  | - | - | - | - | - | - | - |
| 1.B.2.b.ii - Flaring   | - | - | - | - | - | - | - |
| 1.B.2.b.iii - All Other  | - | - | - | - | - | - | - |
| 1.B.2.b.iii.1 - Exploration  | - | - | - | - | - | - | - |
| 1.B.2.b.iii.2 - Production   | - | - | - | - | - | - | - |
| 1.B.2.b.iii.3 - Processing   | - | - | - | - | - | - | - |
| 1.B.2.b.iii.4 - Transmission and Storage                                 | - | - | - | - | - | - | - |
| 1.B.2.b.iii.5 - Distribution   | - | - | - | - | - | - | - |
| 1.B.2.b.iii.6 - Other  | - | - | - | - | - | - | - |
| <b>1.B.3 - Other emissions from Energy Production</b>                    | - | - | - | - | - | - | - |
| <b>1.C - Carbon dioxide Transport and Storage</b>                        | - | - | - | - | - | - | - |
| <b>1.C.1 - Transport of CO2</b>  | - | - | - | - | - | - | - |
| 1.C.1.a - Pipelines  | - | - | - | - | - | - | - |
| 1.C.1.b - Ships  | - | - | - | - | - | - | - |

|                                      |   |   |   |   |   |   |   |
|--------------------------------------|---|---|---|---|---|---|---|
| 1.C.1.c - Other (please specify)     | - | - | - | - | - | - | - |
| <b>1.C.2 - Injection and Storage</b> | - | - | - | - | - | - | - |
| 1.C.2.a - Injection                  | - | - | - | - | - | - | - |
| 1.C.2.b - Storage                    | - | - | - | - | - | - | - |
| <b>1.C.3 - Other</b>                 | - | - | - | - | - | - | - |

#### 2.5.1.5. Emissions from memo and information items in 2014

Memo and Information items include the aviation and shipping (water-borne navigation) industries. Domestic emissions are not included in the national total, while international emissions are reported separately as "Bunker Fuels". Included in the information item is biomass combustion for energy production. Biomass is a special case because CO2 emissions from biomass combustion are not included in the national total. They are reported separately as an information item. Non-CO2 emissions are reported in the national total. Net carbon emissions are accounted for in the LULUCF/AFOLU sector. Peat is treated as a fossil fuel. Table 2-6 provides the estimated emissions from memo and information items for the year 2014.

Table 2-6 Emissions from mem and information items (2014)

| Categories   | Emissions (Gg)  |                     |                     |                     |        |            |                     |
|--|-----------------|---------------------|---------------------|---------------------|--------|------------|---------------------|
|  | CO <sub>2</sub> | C<br>H <sub>4</sub> | N <sub>2</sub><br>O | N<br>O <sub>x</sub> | C<br>O | NMV<br>OCs | S<br>O <sub>2</sub> |
| <b>Memo Items (3)</b>  |                 |                     |                     |                     |        |            |                     |
| International Bunkers  | 112             | -                   | -                   | -                   | -      | -          | -                   |
| 1.A.3.a.i - International Aviation (International Bunkers) (1)               | 90              | -                   | -                   | -                   | -      | -          | -                   |
| 1.A.3.d.i - International water-borne navigation (International bunkers) (1) | 22              | -                   | -                   | -                   | -      | -          | -                   |
| 1.A.5.c - Multilateral Operations (1)(2)                                     |                 |                     |                     |                     |        |            |                     |
| <b>Information Items</b>   |                 |                     |                     |                     |        |            |                     |
| CO <sub>2</sub> from Biomass Combustion for Energy Production                | 245<br>19       |                     |                     |                     |        |            |                     |
| *Not to be included in energy totals   |                 |                     |                     |                     |        |            |                     |

Table 2-7 National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal protocol and greenhouse gases precursors

| Greenhouse gas source and sink categories   | CO <sub>2</sub> Emissions (Gg) | CO <sub>2</sub> Removals (Gg) | CH <sub>4</sub> ((Gg) | N <sub>2</sub> O (Gg) | NO <sub>x</sub> (Gg) | CO (Gg) | NMVOCs (Gg) | SO <sub>x</sub> (Gg) |
|---|--------------------------------|-------------------------------|-----------------------|-----------------------|----------------------|---------|-------------|----------------------|
| Total national emissions and removals       | 11,827                         | -                             | 42                    | 86                    | 98                   | 375     | 90          | -                    |
| 1.Energy                                    | 4,969                          | X                             | 42                    | 43                    | 55                   | 181     | 36          | -                    |
| A. Fuel combustion (sectoral approach)      | 4,969                          |                               | 42                    | 43                    | 55                   | 181     |             |                      |
| 1. Energy industries                        | 2,502                          |                               | -                     | 5                     | 5                    | -       | -           | -                    |
| 2.Manufacturing industries and construction | 2,09                           |                               | -                     | -                     | -                    | -       | -           | -                    |
| 3.Transportation                            | 4,147                          |                               | -                     | 43                    | 43                   | 194     | 54          | -                    |
| 4.Other sectors                             | -                              |                               | -                     | -                     | -                    | -       | -           | -                    |
| 5.Other(specify)                            | -                              |                               | -                     | -                     | -                    | -       | -           | -                    |
| B. Fugitive emissions from fuels            | -                              |                               | -                     |                       | -                    | -       | -           | -                    |
| 1.Solid fuels                               |                                |                               | -                     |                       | -                    | -       | -           | -                    |
| 2.Oil and natural gas                       |                                |                               | -                     |                       | -                    | -       | -           | -                    |

Table 2-8 National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gases precursors

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | CO <sub>2</sub> Emissions (Gg) | CO <sub>2</sub> Removals (Gg) | CH <sub>4</sub> ((Gg) | N <sub>2</sub> O (Gg) | CO (Gg) | NO <sub>x</sub> (Gg) | NMVOCs (Gg) | SO <sub>x</sub> (Gg) |
|---|--------------------------------|-------------------------------|-----------------------|-----------------------|---------|----------------------|-------------|----------------------|
| Memo items                                |                                |                               |                       |                       |         |                      |             |                      |
| International bunkers                     | 112                            |                               | -                     | -                     | -       | -                    | -           | -                    |
| Aviation                                  | 90                             |                               | -                     | -                     | -       | -                    | -           | -                    |

|  |        |  |   |   |   |   |   |   |
|--|--------|--|---|---|---|---|---|---|
| Marine                                 | 22     |  | - | - | - | - | - | - |
| CO <sub>2</sub> emissions from biomass | 24,519 |  |   |   |   |   |   |   |

### 2.5.2. IPPU sector

Major GHGs generated by the IPPU sector include CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub> and PFCs. The main emissions sources for this category are (a) mineral products, mainly cement; (b) metal and iron (c) beverages.

The performance of the economy is the key driver for trends in the IPPU sector. The Liberian economy is directly related to the global economy, mainly through exports and imports. Liberia GDP increased annually by 0.9%, 3.9%, 4.78%, 4.9%, between 2015 and 2017, respectively. However, in 2015, the economy experienced an enormous recession due to the Ebola outbreak, which continued into the first quarters of 2016. As a result of the recession, GHG emissions decreased enormously across almost all IPPU sectors.

Non-energy use of fuels and solvents includes lubricants and paraffin wax. The use of solvents can result in evaporative emissions of various NMVOCs, which can be oxidized and released into the atmosphere. According to the 2006 IPCC Guidelines (p. 5.16), white spirit is used as an extraction solvent, cleaning solvent, degreasing solvent, and solvent in aerosols, paints, wood preservatives, varnishes and asphalt products. Lubricants are used in industrial and transport applications. Lubricants are divided into two types: motor and industrial oil and greases that differ in physical characteristics. Paraffin wax is used in petroleum jelly, paraffin waxes and other waxes (saturated hydrocarbons). Paraffin waxes are used in candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants (as used in detergents) and many others (2006 IPCC, p.5.11). Emissions for this category were estimated using a Tier 1 approach. In line with the 2006 IPCC Guidelines (p.5.9), it was assumed that 90% of the mass of lubricants is oil and 10% is grease.

The Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for the Protection of the Ozone Layer) is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances believed to be responsible for ozone depletion. Hydrofluorocarbons (HFCs) and, to a limited extent, perfluorocarbons (PFCs) are serving as alternatives to ozone-depleting substances (ODS) being phased out under this protocol. According to the 2006 IPCC Guidelines, current application areas of HFCs and PFCs include refrigeration and air conditioning; fire suppression and explosion protection; aerosols; solvent cleaning; foam blowing; and other applications (equipment sterilization, tobacco expansion applications, and as solvents in the manufacture of adhesives, coatings and inks). Unfortunately, there's no available data for the years under review. Table 2-9 shows the total fuel consumption for the production of lubricants and paraffin

wax between 2012 and 2014. It can be seen that over the years, the amount of fuel needed to produce lubricants reduced, whereas the amount of fuel needed to produce paraffin wax increased for 2013 and again reduced in 2014 by 40%.

Table 2-9 Total fuel consumption in the non-energy use of fuels and solvent use category, 2012–2014

| <b>Fuel consumption</b> |                        |                          |
|-------------------------|------------------------|--------------------------|
| <b>Period</b>           | <b>Lubricants (TJ)</b> | <b>Paraffin Wax (TJ)</b> |
| 2012                    | 26357                  | 210                      |
| 2013                    | 23978                  | 230                      |
| 2014                    | 14523                  | 138                      |

### 2.5.2.1. Data sources for the IPPU sector inventory

Data sources by sectors and types and are tabulated in Table 2-10.

| <b>Industrial Process and Product Use</b> |                    |   |                       |                                 |
|---|--------------------|---|-----------------------|---------------------------------|
| <b>Sector</b>                             |                    | <b>Data Type</b>  | <b>Data Source</b>    | <b>Principal Data Providers</b> |
| 1   | Mineral Industry   | Industrial production and Plant specific emission factors | Environmental Reports | Arcelor Mittal                  |
| 2   | Cement Industry    | Clinker Fraction, Clinker Imported                        | Environmental Reports | CEMENCO                         |
| 3   | Coco-Cola          | Solvent and Equipment                                     | Laboratory Reports    | Coco-Cola                       |
| 4   | Alcoholic Industry | Solvent and Equipment                                     | Laboratory Reports    | RITCO                           |

This GHG inventory report contains data from several sources (e.g. national inventories) as listed in Table 21. Priority was given to the data obtained from industries during the data collection process. After the data has been through the data collection phase (collection, selection, generation, review and QC), it enters the GHG inventory database. Each inventory is treated differently, and separate worksheets were completed for each inventory. The database will also assist in streamlining future GHG inventory updates. The database consists of a series of Excel spreadsheets which are linked to ensure consistency and easy updating. The GHG Inventory database contains folders on general sectoral data and GHG inventory datasheets.

### 2.5.2.2. Emission Factors

The IPCC 2006 default emission factor for lubricating oils, grease and lubricants (0.2 tonnes CO<sub>2</sub> per TJ product) was used to calculate emissions from lubricant and paraffin wax use.



### 2.5.2.3. Data sources for the IPPU sector inventory

Table 2-10 presents the GHG emissions for the IPPU sector for 2014.

Table 2-10 GHG emissions from source and sink categories (2014)

| Greenhouse gas source and sink categories              | CO <sub>2</sub> Emissions (Gg) | CH <sub>4</sub> ((Gg) | N <sub>2</sub> O (Gg) | CO (Gg) | NO <sub>x</sub> (Gg) | NMVOCs (Gg) | SO <sub>x</sub> (Gg) |
|--|--------------------------------|-----------------------|-----------------------|---------|----------------------|-------------|----------------------|
| <b>Total national emissions</b>                        | 0.4228                         | NO                    | NO                    | 0.59    | NO                   | NO          | NO                   |
| <b>2. Industrial processes</b>                         | 0.2114                         | NO                    | NO                    | 0.31    | NO                   | NO          | NO                   |
| A. Mineral production                                  | 0.19                           |                       |                       | 0.23    | NA                   | NA          | NA                   |
| B. Chemical industry                                   | NO                             | NO                    | NO                    | NO      | NO                   | NO          | NO                   |
| C. Metal production                                    | 0.0034                         | NO                    | NO                    | 0.05    | NO                   | NO          | NO                   |
| D. Other production                                    | 0.018                          |                       |                       |         | NA                   | NA          | NA                   |
| E. Production of halocarbons and sulphur hexafluoride  |                                |                       |                       |         |                      |             |                      |
| F. Consumption of halocarbons and sulphur hexafluoride |                                |                       |                       |         |                      |             |                      |
| G. Other (please specify)                              | NA                             | NA                    | NO                    | NO      | NO                   | NO          | NO                   |
| <b>3. Solvent and other product use</b>                | NO                             |                       | NO                    |         |                      | NO          |                      |

### 2.5.3. AFOLU sector

The AFOLU inventory covered the following activities:

- Enteric fermentation
- Manure management
- Rice cultivation
- Agriculture soils (manure applied to the soil, manure left on pasture, crop residues and Cultivation of organic soils)
- Burning of crops residues
- Burning of savanna

#### 2.5.3.1. Data sources for the AFOLU sector inventory

#### Activity Data

The source of activity data used in this tier 1 inventory is from the United Nation Food and Agriculture Organization. Official national activity data needed to build a Tier 1 inventory include those typically communicated by member countries to FAO and collected in the FAOSTAT (agriculture activities and land resources) and FRA (forest activities) databases (Table 2-12). There are huge data gaps, especially gathering data on agriculture activities and land resources from the Ministry of Agriculture suitable for GHGs calculation. Considering that The FAO process for food and agricultural data received annually by countries includes the collection, harmonization, gap-filling in case of no communication, and statistical data validation by member countries and FAO according to the United Nations' international standards system, it was judged prudent to use FAO data.

Table 2-11 Activity data used for the calculation of enteric fermentation, manure management, manure applied to soil and manure left on pasture

| No. | Livestock        | Unit      | Quantity | Note  |
|-----|------------------|-----------|----------|---|
| 1.  | Cattle           | Head      | 44156    |   |
| 2.  | Dairy Cattle     | Head      | 6685     |   |
| 3.  | Non-dairy Cattle | Head      | 37471    | Difference b/w cattle & dairy cattle  |
| 4.  | Chicken          | 1000 Head | 7712     |   |
| 5.  | Chicken layers   | Head      | 1156076  | Difference b/w number of head of chicken & chicken layers will give the number of chicken broiler |
| 6.  | Ducks            | 1000 Head | 324      |   |
| 7.  | Goats            | Head      | 345699   |   |
| 8.  | Pigs             | Head      | 287604   |   |
| 9.  | Breeding swine   | Head      | 28760    | Multiply total head of pigs by 0.1 – IPCC 2006 Guideline, Table 60                                |
| 10. | Swine, market    | Head      | 258843   | Multiply total head of pigs by 0.9 – IPCC 2006 Guideline, Table 60                                |
| 11. | Sheep            | Head      | 277045   |   |

Table 2-12 National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal protocol and greenhouse gases precursors

| Greenhouse gas source and sink categories | CO <sub>2</sub> Emissions (Gg) | CH <sub>4</sub> (Gg) | N <sub>2</sub> O (Gg) | CO (Gg) | NO <sub>x</sub> (Gg) | NMVOCs (Gg) | SO <sub>x</sub> (Gg) |
|---|--------------------------------|----------------------|-----------------------|---------|----------------------|-------------|----------------------|
| 4. Agriculture                            | -                              | 3.18                 | 0.11                  | 0.23    | 0.0004               | NE          | NE                   |
| A. Enteric fermentation                   | -                              | 0.6                  |                       |         |                      |             |                      |

|   |   |       |      |      |        |    |  |
|---|---|-------|------|------|--------|----|--|
| B. Manure management                      | - | NE    | 0.11 |      |        | -  |  |
| C. Rice cultivation                       | - | 2.57  |      |      |        | -  |  |
| D. Agriculture soils                      | - | -     | -    |      |        | N- |  |
| E. Prescribed burning of savannahs        | - | 0.005 | -    | 0.10 | 0.0004 | NE |  |
| F. Field burning of agricultural residues | - | -     | -    | 0.13 | -      | NE |  |
| G. Other (please specify)                 | - | NE    | -    | NE   | NE     | NE |  |

### 2.5.3.2. Agriculture greenhouse gas emissions

The GHGs emissions from four agriculture sub-sectors (Enteric fermentation, Manure Management, Rice Cultivation and Agricultural soils prescribed burning of savannahs Field burning of agricultural residues) from 2003 to 2014 are detailed below in Table 2-13. There were challenges in generating these data, but they are considered valid. These data meet international standards as they are recommended by IPCC to be used for tier 1 countries where there are no country-specific data.

Table 2-13 GHGs emissions from the agriculture sector for 2014

| Agriculture Sector                              | Annual Emissions   |                    |                    |
|---|--------------------|--------------------|--------------------|
|   | Gg CH <sub>4</sub> | Gg NO <sub>2</sub> | Gg CO <sub>2</sub> |
| Enteric Fermentation                            | 4.870433           |                    | 102.2791           |
| Manure Management (CH <sub>4</sub> )            | 0.599971           |                    | 12.5763            |
| Manure Management (NO <sub>2</sub> )            |                    | 0.133088           | 41.2574            |
| Rice Cultivation                                | 2.567267           |                    | 53.9126            |
| Manure applied to soil (NO <sub>2</sub> )       |                    | 0.110108           | 34.1335            |
| Manure left on Pasture                          |                    | 0.356939           | 110.6512           |
| Crop residues (NO <sub>2</sub> )                |                    | 0.125265           | 38.8321            |
| Cultivation of Organic soils (NO <sub>2</sub> ) |                    | 0.059473           | 18.4365            |
| Burning – crops residences (CH <sub>4</sub> )   | 0.370995           |                    | 7.7909             |
| Burning – crops residences (NO <sub>2</sub> )   |                    | 0.009618           | 2.9817             |
| Burning – Savannah (CH <sub>4</sub> )           | 0.004724           |                    | 0.0992             |
| Burning – Savannah (NO <sub>2</sub> )           |                    | 0.000431           | 0.1337             |
| TOTAL   | 8.41229            | 0.79492            | 423.0842           |

### 2.5.3.3. LULUCF greenhouse gas emissions

Table 2-14 gives the net CO<sub>2</sub> emission from various sources in the LULUCF sector. According to the table, changes in Forest and other woody biomass stocks contribute to the highest removal and emissions concomitantly, which amounts to 95%.

Table 2-14 Source categories for LULUCF

| Source  | Emission (+) Absolute Removal<br>(-) emission Gigagram of CO <sub>2</sub><br>equivalents |           | Per cent |
|---|--|-----------|----------|
| Changes in Forest and Other<br>Woody Biomass Stocks                                   | -21,467.55   | 21,467.55 | 95%      |
| CO <sub>2</sub> Emissions from Forest and<br>Grassland Conversion                     | 963.66   | 963.66    | 4%       |
| On-Site Burning of<br>Forests:<br>Emissions of non-CO <sub>2</sub> Trace<br>Gases     | 97.30  | 97.30     | 0%       |
| Abandonment of Managed Lands  | 0.00   | 0.00      | 0%       |
| CO <sub>2</sub> Emissions or Uptake by Soil<br>from Land-use Change and<br>Management | 0.00   | 0.00      | 0%       |
| Sum   | -20,406.60   |           | 100%     |

### Land representation

Several guiding questions were identified to describe land representation.

- IPCC climate types
- See Table 1 (this document)
- Source: FAO Ecozone map
- IPCC Soil types
- See Table 1 (this document)
- Source: Harmonized World Soil Database, deriving IPCC classes of the Soil types

### Establish climate and soil categories

**Error! Reference source not found.**5 shows the climate/soil type and the amount of activity clay, Low or High, in each soil type. Tropical wet has the highest in High Activity Clay and Low Activity Clay. Tropical moist and tropical montane do not have high activity clay but have low activity clay, as indicated in the table.

Table 2-15 Area split between climate and soil. Values in hectares

| <b>Climate / Soil</b> | <b>High Activity Clay (HAC)</b> | <b>Low Activity Clay (LAC)</b> | <b>Totals</b>  |
|-----------------------|---------------------------------|--------------------------------|----------------|
| Tropical moist        |                                 | 69658                          | 69658          |
| Tropical montane      |                                 | 4687                           | 4687           |
| Tropical wet          | 991776                          | 8627254                        | 9619030        |
| <b>Totals</b>         | <b>991776</b>                   | <b>8701599</b>                 | <b>9693375</b> |

The team worked with shapefiles previously used for estimating GHG inventory in the country. The shapefile is based on the World Bank 2004 report for forest inventory. Table 2-16 compares the World Bank Classification with the IPCC land category.

Table 2-16 Transformation of country-specific land use to IPCC land use categories

| <b>World Bank Classification</b>             | <b>IPCC Category</b>                 |
|--|--------------------------------------|
| Urban area                                   | Settlements                          |
| Predominant rural agricultural domain        | Cropland                             |
| Agricultural area with small forest presence | Cropland (some shifting cultivation) |
| Mixed agricultural and forest area           | Forestland (35%)                     |
|  | Cropland (65%)                       |
| Agriculture degraded forest                  | Forestland (65%)                     |
|  | Cropland (35%)                       |
| Open dense forest                            | Forestland                           |
| Closed dense forest                          | Forestland                           |
| Free water                                   | Otherlands                           |
| Savanna or bare soil                         | Grassland                            |
| Littoral ecosystem complex                   | Otherlands                           |
| Agro-industrial plantation                   | Cropland (rubber)                    |

Table 2-17 IPCC land classifications in terms of areas and percentages

| <b>IPCC Class</b> | <b>Area [ha]</b> | <b>Percentage</b> |
|-------------------|------------------|-------------------|
| CL                | 4846114          | 50,92%            |
| FL                | 4516576          | 47,46%            |
| GL                | 13311            | 0,14%             |
| OL                | 94678            | 0,99%             |
| SL                | 46046            | 0,48%             |
| <b>Totals</b>     | <b>9516728</b>   | <b>100,00%</b>    |

Following the IPCC methodology and the structure, the areas of different land-use types were divided into the various climate and soil combinations identified earlier in the process (Table 2-18).

Table 2-18 Areas and Percentages for IPCC categories by climate and soil combination

| Climate and Soil | IPCC Category | Area [ha] |              | Percentage     | Replacement |                |
|------------------|---------------|-----------|--------------|----------------|-------------|----------------|
|                  |               |           |              |                |             |                |
| TRW/HAC:         |               | 881373    |              | 9,00%          |             |                |
|                  | CL            |           | 457778       |                | 51,94       | 51,96%         |
|                  | FL            |           | 275142       |                | 31,22%      | 31,22%         |
|                  | GL            |           | 168          |                | 0,02%       |                |
|                  | OL            |           | 124306       |                | 14,10%      | 14,10%         |
|                  | SL            |           | 23980        |                | 2,72%       | 2,72%          |
|                  | Totals        |           | 881373       |                | 100,00%     | 100,00%        |
| TRW/LAC:         |               | 8507225   |              | 88,92%         |             |                |
|                  | CL            |           | 4273941      |                | 50,24%      | 50,24%         |
|                  | FL            |           | 4184699      |                | 49,19%      | 49,19%         |
|                  | GL            |           | 12413        |                | 0,15%       | 0,15%          |
|                  | OL            |           | 16482        |                | 0,19%       | 0,19%          |
|                  | SL            |           | 19689        |                | 0,23%       | 0,23%          |
|                  | Totals        |           | 8507224      |                | 100,00%     | 100,00%        |
| TMon/LAC:        |               | 3425      |              | 0,04%          |             |                |
|                  | FL            |           | 3225         | 94,15%         | 100,00%     |                |
|                  | GL            |           | 200          | 5,83%          |             |                |
|                  | Totals        |           | 3425         |                | 100,00%     | 100,00%        |
| TMSD/LAC:        |               | 61205     |              | 0,64%          |             |                |
|                  | CL            |           | 57882        | 94,57%         |             | 100,00%        |
|                  | FL            |           | 2824         |                | 4,61%       |                |
|                  | GL            |           | 499          | 0,81%          |             |                |
|                  | <b>Totals</b> |           | <b>61205</b> | <b>100,00%</b> |             | <b>100,00%</b> |

Table 2-19 Grassland area

| IPCC Class totals | Country specific classes | Grassland LU subcategory | Area [ha] | Percentage of the country total |
|-------------------|--------------------------|--------------------------|-----------|---------------------------------|
| GL                | savannas or nude areas   | Unmanaged Grassland      | 13311     | 0,14%                           |

Table 2-20 Forest land subcategories

| Forest Land Subcategory         | Percentage | Area [ha] | Description               |
|---------------------------------|------------|-----------|---------------------------|
| Primary and closed dense forest | 48%        | 2153083   |                           |
| Secondary Forest                | 46%        | 2092498   |                           |
| Plantation                      | 6%         | 270995    | (6% of total forest land) |
| Totals                          | 100%       | 4516576   |                           |

Table 2-21 Forest land areas in LAC soils

| Country specific LU Category                                   | IPCC LU Cat / LU Subcategory | Area [ha] | Description  |
|--|------------------------------|-----------|--|
| mixed agricultural and forest area agriculture degraded forest | FL35_CL65                    | 461255    | No Close dense forest  |
|  | OPEN                         | 115314    | eventually being converted to Cropland   |
|  | SF                           | 345942    | => open dense forest 25% secondary forest 75%  |
|  | FL65_CL35                    | 617250    | No Close dense forest  |
|  | OPEN                         | 154312    | Degraded forest is not close dense any more  |
|  | SF                           | 462937    | => Open dense forest 25% (closed dense forest degraded) after +/- 15 years secondary forest 75% occurs there as well |

Table 2-22 Distribution of country-specific mixed Land Use classes to Forest Land Areas

| Country specific LU Category | Area of Forest Land Subcategory [ha] | Deforestation Rate [%] | Area of Deforestation [ha] |
|------------------------------|--------------------------------------|------------------------|----------------------------|
| P+C                          | 2153083                              | 0.0035                 | 7536                       |

|                  |                |               |              |
|------------------|----------------|---------------|--------------|
| Secondary Forest | 2092498        | 0.0035        | 7324         |
| Plantation       | 270995         | 0.0035        | 948          |
| <b>Total</b>     | <b>4516576</b> | <b>0.0035</b> | <b>15808</b> |

Table 2-23 shows the data sources used in the Inventory process for the Second National Communication to the UNFCCC.

Table 2-23 Deforestation rate and areas in Liberia

| Data type                   | Item   | Source                   |
|-----------------------------|--|--------------------------|
| Land cover data             | FAOstat data on CL   | Faostat.fao.org          |
|                             | State of the forest cover in Liberia – Forest information critical to decision making, N. BAYOL et J-F CHEVALIER, 2004 | FDA Liberia              |
|                             | Land cover Map (Shapefile)   | FDA                      |
| Crop management data        | FAOstat data for crop types  | Faostat.fao.org          |
|                             | Production estimates of major Crops And animals 2009   | MoA Liberia              |
| Climate data                | Digital Climate data: FAO Ecozone Map  | Geodata on Fao.org       |
| Soil data                   | Digital Soil data: Harmonized World Soil Database map  | Dataset available online |
| Grassland management data   | Based on expert knowledge  | Inventory team           |
| Livestock information       | Production estimates of major Crops And animals 2009   | MOA Liberia              |
| Deforestation               | State of the forest cover in Liberia – Forest information critical to decision making, N. BAYOL et J-F CHEVALIER, 2004 | FDA Liberia              |
|                             | REDD+ Readiness Preparation Proposal (RPP)   | FDA Liberia              |
| Disturbances                | Expert Guess and Judgment  | Inventory team           |
| Tree types & Timber harvest | Expert judgment  | Inventory team           |
|                             | Statistics   | FDA/ SGS                 |
| Emission Factors            | IPCC set of GPG and GL   | Available online         |
|                             | Calculations based on assorted species of timber harvest   | Inventory team           |



#### 2.5.4. Waste sector

One of the serious Liberian environmental issues is that of poor waste management and sanitation. Poor waste management contributes to environmental conditions that may threaten human health and well-being. Pollution and wastes are often concentrated in urban centers due to high population densities and higher consumption patterns compared to rural areas. The deterioration and lack of capacity of the relevant urban authorities was also a contributing factor. Although the waste collection and disposal system used to exist in some municipalities, these are currently not functioning. Some of the problems include inadequate legislation, weak enforcement, lack of substantial financial and human resources, lack of appropriate technologies and an effective mechanism to coordinate stakeholders.

The Liberian Government emphasizes economic growth as part of its national strategy for development. This will result in an expansion of urban, agricultural and industrial activities. The demands placed on the environment to provide resources for development and absorb waste will continue to grow, presenting challenges for both authorities and communities. The institutional and management framework for the waste management needs to be strengthened. A review or enforcement of the comprehensive waste management plan defining the roles and responsibilities between institutions involved in the sector needs to be carried out for clarity to avoid overlapping of functions. One sector responsible for such management and needs urgent attention is the Liberia Waste Sector (LWS). The sector includes but not limited to the following lines ministries, agencies and institutions where a minimum of data was obtained:

- Environmental Protection Agency
- Ministry of Public Works
- Ministry of Agriculture
- Ministry of Health
- National Environment Policy Council and
- National Environmental Commission of Liberia

##### 2.5.4.1. Data sources for the waste sector inventory

A significant proportion of the waste generated in Monrovia is organic refuse, followed by plastic. The increasing number of plastic waste results from the increased use of plastic products on Monrovia's market. (E.g. plastic sachet water, polyethylene terephthalate (PET) bottles and plastic bags). Other waste generated consisted mainly of plastic 14.2%, glass/ceramics 10.5%, metals 3.0%, rubber 10.0% and batteries 9.9%.) These results are also in line with other studies which revealed that the highest component of wastes generated in developing nations consists of organic materials (UNEP, 2006) (David Jr, V. et al., 2016).

Table 2-24 Projection of waste generation and collection coverage from 2010 to 2016

| <b>Year</b> | <b>Population<br/>(millions)</b> | <b>Generation<br/>(ton/yr)</b> | <b>Collection<br/>coverage<br/>(%)</b> | <b>Collection<br/>(ton/yr)</b> | <b>Collection<br/>(ton/yr)</b> |
|-------------|----------------------------------|--------------------------------|--|--------------------------------|--------------------------------|
| 2010        | 1.059                            | 724                            | 45                                     | 326                            | 118,917                        |
| 2011        | 1.086                            | 743                            | 50                                     | 371                            | 135,567                        |
| 2012        | 1.114                            | 762                            | 55                                     | 419                            | 153,009                        |
| 2013        | 1.143                            | 782                            | 60                                     | 469                            | 171,267                        |
| 2014        | 1.174                            | 802                            | 65                                     | 522                            | 190,372                        |
| 2015        | 1.203                            | 823                            | 70                                     | 576                            | 210,222                        |
| 2016        | 1.233                            | 843                            | 75                                     | 643                            | 230,814                        |

Liberia’s urban population has increased by nearly 71% since the end of the civil war, as more and more people migrated from the leeward counties to the urban centers, particularly Monrovia and Paynesville. Unfortunately, this urbanization has been met by increasingly poor environmental conditions in urban centers. Solid waste disposal has become an overwhelming task for the municipal authorities that face severe constraints in tackling the mounting waste situation. In Monrovia, high costs and difficulties in collecting large quantities of waste generated by households and business are critical challenges facing the solid waste sector. This has resulted in the accumulation of a significant amount of uncollected and haphazardly disposed of solid waste in the city. According to the most recent tonnage data, Monrovia's waste collection rate was approximately 800 tons of domestic solid waste per day, representing approximately 45 % of the total waste generated in the city. The formal solid waste collection system does not cover the remainder (approximately 55 %).

The solid waste management (SWM) programs under the Monrovia City Corporation have progressed over the recent years with support from the Government of Liberia, donors and implementing partners. Between the fiscal year 2015-18, three major solid waste projects were funded by the World Bank and EU: Emergency Monrovia Urban Sanitation Project (EMUS), Cheesemanburg Landfill Urban Sanitation (CLUS) EU Water Facility Project. These projects focused on several activities supporting the primary and secondary collection of waste, waste disposal and hygiene promotion in Monrovia and its environs. The infrastructure for solid waste management includes two transfer stations (Stockton Creek and Fiamah), three installed weighbridges (at the landfill and the two transfer stations), one hundred and twenty communal disposal locations spread over the Greater Monrovia area, and one sanitary landfill (Whein Town Landfill). The Whein Town facility will close in two years and will be replaced by a new landfill in Cheesemanburg as it has almost reached its maximum capacity. Monrovia City Corporation’s solid waste management system is designed to provide the following services:

- Primary Waste Collection involves door-to-door waste collection services in some areas and communal storage in public dumpsters or skips buckets in other areas.

- Secondary Waste Collection Services, which involves a long haul from skip buckets to transfer stations and to final disposal at a sanitary landfill and management of the landfill.

Primary solid waste collection (door-to-door) is conducted through agreements with Community-Based Enterprises (CBEs) while private contractors and the City Government take over the secondary waste collection. Primary Waste Collection Primary waste collection involves door to door waste collection services from households and institutions (restaurants, hotels etc.) to skip buckets or communal dumpsters. While collection from households to skip buckets is conducted through agreements with Community Based Enterprises (CBEs), waste collection from institutions is conducted by small & medium enterprises (SMEs). Each skip location has an attendant who focuses on emptying the skip bucket, notifies the regional supervisor when a skip bucket is filled and is familiar with the waste collection schedule.

The CBE model, created in 2007, is a contractual agreement between the MCC and the enterprise, has evolved with implications that constrain community ownership and competition for accountable service performance. By the end of 2016, when the EMUS project closed, over 40 CBEs were responsible for all primary waste collection in Monrovia (Ministry of Public Works, 2018). Secondary waste collection begins at the skip buckets, where waste is collected and sent to transfer stations and the landfill for final disposal. In August 2014, the MCC awarded contracts to two firms, Libra Sanitation and Caspian Holdings, to provide secondary municipal solid waste collection services in the south of Monrovia through the Fiamah Transfer Station north Monrovia through the Stockton Creek Transfer Station, respectively. Though these private contractors were initially hired for the secondary waste collection, attempts under the EMUS project to engage the private sector to manage the waste transfer stations and transport waste to the landfill were ultimately unsuccessful. These contracts were covered directly by the EMUS project.

Table 2-25 Composition of waste in Monrovia

| <b>Component</b>           | <b>Percentage (by weight)</b> |
|----------------------------|-------------------------------|
| Paper and carbonadoes      | 12.2                          |
| Glass, ceramics            | 10.5                          |
| Metals                     | 3.0                           |
| Plastics                   | 14.2                          |
| Leather, rubber            | 10.0                          |
| Organic refuse, vegetables | 40.2                          |
| Batteries                  | 9.9                           |
| <b>TOTAL</b>               | <b>100.0</b>                  |

Waste generated in Monrovia and its environs are not sorted and are randomly mixed. Wastes are being dumped in open spaces, streets corners, burnt, or buried in backyards. The percentage of waste collected by private companies and the Monrovia city corporation are mixed in refuse

bags. There is little or no recycling of the waste in the city. However, the collection system is ineffective, as wastes collected from households or designated points in communities are collected either once or twice a week, thus creating wastes to be found by the roadside or street corners in the city.

The Monrovia City Corporation is responsible for waste management in the city. The city corporation and the Paynesville city corporation, and five private companies are in charge of collecting and waste disposal of waste. It is worth mentioning that the city corporation and private companies are faced with challenges ranging from insufficient logistic, lack of finance, skilled individuals and inadequate corporation between stakeholders Waste is being disposed of in one disposal site, named Wein town Landfill. The landfill, however, is filled, and the government has designated a new landfill site in Cheesmanburg. Adequate disposal is vital to the sustainability of any waste management system. Adequate disposal of municipal solid waste tends to minimize threats to health and the environment. There are several options for solid waste disposal currently in use in Liberia. These include open dumping, burning, burying, land-fills and various forms of resource recovery such as recycling and reusing. Open dumping is the most commonly used method. Dumpsites are generally located at various locations around communities. Many are located in open lots, wetlands or near-surface water sources.

These locations are not ideal and can cause an environmental hazard. In some instances, waste disposal is used to reclaim land, especially in some urban communities. Other waste disposal methods, especially at the community level, include pits where waste is dumped and subsequently buried or burned. Burning and burying waste can also cause potential environmental problems such as air and water pollution. Communities located within the proximity of watercourses dispose of their wastes directly into these water bodies. This is common in Paynesville, Gardnersville, Barnesville, and Caldwell.

Health-care wastes are generated from various sources. These sources can be classified as major or minor. The Teaching/Specialist and the Regional hospitals form the major sources. Districts Hospitals, Private Laboratories, Health Centres/Post, other health facilities form the minor sources. The composition of the waste is often a characteristic of the type of source. For example, the operating theatres and surgical wards generate mainly anatomical waste such as tissues, organs, body parts and other infectious waste. Solid waste generation depends on numerous factors, such as established waste management methods, type of health-care establishments, the proportion of patients treated daily and the level of complexity and degree of specialization of the health facility. Hence, Teaching Hospitals generate larger quantities of waste per unit than other facilities. Data on waste load generation at the various health institutions are, however, not available. There are not sufficient facilities and reliable scientific methods in place for health-care waste load determination.

Incinerators are available only in some health centers. They are efficient but have a small capacity, thus reducing efficiency when the waste load to be incinerated are high. Open burning is applied to sharps and other infectious wastes in areas that lack incinerators or complete

breakdown of the existed ones. In rural districts with no municipal waste management systems, open burning is applied to general wastes.

Table 2-26 Medical waste disposal facilities

| Hospital/Clinic       | Incinerator |            | Concrete wall |            | Open-pit |            |
|-----------------------|-------------|------------|---------------|------------|----------|------------|
|                       | In use      | Not in use | In use        | Not in use | In use   | Not in use |
| St. Joseph Catholic   | 1           | 0          | 0             | 0          | 0        | 0          |
| Du Port Road          | 1           | 0          | 0             | 0          | 0        | 0          |
| James Davies Memorial | 1           | 0          | 0             | 0          | 0        | 0          |
| Redemption            | 1           | 0          | 0             | 0          | 0        | 0          |
| Island Clinic         | 1           | 0          | 0             | 0          | 0        | 0          |
| SDA Cooper            | 1           | 0          | 0             | 0          | 0        | 0          |

#### 2.5.4.2. Background and sectoral tables of waste sector of Liberia

The relevant greenhouse gases under the various sub-sectors of the waste sectors are indicated in Tables 2-27 and 2-28.

Table 2-27 Background Report Table for GHG Inventory for the Waste Sector. Inventory Year: 2014-2016

| Categories  | Type of Activity Data | Unit | Emissions [Gg]       |                      |                       |
|---|-----------------------|------|----------------------|----------------------|-----------------------|
|   |                       |      | CO <sub>2</sub> (Gg) | CH <sub>4</sub> (Gg) | N <sub>2</sub> O (Gg) |
| <b>4.A - Solid Waste Disposal (1)</b>                   |                       |      |                      | 3.03                 |                       |
| 4.A.1 - Managed Waste Disposal Sites                    | -                     | Gg   |                      |                      |                       |
| 4.A.2 - Unmanaged Waste Disposal Sites                  | -                     | Gg   |                      | -                    | -                     |
| 4.A.3 - Uncategorised Waste Disposal Sites              | -                     | Gg   |                      | -                    | -                     |
| <b>4.B - Biological Treatment of Solid Waste</b>        |                       |      |                      | -                    | -                     |
| <b>4.C - Incineration and Open Burning of Waste (2)</b> |                       |      | -                    | -                    | -                     |
| 4.C.1 - Waste Incineration                              | -                     | Gg   | -                    | -                    | -                     |
| 4.C.2 - Open Burning of Waste                           | -                     | Gg   | -                    | -                    | -                     |
| <b>4.D - Wastewater Treatment and Discharge</b>         |                       |      | -                    | -                    | -                     |
| 4.D.1 - Domestic Wastewater Treatment and Discharge     |                       |      | -                    | -                    | -                     |

|   |   |    |   |   |   |
|---|---|----|---|---|---|
| CH <sub>4</sub> Emissions (3)                         |   |    |   | - |   |
| N <sub>2</sub> O Emissions (4)                        | - | kg |   |   | - |
| 4.D.2 - Industrial Wastewater Treatment and Discharge |   |    | - | - | - |
| CH <sub>4</sub> Emissions (3)                         |   |    |   | - |   |
| N <sub>2</sub> O Emissions (4)                        |   |    |   |   |   |
| <b>4.E - Other (please specify)</b>                   |   |    | - | - | - |

Table 2-28 Sectoral Report Table for GHG Inventory for the Waste Sector. Inventory Year: 2014-2016

| Categories  | Emissions [Gg]  |                 |                  |                 |       |        |                 |
|---|-----------------|-----------------|------------------|-----------------|-------|--------|-----------------|
|   | CO <sub>2</sub> | CH <sub>4</sub> | N <sub>2</sub> O | NO <sub>x</sub> | CO    | NMVOCs | SO <sub>2</sub> |
| <b>4 - Waste</b>                                      | -               | -               | -                | -               | -     | -      | -               |
| <b>4.A - Solid Waste Disposal</b>                     | -               | 3.03            | -                | -               | 12.45 | -      | -               |
| 4.A.1 - Managed Waste Disposal Sites                  |                 |                 |                  | -               | -     | -      | -               |
| 4.A.2 - Unmanaged Waste Disposal Sites                |                 |                 |                  | -               | -     | -      | -               |
| 4.A.3 - Uncategorised Waste Disposal Sites            |                 |                 |                  | -               | -     | -      | -               |
| <b>4.B - Biological Treatment of Solid Waste</b>      |                 | -               | -                | -               | -     | -      | -               |
| <b>4.C - Incineration and Open Burning of Waste</b>   | -               | -               | -                | -               | -     | -      | -               |
| 4.C.1 - Waste Incineration                            | -               | -               | -                | -               | -     | -      | -               |
| 4.C.2 - Open Burning of Waste                         | -               | -               | -                | -               | -     | -      | -               |
| <b>4.D - Wastewater Treatment and Discharge</b>       | -               | -               | -                | -               | -     | -      | -               |
| 4.D.1 - Domestic Wastewater Treatment and Discharge   |                 | -               | -                | -               | -     | -      | -               |
| 4.D.2 - Industrial Wastewater Treatment and Discharge |                 | -               |                  | -               | -     | -      | -               |
| <b>4.E - Other (please specify)</b>                   |                 |                 |                  | -               | -     | -      | -               |

### 2.5.4.3. Summary table for GHG Inventory for the waste sector of Liberia

Table 2-29 National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal protocol and greenhouse gases precursors.

| Greenhouse gas source and sink categories | CO <sub>2</sub> Emissions (Gg) | CO <sub>2</sub> Removals (Gg) | CH <sub>4</sub> (Gg) | N <sub>2</sub> O (Gg) | CO (Gg) | NO <sub>x</sub> (Gg) | NMVOCs (Gg) | SO <sub>x</sub> (Gg) |
|---|--------------------------------|-------------------------------|----------------------|-----------------------|---------|----------------------|-------------|----------------------|
| <b>Waste</b>                              |                                |                               | 3.23                 | NE                    | 12.45   | NE                   | NE          | 0                    |
| A. Solid waste disposal on land           |                                |                               | 3.03                 |                       | 11.02   | NE                   | NE          | 0                    |
| B. Wastewater handling                    |                                |                               | 0.20                 |                       | 0.50    |                      | NE          |                      |
| C. waste incineration                     |                                |                               |                      |                       | 0.93    | NE                   | NE          |                      |
| D. other (please specify)                 |                                |                               | NO                   | NO                    | NO      | NO                   | NO          | 0                    |

## 3. Greenhouse Gas Mitigation Assessment

### 3.1. Mitigation policy context

Liberia's national efforts towards mitigating climate change have been outlined across different policies, plans, and strategies unpacked under the national regulatory frameworks section. Liberia also actively participates in other initiatives that may have direct mitigation benefits, such as UN Sustainable Energy for All programme and REDD+. The National Policy and Response Strategy on Climate Change and Nationally Determined Contribution are key national policies that outline the national plans and commitments. The summary of the country's key policies and enablers for climate change mitigation are below.

#### 3.1.1. Pro-Poor Agenda for Prosperity and Development (PAPD)

The Government of Liberia developed in 2018 a five-year (July 2018 – June 2023) national development plan, “Pro-Poor Agenda for Prosperity and Development (PAPD)”, towards accelerated, inclusive, and sustainable development to build a stable, resilient, and inclusive nation embracing its triple heritage and anchored on its African identity as well as to provide greater income security more Liberians, and reduce poverty levels through sustained and inclusive economic growth driven by scaled-up investments in key economic sectors.

The PAPD is built on the four pillars, namely: i) Power to the People - Liberians empowered with tools to gain control of their lives, ii) the Economy and Jobs - Economic stability and job creation through effective resource mobilization and prudent management of the economic inclusion process, iii) Sustaining the Peace - Promoting a cohesive society for sustainable development and iv) Governance and Transparency - An inclusive and accountable public sector for shared prosperity and sustainable development that are not only going to drive the implementation of the PAPD but also advance vision 2030 goals over the next five years.

Having learned experiences from the past national development plans such as Poverty Reduction Strategy (PRS 2008-2012) and Agenda for Transformation (AfT 2012 -2017), the success of the PAPD depends wholly on the government's commitment to ensure i) availability and effective use of financial resources (domestic and international sources), ii) that growth and development are widely shared equitably amongst the people of Liberia iii) robust institutional and legal frameworks are necessary and should be in place for proper planning and coordination of programmes in the country.

#### 3.1.2. National Policy and Response Strategy on Climate Change

To address the challenges and risks posed by climate change, the Government of Liberia developed the National Policy and Response Strategy on Climate Change in 2018. The policy



aims to have a climate-resilient, low carbon nation that responds to climate change while equally addressing its national development priorities sustainably and equitably. The Policy builds a firm foundation for mainstreaming climate change actions into all key socio-economic programmes to bring about an integrated response across all sectors. The policy outlines thirteen “Adaptation” interventions and eight “Mitigation” Interventions. It also focuses on cross-cutting issues and enabling pillars necessary for successful implementation and achievement of the Policy.

On climate change mitigation, the Policy is specific to the following interventions:

- Forestry and Wildlife - Significantly enhance Liberia’s potential for carbon sequestration by promoting conservation, sustainable forest management, community forestry and curbing, key drivers of deforestation and forest degradation, contributing to sustainable wildlife management.
- Agriculture - Move towards a sustainable agricultural system by encouraging lowland farming, investing in smallholder agriculture and allowing large-scale concessions on degraded land to avoid and reduce national emissions levels.
- Energy - Improve Liberia’s economy and social sectors toward universal access to affordable, sustainable, and environmentally friendly low carbon energy services.
- Mining - Ensure that mining in the Liberia sector develops environmentally sustainable by gradually mixing low emission energy sources and technologies.
- Industry - Ensure that the future of Liberian’s industrial base will not be locked into carbon-emitting technologies but rather develop on an environment-friendly, economically viable and socially acceptable basis so that it will be competitive in domestic and world markets.
- Transport - Build the future of Liberia's transport system and associated infrastructure on a low carbon-emitting basis.
- Tourism - Ensure the development of an environment-friendly tourism management system that contributes to its sustainable development vision.
- Waste Management - Pursue the development and implementation of a comprehensive waste management strategy that includes developing environmentally sustainable landfills, recovery and use of methane emissions for energy generation, instituting programs at the community and national level for recycling, and reducing and reuse of waste.

### 3.1.3. National Strategy for Reducing Emissions from Deforestation and Forest Degradation (REDD+) in Liberia

In 2016, GoL produced the National Strategy for Reducing Emissions from Deforestation and Forest Degradation (REDD+) to join the international community in the fight against climate change and reduce deforestation rate and forest degradation in the country. The total amount of financial resources that Liberia has already benefited from towards the preparation and implementation of REDD+ activities is approximately US\$46 million of committed investment. Recognising the importance and value of forests to contribute to the national

economy and sustain communities and the need to harness opportunities that engage in REDD+ activities, it is imperative to address the root causes foreseen to lead to forest deforestation and degradation in the country. **Error! Reference source not found.**Below outlines five strategic priorities that aim at reducing forest loss.

Table 3-1 REDD+ strategic priorities

|  |  |
|--|--|
| <p><b>Priority 1</b></p> <p>Reduce forest loss from pit sawing, charcoal production and shifting agriculture</p>   | <p>The major forest loss (Approximately 70% of the total forested area) in Liberia is subsistence and small-scale charcoal production, pit sawing, and shifting agriculture. Therefore, restricting these to &gt;80% of canopy cover forest is a priority.</p>   |
| <p><b>Priority 2</b></p> <p>Reduce the impact of commercial logging</p>  | <p>The extent of commercial forestry and associated forest loss may increase if there is the expected shift from company concessions to logging in community forests. Therefore, there is a need for strengthened standards and monitoring procedures of Forest Management Contracts (FMCs) and Community Forest Management Agreements (CFMAs) through Voluntary Partnership Agreements.</p> |
| <p><b>Priority 3</b></p> <p>Complete and manage a network of Protected Areas</p>   | <p>There is a need to complete the Protected Area Network (PAN) to protect around 18% of the total forested land in Liberia (forest canopy cover <math>\geq 30\%</math>).</p>  |
| <p><b>Priority 4</b></p> <p>Prevent or offset clearance of high carbon stock and high conservation value forest in agricultural and mining concessions</p> | <p>The major palm oil concession-holding companies aim to clear land and establish plantations within the next 10-15 years. Deforestation should, therefore, be limited to the less dense forest by Roundtable on Sustainable Palm Oil (RSPO) standards for conservation of High Carbon Stock (HCS) and High Conservation Value (HCV) forest.</p>  |
| <p><b>Priority 5</b></p> <p>Fair and sustainable benefits from REDD+</p>   | <p>The REDD+ Strategy should prioritize strategy options for distributing REDD+ benefits fairly and invest REDD+ income in sustaining the benefits.</p>  |

Implementing the REDD+ Readiness programme helped the country reduce greenhouse gases and put the country in a strategic position to drive its economic and development agenda.

### 3.1.4. Nationally Determined Contribution (NDC)

The Liberian First Nationally Determined Contribution submitted to the UNFCCC in 2015 outlines the country’s intended actions to contribute to the global effort to combat climate change through a two-fold strategy: adaptation and mitigation. According to NDC, Liberia has already undertaken several actions to support adaptation and mitigation based on her national circumstances and capabilities. Such include investment in hydro and embarking on rural electrification projects. However, for the country to realize its full potential in contributing to global mitigation efforts, substantial support from the Government and its international community is imperative. The NDC highlights the crucial role of adaptation in ensuring the resilience of the country’s communities and natural systems.

The country intends to explore opportunities around mitigation measures that will promote sustainable use of resources while contributing to the achievement of goals set out in different development frameworks, including Liberia’s Pro-Poor Agenda for Development (PAPD) 2018, National Renewable Energy Action Plans (NREAPs) 2015, National Climate change Policy and Response Strategy 2018, National Energy Policy 2009, Sustainable Development Goals (SDGs), African Union (AU) Agenda 2063 and other relevant national policies and plans. Liberia’s mitigation target was based on the country’s long-term plan to achieve carbon neutrality by 2050 and aims to reduce greenhouse gas emissions by 15% (797GgCO<sub>2</sub>eq) from the business usual by 2030. The strategic options for mitigation under the NDC are the energy sector (electricity, transport) and the waste sector. The Waste Sector focuses on solid waste disposal on land.

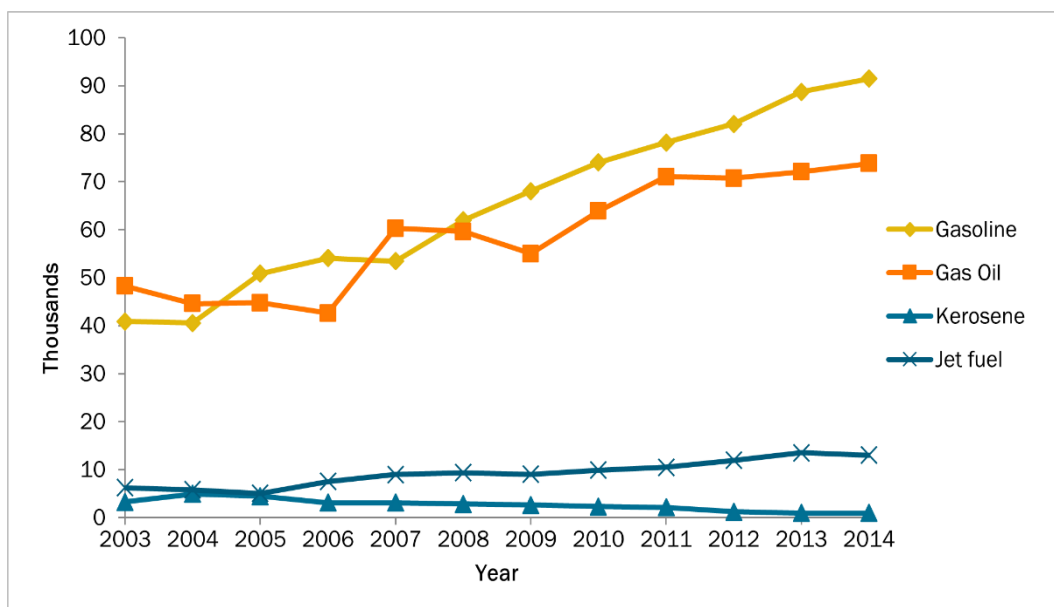


Figure 3.1 Impact on mitigation scenario on emissions

Table 3-2 Liberia's mitigation targets set out in the NDC

| Baseline Information used   | Sectoral Quantitative Target (if applicable)   | Sub-targets and activities identified  |
|---|--|--|
| Energy mitigation targets   |  |  |
| 5,414GgCO <sub>2</sub> e in 2000  | <ul style="list-style-type: none"> <li>• Reducing GHGs by at least 10% by 2030</li> </ul>  | <ul style="list-style-type: none"> <li>• Improving energy efficiency by at least 20% by 2030</li> <li>• Raising the share of renewable energy to at least 30% of electricity production and 10% of overall energy consumption by 2030</li> <li>• Replacing cooking stoves with low thermal efficiency (5-10%) with the higher - efficiency (40%) stoves</li> </ul> |
| Transport mitigation Targets  |  |  |
| In 2000, transport accounted for 40.1% of the total GHG emissions from the energy sector and 27.1% of Liberia's National GHG emissions. | <ul style="list-style-type: none"> <li>• 5% Biofuel use in transport - leading to a 40% reduction in GHG emissions resulting from palm biodiesel use (over fossil fuel) by 2030.</li> <li>• Mainstream climate change into existing transport management plan to strengthen emission control.</li> </ul> | <ul style="list-style-type: none"> <li>• Not stated</li> </ul>   |
| Waste mitigation targets  |  |  |
| In 2000, the waste sector accounted for 0.6% of Liberia's total CO <sub>2</sub> e emissions.  | <ul style="list-style-type: none"> <li>• 316,000 tCO<sub>2</sub>e (Mitigation Scenario 4: Monrovia Landfill Gas Plant)</li> </ul>  | <ul style="list-style-type: none"> <li>• Strengthen institutional and individual capacity for waste management.</li> <li>• Develop waste management infrastructure.</li> <li>• Implement and strengthen policy that promotes private investment in waste management.</li> <li>• Capture methane gas emitted from landfills and used to fuel</li> </ul>             |

|  |  |  |
|--|--|--|
|  |  | vehicles, cook at home, or generate power. |
|--|--|--|

On the other hand, on adaptation, the country focused on short, medium and long-term activities aimed at building Liberia's people's resilience. Sectors prioritised are Agriculture, Energy, Health, Forestry, Coastal Zone, Fishery and Transport/Infrastructure. Currently, the country is reviewing its NDC to have more ambitious and yet realistic targets.

### 3.1.5. National Renewable Energy Action Plan (NREAP) 2015

The National Renewable Energy Action Plans (NREAP) for Liberia 2015 presents Liberia strategy of renewable energy. It focuses on solar water heating, cooking fuels and technologies and biofuels. It, therefore, outlines targets, projections, and scenarios for all planned developments within the energy sector, emphasising the enabling legislative, regulatory, and institutional frameworks that facilitate proper implementation of the plan. **Error! Reference source not found.**3-3 outlines targets set under the under NREAP focusing on grid-connected renewable energy, off-grid renewable energy access applications and renewable energy applications for domestic use. Moreover, the NREAP lists appropriate measures for improved power generation and required standards for a rapid transformation of the electricity sector to include all relevant stakeholders within the power sector.

Table 3-3 Targets set under NREAP

| Targets set under NREAP |  |
|-------------------------|--|
| I.                      | <p><b>Grid-Connected Renewable Energy</b></p> <p>The RE share of total power generation is targeted to be 16% in 2015 and will be significantly increased to 94% in 2020, 96% in 2025 and 95% in 2030.</p>   |
| II.                     | <p><b>Off-Grid RE Access Applications</b></p> <p>The access is expected to increase from 1.4% of the population having access in 2014 and 2015 to 34.2% in 2020, 67.1% in 2025 and 100% in 2030.</p>   |
| III.                    | <p><b>RE Application for Domestic Use</b></p> <p>a. <b>Domestic Cooking Energy (Efficient Cook Stoves)</b></p> <p>i. When the access measures are introduced, the share of population changes to 26% for 2014 and 2015 each and goes up to 49% in 2020, 72% in 2025 and 95% in 2030.</p> <p>ii. Charcoal production for domestic uses produced using efficient technologies will rise from 1% in 2014 to 15% of the charcoal production in 2020 and 58% in 2030.</p> |

- iii. The share of the population using modern fuel alternatives for cooking (e.g. LPG, biogas, solar cookers, kerosene) will increase at the rate of 10% of the population for each of the years 2014 and 2015 but quickly takes off to 20%, 32% and 43% for the years 2020, 2025, and 2030 respectively.
- b. Solar Water Heaters
  - i. The projected number of buildings with solar thermal systems will amount to negligible quantity in 2014 and are projected to rise progressively to 86,000 in 2020 and up to 120,000 in 2030.
  - ii. District health centres, maternity clinics, school kitchens and boarding schools did not use solar thermal systems in 2014, but the percentage share of institutions using solar thermal systems will rise to 5% in 2020 and 10% in 2030.
- c. BioFuels Use
  - i. Bio-fuel usage is projected to rise from 0% share in 2014 up to 2% by 2020 and 5% by 2030.

The NDC reinforces these targets, and appropriate targets, priority measures and programmes have been identified and advanced, as those will enable Liberia to achieve her commitments as a member of the Economic Community of West African States (ECOWAS).

### 3.1.6. National Energy Policy 2009

The National Energy Policy (NEP) was formulated in 2009 to create an enabling environment to attract private sector capital to the energy sector, to restructure and reform energy institutions, to decentralize energy service administration, to fully utilize domestic energy resources and, most importantly, to ensure that all parts of Liberia have access to affordable and modern energy services. The policy addresses the following four key policy issues;

Table 3-4 Strategic policy issues, objectives and goals

| Strategic Policy Issue | Policy Objective   | Goals  |
|------------------------|--|--|
| Access                 | To ensure the availability of modern energy services for all Liberians in urban and rural areas. | <ul style="list-style-type: none"> <li>• Ensure 40% of the population living in rural and peri-urban areas and using traditional biomass for cooking with access to improved stoves and kerosene or efficient-gas cookers to reduce indoor pollution;</li> <li>• Ensure 30% of the urban and peri-urban population have access to reliable modern energy services enabling them to meet their</li> </ul> |

|                          |  |   |
|--------------------------|--|---|
|                          |  | <p>basic needs (lighting, cooking, communication, and small production-related activities);</p> <ul style="list-style-type: none"> <li>• Ensure 15% of the rural population and 25% of the schools, clinics, and community centers in rural areas have access to modern energy services to meet the same basic needs.</li> </ul>  |
| Quality                  | To ensure the acceptability of energy products and services by adopting standards consistent with international best practice.   | <ul style="list-style-type: none"> <li>• Establish quality standards for all energy products and services which will be monitored and enforced by the Energy Regulatory Board (ERB) and the Bureau of Standards as appropriate;</li> <li>• Establish energy efficiency standards for all government and commercial buildings and industrial facilities to import fuel-efficient vehicles, energy-efficient light bulbs, and home appliances.</li> <li>• Minimize and eliminate loss, theft, and corruption and promote international best practices in wholesale and retail energy transactions and granting licenses and concessions.</li> </ul> |
| Cost                     | To ensure affordability through least-cost production and utilization of energy services.  | <ul style="list-style-type: none"> <li>• Provide energy services on a full cost-recovery basis to those who can pay and on a targeted subsidized basis to those who can only afford to pay a portion of the cost.</li> <li>• Establish a regulatory process for monitoring all costs – economic, financial, social, and environmental – and allocating these to the user (ratepayer or polluter) or public (taxpayer) as appropriate.</li> </ul>  |
| Institutional Frameworks | To establish an adequate delivery process for energy products and services through a public and private partnership where investment in new infrastructure and services is provided by the private sector to the | <ul style="list-style-type: none"> <li>• Establish an independent and transparent regulatory process to create an investment environment conducive to increased private sector involvement in the energy sector.</li> <li>• Define and review energy policy and monitor policy implementation by all operators, whether owned by the public sector, private sector, or local communities.</li> </ul>  |

|  |   |  |
|--|---|--|
|  | <p>greatest extent possible, with the public sector providing the supporting policy environment and regulatory oversight.</p>               | <ul style="list-style-type: none"> <li>• Restructure and elevate the Ministry of Land, Mines and Energy (MLME) to ensure energy issues are given enough attention and resources.</li> <li>• Establish a semi-autonomous regulatory body (<i>Energy Regulatory Board</i>) responsible for monitoring all energy policies and standards established by the MLME.</li> <li>• Establish a semi-autonomous agency (<i>Rural and Renewable Energy Agency</i>) dedicated to the commercial development and supply of modern energy services to rural areas, emphasising locally available renewable resources.</li> <li>• Restructure all government-owned energy corporations to remove all policy making and policy monitoring functions and ensure continued operation through sound commercial business practices.</li> <li>• Establish the Liberia National Oil Corporation (LNOC) as the Government’s implementing agency for both the upstream and downstream operations.</li> <li>• Re-establish the National Energy Committee (NEC) to facilitate coordination between energy-oriented organizations.</li> </ul> |
| <p>Small Light Today, Big Light Tomorrow</p> | <p>To establish and communicate a strategic roadmap that will serve as a reference for performance measurement in implementing the NEP.</p> | <ul style="list-style-type: none"> <li>• Adopts a three-pronged strategy towards the realization of the vision expressed by the principal objective of the NEP – <b>the short term</b> (emergency phase), <b>the medium-term</b> (capacity building phase) and <b>the long term</b> (development phase).</li> <li>• For the short term (emergency phase) – Foundation for post-conflict stabilization and redevelopment program</li> <li>• For the medium-term – the strategy is to develop the country’s institutional capacity for policy implementation.</li> <li>• For the long term, vision realisation will focus on developing the country’s large hydropower and other renewable resources.</li> </ul>   |



### 3.1.7. Rural Energy Strategy and Master Plan for Liberia until 2030 (RESMP) 2016

Liberia's Rural Energy Strategy and Master Plan (RESMP) for the period until 2030 aims to set clear targets, to identify least-cost projects and technologies, to propose concrete investments for funding and implementation, with appropriate institutional framework and capacity to increase energy access and renewable energies to the country's rural areas and population – meaning all areas and population outside of greater Monrovia. The RESMP implements the NEP and reinforces the NDC. The RESMP is also responding to two global development goals - the Sustainable Energy for All (SE4ALL) and Sustainable Development Goals (SDGs) By 2030. The ambitious targets set out by the RESMP are as follows:

- Electrification rate for rural population outside Monrovia to reach 35%
- More than 75% of all electricity generated from renewable energy, with 19% coming from other than large hydro: Mini-hydro, Solar and Biomass.
- Universal access to affordable solar lamps, efficient appliances and cookstoves.
- Cooking gas available in all county capitals and efficiently produced charcoal widespread across the country

The Master Plan identifies 92 projects and investments to electrify 265 000 homes and 1.34 million people outside Monrovia until 2030.

### 3.1.8. National Transport Policy Strategy (NTPS)

The government of Liberia endorsed National Transport Policy Strategy in 2009 and launched it in 2014. The NTPS is an integral part of Liberia's plans to reduce its emissions from the transport sector. The NTPS is aimed at providing comprehensive policy guidance and direction for a sustained national transport system. It has at its core the goal of providing efficient transport services. The long-term strategy for the transport sector envisages creating a modern railway and water transport system to reduce emissions from the sector. This would require significant investment, which the government is currently unable to afford. Over the immediate to mid-term, the strategy provides for other measures like requiring all vehicles to have catalytic converters to reduce pollution to be implemented. Its implementation mechanism has also been subsequently developed.

## 3.2. Overall methodology for mitigation assessment

A seven-step approach recommended by the UNFCCC's Consultative Group of Experts (CGE) was followed, illustrated in **Error! Reference source not found.**3.2 below.

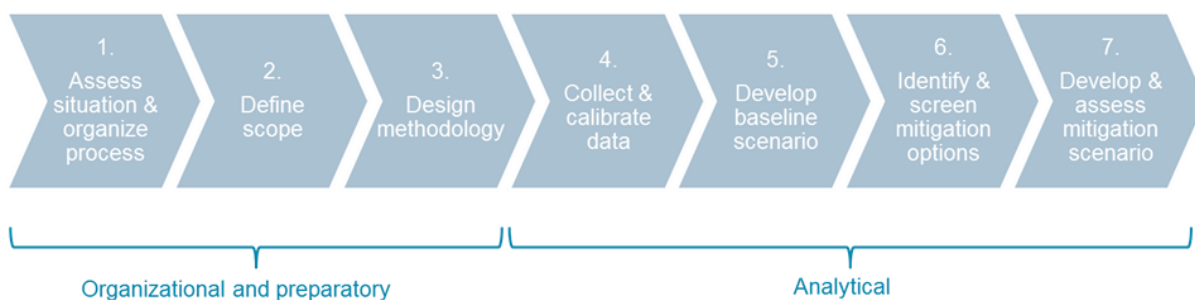


Figure 3.2 Mitigation assessment process recommended by CGE process

Table 3-5 describes each of the seven steps in more detail.

Table 3-5 Mitigation assessment steps

|   |   |
|---|---|
| <p>Step 1<br/>Assess the situation and organize the process</p> | <p>The step consisted of three main phases, namely:</p> <ol style="list-style-type: none"> <li>i. Determining and prioritising objectives of the assessment. The assessment's main objectives were identified as the fulfilment of the country's obligations under the convention and informing the country's climate change response agenda.</li> <li>ii. Assessed existing studies, current capacities, and data availability –This phase entailed reviewing and analysing available national reports relevant to mitigation studies and identifying strengths and gaps.</li> </ol> |
| <p>Step 2<br/>Define the Scope of the assessment</p>            | <p>The step entailed delineation of the extent of mitigation assessment and scoping of mitigation actions per sectors. The key socio-economic sectors, such as energy supply and demand, agriculture, land-use, forestry, solid waste, constituted the assessment basis. Scoping of mitigation options considered the technological scope, relevance to national priorities, timeframe and the base year.</p>   |
| <p>Step 3<br/>Design assessment methodology</p>                 | <p>The methodology was designed based on economic outputs, including cost and benefits (bottom-up approaches), macroeconomic impacts (top-down models) as well as integrated or sector-specific analysis (e.g. power supply or transportation modelling). Other criteria for methodology selection included consideration of GHG inventory and Vulnerability and Adaptation Assessment (V&amp;A).</p>   |
| <p>Step 4<br/>Collect and calibrate data and assumptions</p>    | <p>The latest GHG inventory for Liberia, Energy statistics, energy balances, national economic and demographic statistics and surveys were primary data sources. In cases where there were data inconsistencies and gaps, these were bridged with international data and studies.</p>   |

|  |   |
|--|---|
| <p>Step 5<br/>Develop a Baseline Scenario</p>            | <p>This step involved collecting necessary macro-economic and demographic data required to set up the model, base year setup, and baseline scenario modelling. Projections of GHG emission were informed by macro-economic and demographic data and GHG Inventory Report from the First Biennial Update Report. The scenario was developed based on documented assumptions informed by the Liberia Institute of Statistics and Geo-Information Services reports about the expected economic in the key sectors and demographic changes. The baseline scenario assumed an emissions trajectory without any mitigation from the year 2015 projecting to 2050.</p> |
| <p>Step 6<br/>Identify and Screen mitigation options</p> | <p>Identification and analysis of mitigation opportunities in key sectors of the economy were undertaken in consultation with key stakeholders. Key emitting sectors were identified by the stakeholders guided by the GHG Inventory. Based on the current policies, the consultancy team, in consultation with the EPA, identified and screened mitigation options. The mitigation potential of each of the suggested options was assessed, quantified and appraised.</p>  |
| <p>Step 7<br/>Develop Mitigation Scenario</p>            | <p>This process last step entails compiling the country's mitigation made up of the mitigation actions selected in the previous step. This scenario was then set up, modelled over the study period and compared with the baseline scenario. The Mitigation scenario depicts the country's implied low carbon trajectory if the prioritized GHG mitigation measures would be implemented between 2015 and 2050.</p>   |

### 3.3. Results of mitigation assessment

The results of the assessment are presented in the sections that follow.

#### 3.3.1. Baseline scenario

##### 3.3.1.1. Key assumptions and drivers

The baseline scenario aims to represent the most plausible future GHG emissions pathway of Liberia to 2050 in the absence of new actions and policies that reduce GHG emissions or enhance carbon sinks. The base year of 2015 has been used, and emissions have been projected to 2050 with assumptions of how activity related to specific sources of emissions changes over time. The main drivers of GHG emissions are population growth, economic growth, as well as energy demand. For Liberia, the rate of deforestation and land-use change is also an important

driver of GHG emissions in the land sector. Data on the drivers were extracted from various datasets, including the National GHG Inventory, the Energy Balance, demographic data from the Liberia Institute of Statistics and Geo-Information Services (LISGIS) and the Macroeconomic reports Central Bank of Liberia. Specific drivers and assumptions are presented in the sub-sectors below.

#### 3.3.1.2. Third National GHG Inventory

**Error! Reference source not found.**3.3 and **Error! Reference source not found.**3.4 present Liberia's greenhouse gas emissions outlined in the draft of the First Biennial Update Report (BUR-1). According to BUR-1, Liberia's net GHG emissions amounted to 5,695.16Gg CO<sub>2</sub>e in 2015. AFOLU was the biggest contributor of GHG emissions with a percentage share of 54%, followed by the Energy and IPPU sectors with percentage shares of 20% and 19%, respectively. The Waste sector was the least contributor with emissions amounting to 396.26Gg CO<sub>2</sub>e and a percentage share of 7%.

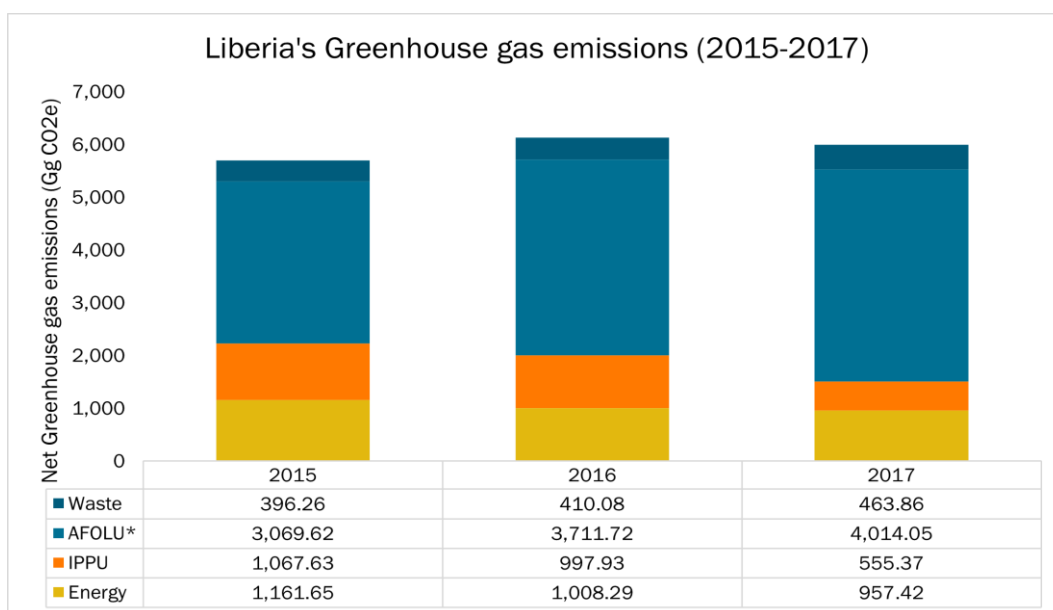


Figure 3.3 Graph of GHG inventories for Liberia, disaggregated by sector (2015 to 2017)

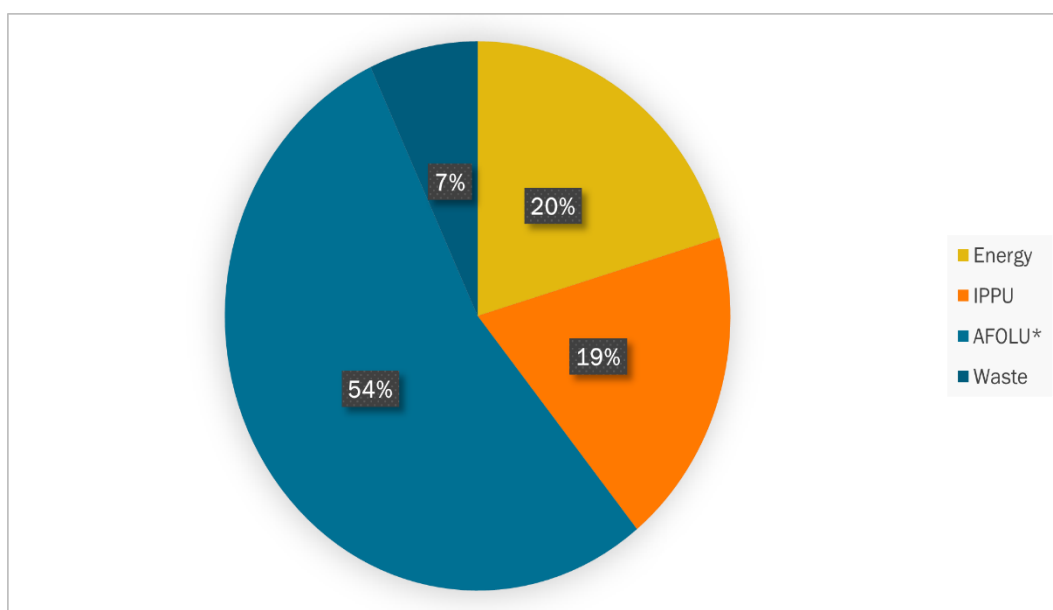


Figure 3.4 Contribution of greenhouse gases by sector (2015)

### 3.3.1.3. Population and economic growth

Population growth is a critical driver of GHG emissions and an essential parameter in building the baseline scenario. Population projections were extracted from the draft BUR report, as shown in Figure 3.5. The population was estimated to be 4,472 million in 2015 with an average growth rate of 2.6% and average household size estimated to be 4.3. These population parameters were used as an assumption to model the baseline scenario.

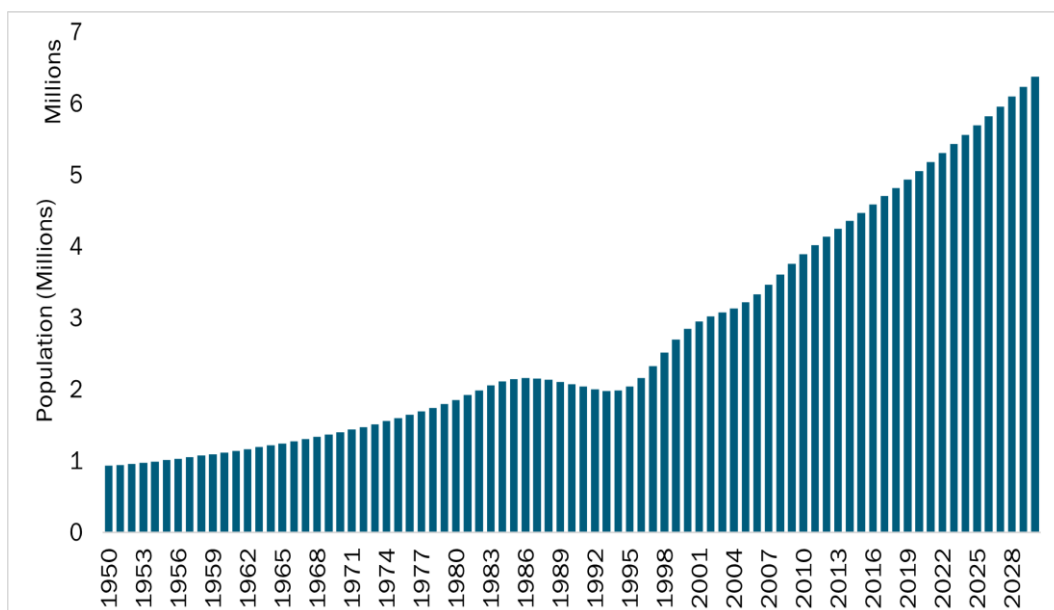


Figure 3.5 Population growth

Another key parameter that governed the assumptions for the baseline scenario is the growth rate for the Actual Gross Domestic Product (GDP) contribution of the key economic sectors as reported in annual reports by the Central Bank of Liberia. Actual GDP growth rates from 2014 to 2019 for key sectors are presented in **Error! Reference source not found.**. The average GDP growth rates observed for each of these industrial sectors during the period 2014 to 2019 were used to project the growth of the respective sectors from 2015 to 2050. The Actual GDP was split as per annual reports from the central bank.

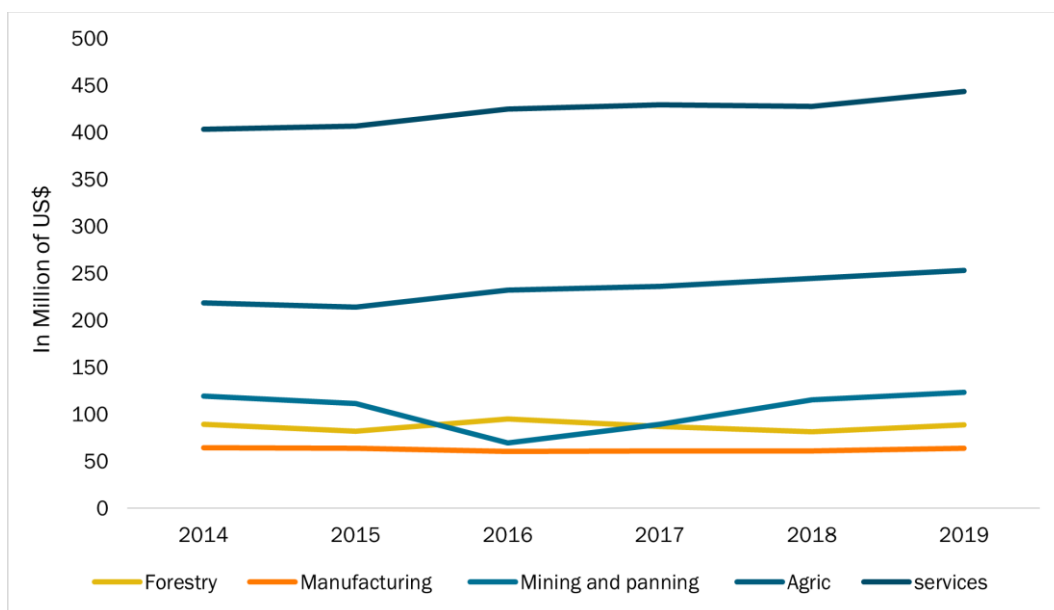


Figure 3.6 Actual GDP contribution for economic sectors

### 3.3.1.4. Energy demand

Assumptions for the baseline emissions projections for energy demand were based on the Second National Communication energy data. **Error! Reference source not found.**3-6 below shows the disaggregation of liquid fuels by sector in Liberia.

Table 3-6 Disaggregated liquid fuel demands

| Year/Product | Gasoline          | Gas Oil           | Kerosene         | Jet fuel          | Total (Product)     |
|--------------|-------------------|-------------------|------------------|-------------------|---------------------|
| 2003         | 40,875.00         | 48,239.00         | 3,255.00         | 6,232.00          | 98,601.00           |
| 2004         | 40,560.00         | 44,567.00         | 4,916.00         | 5,789.00          | 95,832.00           |
| 2005         | 50,852.00         | 44,756.00         | 4,423.00         | 5,058.00          | 105,089.00          |
| 2006         | 54,058.00         | 42,586.00         | 3,100.00         | 7,520.00          | 107,264.00          |
| 2007         | 53,402.00         | 60,234.00         | 3,078.00         | 8,943.00          | 125,657.00          |
| 2008         | 61,932.00         | 59,598.00         | 2,824.00         | 9,356.00          | 133,710.00          |
| 2009         | 68,003.00         | 55,003.00         | 2,599.00         | 9,004.00          | 134,609.00          |
| 2010         | 73,992.00         | 63,855.00         | 2,305.00         | 9,897.00          | 150,049.00          |
| 2011         | 78,142.00         | 71,045.00         | 2,145.00         | 10,451.00         | 161,783.00          |
| 2012         | 82,010.00         | 70,687.00         | 1,214.00         | 11,945.00         | 165,856.00          |
| 2013         | 88,678.00         | 72,043.00         | 956.00           | 13,483.00         | 175,160.00          |
| 2014         | 91,442.00         | 73,789.00         | 914.00           | 13,001.00         | 179,146.00          |
| Total (year) | <b>783,946.00</b> | <b>706,402.00</b> | <b>31,729.00</b> | <b>110,679.00</b> | <b>1,632,756.00</b> |
| % Total      | 48.01%            | 43.26%            | 1.94%            | 6.78%             | 99.99%              |

Disaggregation of these fuels per sector was based on the 2018 energy balance and the fuel disaggregation used in the 2015 GHG inventory. For electricity, the baseline projection was based on the factors specified in **Error! Reference source not found.**3-7.

Table 3-7 Electricity generation assumptions used in projecting the baseline

| Driver / assumption   | Value                                      | Source, Year   |
|---|--|--|
| 2015 (current) power generation (national grid)                       | 131 MW                                     | LEC, 2017  |
| Increase electricity generation from 123 MW to 270 MW by 2023         | 270 MW by 2023, and 2.6% growth after that | Pro-Poor Agenda for Prosperity and Development is a national development plan 2018-2023 (2018) |
| The relative contribution of energy sources to electricity generation | Remains constant throughout                | Assumption   |

### 3.3.1.5. Transportation

The baseline scenario was modelled using the information and data from the Report on Liberia's Fuel Economy and Vehicle CO<sub>2</sub> Emission and the 2018 energy balance. 77.37% of total diesel imports and 96.50% of Petrol imports are used for transport. **Error! Reference**

**source not found.** below shows the country’s vehicle population from 2005 to 2016. In projecting the baseline to 2050, it is assumed that the growth of the vehicle population beyond 2016 is in line with the growth observed between 2013 and 16 at 2.67% annually.

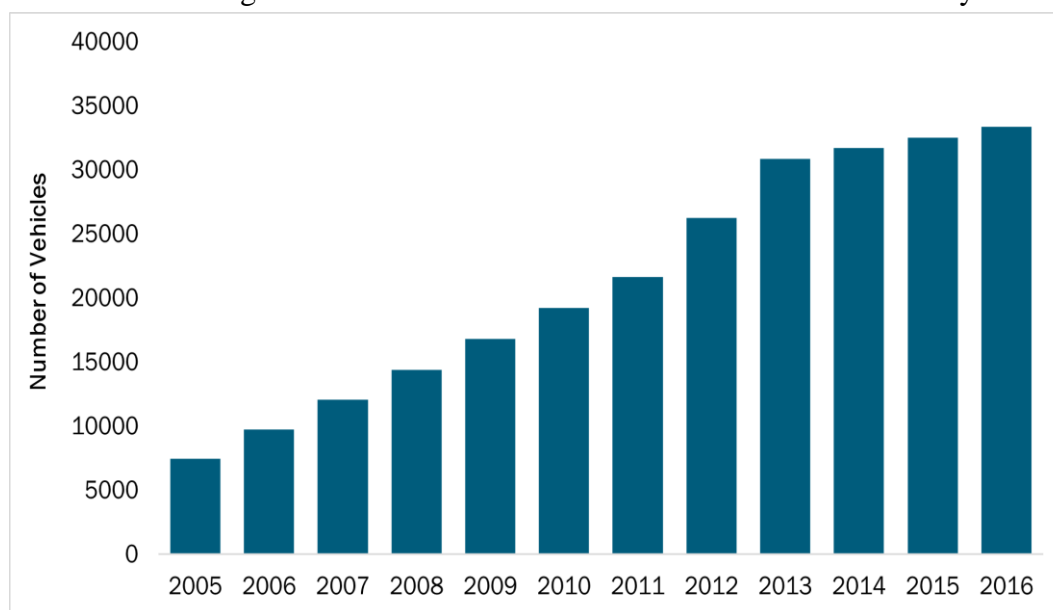


Figure 3.7 Vehicle population of Liberia (2005 to 2016)

### 3.3.1.6. Agriculture, Forestry and Land Use drivers

For the baseline scenario projections of non-energy sectors, the historical emissions for the base year 2015 were used to model the baseline scenario. The sector-specific data that are drivers of emissions were used to project into the future. The non-energy sectors included land-use change, Agriculture (including rice cultivation), waste management, and industry. Key drivers and assumptions used for projecting agriculture, forestry and land-use emissions are presented in **Error! Reference source not found.3-8** below.

Table 3-8 Drivers and assumptions used for projecting agriculture, forestry and land use

| Driver type                  | Driver             | 2015 value     | Projection                               |
|------------------------------|--------------------|----------------|--|
| Animals                      | Sheep              | 276 406        | 303 081 in 2017; 2.98% growth thereafter |
|                              | Goats              | 345 698        | 400 016 in 2017; 4.67% growth thereafter |
|                              | Cattle             | 44 114         | 44 223 in 2017; 1.09% growth thereafter  |
|                              | Swine              | 287 380        | 307 546 in 2017; 2.55% growth thereafter |
|                              | Poultry            | 7 673          | 8 667 in 2017; 4.2% growth thereafter    |
| Land-use change and forestry | Deforestation rate | 0.46% annually | 0.46% annually (FAO stat, 2020)          |



### 3.3.2. Liberia’s baseline trajectory (2015 – 2050)

Baseline projections of Liberia’s greenhouse gases for the 2015 – 2050 period are presented in **Error! Reference source not found.3-9** and **Error! Reference source not found.3.8** below. The results show that if no new climate change mitigation measures are to be implemented, Liberia’s net GHG emissions are projected to increase by 59.3% between 2015 and 2050, reaching (8,536.9 kt CO<sub>2</sub>e) by 2050 (compared to 5357.7 kt CO<sub>2</sub>e in 2015).

Table 3-9 Baseline scenario emissions

| Sectors   | 2015<br>(kt CO <sub>2</sub> e) | 2035<br>(kt CO <sub>2</sub> e) | 2050<br>(kt CO <sub>2</sub> e) |
|---|--------------------------------|--------------------------------|--------------------------------|
| Energy  | 629.62                         | 853.53                         | 1 279.87                       |
| Non- Energy (Agriculture, Forestry, land use, IPPU and Waste) | 4,728.1                        | 5,845.607                      | 7,256.98                       |
| Total   | <b>5,357.723</b>               | <b>6,699.139</b>               | <b>8,536.85</b>                |

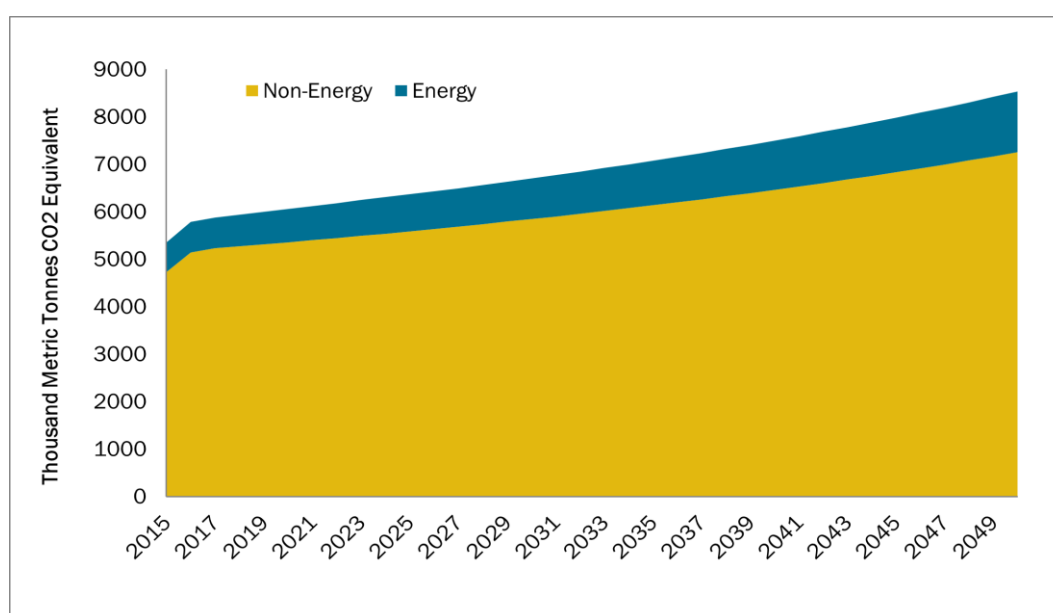


Figure 3.8 Projection of greenhouse gases for all sectors under the baseline scenario

Non-energy emissions, comprising emissions from agriculture, forestry, land use, IPPU and waste, make up the bulk of Liberia’s emissions, contributing 88% in 2015 and 82% in 2050. Both energy and non-energy emissions are further disaggregated in the sections that follow.

#### 3.3.2.1. Non-energy baseline trajectory

Liberia’s emissions from non-energy sources were 4,728.1 kt CO<sub>2</sub>e in 2015 and are expected to reach 7,257.0 kt CO<sub>2</sub>e in 2050 under the baseline scenario. **Error! Reference source not found.3.9** and **Error! Reference source not found.3-10** below present the projected make-up of the non-energy emissions under the baseline trajectory.

## Land-use change

The most significant contributor to the current and future emissions is from the Land Sector, which comprises emissions mainly from Changes in Forest and Other Woody Biomass Stocks. Land Sector accounted for 54% (2910.39 ktCO<sub>2</sub>e) in 2015 and projected to increase to 4,468.810164 ktCO<sub>2</sub>e in 2050 if no mitigation measures are implemented. Liberia is the most forested country in West Africa, with about 68% of Liberia's land surface covered by forests. Liberia's forest sector is uniquely placed with a significant contribution of the sector to the national economy. However, the country faces challenges deforestation with a deforestation rate estimated at 0.46% per year for 2005–2015, leading to an increasing emission.

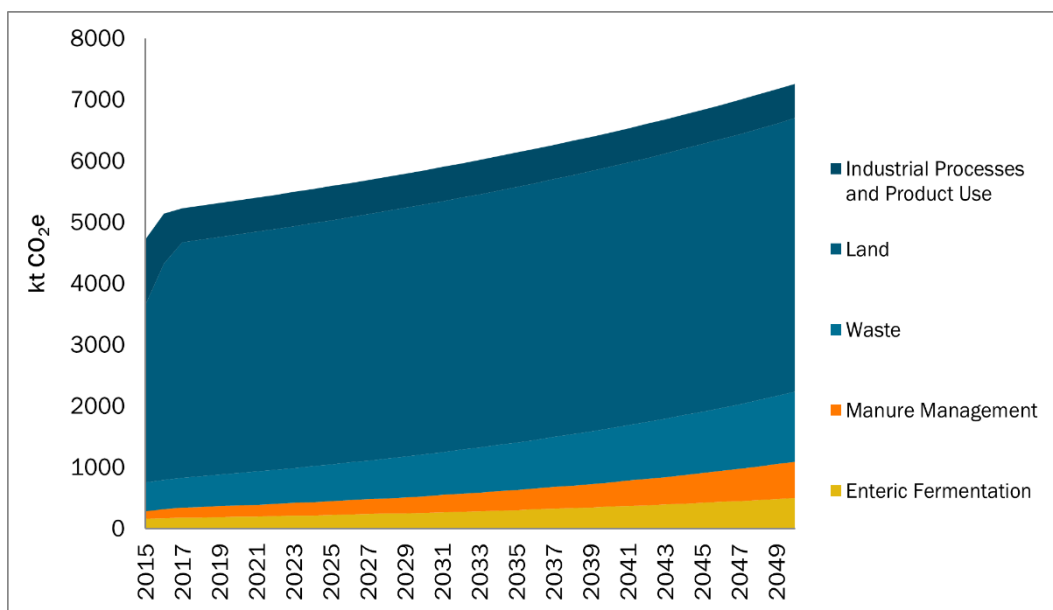


Figure 3.9 Non-energy baseline trajectory

Table 3-10 Non-energy baseline (2015 - 2050)

| Sectors                              | 2015(kt CO <sub>2</sub> e) | 2025(kt CO <sub>2</sub> e) | 2035(kt CO <sub>2</sub> e) | 2045(kt CO <sub>2</sub> e) | 2050(kt CO <sub>2</sub> e) |
|--------------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| Enteric Fermentation                 | 162.8                      | 221.8                      | 302.3                      | 420.2                      | 498.9                      |
| Manure Management                    | 123.4                      | 223.7                      | 327.8                      | 485.0                      | 592.0                      |
| Waste                                | 463.9                      | 599.6                      | 775.1                      | 1001.9                     | 1139.1                     |
| Land                                 | 2910.4                     | 3984.4                     | 4171.5                     | 4367.4                     | 4468.8                     |
| Industrial Processes and Product Use | 1067.6                     | 558.3                      | 558.3                      | 558.3                      | 558.3                      |
| Total                                | 4728.1                     | 5587.8                     | 6134.9                     | 6832.8                     | 7257.0                     |

## Livestock Baseline Emissions

Livestock is the least contributor to Liberia's overall emissions as it accounts for only 5% of total emissions. Livestock baseline emissions are expected to become 1090.8 ktCO<sub>2</sub>e by 2050,

as indicated in **Error! Reference source not found.**3-10. Livestock emissions are mostly made up of methane emissions from enteric fermentation and manure management and nitrogen oxide emissions from manure management.

### Waste Baseline Projections

Wastewater treatment and solid waste disposal both account for 99.9% of the total waste emissions, while incineration and open burning of waste is 0.01%. Under the baseline scenario, these emissions are expected to increase from 463.9 ktCO<sub>2</sub>e in 2015 to 1,139.1 ktCO<sub>2</sub>e in 2050 due to population growth.

#### 3.3.2.2. Energy sector emissions

Energy sector emissions contributed 629.6 ktCO<sub>2</sub>e in 2015, which is about 12% of the total emissions and is projected to increase by about 103% to 1279.87 ktCO<sub>2</sub>e in 2050 if business as usual continues and no mitigation measures are implemented (Figure 3.10). The baseline scenario projections show that the largest share of energy emissions currently is from the transport sector, which constitutes about 35% in 2015 of total energy emissions and will continue to dominate, increasing to 45.7% in 2050 (Figure 3.11 and Figure 3.12). The second-largest contributor to energy sector emissions is the Energy industries, which includes electricity generation and charcoal production. Energy industries are projected to contribute 37.89% to energy emissions by 2050. Other sectors, comprising emissions from residential, commercial institutions and fishing, are projected to contribute 85.63 ktCO<sub>2</sub>e to the sector.

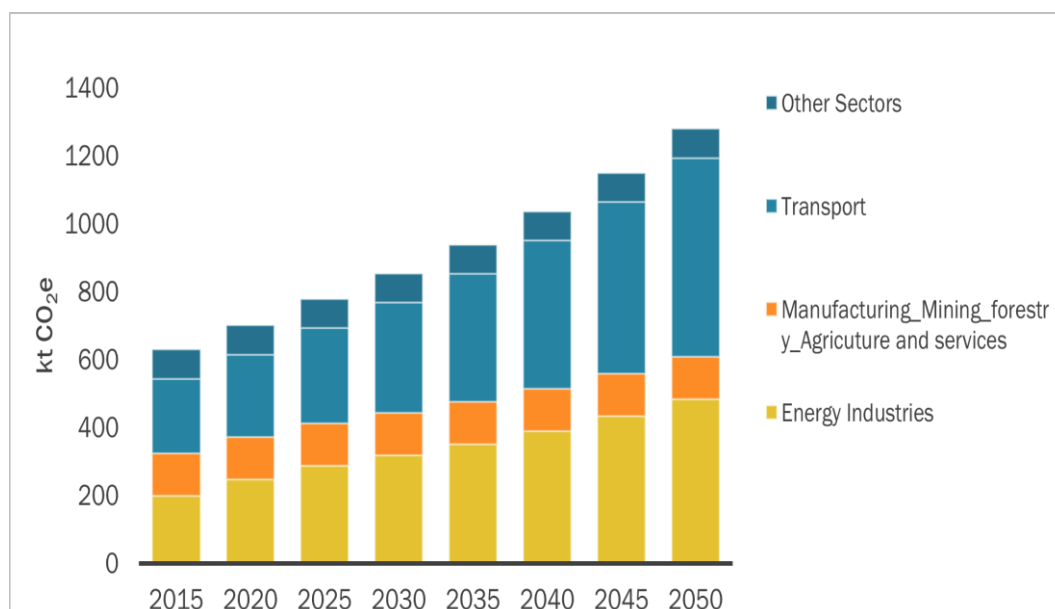


Figure 3.10 Energy demand baseline scenario

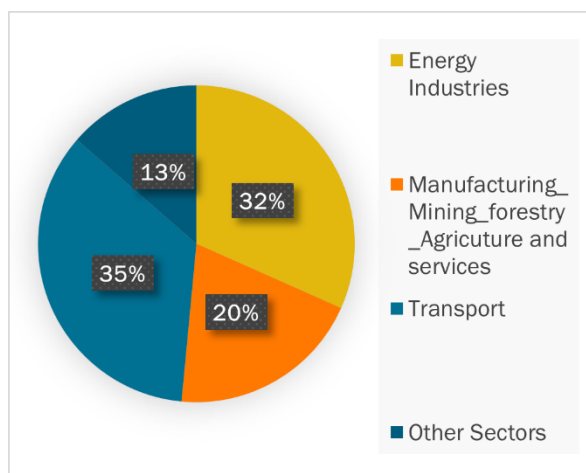


Figure 3.11 Energy demand baseline scenario for 2015

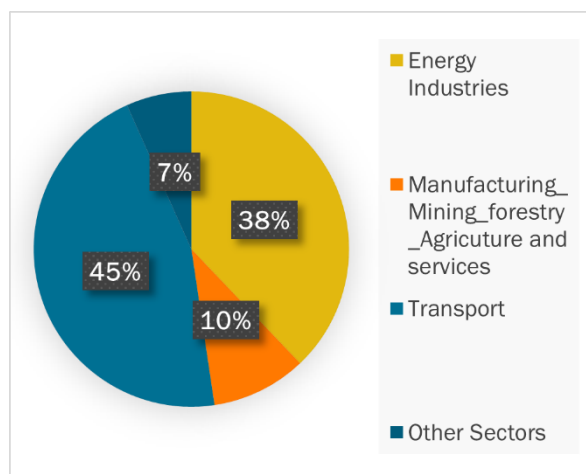


Figure 3.12 Energy demand baseline scenario for 2050

### 3.3.3. Identification, selection and assessment of mitigation measures

The individual potential mitigation measures were identified and assessed for their mitigation potential to develop a mitigation scenario. The identification process took into account the alignment of national policy and strategy documents. This chapter presents the steps taken in this selection process as well as the respective outcomes.

A long list of mitigation actions was identified from existing policies and national plans. Specific policies that informed the selection of mitigation measures include:

- The National Policy and Response Strategy on Climate Change
- Liberia National Energy Policy - An agenda for action and economic and social development (NEP, 2009)
- The Pro-Poor Agenda for Prosperity and Development is a national development plan 2018-2023 (PAPD, 2018):

- National Renewable Energy Action Plans (NREAP, 2015):
- Initial National Communication (INC, 2013)
- Rural Energy Strategy and Master Plan for Liberia until 2030 (RESMP, 2017).
- First Nationally Determined Contribution (NDC, 2015)
- National Strategy for REDD+ in Liberia (REDD+, 2016)

To identify the most appropriate mitigation measures to be included in the mitigation scenario, a desktop review and screening of existing policies and plans were conducted to identify a list of mitigation actions of national priority. From the review and screening process, eight priority mitigation measures were identified and selected, as shown in Table 3-11 below. The Table also outlines the penetration rates and assumptions for each mitigation measure used to assess each mitigation measure's ex-ante mitigation impact.

Table 3-11 Description and assumptions of prioritised mitigation measures

| <b>Mitigation Action</b>   | <b>Description and Penetration Rates From Published Docs</b>  | <b>Penetration Rates And Assumptions Used In The Model</b>  |
|--|---|---|
| <b>Renewable Energy and Energy Efficiency</b>  |   |   |
| 1. Replacing cookstoves with more efficient ones (wood & charcoal)   | Replacing cookstoves with low thermal efficiency (5-10%) with the higher-efficiency (40%) stoves (NDC, 2015)  | Replacing cookstoves with low thermal efficiency (5-10%) with the higher-efficiency (40%) stoves  |
| 2. Scaling up Electricity generation from renewables:<br>a. Large hydro<br>b. Other renewables (mini-hydro, solar and biomass) | <ul style="list-style-type: none"> <li>• Raise the share of renewable energy in electricity generation to 30% by 2030 (NDC, 2015; NEP, 2009)</li> <li>• More than 75% of all electricity generated from renewables by 2030, with 19% coming from other than large hydro: Mini-hydro, Solar and Biomass (RESMP, 2017)</li> <li>• Increase electricity generation from 123 MW to 270 MW by 2023 (PAPD, 2018)</li> </ul> | <ul style="list-style-type: none"> <li>• Raise the share of renewable energy in electricity generation to 30% by 2030</li> <li>• Increase electricity generation from 123 MW to 270 MW by 2023</li> </ul> |

|   |  |  |
|---|--|--|
| 3. Electricity energy efficiency                  | <ul style="list-style-type: none"> <li>Improving energy efficiency by at least 20% by 2030 (NDC, 2015)</li> </ul>  | Improving residential and commercial energy efficiency by 20% by 2030  |
| <b>Transport Sector</b>                           |  |  |
| 4. Biofuels – Palm biodiesel                      | <ul style="list-style-type: none"> <li>5% Biofuel use in transport by 2030 - - leading to a 40% reduction in GHG emissions from palm biodiesel use (over fossil fuel) (NDC, 2015)</li> </ul>       | <ul style="list-style-type: none"> <li>40% reduction in GHG emissions in transport emissions by 2030</li> </ul>  |
| 5. Road expansion                                 | By 2023- 517 km roads connecting all county capitals, 260km of urban roads, 237.1km secondary road constructed and paved; 6,184.7km of primary, secondary and urban roads maintained; (PAPD, 2018) | By 2023- 517 km roads connecting all county capitals, 260km of urban roads, 237.1km secondary road constructed and paved; 6,184.7km of primary, secondary and urban roads maintained |
| 6. car import standards                           | No details   | Use existing car import policy or standard, including implementation timelines   |
| <b>Waste Sector</b>                               |  |  |
| 7. Biogas from wastewater treatment plants (WWTP) | wastewater treatment and reuse technology for the reduction of methane emissions from wastewater and providing nutrient-rich digestors that can be used as fertilizers                             | All wastewater treatment plants by 2050. Implemented incrementally from 2021   |
| <b>AFOLU Sector</b>                               |  |  |
| 8. Reforestation                                  | No details   | 10% reforestation of tropical forests by 2050. Implemented incrementally from 2016   |

### 3.3.4. Mitigation potential assessment

The calculation of the abatement potential for the identified mitigation actions was calculated to determine how much each action can reduce GHG emissions. The mitigation measures in this study were based on absolute mitigation potential in the various sectors for 2015 to 2050. Table 3-12 below presents the projected mitigation impact of each of the prioritized mitigation measures in 2030, 2050 and cumulatively over the entire period, based on the penetration rates and assumptions outlined in the preceding section.

Table 3-12 GHG reduction impact of each mitigation measure

| Mitigation actions                                      | Mitigation impact (kt CO <sub>2</sub> e) |              |               |
|---|--|--------------|---------------|
|   | 2030                                     | 2050         | cumulative    |
| Reforestation   | 1 013.57                                 | 2 365.00     | 42 570        |
| Biofuel - palm biodiesel for transport sector           | 130.00                                   | 234.00       | 5 280         |
| Biogas production in WWTPs                              | 158.11                                   | 264.18       | 4 993         |
| Renewable electricity generation                        | 141.00                                   | 141.00       | 3 948         |
| Car import standards                                    | 85.90                                    | 234.66       | 3 887         |
| Road expansion & upgrade                                | 66.21                                    | 119.05       | 2 689         |
| Energy efficiency in residential and commercial sectors | 30.01                                    | 30.01        | 1 102         |
| Cooking stoves  | 2.89                                     | 4.84         | 119           |
| <b>TOTAL</b>  | <b>1 628</b>                             | <b>3 392</b> | <b>64 588</b> |

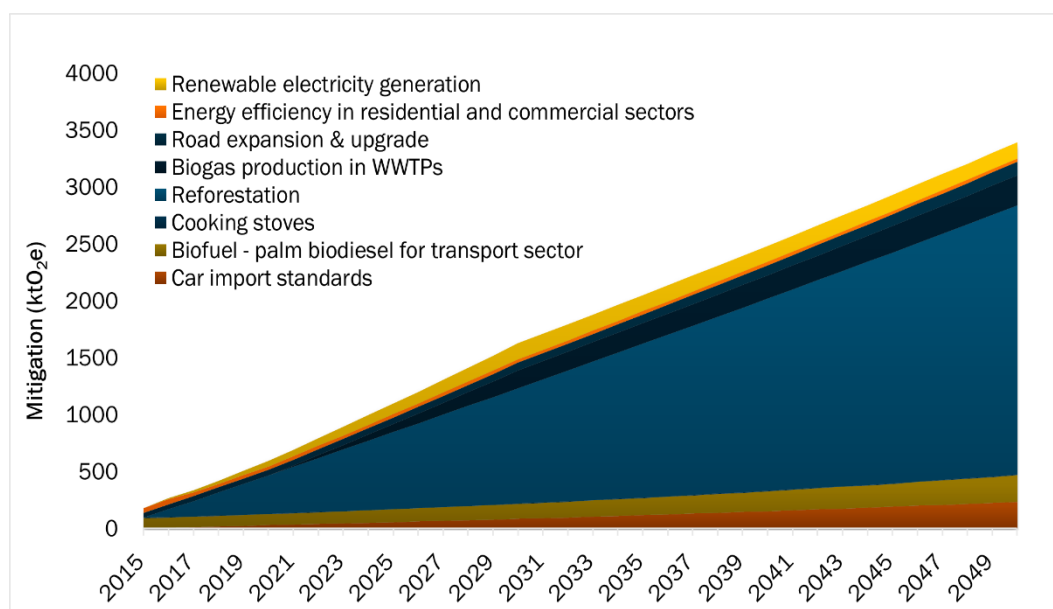


Figure 3.13 Combined contribution of mitigation actions 2015-2050

**Error! Reference source not found.**13 presents the total mitigation potential of implementing the country's identified mitigation measures between 2015 and 2050. The results show that the total mitigation potential starts at 180 ktCO<sub>2</sub>e in 2015 and increases to 1 628 ktCO<sub>2</sub>e and 3 392 ktCO<sub>2</sub>e by 2030 and 2050. The combined mitigation potential for all the identified mitigation action over the entire period is projected at 64 588 ktCO<sub>2</sub>e. Reforestation has the largest mitigation potential, 42 570 ktCO<sub>2</sub>e cumulatively, over the entire period.

### AFOLU Sector mitigation

Liberia faces challenges deforestation with a deforestation rate estimated at 0.46 per cent per year for 2005–2015, rendering forests the largest source of the national greenhouse emissions.

Recognizing the detrimental impact of forest degradation on the climate and the economy, it is crucial to reverse deforestation. Reforestation remains the primary tool for addressing deforestation and land degradation with considerable climate change mitigation potential. According to the World Bank's Liberia Forest Note, in 2015, forests (greater than 30 per cent crown cover) made up 6.5 million ha in Liberia, with 4.3 mil ha of this being tropical forests. The report further states that 15% of these tropical forests had been degraded by 2015. According to this mitigation assessment, reforestation or rehabilitating 10% of this degraded forest lands is the single most effective mitigation measure that the country can implement.

### **Waste mitigation**

From the prioritized mitigation measures, the waste sector accounts for 7.73% of the combined mitigation potential. Moreover, there is an economic benefit in improving waste management practices and potential energy production from waste. The identified mitigation action - Biogas production from wastewater treatment plants – can reduce emissions from both the waste sector and the energy sector by replacing LPG with biogas. The total mitigation potential from the waste sector for the projection period of 2015- 2050 is 4,993 ktCO<sub>2</sub>e.

### **Energy sector mitigation**

Household energy demand for cooking is predominantly met with the use of fuelwood and charcoal. The increasing demand for fuel and unsustainable use of biomass has added a significant burden to the forests. Furthermore, electricity generation from in-efficient diesel generators is a very GHG intensive method. The proposed mitigation actions for this sector, which are the use of fuel-efficient cookstoves, seeks to address the unsustainable use of biomass, scaling up renewable energy generation and implementing residential and commercial energy efficiency have the potential of reducing emissions by 175.84 ktCO<sub>2</sub>e in 2050 and 5,169 ktCO<sub>2</sub>e cumulatively over the entire period.

### **Transport sector mitigation**

The three identified mitigation actions under transportation aim to address three main drivers of GHG emissions from the transportation sector. These drivers are traffic congestion, decreasing vehicle efficiency and use of GHG intensive fuels. These mitigation actions can reduce Liberia's transport emissions by 587.65 ktCO<sub>2</sub>e in 2050.



### 3.3.5. Identification, selection and assessment of mitigation measures

#### 3.3.5.1. 2015-2050 mitigation

The mitigation scenario for 2015-2050 was constructed based on the combined mitigation potential for the proposed mitigation measures.

**Error! Reference source not found.** presents the total annual mitigation potential of implementing the eight mitigation measures between 2015 and 2050 against the baseline scenario. Reducing baseline emissions by the combined impact of the mitigation measures gives rise to the country's mitigation scenario.

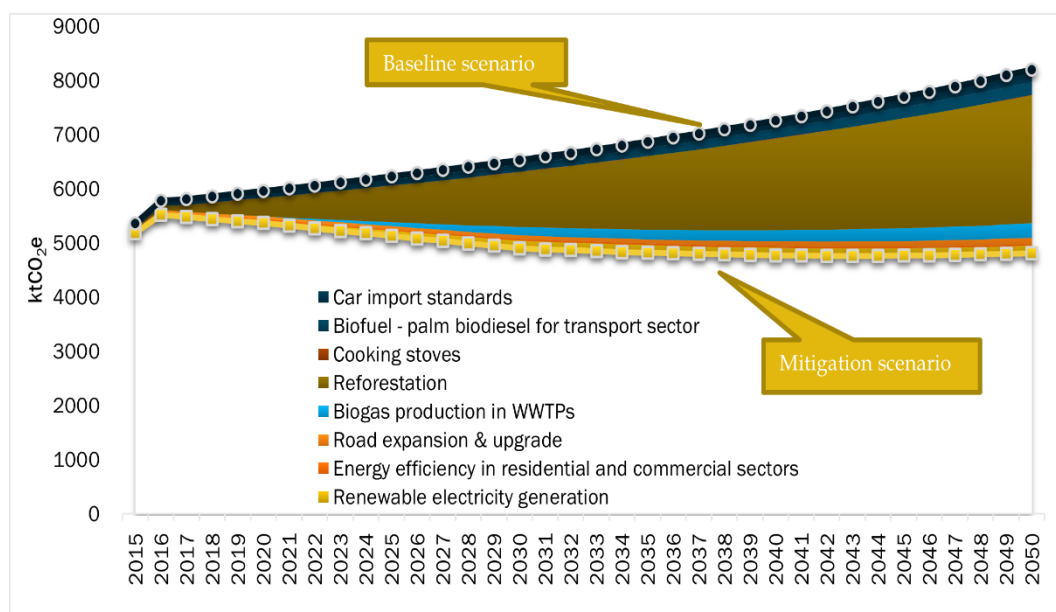


Figure 3.14 Development of the mitigation scenario

**Error! Reference source not found..15** compares the mitigation scenario with baseline emissions since 2015. Under the mitigation scenario, the emissions are projected to be reduced to 4904 ktCO<sub>2</sub>e by 2030 (compared to 6531 in the baseline) and ultimately reach 4810 ktCO<sub>2</sub>e by 2050 and 8202 ktCO<sub>2</sub>e under the baseline scenario. This is a 41% reduction from baseline.

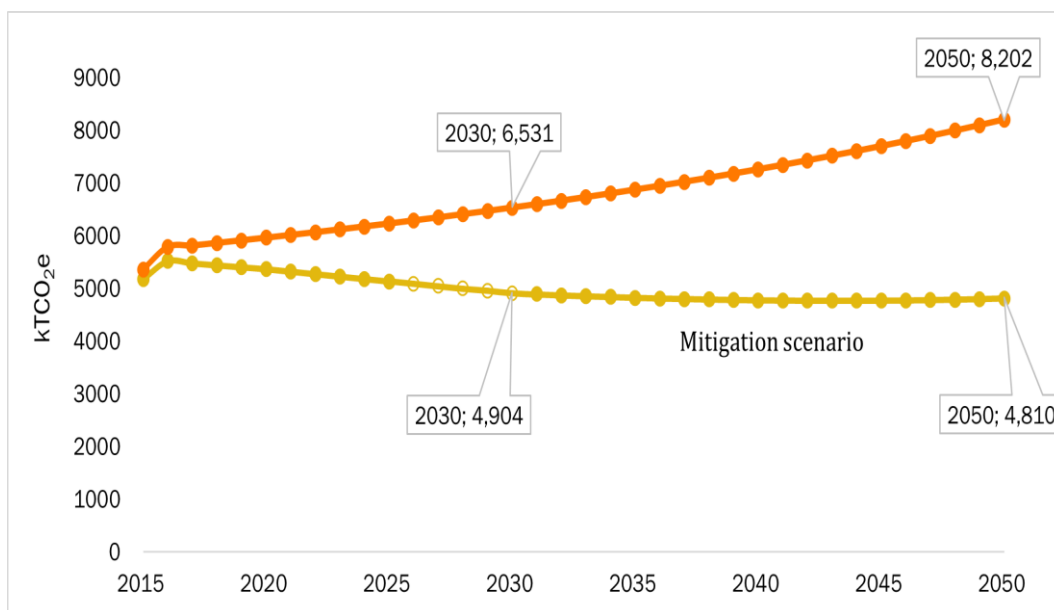


Figure 3.15 2015-2050 mitigation scenario compared with the baseline scenario

### 3.3.6. Benchmarking

The NDC submitted by Liberia under the UNFCCC was used to benchmark the emission reduction potential determined in the mitigation assessment. Liberia’s submitted NDC aims to reduce greenhouse gas emissions by 15% (797GgCO<sub>2</sub>e) from the business as usual by 2030., **Error! Reference source not found.** 16 presents the results of this mitigation assessment in the same way the NDC target has been presented and shows that the eight mitigation actions assessed in this report have the potential to reduce Liberia’s emissions by 24.9% by 2030 (1 627.7 ktCO<sub>2</sub>e).

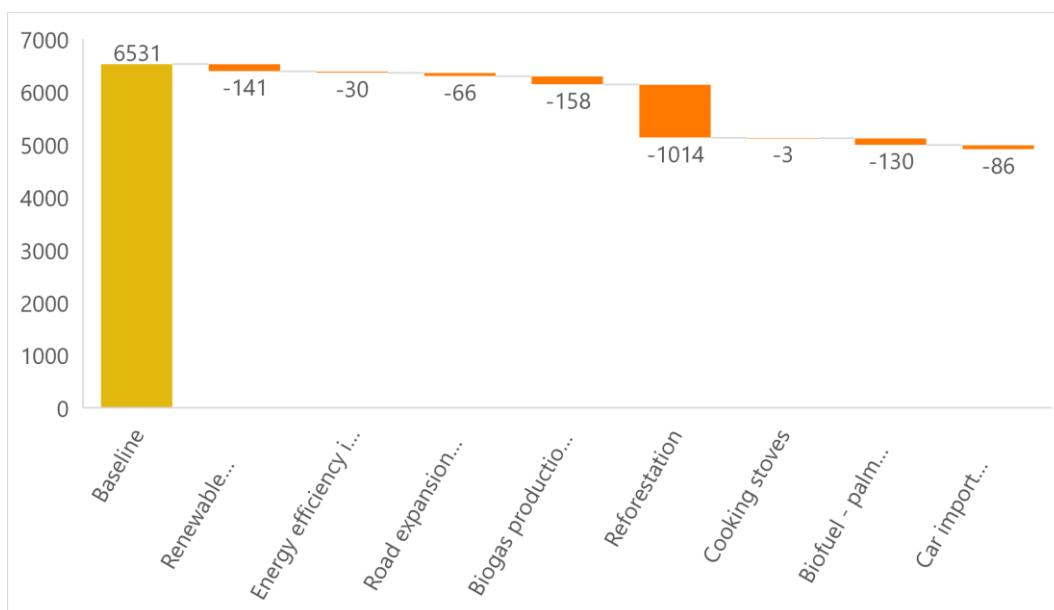


Figure 3.16 Comparison of the GHG reductions in this study and the NDC



## 4. Climate Change Vulnerability and Adaptation Assessment

### 4.1. Introduction

Liberia faces a wide range of environmental and socioeconomic challenges including but not limited to variable food security, uneven water and sanitation infrastructure, fragile health systems, and a high unemployment ration. Consequently, it is particularly vulnerable to the health risks of climate change. The key risk factors are under-nutrition, malaria and diarrheal diseases – already leading causes of morbidity and mortality – are likely to grow as temperatures warm and rainfall becomes more variable.

In Sub-Saharan Africa, climate change is already having a significant impact, threatening efforts to meet the growing needs of the most vulnerable. Temperatures have increased by over 0.5°C or more during the last 50 to 100 years. The increase in extreme weather events such as droughts, floods and cyclones is well documented. While claiming lives, these events also foster under-nutrition and catalyze outbreaks of diseases such as cholera and viral diseases. The more this continues the greater the impediment to development. Current evidence shows that the ranges of some species and ecosystems are shifting due to elevated carbon dioxide and other climate change drivers, with significant implications for the incidence of malaria and other diseases. The situation is compounded by a complex variety of underlying physical, social, economic, political and cultural forces and trends operating on local, national and international scales.

This section of the SNC summarizes the impacts of climate change risks and vulnerability on the health, agriculture and coastal zone sectors for adaptation in Liberia. In so doing, the energy sector is the major area of GHG emission in the country; therefore it is presented herein for climate change mitigation initiatives taken in Liberia. This report also illustrates climate threats and impacts to the three mentioned adaptation sectors and that of the mitigation sector including their development and investments potentials. It highlights opportunities or possible adaptation or mitigation measures and other climate change initiatives such as projects/ programs and policies documents developed by the government of Liberia to achieve or address the ongoing national concerns of climate change in these major sectors. . This report also includes information for health specialists on the basics of climate projections for Liberia, climate change and health vulnerability, response opportunities (i.e. policy response and frameworks for action), as well information on future efforts, including current gaps in knowledge and capacity on health and climate.

The question is “how can climate or weather impact human health?” The IPCC sixth assessment reports reflect the most comprehensive assessment of scientific knowledge of

climate change. Credit for most of the findings presented in this report given to the most recent 2019 new special report by the sixth IPCC and the USAID.

Although Liberia emerged from a civil war in 2003, the country has made significant economic and development progress. However, Liberia still remains in a fragile situation, confronting widespread, high inequality, unemployment and limited access to basic services such as water, sanitation and energy (USAID, 2019). The economic growth of Liberia exclusively depends on agriculture, fisheries and forestry. These sectors are major part of Liberia's poverty reduction goal and are considered high climate-sensitive activities. High reliance on climate-sensitive activities renders Liberia vulnerability to climate variability and change. Hence, changes in the climate leading to high temperatures is expected to produce more extreme weather events, such as heavy rains and rising sea levels. Considering that agriculture productivity in Liberia already suffers from land degradation and extreme weather events makes Liberia even more vulnerable to changing climate given its reliance on climate-sensitive staple crops such as rice and cassava.

The key climate impacts on the following sectors in Liberia are summarized below:

1. Agriculture Productivity: increased crop loss and / or crop failure as a result of extreme weather events; such events can lead to increased pests, weeds, and likelihood of widespread pathogen outbreak.
2. Water Resources: the impact of rising temperature in the climate can lead to insufficient water levels for basic sanitation and infrastructure. This can also diminish the water quality.
3. Fisheries: rising temperature in Liberia can lead to shifts in distribution of species, loss of biodiversity and mere livelihoods.
4. Coastal Zones: the occurrence of coastal zone flooding can lead to erosion of the coastline, damage to houses and infrastructure, and poor sanitation of land and aquifers.

Human Health: the rising temperature in the climate can seriously impact human health and health of other animals. For example, the rising temperature can lead to increased risk of vectors, airborne and waterborne diseases, and potential increase in food insecurity.

It is projected that in the year 2060 Temperature will increase from 0.9oC to 2.6oC. This will lead to increase in frequency and intensity of extreme weather events, as well as a 0.13 to 0.56 m increase in sea levels by 2100.

#### 4.1.1. Climate risks to health

The impact of climate risks on health is an enormously important consideration for sub-Saharan Africa and Liberia. Studies show that the death rate per year due to climate change will increase to 270,000 deaths per year by 2030. And the number of deaths per year from heat will rise to 38,000 per year by 2030. The number of diarrhoea deaths will increase by 48,000; 60,000 from malaria; 131,000 from childhood undernutrition. Liberia being one of the regions in sub-

Saharan Africa with weak health infrastructure and preparedness capabilities, will be least able to cope with climate change. In such cases, risk management becomes very significant in reducing climate-related impacts on health and lowers the cost of public interventions to cope with climate change.

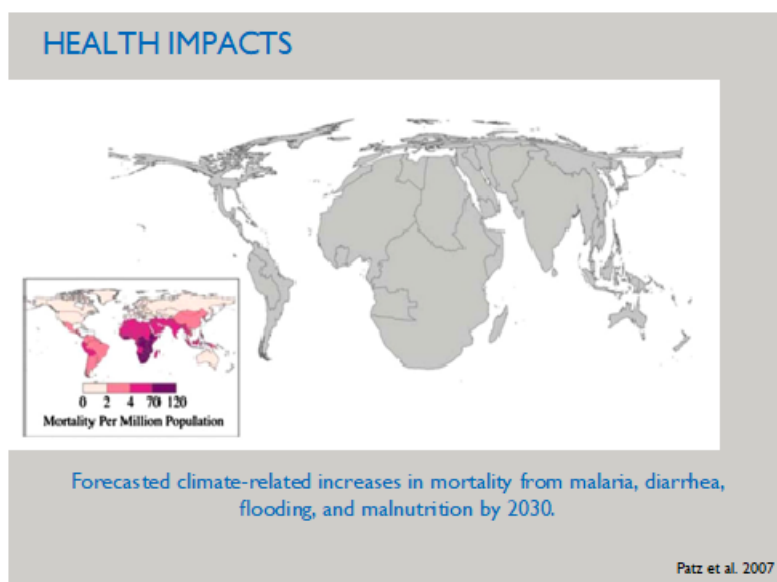


Figure 4.1 Impact of climate change on increases in mortality from malaria, diarrhea, flooding and malnutrition by 2030

#### 4.1.2. Review of related literature

The anticipated future health outcomes, based on the most recent literature, are displayed on the map (**Error! Reference source not found.2**). As noted in Lloyd et al. (2011), nutrition-related outcomes are expected to vary region—to-region in sub-Saharan Africa.

Recent findings suggest out of the 7 abnormally warm El Nino between 1978 and 2008, six coincided with an increase in reported cases of cholera in Burundi, Democratic Republic of Congo, Kenya, Rwanda, Tanzania and Uganda.

Within certain range of temperature, mosquitos digest more rapidly and bite more frequently, potentially increasing the spread of disease.

In tropical regions, cereal crops are growing near their thermal tolerance. Increasing temperatures are likely to reduce yields in maize, wheat, rice and sorghum.

Many short-cycle crops such as corn are helpful in increasing food production, particularly in areas where rainy seasons are starting later or becoming shorter, but research shows that these crops may offer lower levels of nutrients. This finding may indicate the possibility of greater micronutrient deficiencies.

Some climate adaptation interventions, such as irrigation dams, increase the risk of waterborne diseases by providing habitat, for example, for snails that carry schistosomiasis (Martin and Zermoglio, 2016).

There are two types of responses to climate change: 1) mitigation and 2) adaptation. Both of these are adjustments in human and or natural systems in response to actual or expected changes in climate to reduce adverse impacts or take advantage of opportunities. The figure below shows two types of mitigation response to climate change.

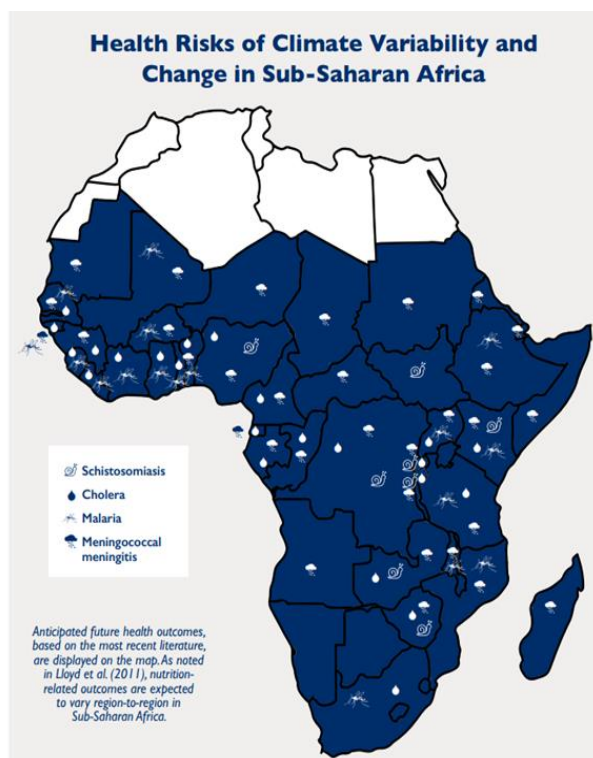


Figure 4.2 Health risks of climate variability and change in Sub-Saharan Africa

A list of mitigation/adaptation responses to reduce the impact of climate change on health will include

1. improved access to safe water
2. improved sanitation
3. enhanced public health functions
4. vulnerability mapping and early warning systems
5. improved surveillance
6. coordination across sectors of government and
7. sustainable urban development.

It goes without saying that the burden of diseases as a result of climate change is compounded by other factors such as malnutrition and hunger. **Error! Reference source not found.**3 shows countries where these challenges exist. It is compounded by the vagaries of weather and climate that lead to crop loss and declining yields. These countries suffer the impacts of consistent and

persistent extreme events like droughts, and floods. These vulnerabilities are highest in countries that suffer the greatest disparity.

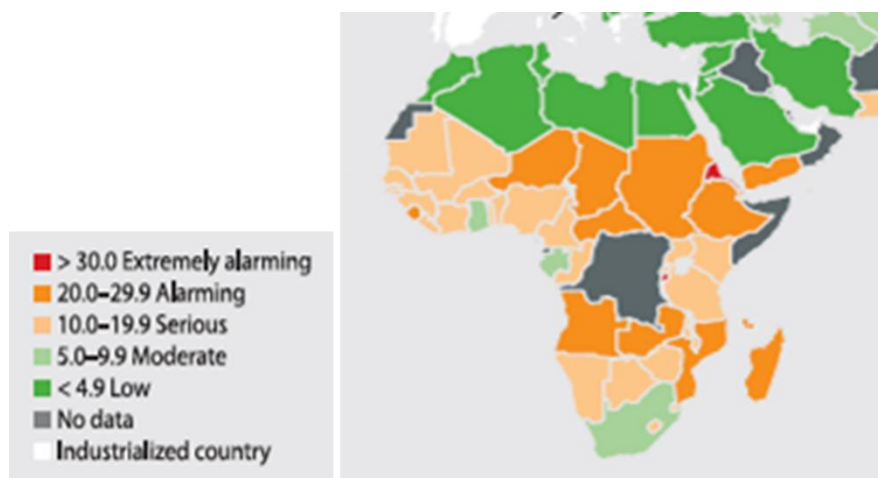


Figure 4.3 Climate change impact on nutrition

Table 4-1 Regions of the world and the projected impacts of climate change on nutrition

| Scenario          | South Asia | East Asia/Pacific | Europe and Central Asia | Latin America and Caribbean | Middle East/North Africa | Sub-Saharan Africa | All Developing Countries |
|-------------------|------------|-------------------|-------------------------|-----------------------------|--------------------------|--------------------|--------------------------|
| 2000              | 75.6       | 23.8              | 4.1                     | 7.7                         | 3.5                      | 32.7               | 147.9                    |
| 2050              |            |                   |                         |                             |                          |                    |                          |
| No climate change | 52.3       | 10.1              | 2.7                     | 5.0                         | 1.1                      | 41.7               | 113.3                    |
| Climate change    | 59.1       | 14.5              | 3.7                     | 6.4                         | 2.1                      | 52.2               | 138.5                    |

The observations and predictions are a direct result of climate impact on food production in those regions. With medium confidence, in mid- to high-latitude regions, moderate warming will raise crop and pasture yields. Slight warming will decrease yields in low latitude regions. With high confidence, extreme climate and weather events will reduce food production. The benefit of adaptation varies with crops and across regions and temperature changes (**Error! Reference source not found.**4).



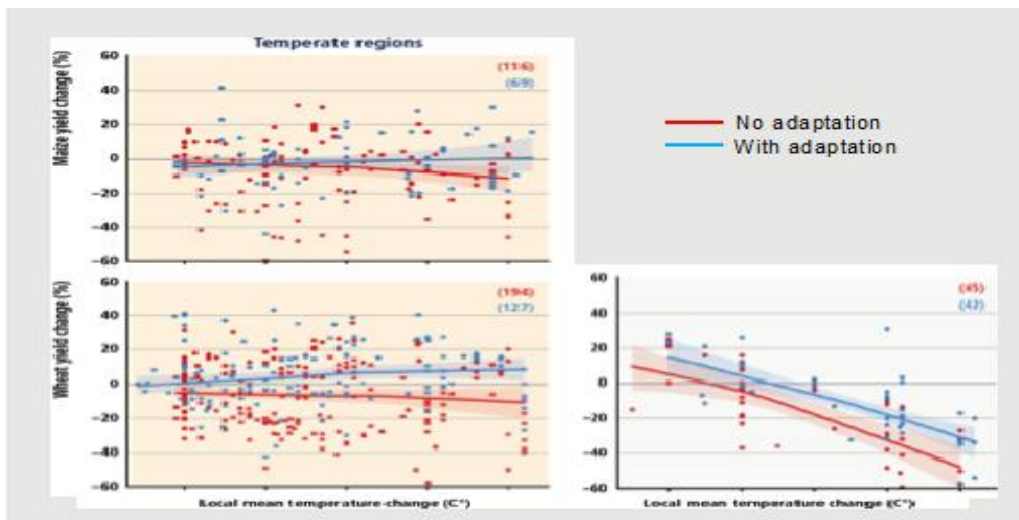


Figure 4.4 Impact of climate change on food production

#### 4.1.3. Climate change and malaria

Studies show that climate has significant impact on the prevalence of malaria. In **Error! Reference source not found.5A**, a direct correlation between the biting frequency of mosquitos and temperature. It shows that the biting frequency increases with the rise in temperature. Rising temperature is also shown to reduce the incubation period (**Error! Reference source not found.5B**). as the temperature rise the probability of mosquito survival increases slightly and declined as the temperature increases above 35oC (**Error! Reference source not found.5C**). the survival of the vector and the frequency with which it bites both show some temperature dependence. Similarly, the incubation period of the parasite can be quantified. Combining all three functions allows the calculation of a ‘transmission potential’ (**Error! Reference source not found.5D**), which provides a quantified measure of the relative potential for transmitting malaria under specific temperature conditions.

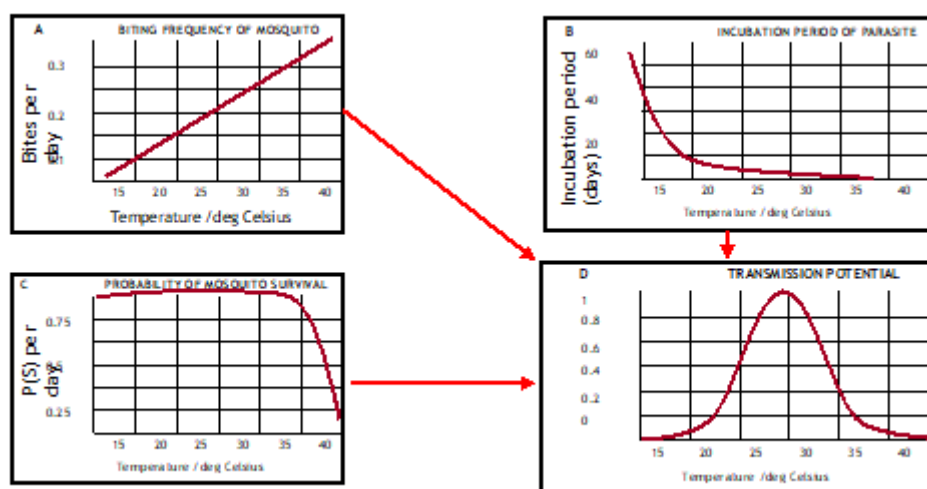


Figure 4.5 Impact of climate change on the prevalence of malaria

On its own, this sort of approach can provide evidence about the possible change in disease transmission if temperatures increase under climate change, but the actual effect on the geographical distribution of disease depends on many factors other than the climate/weather.

Biological models alone therefore provide only a partial answer and must be interpreted in the light of other evidence about the determinants of disease, such as the effect of socio-economic development. **Error! Reference source not found.**6 shows the current forecast of range of malaria in countries in Africa indicating where previously suitable or endemic as a result of climate change. Figure 4.7 shows the percent change in the number of people that could be at risk in areas that will become newly endemically suitable but where previously unsuitable.

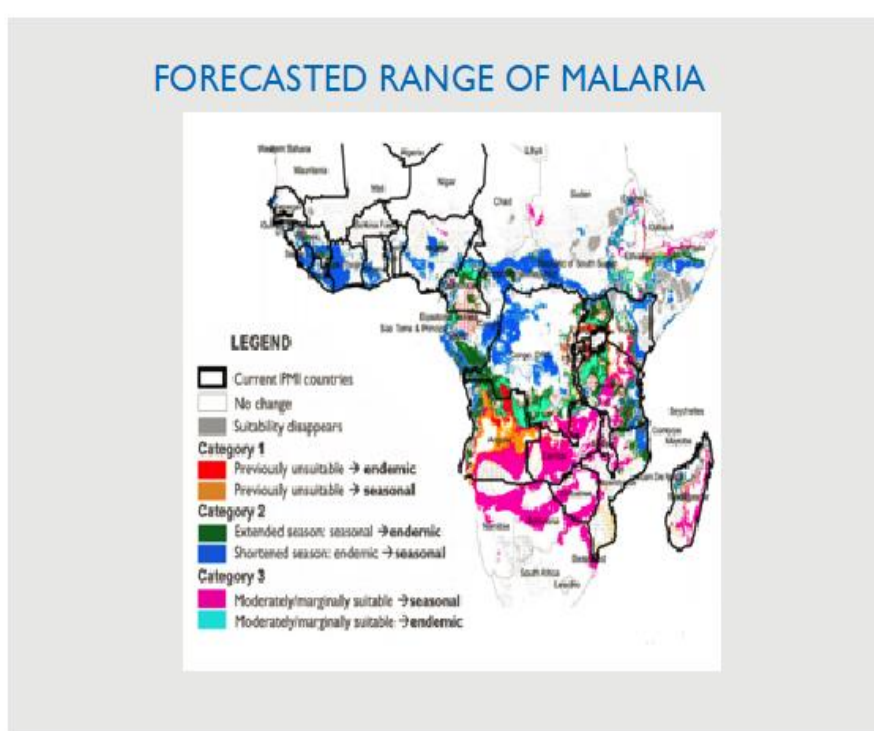


Figure 4.6 Range of malaria as forecasted in PMI countries in Africa

Areas where spring and autumn are currently too cold for the reproduction of malaria vectors may become more suitable in the future, thus extending the malaria season. In these areas, increases in temperature may not impact midsummer malaria incidence greatly, but may result in a longer malaria season. In some cases, malaria may shift from being a seasonal disease burden to an endemic (year-round) burden.

Areas where seasonal suitability will likely become endemic, thus extending the malaria season, include priority areas for the 2030s: the coasts of Central Africa (Gabon, Congo, Cameroon, central Tanzania, northern Uganda, and northern Mozambique). By the 2030s this change will put an additional 400,000 to 600,000 people at risk, with the highest changes in total numbers of people affected relative those currently living in seasonal conditions of suitability expected in Uganda, Somalia and Madagascar, where the reduced seasonality will

impact many currently living in endemic conditions of suitability. The incidence of malaria with respect to climate is depicted in **Error! Reference source not found.8** below.

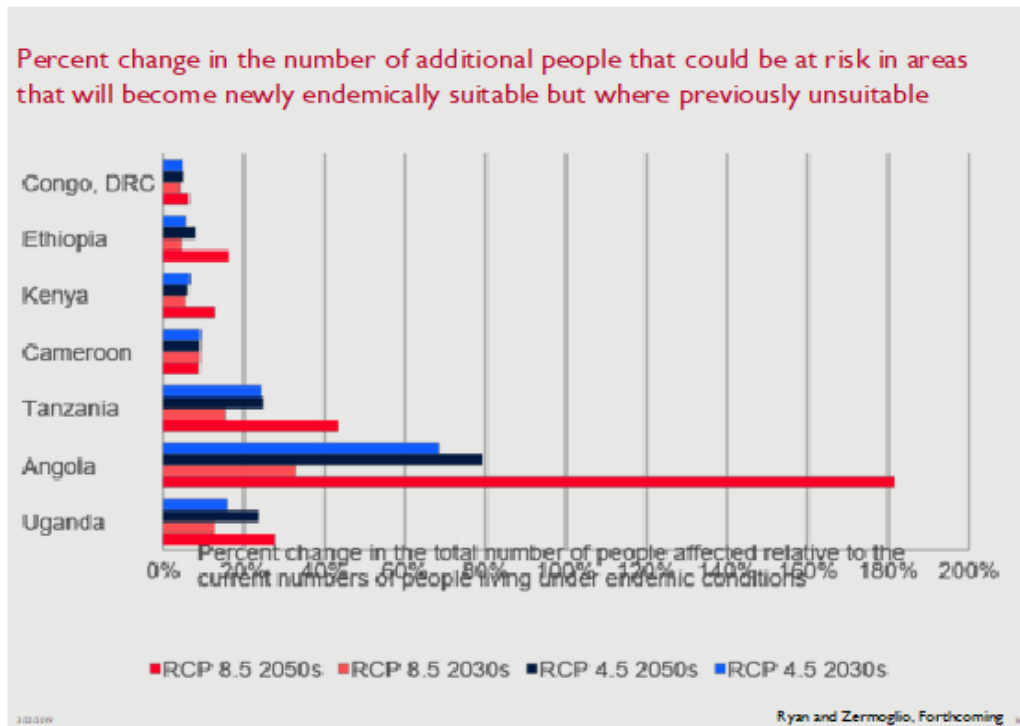


Figure 4.7 Percent change in the number of people that could be at risk in areas that will become newly endemically suitable but where previously unsuitable

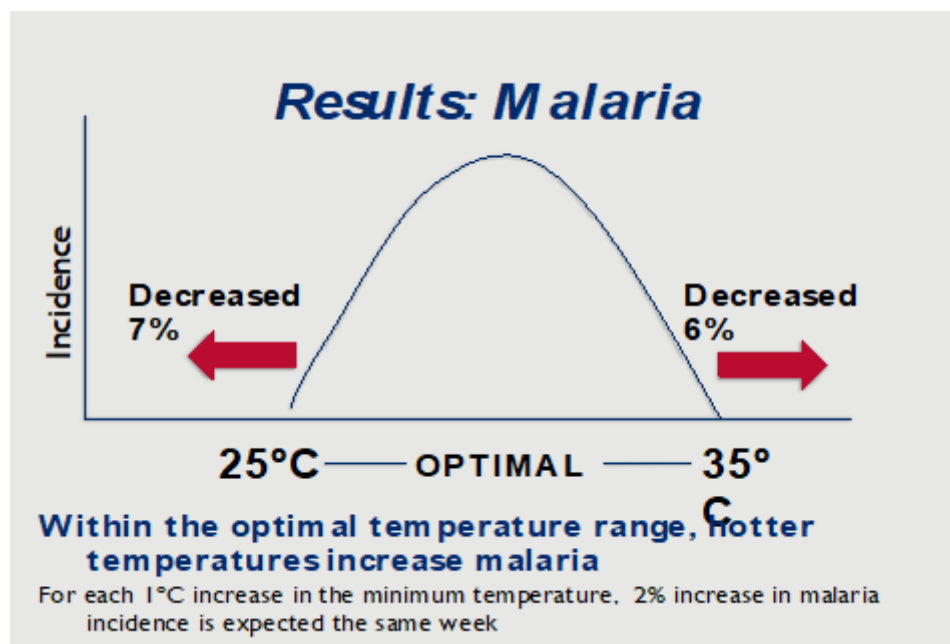


Figure 4.8 Incidence of malaria as a result of changes in optimal temperature

Heavy rains tend to decrease the incidence of malaria whereas normal rainfall will increase malaria incidence. An increase of one day a week with at least 50 mm precipitation led to an 11% decrease in malaria incidence four weeks later. Normal rainfall, for each 1-day increase in days with at least 1 mm or 50 mm rainfall, a 2% increase in malaria incidence is observed 4 weeks later.

Climate change can pose indirect risks as result of air/water pollution. In West Africa, emission of black carbon (BC), organic carbon (OC), oxides of nitrogen (NO<sub>x</sub>) and sulfur dioxide (SO<sub>2</sub>), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) emissions are shown for 2005, and projected emissions 2030 for a reference scenario (REF) and for a “carbon constraint case scenario (CCC)” (Error! Reference source not found.9).

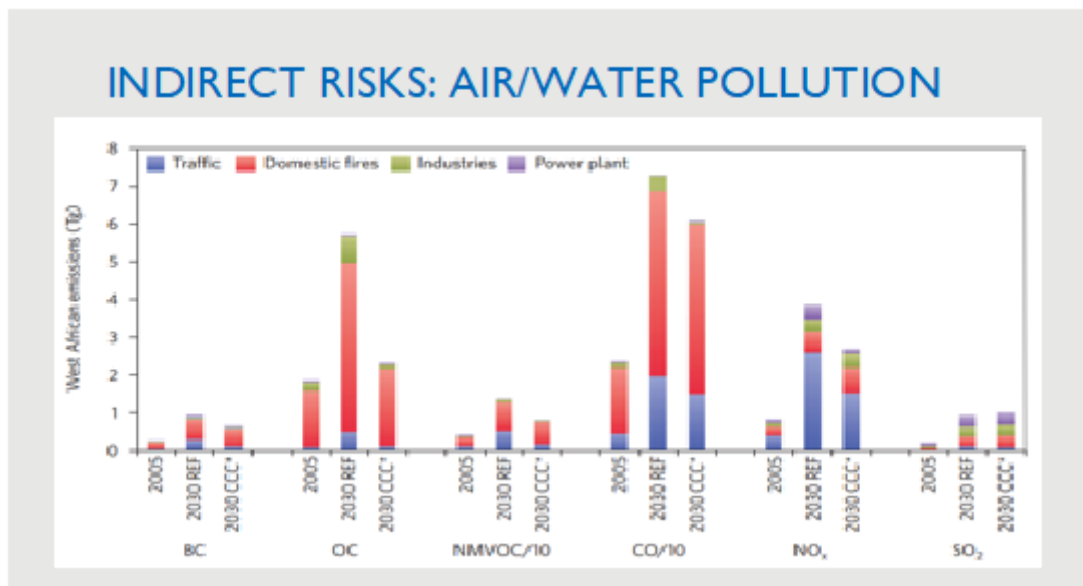


Figure 4.9 Indirect risks: air/water pollution

In conclusion, what can Liberia do as climate change impacts the public health and other sectors? There is a need to improve public health decision-making (policies) incorporating climate change and weather information. The relationship between the Liberian government, the donor organization and the scientific NGO communities needs to be harnessed and strengthened. Education in environmental awareness of the risks and institutional capacity building is paramount. With climate change, Africa’s leading challenges are likely to persist and even grow, resulting into declining income if not taking seriously. Potential temperature increases may reduce crop yields and increase food insecurity. In addition, the increasing use of less nutritious, short-cycle crops, coupled with high levels of carbon dioxide in the air, may reduce the availability of nutrients in crops, catalyzing an increase in micronutrient deficiencies. Climate variability threatens growth in the disease burden. In particular, increasing cases of malaria, cholera and meningococcal meningitis as the corresponding vectors or pathogens respond to anticipated changes in temperature and precipitation. There is urgency to the need for investment in systems linking weather and climate forecasting to health

early warning. To advance national policy processes, key interventions should include health components in National Adaptation Plans as well as specialized assessments of health impacts, vulnerability and adaptation options.

## 4.2. Health adaptation measures taken

Liberia has set a target of becoming a middle-income country by 2030 (Republic of Liberia, 2012), and the health and social welfare of the population is critically important in achieving this goal (Ministry of Health and Social Welfare, 2007). The UNDP, in partnership with the EPA, has recently initiated a climate vulnerability assessment for the health sector of Liberia which is expected to provide and update information on climate risk and vulnerability on the health sector. As such, several studies by the Ministry of Health (MoH) and the National Public Health Institute of Liberia (NPHIL) have confirmed the correlation between temperature and precipitation patterns and malaria, cholera, dysentery, giardiasis, amebiasis, and typhoid fever which are diseases that afflict thousands throughout the country.

To address these issues, the following adaptation measures have been implemented to cope with health outbreaks.

- Identifying and disinfecting stagnant water sources that are breeding grounds for insects;
- Promoting hygiene and sanitation education and awareness in the country, including clinical interventions and community health education programs;
- Strengthening the Roll Back Malaria program and providing a range of herbal treatments.

### 4.2.1. Impacts of climate change in Liberia's agriculture sector and the adaptation measures taken

The agriculture sector of Liberia is one of the most current and future economic potential of the country. The economically viable sector contributed about 38.8% of Liberia's GDP in 2015, while providing employment opportunities to more than 70% of rural households involved in the sector and at the same time, contributing 23.9% to the real GDP (EPA, 2018 and USAID, 2015). Liberia has a very favourable seasonal variation that supports agricultural activities. The country hosts vast forests and many water bodies constituting both surface and ground waters with low lying lands suitable for farming.

According to Liberia's ministry of agriculture, before the 14 years of civil conflicts from 1990 to 2003; the agriculture sector accounted for about 40% of GDP and Liberia was a producer and exporter of basic products, primarily raw timber and rubber; for which the rubber industry generated over US\$100 million export earnings yearly. In 2000, agriculture and forestry contributed over 90% of export earnings, mainly from rubber, timber, cocoa and coffee.

According to MOA (2009), the principal food crops of Liberia are rice and cassava. MOA (2009) also reported that Rice, cassava and vegetables production accounted for about 87% of cultivated land in Liberia. In so doing, some of the most common agricultural products grown in the country for commercial purposes include large plantations of rubber, palm, coffee, cocoa, sugarcane and etc. while crops grown for local consumption include banana, plantain, citrus, pineapple, sweet potatoes, maize, and vegetables. These agricultural products and their related activities provide food, employment, tax revenues, and livelihoods' earnings for the local population. As such, the agriculture sector is central to Liberia's vision of economic transformation and wealth creation to enhance poverty reduction.

However, Liberia is faced with climate change related risks and vulnerability for which the agriculture sector is not an exception. According to EPA (2019), Climate change remains a major challenge to Liberia's agriculture sector. The Environmental Protection Agency of Liberia EPA (2019), report reveals that warmer temperatures which have led to a reduction in chill hours are potentially reducing yields for some crops like maize, rice, rubber, and cassava. It was also reported by ACPC (2014) that for every 1o C increase above 30oC temperature per day during maize growing season, there is a corresponding 1% reduction in yield each day under optimal rain fed condition.

According to the EPA technology development and transfer report, current climatic variability and predicted climate change scenarios for Liberia indicate that the agriculture sector is expected to be significantly undermined by rainfall patterns changes, hotter temperatures resulting in difficulties to identify the optimal time for crop planting, more pests, weeds, and animal diseases, reduction of soil moisture and increase of flooding. The TNA (2019) agriculture report on Liberia, states that 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. According to USAID (2012), these scenarios are projected to 0.9°–2.6°C increase in temperature by 2060. Hence, this is a direct threat to the country's agricultural production and food security.

In order to address these climate change related risks and vulnerability that are negatively affecting the agriculture sector, the government of Liberia has developed climate change policy documents and continues to facilitate and implement adaptation projects in the agriculture sector. Some key steps/ initiatives taken by Liberia in its agriculture sector that gear towards adapting to climate change vulnerabilities include but not limited to the followings:

*Liberia's Technology Needs Assessment for adaptation in the Agriculture Sector (TNA Agriculture report, 2019):*

The TNA for climate change adaptation in Liberia has been a set of activities to identify and determine the adaptation technology priorities of the country. TNAs are central to the work of the Parties to the Convention (Article 4.5 UNFCCC). The TNA is supported by the Global Environmental Facility (GEF) through the United Nations Environment Programme (UNEP)

and the Technical University of Denmark (DTU), UNEPDTU partnership that provided technical and methodological support in conducting the TNA process. The TNA aims at developing a national Technology Action Plan (TAP) that prioritizes technologies, recommends an enabling framework for the diffusion of these technologies.

The TNA project has identified and prioritized three climate change adaptation technologies to be transfer and diffused within the agriculture sector of Liberia. According to the *TNA Liberia Agriculture Report, 2019*, the three technologies are:

- I. **Value addition to agriculture products (rice, cassava, vegetables and fruits):** establishing 3 major facilities for value addition of agricultural products in rice, cassava, vegetables and fruits;
- II. **Improved Storage (drying and freezing of agriculture products):** building of 3 storage facilities for seed, grain and vegetables in 3 agro-ecological zones of Liberia; and
- III. **Integrated Soil Fertility Management:** introducing and running at least 4 Integrated Soil Fertility Management facilities in four agro-ecological zones of Liberia;

*Liberia's Agricultural Sector Investment Plan:* The LASIP phase I: 2011 - 2015 and LASIP phase 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, (*TNA Liberia Agriculture Report, 2019*).

*West Africa Agricultural Productivity Project (WAAPP-Liberia):* A regional project supported by the World Bank and Japanese Government; it has helped fund the 40 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, (*TNA Liberia Agriculture Report, 2019*).

*Liberia Agribusiness Development Activity 2015-2020 (LADA):* an initiative by USAID's Feed-the-Future programme. Started in December 2015; the LADA aims to increase incomes of smallholder farmers and entrepreneurs throughout Liberia. The project aims to expand access to and use of agricultural inputs, improved post-harvest activities, and streamlined high-potential agricultural value chains; (*TNA Liberia Agriculture Report, 2019*).

*Smallholder Agriculture Transformation and Agribusiness Revitalization Project (STARP) of Liberia:* A 25 million \$ project funded by the World Bank; (*TNA Liberia Agriculture Report, 2019*).

*The Liberian National Adaptation Program of Action (NAPA, 2008):* According to the EPA technology development and transfer report, the program has identified as urgent priority interventions, to enhance resilience of increasing rainfall variability through the diversification

of crop cultivation and small ruminants rearing; modifying the timing of crop cultivation in response to changing rainfall patterns; intercropping, irrigation, and optimization of lowland/swamp farming practices; pest control, including fencing of farms against rodents, bird scare scrolls, regular weeding and the use of echoing bells; and maintaining fast growing nitrogen fixing tree species to improve soil fertility and using multiple-purpose tree species on farmlands to maintain forest cover ([www.moa.gov.lr](http://www.moa.gov.lr)).

*The Smallholder Agricultural Productivity Enhancement and Commercialization (SAPEC):*

The 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; (*TNA Liberia Agriculture Report, 2019*).

Table 4.2 below presents a list of some important adaptation policies or regulatory framework to address climate change impacts in the agriculture sector of Liberia.

Table 4-2 Important adaptation policies and regulatory frameworks in the agriculture sector

| <b>Policy</b>   | <b>Description and relation to climate change adaptation</b>   |
|---|--|
| Liberia Commodity Authority Regulatory Authority (LACRA), 2016:               | The LACRA Act was passed in 2016 under the LATA. It has been set up to develop functioning value chains and market systems. It is an effective regulatory system for the trading of agricultural commodities. It protects value chains from under investment and poor crop quality. Its 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.   |
| 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. |
| 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 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.  |
| 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. |

#### 4.2.2. The impacts of climate change in Liberia’s Coastal Zone Sector and adaptation measures/ initiatives taken by the country

The coastal zone is one of Liberia’s greatest environmental and economic assets; it is to be noted that more than 70% of Liberia’s population lives within its coastal areas of about 580 km long (DAI 2008). However, the coastline of Liberia from Cape Mount (NW) to Maryland (SE) which hosts nine (9) coastal counties has become vulnerable to climate change related impacts.

In regards to climate change impacts, Liberia’s coastal zone Technology Needs Assessment (TNA, 2019) reported that the coastal sector of Liberia is highly and negatively affect by some direct climate change related impacts that are considered as impediment to the progress of the sector’s socio-economic and environmental activities. According to the report, coastal erosion, coastal flooding, marine/ Saline intrusion into fresh drinking waters and other sea level rise impacts are the most common and identified climate change impacts that are destroying livelihoods, properties, coastal ecosystems, socio-economic activities and etc. in majority of Liberia’s coastal areas.

As thousands of the coastal residents become homeless from the impacts of coastal flood and erosion along the Liberian coastline: West-point, New Kru-town, Greater Monrovia and others of Montserrado county, Atlantic street, Fanti-town of Grand Bassa county, Robert’s Sport of Cape mount county, Greenville of Sinoe county, Harper of Maryland county are the most vulnerable; as many more become and remain vulnerable; Liberia’s Coastal report, (TNA 2019).

According to Liberia’s “National Policy and Response Strategy on Climate Change 2018” (NPRSCC, 2018), Settlements in coastal lowlands of Liberia are especially vulnerable to risks resulting from climate change; yet these lowlands are densely settled and growing rapidly (McGranahan et al., 2007). For example, it is projected that about 95 km<sup>2</sup> of land in the coastal

zone of Liberia will be inundated as a result of one-metre sea level rise, with about 50% (48 km<sup>2</sup>) of the total land loss due to inundation being the sheltered coast (Wiles, 2005). The Inundation will be followed by shoreline retreat (Wiles, 2005); yet the population of Monrovia continues to grow. The potential rise in sea levels could add to existing trends of coastal erosion in areas like Buchanan, Monrovia and Greenville with a loss in infrastructure and land of around \$250 million apart from the social and psychological stress on the population (Tumbey, 2015; Wiles, 2005). According to USAID (2013), the underlying rates of erosion are likely primarily related to natural conditions (e.g., geology, longshore currents, wave action). In so doing, McSweeney et al. (2010), reported that various global climate models project a sea-level rise in Liberia of 0.13 to 0.56 m by the 2090s relative to the sea level from 1980-1999. Also DAI (2008) reported the then current beach erosion rates are as high as 3 m/yr with ongoing structural damage and loss.

It is therefore in an effort to address the above mentioned climate change related vulnerability and risks that the government of Liberia has taken many initiatives and yet continuous to facilitate and implement many climate change adaptation policies, programs /projects, among which some major adaptation projects in climate change vulnerable coastal cities or communities are as follow:

Liberia Technology Needs Assessment (TNA, 2019) on Coastal Zone Climate Change Adaptation: The TNA for climate change adaptation in Liberia has been a set of activities to identify and determine the adaptation technology priorities of the country. TNAs are central to the work of the Parties to the Convention (Article 4.5 UNFCCC). The TNA is supported by the Global Environmental Facility (GEF) through the United Nations Environment Programme (UNEP) and the Technical University of Denmark (DTU), UNEPDTU partnership that provided technical and methodological support in conducting the TNA process.

The TNA aims at developing a national Technology Action Plan (TAP) that prioritizes technologies, recommends an enabling framework for the diffusion of these technologies, and facilitates the identification of suitable technology transfer projects and their links to relevant financing sources in order to have the prioritized technologies adopted within the country's most vulnerable areas to the above climate change impacts.

As such, Liberia coastal zone technology prioritization process was carried out using the TNA's "Multi Criteria Analysis (MCA)" for which three (3) technologies were prioritized/ selected to be transferred and diffused in the vulnerable coastal areas of Liberia to adapt or mitigate the ongoing climate change impacts. The three technologies to be used in the coastal zone for the TNA project are: *Integrated Coastal Zone Management (ICZM)*; *Flood early Warning System (FWS)* and *Armour or Rocks Revetment*.

The Coastal Add-On project (CAP): funded by the Global Environmental Facility (GEF) through the United Nations Development Programme (UNDP) seeks to Enhance Resilience of Liberia's Montserrado County Vulnerable Coastal Areas to Climate Change Risks. The CAP

constructed from June 2018 to June 2019, some 900 (Nine Hundred) linear meters coastal defense “Revetment” in the D-Twe Kru-town area. The project seeks to reduce the vulnerability of the community’s population and natural coastal environment to climate change risks and enhance the capacity of the community to recover from coastal erosion impacts.

Buchanan Coastal Defence Project: also a CAP, supported by the UNDP and implemented by the Ministry of Mines and Energy during 2016 to 2017. This project constructed about 250 linear meters of coastal defense (revetment) in Buchanan city, Grand Bassa County, along the Fanti-town and Atlantic street area to mitigate the alarming rate of coastal erosion that was of national concern.

Liberia Climate Change Assessment (2013) was a project implemented by the United States Agency for International Development USAID-Liberia Mission to assist the Government of Liberia to develop climate data. In an effort, this project assessed and developed a climate data and future climate projections for the country. The project presented the level of coastal vulnerability identified in the coastal zone of Liberia from climate change impacts and recommended sustainable intervention. The result of this assessment for the coastal zone is an asset to be used by stakeholders to solicit funding from climate change donors in order to implement coastal mitigation and or adaptation measures projects.

Below presents some additional policy documents, programs and projects developed to sustainably minimize the level of vulnerability to climate change and linked to existing development efforts include:

- “Liberia’s National Adaptation Plan Process (NAP)”
- “National Disaster Management Policy of 2012”,
- “Liberia National Adaptation Programme of Action (NAPA, 2008)”
- “Liberia forest sector project (2016), Report No: PAD1492”
- “The Land-use & Zoning code of Liberia”,
- “Liberia’s Intended Nationally Determined Contributions (INDC, 2012)”
- “NDMA Nation hazard contingency plan” and etc.

#### 4.2.3. Mitigation measures taken in the Energy sector of Liberia to address climate change impacts

The energy sector in Liberia is a key mitigation area because of the country's fossil-fuel-dominated energy generation which is the primary source of Green House Gas (GHG) emissions. According to the Environmental Protection Agency of Liberia (2013), the energy sector is Liberia's main contributor to GHG emissions followed by agriculture, which accounts for 31.9% Liberia’s GHG emissions while the remaining 0.6% of emissions is attributed to the waste sector. The Initial National Communication (INC) research undertaken in 2013 showed a median annual growth of 14% in diesel and gasoline consumption since 2004. It is expected

to grow by an approximately 10.3% until 2020 and by 3.4% between 2020 and 2028. Baseline electricity demand estimates range from 11 to 25 MW and will rise by an average of 10.3% annually by 2010 before slightly dropping to 3.4% annual growth by 2020 (EPA, 2013). The energy sector accounted for about 67% of GHG in the country in the year 2000.

The INC (2013) on climate change which was submitted to the UNFCCC concluded that Liberia is a net carbon sink since it removes more carbon dioxide than it emits (Environmental Protection Agency, 2013). The energy sector is the largest contributor of GHG in the country, accounting for about 67% in 2000 (Figure 3.1). Using 2000 as the base year, the INC states that the country's emissions amounted to 8,022Gg of equivalent CO<sub>2</sub> while the uptake from the Land Use, Land-Use Change and Forestry (LULUCF) sector was 96,811Gg Co<sub>2</sub>eq resulting in net emissions removal of -88,789 Gg Co<sub>2</sub>eq.

In so doing, the TNA (2019) energy report indicates that most of the emissions from this sector come from petroleum products (primarily gasoline and diesel, and some jet fuel and kerosene) which supply over 95% of the country's main energy. Consumption of petroleum products has increased by 66% from 1999 to 2008, with transportation consuming 61% and electricity generation (which uses gasoline and diesel oil) 29% in 2008 (EPA, 2013). The EPA technology development and transfer (2020) report states that more than 95% of people in Liberia highly depend on firewood and charcoal for domestic use/ cooking. In urban populations (85% of which are in Monrovia) 70% of people use charcoal for cooking versus 5% of those in rural areas.

Despite these global negligible GHG emission values, the Republic of Liberia is committed to fulfilling its obligation for reducing greenhouse gas emission into the atmosphere. As such, the numerous international conventions and protocols to which the country is signatory have demonstrated said commitment. In 2002, Liberia ratified the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol and has since implemented numerous programs related to climate change mitigation.

Another key step /initiative to Liberia's commitment concerning mitigation in the energy sector to climate change is the country's vision and targets set by its Initial National Communication (INC, 2013). Liberia's Initial National Communication (2013) strengthens the National Energy Policy with extra long-term objectives and associated operations, which includes:

- At least 10% reduction in GHGs by 2030,
- Improving energy efficiency by at least 20% by 2030,
- Raising share of renewable energy to at least 30% of electricity production and 10% of overall energy consumption by 2030,
- Replacing cooking stoves with low thermal efficiency (5-10%) with the higher efficiency (40%) stoves; (*Liberia TNA Mitigation report, 2019*).

Some existing key national mitigation policies/ projects on climate change in the energy sector are presented in table 4-3 below:

Table 4-3 Existing national mitigation policies on climate change

| <b>Policy</b>                          | <b>Description and relation to climate change mitigation</b>   |
|--|--|
| National Environmental Policy of 2003  | The National Environmental Policy of Liberia is a legal instrument that provides a broad framework for the implementation of national environmental objectives and plans (EPA, 2003). The primary objective of the policy is to “ensure a sound management of resources and the environment, and attempts to avoid any exploitation of these resources in a manner that might cause irreparable damage to the environment”. This primary objective of the policy is expected to be pursued and achieved through the harmonization and enforcement of relevant laws on environment protection. The policy also seeks to integrate environmental considerations in sectoral, structural, regional, and socioeconomic planning at all levels.   |
| Electricity Law of Liberia of 2015     | The Electricity Law provides the legal and regulatory framework for the production, transportation, distribution and sale of energy products and services in Liberia. The Law further regulates the import and export of energy products and defines the rights and obligations of all entities and parties involved in or affected by the energy activities. The law aims to facilitate the implementation of the goals of the National Energy Policy (Republic of Liberia, 2015a).   |
| National Energy Policy of Liberia 2009 | Activities in Liberia’s energy sector are guided by a National Energy Policy (NEP) that was adopted by cabinet in 2009 (Republic of Liberia, 2009). The policy articulates the country’s national vision for the energy sector of Liberia and set clear development goals for the short, medium and long term in the energy sector at the urban, rural and regional levels. The primary objective of the NEP is to ensure universal and sustainable access to affordable and reliable modern energy supply in order to foster the economic, political, and social development of Liberia. The four pillars of the NEP are: (i) universal energy access, including the development of an energy master plan; (ii) least-cost production of energy and protection of the most vulnerable households; (iii) the adoption of international best practices in the electricity sector; and (iv) the acceleration of public and private partnership in the sector. The NEP also calls for: (i) the creation of an Energy Regulatory Board (ERB) and the RREA; (ii) reorganization of the Ministry of Lands, Mines and Energy (MLME) to expand its capacity in and focus on energy; (iii) creation of a Saint Paul River authority or other river authority; and (iv) changes to the legislation establishing the Liberia Electricity Company (LEC), the National Oil Company of Liberia |

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|   | (NOCAL), and Liberia Petroleum Refining Corporation (LPRC), to separate policy making from operational functions and, in the case of the LEC, to clarify jurisdiction over generation, transmission, and distribution according to geographic area, generation type, and size.  |
| Agenda for Transformation 2012 – 2017                           | <p>The Agenda for Transformation (AfT) is the GoL five-year development plan which articulates the country’s goal and aspirations of attaining middle income status by 2030 through sustained and inclusive economic growth (Republic of Liberia, 2012a). The plan focuses on five strategic pillars to increase productivity, boost economic growth, and improve social inclusion, particularly by creating jobs, specifically for its young population. The pillars are:</p> <ul style="list-style-type: none"> <li>• Economic transformation through investing in infrastructure.</li> <li>• Human development.</li> <li>• Peace, security, and the rule of law.</li> <li>• Governance and public institutions.</li> <li>• Cross-cutting issues. The AfT was adopted as a framework or roadmap for meeting the goals set out in Liberia Rising 2030 which is the country’s long-term vision of socio-economic transformation and development (Government of Liberia, 2010).</li> </ul> |
| Rural Energy Strategy and Master Plan (RESMP) of 2016           | <p>The Rural Energy Strategy and Master Plan (RESMP) of Liberia for the period until 2030 major objective is to set clear targets, to identify least-cost projects and technologies, to propose concrete investments for funding and implementation, with appropriate institutional framework and capacity to increase energy access and renewable energies to the country’s rural areas and population – meaning all areas and population outside of greater Monrovia (RREA, 2016). The Master Plan identifies 92 projects and investments to electrify 265,000 homes and 1.34 million people outside Monrovia until 2030. The action plan and rural energy projects are structured under 5 key programs: <i>GTG: Growing the Grid Program, DG: Decentralized Grids Program, BTG: Beyond the Grid Program, OTP: Other than Power Program, BC: Building capacity.</i></p>   |
| National Policy and Response Strategy on Climate Change of 2018 | <p>The National Climate Change Policy and Response Strategy is a framework to establish specific provisions for dealing with climate change issues, understanding the extent of the threat and putting in place specific actions to mitigate potential impacts (Republic of Liberia, 2018). The policy and strategy is intended to guide national response measures in addressing climate change. The strategy further provides guidance on incorporating climate change issues into national development planning efforts at national, county, district and local levels for effective implementation. It also highlights adaptation and mitigation policies in key sectors in the country. The policy and strategy aims at enabling better</p>  |

|  |  |
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|  | <p>coordination of climate change work in Liberia, providing cooperation and collaboration opportunities between the government and stakeholders, and enhancing ongoing efforts related to Liberia’s National Adaptation Plan (NAP) and Nationally Determined Contribution (NDC).</p>  |
| <p>Pro-Poor Agenda for Prosperity and Development 2018 to 2023 (PAPD)</p>              | <p>The Pro-Poor Agenda for Prosperity and Development 2018 to 2023 (PAPD) is the second in the series of 5-year National Development Plans (NDP) anticipated under the Liberia Vision 2030 framework (Government of Liberia, 2018). It follows the Agenda for Transformation 2012-2017 (AFT). It is informed as well by lessons learned from the implementation of the Interim Poverty Reduction Strategy 2007 (iPRS) and the Poverty Reduction Strategy (2008-2011).</p>  |
| <p>Renewable Energy and Energy Efficiency Policy and Action Plan of Liberia (2006)</p> | <p>The purpose of this Policy is to increase national awareness on renewables and energy efficiency and remove barriers to investment and market development through a national policy instrument (Republic of Liberia, 2006). According to the renewable energy and energy efficiency policy, its primary objective is “to support the development process in Liberia by exploiting renewable energy resources to attract investment, develop the market, transfer technology and build local capacity in the renewable energy sub-sector”. The GoL has outline a number of measures intended to make the policy operational. These measures include the following:</p> <ul style="list-style-type: none"> <li>• Make renewable energy services accessible; this implies that the infrastructure for the supply of renewable energy would be extensive to the extent that the electricity produced from it can be easily procured by any person or institution when needed;</li> <li>• Make renewable energy services reliable so they can meet all demands at any particular time in the future;</li> <li>• Make renewable energy services affordable with the view to improving the living conditions of the population, especially the poor;</li> <li>• Ensure that renewable energy is produced and supplied in an acceptable form so that its production, supply and use have no adverse health and environmental impact;</li> <li>• Ensure that renewable energy is used in the most efficient manner.</li> </ul> |

## 5. Technology Transfer and Development

### 5.1. Introduction

Climate change is the burning of fossil fuels, such as oil and coal, which emits greenhouse gases into the atmosphere – primarily carbon dioxide. Other human activities, such as agriculture and deforestation, also contribute to the proliferation of greenhouse gases that cause climate change. It affects the society as it is projected to increase the frequency and intensity of extreme weather events, such as heat waves, droughts, and floods. These changes are likely to increase losses to property and crops and cause costly disruption to society.

Climate change poses significant risks to Liberia in reaching its goals for sustainable development and climate action. Strong governance will be a key in building the enabling and transformative institutions necessary to protect the people of Liberia from sea level rise and other climate impacts, propel development gains to reduce hunger and poverty so that no one is left behind, and protect peaceful climate-resilient economic and social development. Liberia faces significant risks as a result of climate change owing to the fact that there is a high level of dependence on climate-sensitive activities, such as rain-fed agriculture, which makes the country vulnerable to climate variability and change – higher temperatures, more extreme weather events such as heavy rains, and rising sea levels (UNDP: March 8, 2018).

The options at reducing the consequences of climate change generally fall into four categories: Mitigation, Adaptation, Geo-engineering, and Earth manipulation. Based on the complexities of the latter two, Liberia, having conducted a Technical Needs Assessment has proposed an applied process to leverage funding for the implementation of prioritized technologies for climate change in mitigation and adaptation measures due to prevailing climate change impacts affecting livelihoods and the natural environment. Based on the research and Multi Criteria Decisions Analysis (MCDA), Agriculture, Coastal zone and Energy sectors were identified as the sectors that are most vulnerable to climate change and their social, economic and environmental losses are expected to be higher than those of other sectors. These sectors were selected using some of the below conditions:

- Most vulnerable to the impacts of climate change;
- Current mitigation and adaptation needs;
- Sectors for mitigation should be those that account for most of the national GHG emissions;
- Sector should have Socio-economic importance;
- Government’s support in technology rollout.

Technology alone will not be able to solve adaptation challenges, but will be able to play an important role. As a result of the role of technology in adaptation, and the importance of international collaboration for climate change, technology transfer for adaptation is a critical



but an understudied issue. Through an analysis of Global Environmental Facility-managed adaptation projects, it is observed that there is significantly more technology transfer occurring in adaptation projects than might be expected given the pessimistic rhetoric surrounding technology transfer for adaptation. Most projects focused on demonstration and early deployment/niche formation for existing technologies rather than earlier stages of innovation which is understandable considering the pilot nature of the projects (Technology transfer for Adaptation, July 13, 2014).

The report's prioritization will take into account sectors that are earmarked in Liberia's Initial National Communication as well as the much talk-about project, the National Adaptation Programs (NAPs) that deals with climate change from sectorial level to a policy and strategic perspective, and the TNA report project complementing existing efforts in terms of nationally appropriate technology options.

It also provides a climate risk issues in Liberia, including how climate change will potentially impact agricultural production, energy sectors, coastal zones, fisheries, forestry, and human health. This includes an overview and climate summary of Liberia, information on sector impacts and vulnerabilities to climate change, the policy context and information regarding ongoing climate change projects in Liberia.

## **5.2. Technology Needs Assessment (TNA) process**

Technology Needs Assessments (TNAs) are a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of a country. TNAs are central to the work of the Parties to the Convention (Article. 4.5 UNFCCC). They present a unique opportunity for countries to track their needs for new equipment, techniques, services, capacities and skills necessary to mitigate GHG emissions and reduce the vulnerability of sectors and livelihoods to climate change (TNA Report July 2019).

TNA development is a key component of the Poznan Strategic Program on Technology Transfer supported by the Global Environmental Facility (GEF). United Nations Environment Program (UNEP), on behalf of the GEF, is implementing a new round of TNAs with objectives that go beyond identifying technology needs. The TNAs will lead to the development of a national Technology Action Plan (TAP) that prioritizes technologies, recommends an enabling framework for the diffusion of these technologies and facilitates identification of good technology transfer projects and their links to relevant financing sources. The TAP will systematically design practical actions necessary to reduce or remove policy, financial and technological related barriers. UNEP Division of Technology, Industry and Economics (DTIE) in collaboration with the UNEP Risoe Centre provide targeted financial, technical and methodological support to assist countries in conducting TNA projects.

The purpose of the TNA project is to assist participant developing country Parties identify and analyze priority technology needs, which can form the basis for a portfolio of environmentally

sound technology (EST) projects and programs to facilitate the transfer of, and access to, the ESTs and know-how in the implementation of Article 4.5 of the UNFCCC.

The TNA project seeks to identify and prioritize through country-driven participatory processes, technologies that can contribute to mitigation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities.

According to the TNA report, Climate change has noticeably and adversely affected natural resources, agriculture, the natural environment and other socio-economic sectors in Liberia. Consequently, the vulnerability of the country to climate change needs to be reduced to ensure sustainable development. This will require adaptation and mitigation measures in order to increase the country's resilience in areas like: health and social systems; agriculture; biodiversity and ecosystems; production systems and physical infrastructure, including even the energy grid. Within this overall development and climate policy context, a key step is to select technologies that will enable the country to achieve social equity and environmental sustainability, and to follow a low emissions and low vulnerability development path.

The TNA process led to Liberia identifying for mitigation and adaptation Agriculture, Energy, and Coastal zones as three priorities areas for technology transfer. The extent to which each of these sectors' policies and programs - that has been initiated - to tackle climate change and bring about social equity and environmental sustainability needs to be carefully examined.

### **5.3. Existing national policies on climate change mitigation, adaptation and development priorities**

Policies are formulated and intended to achieve set goals; which should be executed and thoroughly monitored in order to realize the needed results. Unclear directions and weak implementation of existing policies and strategies will hinder the cause of what is proposed to be realized.

With a growing population and continuous depletion of its natural resources, Liberia, recovery from a long civil crisis, that destroyed its infrastructures, socio-economic and political structures to a greater extent is slow. USAID, 2013 Climate change impact assessment revealed that climate change will and is currently affecting the wellbeing of Liberians and impacting socio-economic aspects of the country owing to the facts that the ecosystems of the country is fragile to Climate change, while vast portion of the country's livelihoods depend on the weather and environment.

Accordingly, there is environmental degradation with a gradual loss of forest cover and the impact of climate change is already being felt in variability of climactic conditions with uncertain rainfall, increasing temperatures and sea erosion (noticeably in coastal communities).

In the wake of addressing some of the challenges being encountered regarding the effects of Climate change, the Government of Liberia has passed several important policies and strategic documents of long-term sustainable development to combat climate changes, outlining main policies and strategies of development stating the importance of adaption and mitigation of major sectors (TNA Report, July 2019).

Table 5-1 Major development strategies, policies and projects of Liberia related to climate change adaptation

| Policy   | Description and relation to climate change adaption  |
|--|--|
| The Agenda for Transformation (AfT), 2013  | The country’s national development document recognizes climate change adaptation and mitigation under Pillar V as across cutting issue.  |
| AfT (2013), Agenda for Transformation, Republic of Liberia, The Governance Commission of the Republic of Liberia, viewed 4 June 2019. National Policy and Response Strategy on Climate Change (NPRSCC), 2018 | <p>The climate change policy and strategy document is prepared in order to ensure that climate change adaptation and mitigation issues are mainstreamed at policy level and in key sectorial and cross-sectorial development efforts.</p> <p>The NPRSCC includes concrete policy and measures in specific areas on climate change adaption and mitigation, action and resource mobilization plans and monitoring and evaluation framework.</p> <p>NPRSCC (2018), National Policy and Response strategy on Climate change Liberia, NUDRR Prevention Web, viewed 5 June 2019.</p>  |
| Pro-Poor Agenda for Prosperity and Development 2018 to 2023 (PAPD)   | <p>The Pro-Poor Agenda for Prosperity and Development 2018 to 2023 (PAPD) is the second in the series of 5-year National Development Plans (NDP) anticipated under the Liberia Vision 2030 framework (Government of Liberia, 2018). It follows the Agenda for Transformation 2012-2017 (AfT). It is informed as well by lessons learned from the implementation of the Interim Poverty Reduction Strategy 2007 (iPRS) and the Poverty Reduction Strategy (2008-2011).</p> <p>The objectives of the PAPD are:</p> <p>To build a stable, resilient, and inclusive nation embracing our triple heritage and anchored on our identity as Africans.</p> <p>To lift an additional one million Liberians out of absolute poverty over the next six years (and reduce absolute poverty by 23 percent across 5 of the 6</p> |

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|                              | <p>regions) through sustained and inclusive growth driven by scaled-up investments in agriculture, in infrastructure, and in human capital development. Key objectives to be actualized under the four pillars which form the pathways for the next five years:</p> <p>Power to the People: To reduce developmental inequalities so the people can prosper;</p> <p>Economy and Jobs: Economic stability and job creation through effective resource mobilization and prudent management of economic inclusion;</p> <p>Sustaining the Peace: Promoting a cohesive society for sustainable development and;</p> <p>Governance and Transparency: An inclusive and accountable public sector for shared prosperity and sustainable development.</p> <p>Each pillar has an objective and a set of development outcomes to be produced over the next five years in support of the two high level national objectives.</p> |
| Coastal Add-On project (CAP) | <p>Government of Liberia obtained funding from the Global Environmental Facility (GEF) through the UNDP to Enhance Resilience of Liberia’s Montserrado County Vulnerable Coastal Areas to Climate Change Risks.</p> <p>The CAP constructed a 1200 (One Thousand, Two Hundred) linear metres coastal defence “Revetment” in the D-Tweh, Kru-Town area to reduce the vulnerability of the community’s population and natural coastal environment to climate change risks, and enhance the capacity of the community to recover from coastal erosion impacts.</p> <p>Republic of Liberia Ministry of Mines &amp; Energy 2018, Coastal Add-On project (CAP) Coastal Defense, Republic of Liberia Ministry of Mines &amp; Energy, viewed 2 April 2019.</p>   |

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|--|--|
| <p>Renewable Energy and Energy Efficiency Policy and Action Plan of Liberia (2006)</p> | <p>The national Policy and action plan highlighted the relevance to increase national awareness on renewables and energy efficiency and remove barriers to investment and market development through a national policy instrument (Republic of Liberia, 2006). The primary objective of this policy is “to support the development process in Liberia by exploiting renewable energy resources to attract investment, develop the market, transfer technology and build local capacity in the renewable energy sub-sector”.</p> <p>The Government of Liberia has outline a number of measures intended to make the policy operational. These measures include the following:</p> <ul style="list-style-type: none"> <li>Make renewable energy services accessible; this implies that the infrastructure for the supply of renewable energy would be extensive to the extent that the electricity produced from it can be easily procured by any person or institution when needed;</li> <li>Make renewable energy services reliable so they can meet all demands at any particular time in the future;</li> <li>Make renewable energy services affordable with the view to improving the living conditions of the population, especially the poor;</li> <li>Ensure that renewable energy is produced and supplied in an acceptable form so that its production, supply and use have no adverse health and environmental impact;</li> <li>Ensure that renewable energy is used in the most efficient manner.</li> </ul> |
| <p>National Environmental Policy of Liberia, 2003</p>                                  | <p>The overall goal of the national environment policy is to ensure long-term economic prosperity of Liberia through sustainable social and economic development, which enhances environmental quality and resource productivity on a long-term basis that meets the requirements of the present generation without endangering the potential of future generations to meet their own needs.</p> <p>NEP (2003), National Environmental Policy, EPA Republic of Liberia, viewed 8 May 2019.</p>   |

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| <p>National Disaster Management Policy of Liberia, 2012</p>           | <p>The National Disaster Management Policy provides an overall framework for disaster management in Liberia. The NDMP compliments other national plans, policies and legislations related to drought and climate change management and it provides a platform for the harmonization of all disaster risks management strategies/policies in Liberia. It particularly aims at integrating risk reduction as appropriate into development policies and planning at all levels of government, including the environment, land, agriculture &amp; forestry sectors, coastal areas and etc.</p> <p>National Disaster Management Agency 2012, National Disaster Management Policy (NDMP) of Liberia, Prevention Web, viewed 2 September 2019.</p> |
| <p>The New Policy for Agricultural Advisory Services of 2009</p>      | <p>The agricultural advisory policy for services provides the legal and enabling framework for transforming and strengthening a broad-based, pluralistic system (MOA, 2009). While this new policy for agricultural advisory services in Liberia is recognized as the way forward for reforming the current top-down system in the long term, the strategy for implementation should be carried out on a pilot basis in selected counties and districts using multi-stakeholder learning approaches to assess its wider suitability to the Liberian conditions (MOA, 2009).</p>   |
| <p>National Adaptation Programme of Action (NAPA) 2008 - Liberia.</p> | <p>The Liberia's National Adaptation Program of Actions (NAPA) provides measures to cope with the urgent and immediate needs associated with the increasing climatic volatility and future climate change.</p> <p>NAPA prioritizes three sectors for adaptation: Agriculture- Enhancing resilience to increasing rainfall variability through the diversification of crop cultivation and small ruminants rearing; - Building of a national hydro-meteorological monitoring system and improved networking for the measurement of climatic parameters; and -Building of coastal defense systems to reduce the vulnerability of urban coastal areas.</p>   |

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|  | <p>The NAPA further recognizes long-term adaptation initiatives, which will include fisheries, health, and transport; all with an integrated gender-responsive approach to ensure progress toward efficient and effective adaptive capacity and resilience.</p> <p>NAPA. (2008). National Adaptation Program of Action- Republic of Liberia, UNDP Liberia.</p>  |
| <p>Intended Nationally Determined Contributions (INDC) 2010, Liberia</p> | <p>The INDC (2010) shows that Liberia recognizes the current and future threats of climate change. The document provides some efforts and initiatives that have been undertaken by Liberia towards addressing climate change threats.</p> <p>Liberia’s INDC presents a platform to integrate its Low Carbon Development Strategy into the country’s long-term sustainable development Vision by 2030 (Agenda for Transformation). The INDC includes one component on mitigation and one on adaptation.</p> <p>INDC EPA Liberia (2010). Intended Nationally Determined Contributions of Liberia, UNFCCC INDC, viewed 2 April 2019.</p> |

These policies intend to reduce the risks posed by climate change and ensure long-term economic prosperity of Liberia through sustainable social and economic development, which enhances environmental quality and resource productivity. On a long-term basis, these policies are crafted so that they meet the requirements of the present generation without endangering the potential of future generations to meet their own needs. In fighting to reduce the risks climate change is posing, the major actors should heed to ensuring that these policies and strategies are executed and monitored.

#### 5.4. Vulnerability assessments

A vulnerability assessment is the process of defining, identifying, classifying and prioritizing vulnerabilities. It also provides organization doing the assessment with necessary knowledge, awareness and risk backgrounds to understand and react to the threats to its environment.

Accordingly, as up to recent, about three major climate vulnerability assessments have been carried out in Liberia:

- EPA, 2008: focused on development challenges and vulnerability to climatic variability.
- USAID, 2013: concentrated on both social systems vulnerability and natural systems vulnerability.

- EPA, 2019: focused on agriculture, fisheries and forestry sectors.

According to USAID, 2013 report, a climate change assessment and vulnerability and adaptation assessments (INDC, 2010) revealed that Liberia is faced with climate change and variability leading to extreme events, which have negative impact on agriculture, forestry, health, energy, coastal zone and affecting both the environment and the socio-economic structures of the ordinary people (TNA Report: Coastal Zones, 2019).

From the vulnerability and climate change assessment, measures and strategies were put in place at addressing the effects of climate change in the country. As a result and based on the consideration of recommendations, the Liberia's National Adaptation Program of Actions prioritized three sectors for adaptation and mitigation.

- Adaptation: Coastal zone sector and Agriculture sector;
- Mitigation: Energy sector

Other sectors from the National Adaptation Program of Action (NAPA) were also highlighted as long-term adaptation initiatives. They include fisheries, health, and transport; all with an integrated gender-responsive approach to ensure progress toward efficient and effective adaptive capacity and resilience.

## **5.5. Identification of priority sectors, adaptation options and mitigation measures**

The TNA process is meant to guide stakeholders or decision makers to gather information on how adaptive or mitigation measures can be put into place to address the effects of climate change.

According to the report, the knowledge acquired was used by the stakeholders to make informed decisions in regards to sector identification and selection, and as well as the prioritization of technology options for adaption and mitigation.

Liberia's climate change and vulnerability assessments considered three major sectors to be vulnerable to climate change. These sectors were pointed out and prioritized in the country's NAPA due to prevailing climate change impacts affecting livelihoods and the natural environment.

- Adaptation: Coastal zone sector and Agriculture sector;
- Mitigation: Energy sector

The sectors were selected using some of the below conditions:

- Most vulnerable to the impacts of climate change;
- Current mitigation and adaptation needs;
- Sectors for mitigation should be those that account for most of the national GHG emissions;



- Sectors for adaptation should be those that are most vulnerable to the impacts of climate change
- Sector should have Socio-economic importance;
- National priority based on policy and development plans;
- Sectors to be prioritized should have some ongoing activities that the TNA project will compliment;

The coastal zone and agriculture sectors are prioritized for climate change adaptation considering the following criteria but not limited to: - Vulnerability to climate change; - Adaptive capacity; - National priority based on policy and development plans; - Socio-economic importance; - Technological feasibility; - Potential impact on large segments of the population.

## **5.6. Overview of expected climate change and its impacts in sectors vulnerable to climate change**

Liberia lies just north of the equator and thus has an equatorial climate that is split into two seasons, wet and dry. The climate is tropical, hot and humid all year round, with a rainy season from May to October due to the African monsoon, and pretty frequent rains in the other months, except in the short dry season that runs from December to February, which is more marked in the north.

Along the coast, the rainfall exceeds 3,000 millimeters (118 inches) per year. In the northern part of the coast, in Monrovia, rainfall reaches as high as 5 meters (16.5 feet) per year. In the interior, precipitation is less abundant, and drops in some areas below 2,000 millimeters (79 inches) per year ([www.climatestotravel.com](http://www.climatestotravel.com)).

High reliance on climate sensitive activities renders Liberia vulnerable to climate change variability and change, expected to manifest in higher temperatures, more extreme weather events such as heavy rains, and rising sea level. Agricultural productivity is likely to suffer as sea temperatures increase and coastal ecosystems (mangroves and wetlands) are damaged. Coastal zones, home to the majority of the population, infrastructure and economic activity, are at risk from flooding and erosion associated with sea level rise, which will lead to salinization of coastal agricultural fields ([climatelinks.org](http://climatelinks.org)).

Liberia is particularly vulnerable to climate change. Like many other countries in Africa, Liberia both faces existing environmental issues, as well sustainable development challenges. Because of its location in Africa, it is vulnerable to extreme weather, coastal effects of sea level rise, and changing water systems and water availability. Climate change is expected to severely impact the Liberian economy, especially agriculture, fisheries, and forestry ([www.wilkepedia.com](http://www.wilkepedia.com)).

High evaporation, changes in seasonal rainfall patterns, and runoff decreases, are expected to lead to decreased water and worse water quality. Additionally, by 2020s, the Mount Coffee Hydropower Plant is expected to have challenges to maintain water supply. Moreover sea level rise is expected to cause salinization in important coastal communities. In particular, increased runoff is expected to create water quality challenges.

Population density and low elevation coastal zones is making Liberia especially Monrovia vulnerable to sea level rise. As 60% of the population of Liberia lives along the coast, sea level rises is expected to put pressure on a number of the population, including communities in slums, such as the West Point Slum and is expected to incur properties' losses of over millions of US dollars. 61% of the GDP and 75% of employment is in the agriculture sector. Climate change is expected to have a number of impacts on extreme weather, plus decreasing crop yields to create food insecurity ([www.wilkepedia.com](http://www.wilkepedia.com)).

Changes in the climate means decreased in water availability - which affects cooling at thermoelectric power plants, such as the Mount Coffee Hydro Plant as a requirement for operation. Climate change threatens coastal areas, which are already stressed with human activity, pollution, invasive species, and storms. Sea level could rise and inundate coastal ecosystems while acidic oceans are likely to disrupt coastal and marine ecosystems.

## **5.7. Process and results of sector selection**

Liberia is vulnerable to the impacts of climate variability and change, such as warmer temperatures, increase in annual rainfall, and increase in the frequency of heavy rainfall events. Intense rainfall and flooding events during the rainy season have increased since 1960. ([Climatelinks.org](http://Climatelinks.org)). The occurrence over the years of the effects of climate change and variability have continue to impose negative impacts on agriculture, forestry, health, energy, coastal zone and other sectors.

Owing to the growing wave of climate change vulnerability, the selection of sectors for technology prioritization was conducted by the Liberia's National Adaptation Program of Actions, the Technology Needs Assessment project in the country (headed by EPA) and in consultation with multiple stakeholders, government ministries and agencies, non-governmental organizations (NGOs), private sectors, research groups, representatives of traditional farmers and etcetera for adequate intervention of adaptation and mitigation.

As the result of the recommendations from some of the mentioned climate change vulnerability assessments of Liberia, the TNA national coordinator alongside the mentioned stakeholders selected three sectors (Coastal, Agriculture and Energy) as priority for urgent adaptation and mitigation measures due to prevailing climate change impacts affecting livelihoods and the natural environment.

The development of these sectors requires the exertion of government relevant actors at ensuring that the policies and would be projects in curbing the risk posed by climate change is fully implemented and monitored.

## **5.8. Institutional arrangements for the TNA and stakeholder involvement**

Fighting climate change especially in a developing country like Liberia requires concerted efforts. As a result and ensuring that the TNA process becomes successful, major national institutions involved in environmental or climate change policy making that are considered important to the TNA process were approached; basically the Environmental Protection Agency (EPA) and the Ministry of Mines and Energy (MME).

The Environmental Protection Agency (EPA) serves as lead of the TNA process. The role of the EPA is the regulatory authority of the government of Liberia for the management of the environment, and mandated to coordinate, monitor, supervise, and consult with the relevant stakeholders on all activities in the protection of the environment and sustainable use of natural resources; promote environmental awareness and implement the national environmental policy and the environmental protection and management law; and oversee the implementation of international environment related conventions.

The Ministry of Mines and Energy (MME) is the government institution that is responsible to administer all activities related to mineral, water and energy resource exploration, coordination and development in the Republic of Liberia. In particular to the TNA process, the MME has an established unit called the “Integrated Coastal Zone Management Unite” (ICZMU) responsible for both adaptation and mitigation options relating to coastal risks and vulnerabilities. Therefore, the MME gives support to the EPA with respect to the coastal zone.

The overall responsibility for the implementation of TNA activities lies with the EPA. With said responsibility to coordinate, monitor and supervise the TNA project, the EPA consulted relevant government ministries, agencies, stakeholders, non-governmental organizations (NGOs), private sectors, and community representatives for the selection of the sectors to be covered by the first phase of the TNA project in the country. This resulted to three (3) key sectors currently covered by the TNA process in Liberia; (Mitigation: Energy) and (Adaptation: Agriculture and Coastal zone).

To ensure the successfulness of the TNA process for the selection of the sectors vulnerable to climate change, the EPA as head, set-up a nation team to oversee the implementation of the project having a national steering committee to supervise, coordinate and facilitate the progress of the project’s activities. As well, technical working groups for each of the sectors were set-up (TNA Report, August 2019).

## **5.9. Gender considerations in the TNA**

Across societies the impacts of climate change affect women and men differently. Women are often responsible for gathering and producing food, collecting water, and sourcing fuel for heating and cooking. With climate change, these tasks are becoming more difficult. Extreme weather events such as droughts and floods have a greater impact on the poor and most vulnerable – 70 % of the world’s poor are women. (iucn.org)

Despite women being disproportionately affected by climate change, they play a crucial role in climate change adaptation and mitigation. Women have the knowledge and understanding of what is needed to adapt to changing environmental conditions and to come up with practical solutions. But they are still largely untapped resource. Restricted land rights, lack of access to financial resources, training and technology, and limited access to political decision-making spheres often prevent them from playing a full role in tackling climate change and other environmental challenges.

As unleashing the knowledge and capacity of women represents an important opportunity to craft effective climate change solutions for the benefit of all, gender balance or representation was considered in the TNA process as both male and female were included in the technical working groups of each sector and as well interviews held with women, youths and community leaders in communities highly vulnerable to the effects of climate change.

Moreover, during the implementation of the vulnerability assessments, the views of these people were solicited as to what adaptive and mitigation measures could be considered that wouldn’t interrupt their socio-economic activities, livelihoods and environment.

## **5.10. Assessment of technologies and sectors**

### **5.10.1. Adaptation mitigation technologies**

The identification of technologies for adaptation and mitigation to climate change can be informed by other processes, e.g. national and local climate change vulnerability and risk assessment; where consultants do a review of such studies. Another source of information on technologies is the TNA Guidebook for adaptation and mitigation. In addition, the technologies are then identified based on the expert views, and brainstorming with relevant stakeholders, during sectors working group sessions. The technology identification process may result in a long list of technologies, and the identified technologies are regrouped under different categories.

The subsequent steps involve the prioritization of sectors vulnerable to climate change done by sectors’ working groups and carried out using the multi-criteria analysis (MCA) Excel template tool (See TNA Report Energy Sector, June 2019).

#### 5.10.1.1. Energy technologies

Climate change is a long-term shift in weather conditions identified by changes in temperature, precipitation, winds, and other indicators. Climate change can involve both changes in variability, including, for example, extreme events. The earth's climate is naturally variable on all time scales. However, its long-term state and average temperature are regulated by the balance between incoming and outgoing energy, which determines the earth's energy balance. Any factor that causes a sustained change to the amount of outgoing energy can lead to climate change.

Access to public electricity in Liberia is with less than 10% among the lowest in the world. The reach of the national grids is very limited. Self-generated electricity from gasoline or diesel generators is used by 10% of urban and less than 2% of rural residents. More common are the lowest quality energy forms like candles and flashlights ([www.renewables-liberia.info](http://www.renewables-liberia.info)).

More than 95% of people in Liberia rely on firewood and charcoal to cook; in urban populations (85% of which are in Monrovia) 70% of people use charcoal for cooking versus 5% of those in rural areas. There are huge potential for renewable energies in Liberia. Few projects and activities have started and more need to be initiated to help mitigate the growing treats climate change is posing on the livelihoods of the people.

The demand for electricity nationwide is much larger. The limited development of power network operations in the country implies poor statistical information for demand projections. In rural areas, there has been a little or no public electricity supply for about two decades; therefore data on customer energy characteristics are unavailable.

Perhaps the most notable way that reducing energy helps the environment is by decreasing power plant emissions. To generate electricity, most power plants burn coal, crude oil or fossil fuels. As power plants burns more fuel to create more energy, the extra carbon waste traps too much heat.

As mentioned in the Liberia's Intended Nationally Determined Contribution (INDC) reports, energy is the leading source of GHGs due primarily to the use of traditional fuels such as firewood, charcoal and palm oil and the use of fossil fuels, mainly petroleum products. The country's Initial National Communication (INC) on climate change to the UNFCCC also concluded that the country is a net carbon sink since it removes more carbon dioxide than it emits (Environmental Protection Agency, 2013). According to the report, the energy sector is Liberia's main contributor to Green House Gas (GHG) emissions followed by agriculture, which accounts for 31.9 percent Liberia's GHG emissions while the remaining 0.6 percent of emissions is attributed to the waste sector (Environmental Protection Agency, 2013). The Initial National Communication research undertaken in 2013 showed a median annual growth of 14 percent in diesel and gasoline consumption since 2004. It is expected to grow by an approximately 10.3% until 2020 and by 3.4% between 2020 and 2028. Baseline electricity

demand estimates range from 11 to 25 MW and will rise by an average of 10.3 percent annually by 2010 before slightly dropping to 3.4 percent annual growth by 2020 (Environmental Protection Agency, 2013). The Liberian government has chosen the energy sector as a key mitigation choice because of the country's fossil-fuel-dominated energy generation which is the primary source of GHG emissions.

Although Liberia's contribution to global GHG emissions is estimated to be about 1.89 Mt CO<sub>2</sub>eq (TNA Report, June 2019) it has committed itself to reduce GHG emissions and has started to implement some mitigation technologies to further limit the danger.

Due to prevailing climate change impacts affecting livelihoods and the natural environment of Liberia, Energy, as spelled out in the TNA report is a priority for urgent mitigation measures.

The use of energy as a measure of mitigating climate change in Liberia is a delicate task as it is concerned with developing systems capable of producing, transporting and delivering energy in a way that is safe, economical and increasingly environmental friendly.

The humid, tropical climate in Liberia shows relatively constant temperatures throughout the year, around the average of 27°C (81°F), hardly ever outside the of 20°C (68°F) to 36°C (97°F). In Liberia, monthly solar radiation on horizontal surface ranges from about 4kWh/m<sup>2</sup>/day during the rainy in June., July, August to 6kWh/m<sup>2</sup>/day during the height of the dry season in February and March. The high and consistent potential for solar energy across the country adds to an average level of 1,712kWh/m<sup>2</sup>/year, which could generate 1,400 to 1,500kWh/kWp (renewables-liberia.info)

The main decision context is based on the climate change vision and the targets set by the Liberia's INC. Liberia's Initial National Communication (2013) strengthens the National Energy Policy with extra long-term objectives and associated operations, which includes:

- At least 10% reduction in GHGs by 2030,
- Improving energy efficiency by at least 20% by 2030,
- Raising share of renewable energy to at least 30% of electricity production and 10% of overall energy consumption by 2030,
- Replacing cooking stoves with low thermal efficiency (5-10%) with the higher efficiency (40%) stoves.

The TNA project main objective is to identify and prioritize the use of renewable energy technologies to curtail the country's increasing GHG emissions from the energy sector. Considerations such as the application of the technology, investment and operating costs, whether the technology will bring about social, gender, and environmental benefits as well as the level of application and maturity of the technology in Liberia formed the criteria for the Multi-criteria Analysis exercise. This led to three technologies - : Solar Home PV System,

Solar Grid-tied System and Small Hydropower – from several as the most in the fight to reduce GHG emissions.

Regardless of the objectives a country might have for deploying clean energy technologies, increasing their deployment will depend on implementing effective policies and attracting public and private finance. Equally important is to ensure that barriers to implementing effective policies and attracting finance are removed.

#### 5.10.1.2. Renewable energy

Since the beginning of the 21 century, renewable energy has been a significant area of research amongst scientists. However, despite scientists coming up with practical and convincing technologies on renewable energy, the switch from their use of non-renewable energy sources has been quite slow and uncertain especially in the developing nations (energytoday.net).

Renewable energy is an important source for power generation, because it can be used again and again to produce useful energy. Different renewable energy resources, like hydropower, wind, solar, biomass, ocean energy, energy, biofuel, geothermal, etcetera, provide 15-20% of the total world's energy (www.sciencing .com).

The world has or is turning into a global village where there is more requirement of energy due to the fast growing population. This leads to the use of more fossil fuels like coal, gas, and oil to fulfill the energy requirement which creates unsustainable situations and many problems like depletion of fossil fuels, environmental and geographical conflicts, greenhouse effect, global warming, and fluctuation in fuel prices.

Due to environment-friendly and less emission of gases from renewable energy, it is considered as sustainable energy; and also supported for the society from each dimensions like economic, social and environmental.

Solar energy is radiant light and heat (photons) from the sun. This energy can be used by plants in the process of photosynthesis. Technologies can also make this energy usable, either directly for heating or with the photovoltaic (PV) effect to produce electricity (renewables-liberia.info).

In Liberia, several schools and clinics have solar lighting systems and/or fridges for vaccinations. Also, solar streetlamps are installed in various areas too. In Monrovia, traffic lights are powered by solar energy.

There are many social benefits that can result from the use of solar energy in Liberia. When cities or companies decide to build and operate solar energy facilities, the projects often help to create numerous jobs. For instance, workers are needed to plan the project, built the solar energy plant, manage the equipment and operate the facility. This would help decrease the unemployment rate of a given area. As a result of increased number of jobs created by

development and operation of solar energy panels, more people would have money to contribute to the nation's economy.

Also cities or areas that decide to use solar energy to power the buildings would thus enjoy a cleaner quality of air in the region which in turn can make the citizens and workers in the area more healthy.

Table 5-2 Proposed technologies for the energy sector

| <b>System</b>                        | <b>Description</b>   | <b>Power range</b>                                 | <b>In Liberia</b>  |
|--------------------------------------|--|--|--|
| <b>Pico PV System</b>                | Small rechargeable solar devices such as lanterns, phone charger, radio etc., that is easy to carry around. Its small amorphous panel makes the system easy to charge even if clouds cover the sun. The panel is either on the device or can be easily connected to the device.  | Battery sizes of 1.5, 3, 4.5 & 6 volts DC          | used in rural and urban Liberia  |
| <b>Small Solar Home System (SHS)</b> | Mainly provides light at night with a mini solar system comprising of several lamps, a battery, cables and switches. The solar panel can be installed by a non-technical person ("PLUG N Play system") on a sun-exposed rooftop.   | 6 to 12-volt dc, Mainly built with Lithium battery | Used, but not yet very common  |
| <b>Off-grid Home System</b>          | Separate power distribution in separate homes. A set-up mechanism for maintenance security allows monitoring performance and collecting tariff. SHS is a home based system or a PNP which operates on DC mainly with a small power source, while a Mini-grid is slickly bigger and can be operated using DC or AC power by adding an inverter without synchronization. | 12 to 24 v dc depending on its size                | in rural Liberia at clinics, school and public facilities                  |
| <b>Solar Power Mini-grid</b>         | Solar panels on or around a powerhouse with batteries can supply connected households in rural towns or villages with solar electric power. To ensure maintenance, repair, and   | 220- 240 AC depending on its capacity              | 40 Kilowatts power system in Totota, Bong; five mini-grids planned in Lofa |



|   |  |   |   |
|---|--|---|---|
|   | replacement of batteries (after xxx years, depending on system and care) households are often asked to pay small tariffs and are disconnected if they fail to pay.   |   |   |
| <b>Solar Stand-alone photovoltaic systems</b> | Fridges, TV set, fans, street lamps, water pumps. These can also be powered by solar with DC or an AC power conversion with a separate power grid that has been generated from the sun. A standalone has no inter- or hybrid connectivity. | This can either be a DC or Ac power connection rating from 12, 24 or 48 vdc power conversion. | solar fridges in clinics, solar street lamps, e.g., in Monrovia, Barclayville, Zorzor |
| <b>Stand-alone solar heating products</b>     | This can either be a Solar Dryer or a Solar Cooker that uses the solar energy to generate power by radiation. Power dissipated from this source can be used for drying, cooking or sterilization.  | Radiation from the sun or heat condensation.  | Solar cocoa dryers in several counties, e.g. Bong, Nimba                              |

### 5.10.1.3. Solar home PV systems

Solar photovoltaic (PV) systems are well-established amongst environmental circles as one of a number of technologies that can help to mitigate climate change and improve the sustainability of energy provision (yesenergysolutions.co.uk).

Solar PV systems are mostly installed in rural areas where the electricity it provides can be used in different forms and uses such as street lighting, food storage, cooking, and etcetera.

Solar PV system has the potential for attracting investment and demand which that creates job opportunities for the population.

### 5.10.1.4. Solar grid-tied systems

Grid-tied solar systems are designed for those who already have electric utility service, but wish to significantly reduce their electric bill.

Grid-tied home solar panel systems are designed to produce more power than the house uses during the day the excess power is fed into the grid. That excess power actually causes the homeowner's meter to spin backward. Grid-tied solar is reliable and very little maintenance is required

In Liberia, solar mini-grid systems with the capacity of 3kwh has been installed at the Sinje Health Center in Grand Cape County as part of the United Nations Development Program (UNDP) as its objectives to increase access to health services for vulnerable populations,

reduce carbon emissions as Liberia tackles climate change and improve overall power supply to health facilities. The program tends to cover 12 other health facilities across the country: Palala Health Center in Bong County, Konia Health Center, Telewoyan Hospital, Vahun and Kolahun Health Centers, all facilities in Lofa County as well as St. Timothy’s Hospital in Robertsport and Buchanan Hospital in Grand Bassa County (afrik21.africa).

#### 5.10.1.5. Small hydropower system

Liberia has considerable potential for hydroelectricity power. At the onset of civil crisis, there were three operational hydroelectric power plants in Liberia: Harbel (Firestone), 4MW, Mount Coffee (LEC), 64MW, and Yandohun (a community micro hydro in Lofa County), 30KW. The Mount Coffee and Yandohun plants were destroyed during the war and have been rehabilitated with higher capacities.

According to the International Renewable Energy Agency Report, entitled Renewable Power Generation Costs 2017, hydropower remains the lowest-cost source of electricity worldwide. With the availability of potential rivers across the Liberia – Mano, Cestos, Cavalla, Lofa, Saints Paul and John - small hydropower systems could be developed to address the growing needs faced by the population regarding electricity nationwide.

Many benefits could be realized once these potential rivers are utilized to construct mini hydropower dams as they will help improve the national economy, create more jobs, decrease the unemployment rate of the country, and decrease the growing challenge faced in accessing electricity.

Table 5-3 Hydropower potential

| Potential Site/Project                     | Capacity (MW) |
|--|---------------|
| St. Paul                                   | 1,200         |
| Lofa-Mano Diversion                        | 518           |
| St. John River                             | 225           |
| Cavalla River (jointly with Cote d’Ivoire) | 250           |
| Mano River (jointly with Sierra Leone)     | 150           |
| <b>Total</b>                               | <b>2,343</b>  |

#### 5.10.1.6. Barriers

Liberia experiences a slow development rate as a result of little access to renewable energy. This is because of the high levels of limitations from underprivileged energy policies, inadequate funds, as well lack of adequate infrastructures.

Apart from over-reliance on fossil fuels, most people in Liberia can also attribute their reluctance to adopt renewable energy technologies to several categories of barriers such as

social, technical, economic, geographical and political and regulatory. Also, the common general barriers and measures spelled out in the TNA Report in the Energy sector could be used at addressing the effect of climate change.

Table 5-4 Common barriers unique to the three prioritised technologies

| <b>Associated common Barriers</b> | <b>Description</b>   | <b>Measures to address</b>   |
|-----------------------------------|--|--|
| Political                         | <ul style="list-style-type: none"> <li>• Lack of policies and regulations favouring the development</li> </ul>   | <ul style="list-style-type: none"> <li>• The need of clear policies and legal procedures to increase the interest of investors</li> <li>• Strong policy for lending institutions to lower interest rates.</li> </ul> |
| Technical                         | <ul style="list-style-type: none"> <li>• Lack of infrastructures and infrastructures necessary to support the technologies.</li> <li>• Lack of trained personnel to train, demonstrate, maintain and operate renewable energy structures.</li> <li>• Lack of physical facilities for transmission and distribution networks</li> </ul> | <ul style="list-style-type: none"> <li>• Establish training centers to train and accredit human resource in the energy sector.</li> <li>• Set-up scholarship programs</li> </ul>                                     |
| Economic                          | <ul style="list-style-type: none"> <li>• Initial investment costs for renewable energy are usually high.</li> <li>• Inadequate or lack of credit facilities to purchase sustainable energy technologies.</li> </ul>  | <ul style="list-style-type: none"> <li>• Provision of subsidies to small and medium entrepreneurs.</li> <li>• Reducing of import duties of renewable energy equipment, materials and accessories.</li> </ul>         |
| Social                            | <ul style="list-style-type: none"> <li>• Household unwillingness to adopt renewable energy for fear of unreliability.</li> <li>• Lack of knowledge of renewable energy technologies and systems especially in rural communities.</li> </ul>  | <ul style="list-style-type: none"> <li>• Creation of awareness and focus on socio-cultural practices.</li> </ul>   |

### 5.10.2. Agricultural technologies

Agriculture is the bedrock of Liberia, and provides food, employment, tax revenues, export earnings and a market for non-farm goods, securing the livelihoods of the majority of the population ([www.fao.org](http://www.fao.org)). The agriculture sector is central to Liberia's vision of economic transformation and wealth creation to enhance poverty reduction. The annual growth rate of this sector is less than 4 percent in 2010 – 2011 (GoL, 2013).

Agriculture in Liberia is a major sector of the country's economy worth 38.8% of GDP, employing more than 70% of the population and providing a valuable export. Liberia has a climate favourable to farming, vast forests, and an abundance of water, yet low yields mean that over half of foodstuffs are imported, with net agriculture trade at -\$73.12 million in 2010 ([Wikipedia.org](http://Wikipedia.org)).

According to current climatic variability and predicted climate change scenarios for Liberia, agriculture and farming are expected to be significantly undermined by 1) rainfall patterns changes, hotter and temperatures increases resulting in difficulties to identify the optimal time for crop planting, more pests, weeds, animal diseases; 2) reduction of soil moisture; (3) increase of flooding and salinity in coastal regions. As a result, the forecasted climate change may undermine national efforts to revitalize the agriculture sector and to increase food production. This is a direct threat to agricultural production and food security and in turn a threat to agricultural development, peace and stability.

In order to respond to these threats, the Liberian National Adaptation Program of Action (NAPA) has identified, as urgent priority interventions, to enhance resilience to increasing rainfall variability through the diversification of crop cultivation and small ruminants rearing; modifying the timing of crop cultivation in response to changing rainfall patterns; intercropping, irrigation, and optimization, of lowland/swamp farming practices; pest control, including fencing of farms against rodents, bird scare scrolls, regular weeding and the use of echoing bells; and maintaining fast growing nitrogen fixing tree species to improve soil fertility and using multiple-purpose tree species on farmlands to maintain forest cover ([www.moa.gov.lr](http://www.moa.gov.lr)).

Liberia generally has a climate favorable to farming, vast forests, and an abundance of water. However, climate change is affecting food production and increasing food insecurity (EPA, 2018). Based on past and current climate change assessments, there are a number of documents that have provided adaptation measures for the agriculture sector.

Furthermore, the TNA project in its phase-I identified and prioritized three climate change adaptation technologies in the agriculture sector of Liberia:

- I. **Value addition to agriculture products (rice, cassava, vegetables and fruits)** – establishing 3 major facilities for value addition of agricultural products in rice, cassava, vegetables and fruits;
- II. **Improve d Storage (drying and freezing of agriculture products)** – building of 3 storage facilities for seed, grain and vegetables in 3 agro-ecological zones of Liberia; and
- III. **Integrated Soil Fertility Management** - introducing and running at least 4 Integrated Soil Fertility Management facilities in four agro-ecological zones of Liberia. (TNA Report, Agriculture Sector, July 2019).

Despite a high degree of involvement by the local population in agriculture, the sector’s productivity remains low. Little technology and poor pest management, combined with the extremely limited use of fertilizer and other modern cultivation methods, are the factors responsible for this.

#### 5.10.2.1. Value addition to agriculture products (rice, cassava, vegetables and fruits); technology

Value-added agriculture generally focuses on production or manufacturing processes, marketing or services that increase the value of primary agricultural commodities, perhaps by increasing appeal to the customer’s willingness to pay a premium over similar undifferentiated products. Usually, a value-added addition is a worthwhile investment because it generates higher returns, allow penetration of a new, potentially high-value market, extend the production season, or perhaps create brand identity or develop brand loyalty ([www.agmrc.org](http://www.agmrc.org)).

Value-added products are a major aspect of the agricultural industry. That’s because food is often combined with other products and or processed in some ways. A product could be considered value-added if:

- There has been a change in the physical state or form
- The manner of production enhances value in a way that can be outlined in a business plan
- The product is segregated in a way that enhances value.

The worth of a national agriculture production does not purely lie on the quantity of raw produce but the economic benefits accrued in terms of adding value to produce coming from the farm. For example, Liberia is one of the largest producers of unprocessed rubber/latex. But interestingly, we are not among the highest producers rubber products in Africa not to say the world. If we have concentrated on value addition, we would have created more jobs and expand our economy ([www.farmingportal.co.za](http://www.farmingportal.co.za)).

When farmers grow their crops and their produce can be fully utilized at an economic advantage to them, they can have the moral and motivation to till the soil more and labor for surplus harvest.

Farmers in Liberia grow variety of crops but are short-lived as they normally do not benefit from their productions. A vast majority of them has limited knowledge of value-added technologies and infrastructure facilities. As the result, farmers do not extend the production season of most crops. Normally, they produced limited quantities that are quickly consumed or sold to avoid spoilage.

In spite of the widespread introduction and adaptation of the strategies to adapt to climate change, value addition (rice, cassava, vegetables & fruits), faces a series of barriers that are impeding progress. They include but not limited to the below listed:

### **Barriers**

- Low or no budgetary allocation for research into the technology;
- High cost of constructing physical infrastructure and value addition facilities;
- Limited experience with farming
- Lack of knowledge about business planning
- Access to market
- Farm policies
- Low usage of technology and market data
- Lack of access to affordable financial products
- Limited knowledge of high-quality inputs
- Poor market links

Some measures that could help to remedy challenges to the barriers faced are:

### **Measures:**

- Accessing Finance: devise more efficient cost-effective and customized financial solutions to unlock credit and manage risks.
- Creating value chain and Market Linkages: remove middlemen from the distribution chain and provide multi-stakeholder platforms that facilitate information flows and business transactions between supplies and buyers.
- Rehabilitate farms to market roads.

### 5.10.2.2. Improved storage (drying and freezing agricultural products)

Storage is the phase of the post-harvest system during which the products are kept in such a way to guarantee food security other than during periods of agricultural production. The main objectives of storage can be summed up as follows:

- At the food level, to permit deferred use (on an annual and multi-annual basis) of availability of seeds for the crop cycles to come.
- At the agro-industrial level, to guarantee regular and continuous supplies of raw materials for processing industries;
- At the marketing level, to balance the supply and demand of agricultural product, thereby stabilizing market prices;
- At the national level, creation of more jobs and improvement of the economy.

In order to attain these general objectives, it is obviously necessary to adopt measures aimed at preserving the quality and quantity of the stored products over time. The lack of storage facilities in Liberia is the cause of produce being lost to rodents, other pests and general deterioration before it reaches the consumer. As a result, farmers sell their produces immediately after harvest to buyers at low prices that are unfavorable to them.

#### **Barriers**

- Low or no budgetary allocation for research into the technology;
- High cost of constructing physical infrastructure and storage facilities;
- Lack of economic and financial incentives for community ownership and participation;
- Lack of knowledge;
- Lack of appropriate policy;
- Lack of data and information sharing

#### **Measures**

- Allocate funding for the development of the technology;
- Ensure reduce taxes on research instruments, and other necessary materials used for development of the technology;
- Review existing policies and strategies
- Strengthen institutional capacities

### 5.10.2.3. Integrated soil fertility management

Low agricultural yields are a key challenge facing Sub-Saharan countries. Low adaptation of technologies like chemical fertilizers and improved seeds is a main reason for such low agricultural performance. As farmers in Africa face major constraints to adaptation, an alternative to promoting “capital-only” farming practices is Integrated Soil Fertility Management (ISFM), in which chemical fertilizers are used in conjunction with labor intensive techniques such as field preparation, innovative planting techniques, and other organic fertilizers ([www.poverty-action.org](http://www.poverty-action.org)).

Most of the soils in Liberia are Oxisols and Ultisols which contain oxides of aluminum and iron and are very acidic (pH 3-5). The most alarming crop production problem on these soils is that available plant nutrient is deficient thus leading to inherent low soil fertility. Presently deforestation is on the increase in Liberia thus resulting to soil erosion, poor soil management and decline in productivity ([www.poverty-action.org](http://www.poverty-action.org)). The constraints encountered could be linked to barriers impeding the progress of the technology.

#### **Barriers**

- Lack of knowledge on management of soil by farmers
- Lack of legal and economic instrument for the promotion of sustainable soil management
- Limited use of research technology for farming population

#### **Identified measures**

- Promotion of more assistance to the overall budgetary support to the agriculture sector
- Promotion of soil management practices
- Afforestation of deforested land to reduce desertification and excessive erosion
- Legislation of policy on sustainable soil management
- Capacity building for stakeholders in agriculture production and land use activities
- Promote lowland development and integrated farming this reducing upland shifting cultivation, increasing sedentary farming.
- Improving production: introduce user-friendly ICT applications, non-ICT extensions (such as advisory and consulting services). And capacity building services to use yield-enhancing solutions more effectively.



### 5.10.3. Coastal environment

The coastal environment is basically the areas where the land meets the sea. Coastal environments include tidal wetlands, estuaries, bays, shallow near-shore waters, mangrove, swamps, and in-shore reef systems. The critical habitats of these zones are: feeding, breeding, nursery, and resting areas (www.elonet.europa.eu).

The coastal zones in Liberia serve functions and activities such as:

- a. Beach sand mining
- b. Transportation
- c. Recreation
- d. Solid and liquid wastes disposal
- e. Supply of firewood, charcoal and construction materials
- f. Supply of foods fishing

The overall marine and coastal data base for Liberia is quite limited. Information on climate condition and the pattern of climate change are inadequate. The coastal habitat is rich in resources but is readily being altered by human activities. The activities include:

- a. High levels of sedimentation in estuaries, lakes, lagoons, resulting from poor upland agricultural practices.
- b. Loss of utilization of the mangrove forest and tidal marshlands which support traditional fisheries
- c. Agricultural run-off and potential pesticide pollution in lagoons, estuaries, lakes and fishery production.
- d. Over-fishing and use of destructive fishing methods
- e. The effect of anthropogenic effluents to the coastal and marine zones and their environmental consequences
- f. The implications of all these problems for the socio-economic livelihood status of the already poor Liberian people.

It is projected that about 95km<sup>2</sup> of land in the coastal zone of Liberia will be inundated as a result of one meter sea level rise. About 50% (948km<sup>2</sup>) of the total land loss due to inundation will be sheltered coast. It is evident that with a one meter sea level rise, parts of Monrovia, and its environs, West Point, New Kru Town, Rivercess, Buchanan, and Robertsports will be lost due to the fact that the greater parts of these areas are below one meter. (Coastal zone vulnerability and adaptation to climate change- unfccc)

#### 5.10.3.1. Coastal zone response strategy

In the coastal zones of Liberia, the suggested response to sea level rise and particularly to coastal erosion is to protect important areas in Monrovia and its environs, Rivercess, Buchanan, and Greenville. Options from the TNA and UNFCCC reports based on technology's potential

to reduce vulnerability to climate change, and social, economic, and environmental could be useful.

Table 5-5 Shoreline hardening and stabilisation techniques that could be utilised

| <b>Shoreline technology</b>                  |   |
|--|---|
| <b>The construction of Groyne System</b>     | Groynes are major techniques of beach stabilization in Africa, where by trunks of rheum palm trees are jetted into the beach and tied together with timber. They are also constructed from reinforced concrete, as on the Maputo shoreline in Mozambique. They are easy to build, fairly cost effective and locally hold or capture moss sand in long shore sediments transport system. They do not create new sand but merely re-distribute the sand along the beach. Groynes have been found to be very effective in stabilizing eroded beaches particularly in the republic of to go, West Africa. |
| <b>The construction of Breakwater system</b> | Another shoreline stabilization technique that could be useful in the protection of the sandy beaches of Liberia is the breakwater system. Breakwater system has the ability to reduce the strength of breaking waves coming onshore, reduce their impact on the shorelines and thus reduce the quantity of sand eroded.  |
| <b>Construction of Revetment System</b>      | Revetments are also useful in reducing erosion but need proper construction to be effective. They are expensive and un most cases the beach is lost. Revetments consist of a layer of large boulders on the seaward side and a layer of filter screening material separates these two layers. The void structure of the upper layer on the seaward side is used to dissipate wave energy. The filter screening material of the landward layer allows water to pass through.   |
| <b>Construction of seawalls or Bulkhead</b>  | It is sufficient to build a low cost seawall or bulkhead. The seawall has a 1.2 slope a 2-meter beam and a height above water of 1.2 times sea level rise scenario. Particularly for the Liberia, it may be necessary to employ an innovative sand management approach to solve the large erosion problem. This could be achieved by trying the end of the sand pit of the Hotel Africa   |

|  |   |
|--|---|
|  | <p>Complex to the mainland so that it becomes a sand-feed to the areas in the Bushrod Island and the city of Monrovia. This will, however, result to the flow of large quantity of sand to the beaches. Also to protect areas in New Kru Town, West Point Buchanan, Rivercess City, Greenville, Marshall, and Harper, it is sufficient to use dikes made up of about 1.5 to 2 meters of sand on which is planted some vegetation.</p> |
|--|---|

### 5.10.3.2. Adaptation measures

Long term adaptation measures that are identified in the UNFCCC report are:

- a. **Public awareness and outreach activities-** the public is informed of the danger of living in coastal lowlands that are at risk of being affected by sea level rise. Impacts and risks could be a cost-effective means of reducing future expenditures.
- b. **Increase in height of coastal infrastructure and urban growth planning** – physical planning and building control measures and regulations should be instituted and implemented. The Ministry of Lands, Mines and Energy and the Ministry of Public Works should avoid allocation of land that is likely to be flooded such as in the dried-up swamps around Monrovia and its environs that have recently witnessed flooding during the rainy season.
- c. **Wetland Preservation and Mitigation – the estuaries** and rivers of Liberia in the coastal zone contain economically important wetlands and mangrove systems. The mangrove systems around Monrovia and its environs are important breeding grounds for various aquatic species. Efforts should be made to protect areas by declaring them as protected wetlands. This would discourage exploitation of the resources in these wetlands. The possible impact of upstream of damn on the St. Paul River in terms of reduced sediment supply should be investigated.
- d. **Coastal zone Management Plan-** land-use planning in Coastal zone, such as the use of building setbacks or allocating low-lying vulnerable lands to lower value-used (e.g. parks rather than housing), will help reduce the overall vulnerability to sea level rise. Other land use planning mechanisms, such as construction standards, reduce the risks of living in coastal areas; additional risk reduction measures can be encouraged through appropriate financial mechanisms. Each of these policies reduces the risks from the current climatic variability and protects against potential sea level impacts. When put together in the form of a program, they constitute a coastal zone management plan.

In view of the above shoreline options and measures, the TNA based on the technology’s potential to reduce vulnerability to climate change and social, economic, and environmental benefits, selected three technologies using the TNA “Multi Criteria Analysis (MCA)”. The

MCA provides a structured framework for comparing a number of technologies - some of which are proposed above - against multiple criteria. The prioritized three technologies and brief descriptions to be used for the TNA project in the coastal zone of Liberia are:

**Integrated Coastal Zone Management (ICZM):** The ICZM is a dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones. The ICZM seeks over the long-term to balance environment, socio-economic, cultural and recreational objectives all within the limits set by natural dynamics. It covers the full cycle of information collection, planning, decision making, management and monitoring of implementation in the coastal zone.

**Flood early Warning System (FWS):** In general, the FWS aims to reduce the degree of casualty that could be caused by coastal flooding through alerting the public in advance to take appropriate actions (Response). It detects threatening events in advance to help protect lives and properties in coastal areas.

**Armour or Rocks Revetment.** The armour or rocks revetment is a type of coastal defence that protects against erosion caused by wave action, storm surge and tidal effects. It protects and fixes the boundary between the sea and land; these actions protect and assist in maintaining the landward environment. Rocks revetments also minimize the destructive and hazardous risks to coastal ecosystem, vegetation, sand dunes and important infrastructures.

Despite the low level of adaptive capacities, some efforts and initiatives according to the TNA report, that have been taken to address the alarming impacts of coastal erosion, coastal flooding and marine or saline intrusion into fresh drinking water that are disrupting livelihoods, destabilizing socio-economic activities and accelerating environmental degradation. To mitigate or adapt to some of the impacts, climate change projects/ programs were and are still being facilitated and implemented in Liberia (TNA Report, Coastal Zones; July 2019). Some major adaptation projects in climate change vulnerable communities are as follow:

**The Coastal Add-On project (CAP):** funded by the Global Environmental Facility (GEF) through the United Nations Development Program (UNDP) seeks to Enhance Resilience of Liberia's Montserrado County Vulnerable Coastal Areas to Climate Change Risks. The CAP constructed from June 2018 to June 2019, some 900 (Nine Hundred) linear meters coastal defense "Revetment" in the D-Twe Kru-town area. The project seeks to reduce the vulnerability of the community's population and natural coastal environment to climate change risks and enhance the capacity of the community to recover from coastal erosion impacts (Figure: 5).

**Buchanan Coastal Defence Project: also a CAP,** supported by the UNDP and implemented by the Ministry of Mines and Energy during 2016 to 2017. This project constructed about 250 linear meters of coastal defense (revetment) in Buchanan city, Grand Bassa County, along the

Fanti-town and Atlantic street area to mitigate the alarming rate of coastal erosion that was of national concern.

**Liberia Climate Change Assessment (2013)** was a project implemented by the United States Agency for International Development USAID-Liberia Mission to assist the Government of Liberia to develop climate data. In an effort, this project assessed and developed a climate data and future climate projections for the country. The project presented the level of coastal vulnerability identified in the coastal zone of Liberia from climate change impacts and recommended sustainable intervention. The result of this assessment for the coastal zone is an asset to be used by stakeholders to solicit funding from climate change donors in order to implement coastal mitigation and or adaptation measures projects.

#### 5.10.3.3. Assessment of barriers to and opportunities for implementation of technologies

- Low or no budgetary allocation for research into the technology;
- High cost of constructing physical infrastructure;
- Lack of knowledge;
- Lack of appropriate policy;
- Lack of data and information sharing

#### Measures

- Allocate funding for the development of the technology;
- Empower inter-sectorial coastal protection unit;
- Clearly established policies and an operational plan, revised sectorial policies;
- Create a division for a cadre of coastal engineers and planners;
- Establish adequate tertiary education.

### 5.11. Conclusion

Having a good climate is important as it affects nearly every aspect of our lives. It has a huge effect on our livelihoods, our health and our future. But our climate is changing due to humans, and these changes are already having a big impact on our lives.

The effect of climate change has cause humans and wide animals to face new challenges for survival. More frequent and intense storms, heat waves, rising sea levels, melting glaciers and warming oceans can directly harm animals, destroy the places they live, and wreak havoc on people's livelihoods and communities.

To stop climate change, we need to reduce the amount of greenhouse gases emissions being released by human activities around the world. To reduce the risk climate change poses on the vulnerable population, the TNA process involving major stakeholders in these sectors prioritized three adaption and mitigation technologies areas through stakeholders' Multi-Criteria Analysis workshops. It further created the opportunity for each sector to prioritize technologies deemed necessary to address the effect climate change in their sector.

Moreover, many policy documents have been crafted that could be used as instruments in the fight to reduce the risk climate change is posing on the livelihoods of the population. Also some projects with funding from government and international organization have been implemented to address this growing problem.

Despite progress, Liberia's recovery remains fragile and key challenges must be addressed for the country to embark on a sustainable development path. Based on this, several identified barriers and measures to reducing climate change regarding the prioritized technologies are highlighted with additional mentioned in each of the sectors' Technology Needs Assessment reports.

## **6. Research, Systematic Observation and Early Warning Systems**

### **6.1. Introduction**

Articles 4.1(g) and 5 of the United Nations Framework Convention on Climate Change (UNFCCC) mandate Parties to promote, and cooperate in research and systematic observation of the climate system, including through support to existing international programmes and networks. In doing so, the Convention commits Parties to cooperate to improve the capacities of developing countries to participate in research and systematic observation. A key dimension to the implementation of these Articles has been cooperation with the Global Climate Observing System (GCOS) of the World Meteorological Organization (WMO) and other agencies participating in WMO's Climate Agenda. The GCOS was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users including the UNFCCC. It addresses the total climate system including physical, chemical and biological properties, and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes.

Continuous research and systematic observations are necessary in order to understand the climate system and how the climate at global, regional and local scales is likely to change in the future and significantly, how the changing climate is likely to affect natural and human systems. An effective people-centered Early Warning System (EWS) is essential in the mitigation/management of the risks posed by hydro-meteorological disasters/hazards (i.e. desertification, droughts, floods, tropical storms, storm surges, etc.). With research, systematic observations and early warning system, there can be improved agriculture and food security, water resources management, human health, energy production, transportation, coastal zone management, among others.

In 2000 Africa had 155 stations in the Global Surface Network (GSN) and the Global Upper Air Network (GUAN). In the 2001 GCOS report to the Subsidiary Body on Scientific and Technological Advice (SBTSTA), (ref.: FCCC/SBSTA/2001/MISC.9), that only 8% of these stations were classified as “good” (i.e. those from which at least 90 per cent of required reports were received at the relevant monitoring Centre) and 47% were classified as “silent” (i.e. those from which no data were received). This situation has not improved and could be deteriorating further. Liberia is a contributor to this inadequacy due to the deplorable status of the country's Meteorological and Hydrological Services especially arising from the consequences of the civil war.

### **6.2. Objective of study**

The objectives of this study included:

1. Updating the information provided in the Initial National Communication;
2. Establishment of a network of contacts for accessing data and designing a system for data management;
3. Improving and upgrading information related to climate change research and systematic observation, including improved documentation and archiving; and
4. Elaborating an acceptable report on climate change research and systematic observation, including gaps, needs, new areas of work and baseline according to guidelines.

### **6.3. Methodology**

The methodology used in this study included the following:

1. The Environmental Protection Agency (EPA) prepared an official communication introducing the hired lead consultant to concerned institutions requesting them to grant him in gathering needed data/information and documentation to assist him in the performance of the assigned task in a timely manner;
2. Collection of the required data and information from different sources through interviews and obtaining realistic information through field surveys;
3. In depth analysis of all types of gaps and needs in each cross-cutting component; and
4. Consultation meetings with concerned institutions.

### **6.4. Current and planned research and systematic observations**

#### **6.4.1. Research institutions and funding**

There are no research institutions on weather, climate and environment in the country. Therefore, there is no funding for such.

#### **6.4.2. Systematic (Land, Marine, Atmosphere and Space) Observations**

Liberia does not produce marine-based, ocean-based and space-based observations due to lack of observing networks and stations in this domain.

Land and atmospheric observations are provided by the National Meteorological and Hydrological Services (NMHS) of Liberia. The Liberian NMHS, one of the earliest in Sub Saharan Africa was established in 1952 in the Ministry of Public Works and later transferred to the Ministry of Transport as a Directorate. Other sections dealing with meteorology are spread across other Ministries and Agencies of Government. It is no exception to the inadequate response of Africa to the provision atmospheric and earth observations. Presently, there are only two WMO Recognized meteorological stations operating in the country as indicated in the Table 6-1 below.



Table 6-1 WMO recognised meteorological stations operating in Liberia

| Type of Station       | Location                           | Meteorological Elements measured |            |       |           |          |             |                   |          |
|-----------------------|------------------------------------|----------------------------------|------------|-------|-----------|----------|-------------|-------------------|----------|
| Synoptic              | Robertsfield International Airport | Wind speed and direction         | Visibility | Cloud | Dew point | Pressure | Temperature | Relative Humidity | Rainfall |
| Observational Station | James Spriggs Payne Airfield       | Wind speed and direction         | Visibility | Cloud | Dew point | Pressure | Temperature | Humidity          | Rainfall |

#### 6.4.3. Current Development Activities of the National Meteorological and Hydrological Services (NMHSs)

There are several development activities being carried implemented through the execution of various development projects under the Ministry of Transport (MoT) and Ministry of Lands, Mines & Energy (MLME) which include:

- a) Agricultural Meteorology (METAGRI Operational Project Phase 1 (2012-2015), MoT;
- b) Early Warning System (EWS) Project (2014-2017), National Meteorological Service (NMS), MoT; and
- c) Hydrometric Networks and Database Upgrading Project Phase 1(2011-2016), Liberian Hydrological Service (LHS), MLME.

#### 6.4.4. National Meteorological Service (NMS)

The METAGRI Operational Project sponsored by Spain and Norway through the World Meteorological Organization (WMO) trained selected farmers in rural Liberia on weather and climate data collection and installed fifteen (15) rain gauges in the fifteen (15) counties at the Headquarters of the Ministry of Agriculture County Agriculture Coordinator (CAC) for the collection of rainfall data to enhance agricultural production and food security in Liberia. The project also installed rain gauges in other areas such as Ministry of Agriculture compound; Cuttington University Campus, Bong County; Central Agricultural Research Institute (CARI), Suakoko, Bong County as well as in Panta and Gbarzon District, Grand Gedeh County. Panta and Gbarzon are two demonstration sites for the Climate Change Agriculture Adaptation Project (CCAAP), one of three priority projects identified under the National Adaptation

Program of Action (NAPA) funded by the Global Environment Facility (GEF) and implemented by Ministry of Agriculture.

The EWS Project which is being implemented by the Ministry of Transport is one of three priority projects identified under the National Adaptation Program of Action (NAPA) and funded by the Global Environment Facility (GEF). The project is intended to rebuild the infrastructures of the National Meteorological and Hydrological Services (NMHSs) and train the required level of staff. The fourteen (14) years devastated civil war ruined the NMHSs and created extensive brain drain.

Under the project training component, twenty-seven (27) staff from various stakeholder institutions were sent to Nigeria on September 2, 2016 to undergo training in tailored Operational Meteorological and related courses at the World Meteorological Organization (WMO) Regional Training Center (RTC) in Oshodi, Lagos. The stakeholder institutions included:

- a) Ministry of Transport (MoT)
- b) Ministry of Lands, Mines & Energy (MLME)
- c) Central Agricultural Research Institute (CARI)
- d) Roberts International Airport (RIA)

Under the project infrastructure development component, the establishment of the National Meteorological Center (NMC) which will serve as the operational workstation is under construction at the Roberts International Airport in Margibi County and it is expected to be completed in October 2016. A United States based company, Earth Network (EN) was awarded the contract for the meteorological component of the project by the United Nations Development Program (UNDP) Country Office to provide eleven (11) Automatic Weather Observing Stations (AWOSs) as well as install, train and maintain them. Earth Network began the installation of the AWOSs on Cellcom Company Towers in the country on August 22 and expected to end in third week of September 2016.

#### 6.4.5. National Hydrological Service (NHS)

The Hydrometric Networks and Database Upgrading Project Phase 1 being implemented by the Ministry of Lands, Mines & Energy under the supervision of its Hydrological Service (Liberian Hydrological Service) is funded by the Government of Norway under its LHS-NVE Cooperation Program. Prior to the start of the project, the Liberian Hydrometric network was non-operational for nearly thirty (30) years during which the LHS did not collect any hydrological data. Implementation of the activities has changed the situation radically.

The project established ten (10) hydrometric stations in the six (6) major river basins in Liberia. It trained and equipped LHS Staff hydrometric team who are qualified and capable to install and maintain hydrometric stations and to carry out river discharge measurements. Continuous

collection of hydrological data is particularly important for the ongoing and future hydropower studies and projects. The six (6) major river basins include:

- Mano River
- Lofa River
- Cesto River
- St. John River
- St. Paul River
- Cavalla River

The project also established one Automatic Weather Observing Station (AWOS) situated in the Firestone Plantation Company in Harbel, Margibi County and installed six (6) manual gauges in other parts of the country. The weather parameters/elements measured by the AWOS include:

- Rainfall
- Air Pressure
- Humidity
- Air Temperature
- Wind Speed
- Wind Direction
- Sunshine Duration
- Solar Radiation
- Dew Point

## **6.5. Planned programs of the National Meteorological and Hydrological Services (NMHSs)**

### **6.5.1. National Meteorological Service (NMS)**

The planned program of the National Meteorological Service (NMS) include:

- a) Participation in WMO World Weather Watch (WWW) Program;
- b) Establishment of WIGOS and WIS in Liberia;
- c) Implementation of ECOWAS Meteorology Program in Liberia;
- d) Establishment of a National Framework for Climate Services (NFCS) as recommended by the Global Framework for Climate Services (GFCS) Intergovernmental Board on Climate Services (IBCS);

- e) Participation in AU Integrated African Strategy on Meteorology (Weather and Climate Services) Program;
- f) Play active role in the Expert Segment of the African Ministerial Conference on Meteorology (AMCOMET);
- g) Implementation of WMO/ICAO Quality Management System (QMS);
- h) Participation in the West African Science Service Center on Climate Change and Adapted Land Use (WASCAL) when Liberia process is concluded;
- i) Implementation of METAGRI Services Project Phase 2 (2017-2019).

The METAGRI Services Project Phase 2 will focus on providing weather and climate services to the agriculture sector to enhance agricultural production and food security in Liberia and provide short-, medium-term technical training for staff in the use of application software and climate database management and applied agrometeorology, etc.

### 6.5.2. National Hydrological Service (NHS)

The planned programs of the National Hydrological Service (NHS) include:

- a) Implementation of the Hydrometric Networks and Database Upgrading Project Phase 2 (July 2016-July 2020) which will focus on the following:
  - i. Improving the system for collecting data and data management;
  - ii. Maintain the existing ten (10) hydrometric stations and providing all of them with automatic water loggers;
  - iii. Maintain the automatic weather stations and rainfall stations; and
  - iv. Expand the hydrometric network with four (4) additional stations.
- b) EWS Project to train National Hydrological Service (NHS) staff at the National Water Resources Institute (NWRI) in Kaduna, Nigeria.

## 6.6. Monitoring for Environment and Security in Africa (MESA) Program Implementation in Liberia

### 6.6.1. MESA brief overview

The Economic Community of West African States (ECOWAS) as a Regional Economic Community (REC), it is the Governing Body for the implementation of MESA in West Africa. For MESA implementation, there are two (2) Regional Implementation Centers (RICs) with two (2) thematic areas (i.e. Land Thema and Marine Thema). The two (2) RECs are the University of Ghana and the Regional AGRHYMET Center in Niamey, Niger. The University of Ghana is responsible for the implementation of the Marine Thema while AGRHYMET Center is responsible for the implementation of the Land Thema. The Marine Thema has two (2) sub-thematic areas (i.e. fisheries and oceanography) while the Land Thema has three (3) sub-thematic areas (i.e. livestock, crop and bushfire). In Liberia, the Land Thema is under the

Ministry of Agriculture in collaboration with the Forestry Development Authority (FDA) for purpose of bushfire monitoring and Marine Thema is under the Ministry of Agriculture Bureau of National Fisheries (BNF).

MESA (2013-2016) which is funded under the European Development Fund (EDF) by the European Union (EU) through the African Union Commission (AUC) and African, Caribbean and Pacific (ACP) is an African project that builds on results of previous projects, i.e. Preparation for the Use of Meteosat in Africa (PUMA) project (2001-2005) and the African Monitoring of the Environment for Sustainable Development (AMESD) program (2007-2013) program to increase the information management, decision-making and planning capacity of African continental, regional and national institutions mandated for environment, climate, food security and related responsibilities by enhancing access to and exploitation of relevant earth observation (EO) applications in Africa. (EPA, 2013)

The MESA Program in Liberia involved several stakeholder institutions which include:

- a) Ministry of Transport (MoT)
- b) Ministry of Lands, Mines & Energy (MLME)
- c) Ministry of Agriculture (MoA)
- d) Bureau of National Fisheries (BNF)
- e) Central Agricultural Research Institute (CARI)
- f) Forestry Development Authority (FDA)
- g) Roberts International Airport (RIA)

#### 6.6.2. MESA training activities in Liberia

There have series of training activities in the implementation process of the MESA as indicated below:

#### 6.6.3. MESA marine thema

One (1) staff from the NMS of Ministry of Transport and a consultant at the Bureau of National Fisheries (BNF) were trained at the University of Ghana, Accra from 16-20 November 2015 as thematic focal points for oceanography and fisheries. The staff of the NMS, Ministry of Transport is the focal point for oceanography while the consultant at the BNF, Ministry of Agriculture is the focal point for fisheries.

#### 6.6.4. MESA land thema

Three (3) staff members were also trained at the Obafemi Awolowo University, Ile-Ife, Nigeria, 30 November-4 December 2015 as thematic focal points for livestock, crop and bushfire. The focal points for livestock and crop are staff of Ministry of Agriculture and the focal point for

bushfire is a staff of the Forestry Development Authority (FDA). The Ministry of Agriculture (MoA) focal point for crop participated in MESA Training Workshop held at WMO RTC in Nairobi, Kenya from 8-12 August 2016.

#### 6.6.5. MESA-PUMA upgrade

For the upgrade of the PUMA Station at the Roberts International Airport (RIA), the MESA program trained two (2) staff from RIA Communications Department at the WMO RTC in Nairobi, Kenya from 25-29 July 2016 as System Administrators for the upgraded system and one (1) from RIA Meteorological Services Department was also trained under MESA Program at the WMO RTC in Nairobi, Kenya from 5-9 September 2016 as System Applications specialist.

#### 6.6.6. Establishment of MESA Earth observation stations in Liberia

Three (3) sets of earth observation equipment have been brought in the under the MESA Program through UMARCO Shipping Line. Upon completion of customs clearance, the equipment will be delivered to Government by UMARCO Shipping Line through the below listed institutions for installation in the country.

- a) Roberts International Airport (RIA)
- b) Central Agricultural Research Institute (CARI)
- c) Ministry of Agriculture (MoA)

The installation sites are:

- a) Roberts International Airport, Margibi County;
- b) Central Agricultural Research Institute, Suakoko, Bong County;
- c) Liberia Maritime Authority (LiMA), Search and Rescue Department, Coast Guard Base for use by the Bureau of National Fisheries (BNF), MoA.

#### 6.6.7. MESA climate database and hydrological database management system

##### 6.6.7.1. MESA climate database management system

The MESA Program through AGRHYMET Regional Center donated to the Ministry of Transport for use by the NMS, a set of computer and other accessories for climate data management and archiving. A team of Technicians is expected from AGRHYMET Regional Center to come to Liberia for the installation of the system and to train data processing and management staff of the NMS.

#### 6.6.7.2. MESA hydrological database management system

The MESA Program through AGRHYMET Regional Center donated to the Ministry of Lands, Mines and Energy (MLME) for use by the National Hydrological Service (NHS), a set of computer and other accessories for hydrological data management and archiving. AGRHYMET Regional Center Technicians installed the system and trained the NHS Staff.

#### 6.6.8. Samaritan Purse Technical Assistance to Government of Liberia

Samaritan Purse established one Automatic Weather Observing Station (AWOS) at the Liberia Domestic Airports Agency (LDAA), James Spriggs Payne Airfield in Sinkor, Monrovia and trained two (2) Engineers from the Roberts International Airport (RIA) Communications Department and one Instrument Technician from the National Meteorological Service (NMS), Ministry of Transport as well as other staff members of LDAA.

#### 6.6.9. Research and Service Provision by National Meteorological and Hydrological Service (NMHS)

Currently there are no organized and coordinated programs on meteorological, hydrological and climate research and observation in Liberia. Only fragmented and limited services are available. Reasons and constraints being put forward include inadequate trained human resources and observation networks. These constraints also include inadequate or lack of weather and climate research; data processing and management facilities, instruments and equipment; public weather services and early warning systems.

#### 6.6.10. Early Warning Services

There are plans to establish an effective early warning system in the country to issue early warning messages and advisories on extreme weather events such as floods, mudslides, droughts, extreme temperature and precipitation pending the successful implementation of the Global Environment Facility (GEF) funded 4-year (2014-2017) Early Warning System (EWS) Project. The proposed Early Warning System is expected to provide timely and effective information through identified institutions. The EWS will allow individuals exposed to hazard to take action to avoid or reduce their risk and prepare for effective response. The EWS allows the integrated documentation and utilization of the following four components:

1. **Risk assessment** component generates, maps and provides essential information to help set priorities for mitigation, prepare and implement prevention strategies and design the early warning system;
2. **Monitoring and predicting** component provides timely estimates of the potential risk faced by communities, economies and the environment. Hazard monitoring and

prediction services are developed and utilized to support the generation of accurate and timely warnings based on sound scientific information;

3. **Disseminate early warning information** using effective communication systems, to the potentially affected locations and alert local and regional governmental agencies. The messages need to be reliable, synthetic and simple to be understood by authorities and public;
4. **Build effective national and sub-national response systems** by enhancing public awareness and education, and the development and regular updating of response plans.

NOTE: Failure in any one part means failure of the whole system.

#### 6.6.11. Provision of forecasts, warning and advisories

There is no existing forecasting technology to enable the NMHS to issue warnings on significant meteorological phenomena such as flash floods, thunderstorms and windstorms. No technology for data processing, quality control and archiving. Needed forecast products are not available to meet the increasing demands for disaster prevention and preparedness activities as well as for sustainable socio-economic development.

The three methods of seasonal forecasting include statistical, dynamical and statistical-dynamical.

In the Statistical method, forecasts are based on empirically determined linkages within the climate system. The four approaches to statistical forecasting method include persistence, trends, cycles and relationship between atmospheric variables. All of them assume that future conditions can be extrapolated from historical conditions/information.

The Dynamical method provides for a process based on the solution of a set of mathematical equations governing the atmospheric state to give the future state of the atmosphere. It refers to the models that use time dependent relationship between atmospheric variables to extrapolate future state. The equations are solved using some approximate solution technique called numerical modelling. The basis of dynamical method is Numerical Weather Prediction (NWP).

The combined Dynamical-Statistical method is a hybrid model designed to improve the results.

Forecasting is conducted in the following four temporal scales:

- a) Now-casting: refers to forecasting limited up to a few hours (e.g. 2-6 hours).
- b) Short-range forecasting: refers to forecasting longer than a few hours, but less than 3 days.
- c) Medium-range forecasting: refers to those that last for between 3 and 14 days.
- d) Long-range forecasting: refers to forecasts exceeding 14 days (2 weeks)



## 6.6.12. Gaps and barriers in the provision of systematic observations

### 6.6.12.1. Gaps

There are several gaps that must be addressed and these include:

- a) No national institution/entity designated by legislation for monitoring and systematic observation of the atmosphere and the provision of weather and climate information and services;
- b) No National Framework for Climate Services (NFCS);
- c) No Climate Database Management System (CDMS) for archiving climate data;
- d) Not participating WMO Information System (WIS);
- e) WMO and International Civil Aviation Organization (ICAO) Quality Management System (QMS) for Aeronautical Meteorological Services not implemented;
- f) Only two meteorological stations which are not measuring all parameters;
- g) Not participating in WMO World Weather Watch (WWW) Program;
- h) Not participating in WMO Integrated Global Observing System (WIGOS);
- i) No National Meteorological Center (NMC);
- j) No data processing and forecasting facilities;
- k) No public weather services;
- l) No public education and awareness on weather and climate;
- m) No Early Warning Systems;
- n) No communication facilities/links;
- o) No IT/ICT facilities for data processing;
- p) Inadequate trained human resources;
- q) Liberia is not participating in the Global Climate Observing System (GCOS) program of the World Meteorological Organization (WMO);
- r) No link to the Global Telecommunication System (GTS);
- s) Liberia is not participating in WMO Data Rescue DARE program;
- t) Inadequate data processing instruments/equipment;
- u) No support for atmospheric research; and
- v) No technologies transfer

### 6.6.12.2. Barriers

The barriers encountered include:

- a) Fragmented and limited services on meteorological/climatological and hydrological activities;
- b) No policy/legal framework; and
- c) No budget support.

### 6.6.13. Development Needs and Priorities for Research and Systematic Observations

Development of the Research and Systematic Observations of Liberia would require the following:

- a) Establishment of an autonomous institution by legislation for monitoring and systematic observation of the atmosphere and the provision of weather and climate information and services;
- b) Establishment and maintenance of representative observational networks for continuous monitoring of weather, climate and environment;
- c) Development of IT/ICT facilities and establishment and maintenance of data processing and forecasting facilities;
- d) Establishment of public weather services;
- e) Implementation of WMO and ICAO Quality Management System (QMS) for Aeronautical Meteorological Services;
- f) Institutionalization of public education and awareness on weather and climate;
- g) Participation in WMO Information System (WIS);
- h) Participation in WMO Integrated Global Observing System (WIGOS);
- i) Participation in WMO World Weather Watch (WWW) Program;
- j) Establishment of a Climate Database Management System (CDMS) for archiving climate data;
- k) Establishment of an effective Early Warning System (EWS);
- l) Establishment of a National Meteorological Center (NMC);
- m) Participation in WMO Global Framework for Climate Services (GFCS) through the establishment of a National Framework for Climate Services (NFCS);
- n) Establishment of communication facilities/links (i.e. Global Telecommunication System-GTS);
- o) Development of an optimum critical mass of human resources;
- p) Participation in the Global Climate Observing System (GCOS) program of WMO;
- q) Participation in WMO Data Rescue (DARE) program;
- r) Support for atmospheric research (i.e. weather/climate);
- s) Acquisition of data processing instruments/equipment; and
- t) Encourage/promote other technologies transfer

### 6.6.14. Improving the National Meteorological and Hydrological Services (NMHSs)

#### 6.6.14.1. Improving service delivery

As the impacts of weather-related hazards continue to unfold, there will be increasing demand for accurate, timely weather and climate forecasts and other relevant hydro-meteorological information for public safety and for planning purposes. To address these demands, Liberia needs to improve and expand her meteorological and hydrological services to meet the emerging needs of the various economic sectors. It is therefore very necessary to put in place the basic requirements for these services to function effectively. The basic requirements are enumerated as follows:

- i. Adequate networks of stations to monitor hydro-meteorological parameters;

- ii. A robust communication system for data transmission, dissemination of forecasts and sharing of information with sister agencies in other countries, particularly in the West African sub-region;
- iii. High speed computing systems for data assimilation and numerical weather prediction for early warnings;
- iv. Human resource equipped with appropriate training and skills;
- v. Close interaction with users of weather and climate information.

The trans-boundary nature of severe weather phenomena also requires closer collaboration among meteorological services in the sub-region for enhanced data sharing through the Global Telecommunication System (GTS) of the World Meteorological Organization (WMO).

Improved observing/monitoring systems could provide reliable data to produce customized, accurate and timely forecasts of great value to the various sectors and promote sustainable economic development.

#### 6.6.14.2. Upgrading of facilities of national meteorological and hydrological services (NMHSs)

The Liberian National Meteorological Service (NMS) needs to be transformed into a fully-fledged agency to enable it to perform its mandate of advising the Government of Liberia on climate and weather issues that have a critical effect on the socio-economic development of the country. All sections of the NMS which are in other Government Ministries or Agencies need to be moved into the NMS in line with international best practices. The NMS needs to be assisted to gain the ISO 9001 certification as required by the WMO Quality Management Systems (QMS) for the provision of weather information which would cover the following areas:

- i. Communication systems
- ii. Data management and GIS Database system
- iii. Meteorological observation network for Surface, Upper Air and Marine
- iv. Hydrological observation network
- v. Maritime observation network
- vi. Remote sensing network
  - Upper air observations (Radiosondes, Wind Profilers).
  - Weather Radars
  - Satellite receiving stations including imagery from polar orbiters.

- Weather Radars, operation and maintenance.
  - Low Level Wind Alert Systems (LLWAS).
- vii. Forecasting tools
- viii. Training of additional Manpower (Meteorologists, IT personnel, Climate change Experts etc.) to the required WMO qualifications.

In addition, the Liberian Meteorological Service needs to be institutionally and technically capacitated to fully meet its mandate, particularly in terms of provision of services to other sectors of the economy as shown in **Error! Reference source not found.** below

| <b>Food Security (Agriculture and Fisheries)</b>   | <b>Forestry</b>   | <b>Water and Energy Resources</b>  | <b>Transport</b>  | <b>Construction</b>  | <b>Land Use and Planning</b>   | <b>Insurance</b>  | <b>Health</b>  | <b>Air Quality</b>  | <b>Disaster Risk Reduction</b>  | <b>Media</b>  |
|--|---|--|---|--|--|---|--|---|---|---|
| <p>Provide more accurate 10-15 day forecasts;</p> <p>Issue long-term seasonal forecast (up to six months)</p> <p>Issue regular daily weather forecasts to the general public, particularly on the situation over the river basins in Liberia;</p> <p>Provide marine forecast to support the fishing industry;</p> <p>Provide accurate and reliable forecasts for maritime traffic;</p> <p>Produce farmers guide, crop-weather-calendar, sowing calendar, weather bulletin, agromet. decadal bulletin;</p> <p>Provide soil temperature, sunshine duration, etc.</p> | <p>Establish meteorological observation stations in forest areas to facilitate monitoring;</p> <p>Provide near real time data of critical parameters (including soil humidity);</p> <p>Conduct modelling and provide forecasts of fuel load in forests;</p> <p>Provide forecast information on dispersion of smoke from bush fires;</p> <p>Assess the impacts of climate change on the forest sector.</p> | <p>Provide historical data and observations for modelling of solar radiation for planning and development of energy activities;</p> <p>Provide accurate site specific weather forecasts for estimation of energy consumption and optimization of power production;</p> <p>Provide wind data for assessment of wind energy potential and for risk mapping;</p> <p>Share hydromet. data for Transboundary and international cooperation;</p> | <p>Enhance cooperation and dialogue with sub-regional NMSs to enable exchange of data relevant to the transport (road, water and air) industry;</p> <p>Monitor river discharge and water level and provide needed forecast on potential flooding;</p> <p>Provide real time data, forecasts and warnings specific to transport (road, air and water) particularly on precipitation, fog/mist, hazy conditions and cloud cover;</p> | <p>Provide site-specific weather outlooks and forecasts to enable effective construction planning and execution;</p> <p>Provide historical meteorological and hydrological data and information needed by the construction industry;</p> <p>Improve the quality and dissemination of data information to the industry;</p> | <p>Provide long-term data series on climate variability and change;</p> <p>Advocate for the integration of climate change in Land Use Policies, Plans and Programmes</p> | <p>Provide site specific data and information on weather phenomena concerning claims (e.g. use of high resolution models and new observation technology) ;</p> <p>Provide long term historical data for risk;</p> | <p>Provide improved forecast on high temperature and air quality;</p> <p>Provide statistics on air quality and warnings of poor air quality and flood forecasts.</p> | <p>Provide data and information meteorological conditions of dispersion;</p> <p>Perform dispersion modelling;</p> <p>Monitor trans-boundary transportation of airborne pollutants;</p> <p>Monitor urban air quality;</p> <p>Establish national database for air quality measurements;</p> <p>Provide forecasts and warning on quality of the air.</p> | <p>Provide more accurate and frequent site specific and general weather and hydrological forecasts;</p> <p>Establish a database on weather and climate related disasters;</p> <p>Improve flood forecasts systems;</p> <p>Improve communication system for timely dissemination of forecasts;</p> <p>Provide outlooks and predictions on drought incidences;</p> <p>Conduct and provide inundation and flood hazard maps;</p> <p>Monitor water level as well as water quality;</p> | <p>Conduct sensitization and public awareness campaigns to increase understanding and awareness of meteorological and hydrological events and their relationships with livelihoods of the population;</p> <p>Enable media access to real time data, warnings, advisories and forecasts for dissemination to the public;</p> <p>Facilitate the media in providing required services to the public;</p> |

Table 6-2 Major Services to be provided to other sectors of the Liberian Economy

## 7. Education, Training and Public Awareness

### 7.1. Introduction

There is no doubt that the impacts of climate change are now being felt nationally, regionally and globally. And regrettably, the effects have left developing countries very vulnerable as compare to developed nations. Unless mechanisms are carefully and systematically put in place to ensure resilience in development and reduce vulnerability, climate change and climate variability may pose serious challenges to national development. The best mechanism urgently needed for implementation and sustainability by governments, communities and individuals is education, training and awareness on climate change to all Liberians. The effectiveness and implementation of mechanism that will either reduce and totally eliminate dangers to society when it comes to climate change are, education, training and awareness to all citizens and people, including government officials, civil servants, in the private sector, students at all levels and ordinary citizens. For the next decades, this is where the government of Liberia and partners must focus if Liberia must be safe for future generations.

The UNFCCC through its Article 6 and Kyoto Protocol on Article 10 mandates and objectives focus on engaging people to people dialogue, interactions and awareness. It is the central core for raising national and global climate change attention in all communities, including Liberia. The UNFCCC in Article 6 and Kyoto Protocol Article 10 call on all governments to train, educate and create awareness for its citizens. Climate change education in its broadest sense is the best alternative in reducing and eradicating climate change. Awareness and education cut across all boundaries of the world. It is imperative to focus on adequate communication and transparency when dealing with climate change education and that decision makers in charge of climate change, education and sustainable development work together to adopt an informed and coherent approach.

In the case with Liberia, public awareness, training and education is not felt. In fact, it is estimated that less than 1% of the population is aware about the functions and objectives of Environmental Protection Agency, (EPA). This is terrifying, especially of a country that is very vulnerable in all aspects that has to do with negative impacts on Liberia. This is where the Government of Liberia must focus very attentively in making sure that the EPA is heavily funded.

As the international community is encouraged to work with nations around the world on scientific and technical research, on the development and exchange of educational and public-awareness material on climate change and in promoting the development and implementation of education and training programs including the strengthening of national capacity building, in particular human and institutional capacities, and facilitate at the national level public awareness of and access to information on climate change, the EPA must now seize these

opportunities from Article 6 of UNFCCC. Already, there are scores of non-governmental, international institutions and governments working in partnership with the EPA, stakeholders, particularly with the media, in fulfilling the commitments in Article 6.

However, one should bear in mind the scale of challenges posed by climate change and the requires outreach activities of its greatest magnitude in Liberia. The primary laws regulating and facilitating education and training sector of Liberia are the 1986 Constitution, the Education Law of A.D. 2001, and the 1989 National Commission of Higher Education Act establishing the National Commission of Higher Education (NCHE). Articles 6 and 15(b) of the 1986 Constitution articulates the right of citizens to education. Article 6 specifies that “[t]he Republic shall ... provide equal access to educational opportunities and facilities for all citizens to the extent of available resources. Emphasis shall be placed on the mass education of the Liberian people and the elimination of illiteracy.” Article 15 (b) grants individual citizens “the right to knowledge.” The Ministry of Education (MOE) interprets “the right to knowledge” as being “the right to education.” The Education Law of A.D. 2001 was passed in January 2002, repealing the Education Law of 1972 and all amendments to it. The 2001 law, which is divided into five chapters, has a number of shortcomings and is in the process of being restructured and revised to reflect present-day realities. The NCHE was established in 1989 to formulate broad policy guidelines for the establishment of institutions of higher education; to monitor, evaluate, and accredit all institutions of higher learning; to approve new and existing programs of higher education for funding according to national needs.

Granted that the government of Liberia might have invested on climate change in training and workshops, yet there are more needed to be done. There is a need that we focus on the reduction of emissions gases through targeted educational activities in every community, schools, colleges and workplace. Communication and dialogue will also make members of the public aware of the need for active climate policy and awareness. This will make citizens to learn about areas where they themselves can take action in term of climate change and protecting their environments.

## **7.2. Education, Research and Public Awareness in Liberia**

On the issue of education, research and public awareness, there are lots needed to be done. The idea of research in any field is the core for success and finding the root cause of problems. In order for the government through its agency to effectively feel the result on education and awareness on climate change, there is a need that the government of Liberia and the EPA direct enormous resources in research and research orientation methodologies. Like other countries around the world and in the region of Africa, research through the assistance and collective efforts of international partners are been implemented yearly.

Higher learning institutions and environmental/climate change institutions need to be contacted and empowered in research on climate change. There are approximately thirty Higher Education Institutions in the country and none is offering studies on Climate Change. Only

four of these institutions (University of Liberia, Cuttington University, TNIMA, AMEU, Mother Patten, Stella Maris) offering degree courses on Environmental Science. In term of research, there is no institutions in the country that has ever done research in climate change. This is troubling to Liberia. Beyond that, the fourteen years' civil war led to a serious brain drainage and the destruction of research and educational infrastructure in the country. Up to present, the country has not recovered from this calamity. This is where the government of Liberia through the EPA and higher learning institutions must be thinking out of the box by heavily partnering with international research institutions and tertiary bodies around the world. The more comprehensive, interdisciplinary, use-inspired, and integrated research enterprise that combines fundamental understanding of climate change and response choices, that improves understanding of human-environment systems; that supports effective adaptation and mitigation responses, and that provides better observing systems and projections will help redirect Liberia's trajectory on climate change. We recommend the Government of Liberia through the EPA should conduct research in the following:

- Provide funding to carry out specific research and assessments to fill the data and information gaps in the NATCOM process.
- Conduct more research on themes that need to be understood for the completeness of the NATCOM development process including projection of GHG emissions, development and costing of mitigation and adaptation measures, modeling for scenario development, and biophysical simulation of impacts of climate change on critical economic sectors.
- Conduct research on how the media can effectively disseminate environmental information related to GHG.

### **7.3. Tertiary Education and Institutions**

As by legal and moral obligations on the part of the Government of Liberia, especially when it comes to the protection of the environment and the wellbeing of its people, the Environment Protection Agency (EPA) was established 2003 and came into full existence in 2006. With the establishment of the EPA in 2003, some of the mandates of this agency are to protect the all parts of the country and mainly the environment by implementing policies that ensure the long-term economic prosperity of Liberia through sustainable social and economic development—meeting the needs of the current generation without compromising the potential of future generations. The EPA is the principal authority responsible for implementing national environmental policy and sustainable management laws for the protection of natural resources in Liberia.

Climate change education in its broadest sense is the mission of Article 6 of the UN Framework Convention on Climate Change (UNFCCC) and its objective. Climate change is not only about studying climate change, but also about understanding it. It is critical to include it in curricula, but it needs to be embedded in the DNA of today's education concept. It is not just another course; it is about how everything else we study or do is affected by climate change. It is about understanding the transformation to be able to act on it.”





Figure 7.1 University of Liberia, a publicly funded institution

Over the years, the Environmental Protection Agency (EPA) has undertaken substantial and qualitative workshops, seminars and written papers on climate change among its staff, NGOs, communities and the general population at large. Among them are: Development and implementation of Environmental Impact Assessment (EIA) administrative procedures; Establishment and operationalization of the certification of environmental consultants for conducting environmental impact assessments; Development of a National Biodiversity Strategy and Action Plan (NBSAP); Active participation in multilateral environmental agreements (MEAs) on climate change, biodiversity, and desertification; regional cooperation initiatives, and projects supported by the Global Environment Facility (GEF); Preparation of a national action plan and strategy to address land-based sources of marine pollution;

Development of a National Adaptation Programme of Action (NAPA) for climate change and implementation of projects identified therein; Development of a dedicated website to improve access to environmental data and information and contribute to the implementation of Article 6 of the UNFCCC and Article 10 of the Kyoto Protocol. 7.4.2. The EPA has also conducted workshops on: Priorities in Education, Training, and Public Awareness for Improving the National Communication (NATCOM); EPA financed a study titled “Technologies and Measures for Mitigation of Greenhouse Gas Emissions.” The report highlighted the dire need for human resource training because of the lack of trained personnel. Focus on education, training, and public awareness.

#### **7.4. Public education, sensitisation and awareness**

The application for a better environment and climate change security in Liberia is highly needed. Liberia needs vigorous climate change awareness in all communities, schools, workplace and homes. It is repeated that education about climate change needs to focus on peoples' emotional as well as intellectual nature because the academic messages from climate science sometimes tends to be difficult in getting through strongly enough. Most humans, understandably, will tend to ignore what creates anxiety and uncertainty but they WILL act once they are moved by emotions that reach out to their core individual or group value. This is where awareness on climate change must be heavily concentrated. The EPA must now be heavily funded by the Government of Liberia, the UN and international partners in order to create an awareness among the people. While the government is yet to legislate law making climate change part of curricula, awareness should be of priority. These are some of the channels needed for climate change awareness:

- Retreat for students. This form of awareness will take students far from their schools, communities and distractions into the wilds for lectures strictly on climate change.

Figure 7.2 A.M.E. University, a privately funded institution



- Talk Show on Radio and TV. These day in Liberia, Talk Shows are considered the major avenue for which citizens. EPA can seize this opportunity by creating the awareness to the citizen. This can be done by experts in climate change, day and night. With everyday awareness, gradually the impact will be felt.
- Jingles and billboards. This is another channel through which the EPA can create awareness within Liberia regarding climate change.

## **7.5. Government policies and engagement on climate change**

Generally speaking, the issue of climate change in Liberia has always been downside or downgraded due to either lack of information, the complexity of the subject matter and the lack of funding to run successful climate change programs. Notwithstanding, the government of Liberia through the EPA has initiated lots of programs and policies on climate change. Among the policy documents crafted by government with assistance or partnership with organizations include:

- National Policy and Response Strategy on Climate Change: The aim is to ensure an effective and coherent climate change adaptation process and serve as the pillar for comprehensive sectoral strategies and action plans.
- Liberia's National Adaptation Plan (NAP). According to the Executive Director of EPA, the aims of NAP are: to mainstream climate change adaptation into development policies, plans and strategies; build long-term capacities of institutional structures involved in NAPs; implement effective and sustainable funding mechanisms, advance research and development in climate change adaptation, and improve knowledge management.
- Liberia Climate Change Gender Action Plan (LccGAP) Report. The overall objective of the policy is to ensure that gender equality is mainstreamed into climate change policies, programs, and interventions. The priority areas identified in Liberia's ccGAP are agriculture, coasts, forestry, health, water and sanitation, and energy.

## **7.6. Role of national and international organisations on climate change**

No country is an island, therefore, every nations desires assistance in solving national and transnational glitches. No nation, no matter how sophisticated a country is, cannot solve these problems alone. It takes the collective efforts of nations and International organizations in resolving these problems Examples of such can be found in the fight against HIV/AIDS, EBOLA, CLIMATE CHANGE and GLOBAL TERRORISM. International institutions are powerful enough in creating powerful tools to solve a particular problem. The involvement of these actors helps to increase their power, access and authority through collaborative efforts, mutual agreements and policy formation. The IPCC works on climate change is an excellent example of international regime in world crisis due to their results based. Intergovernmental Panel on Climate Change (IPCC) was established jointly by the United Nations Environment Program (UNEP) and the World Meteorological Organization in 1988. The purpose of the

IPCC is to assess information in the scientific and technical literature related to all significant components of the issue of climate change.

Table 7-1 NGOs in Liberia working on climate change

| Name of NGOs   | Role  |
|--|---|
| SCNL   |   |
| SIDA   |   |
| Our Chance   | Awareness on climate change and pollution                           |
| Youth Climate Change Initiative                                | Works with EPA in creating awareness on climate change              |
| Liberia Environmental Care Organization                        |   |
| Community Union for Sustainable Development                    | Food processing and preservation                                    |
| Journalist Network for SDGs & Climate Change Promotion-Liberia |   |
| Youth for Education & Agriculture International                | Works with farmers on how to use and apply chemicals on their crops |
| Plant-For-The Planet Foundation                                | Engaging with Youth in Planting of trees the communities            |
| Green Gold –Liberia  | Tree planting/ mitigation and adaptation                            |
| Ever Green Recycling   | Recycle of all types of plastic materials                           |
| Affordable Medical Services of Liberia                         | Cleaning of environment   |
| Farmers Associated to Conserve the Environment                 | Works with communities on subsistence farming                       |
| Concession & Investment Monitoring Agency of Liberia           |   |
| Rural Integrated Center for Community Empowerment              | Collection and disposal of garbage                                  |

## 7.7. Community engagement and knowledge on climate change

There is a maxim that says, “there can be no food security without climate security” Whenever there is a disaster such as, floods, drought, or extreme weather event, it is the poor and vulnerable people that are particularly affected. And many times, these people are purely innocent to the cause of their evacuation, the destruction of their farms, the burning of homes and the drought that leads to the deaths of their cattle. These people are not aware that it is climate change mainly due to emission of greenhouse gases into the ozone layer are the cause of these disasters. But there needs to have a paradigm shift in order to draw the attention of

communities as the risk of climate change are increasingly clear and the damages are beyond the governments and citizens. It is time communities take initiatives of the effects of climate change in their area. This thought is central. These are the channels government needs to undertake in reaching out to communities:

- Engagement of local authorities. The first step needed to be done is for the EPA to engage all counties, districts authorities, community leaders in their respective communities on climate change. The community entry strategy through the chiefs, elders, religious leaders and parents will get all sectors of the community involved.
- Setting up school clubs. The setting school climate change clubs in high schools and tertiaries institutions is been implemented in many countries around the world. Fortunately, and due to the internet, students are actively getting involved into climate change. Students are now seeing the impact of climate change in other countries. The advantage of engaging students is for them to spread the message on climate change to their parents and peers.
- Engagement of Religious Houses. This is another form of community engagement that is very vita in Africa. Majority of Liberia attend services on a regular basic and the influence our religious leaders have on us are tremendous. The regular five minutes of preaching on climate change before the pastors or imams come to preach could make a big change among the worshippers.
- Engagement of Radios and Talk Shows in towns and communities. These days talk shows are of paramount important in engaging community dwellers. With at least twice a week of lectures and interaction on climate change, people gradually understand the concept and the effect it has on their communities.



Figure 7.3 Climate change training program in Monrovia

## **7.8. Analysis of Lima Ministerial Declaration and Doha Work Programme on Article 6**

In the area of education, awareness and research on climate change, The Lima Ministerial Declaration on Education and Awareness and the Doha Work Programme are considered the best two documents in informing every nation. These two papers vividly narrate how the EPA should come up with programs and activities as to how all communities can benefit in the consciousness on climate change. Liberia can seize the opportunity by making use of these documents for educating its citizens and also creating the awareness in every community in the country. If these documents are critically being seriously taken into consideration, the negative impact of climate of change will drastically reduce.

The Lima Ministerial Declaration and Doha Programme are both strategic documents aim at working with nations, local/international institutions, schools, communities and CSOs in resolving the lack of knowledge and awareness concerning climate change. These papers are gear towards making climate change a habitual lifestyle and way of life for all Liberians. This can be done through the engagement of societies and population. It is expected that when the public is fully aware and actively participate climate change exercises, there bound to be some level of improvement in the fight against climate change.

With these strategies from these international papers, it is further recommended that the general public be fully participatory in the decision/policies making. The Doha and Lima documents believe that when key stakeholders in the communities are heavily and actively involved in policies making, it makes it much easier for the implementations of any programs and projects emulating from the EPA to schools, churches and communities. This strategy also encourage the citizens assist the EPA/GOL in formulating their own working programs.

## **7.9. Recommendations**

- There is a need that the EPA creates a friendly environment between it and the Liberia National Legislature. Since the legislature is the first branch of government with the sole mandate of making laws, it will be good for both institutions to regularly meet in informing them on the nature and causes of climate change. With friendly interactions, it makes it easier for EPA/ Climate Change bills, protocols and documents to be legislated.
- Recommend an integrative, interdisciplinary and decision-making research program to assist the nation in understanding climate change and in supporting well-crafted and coordinated opportunities in reducing the magnitude of climate change.
- Recommend that the EPA should not only focus on improving understanding, but helps to inform solutions for problems at local, regional and national.
- Integrates diverse kinds of knowledge and explicitly engage the social, ecological, physical, health, and engineering sciences within the country.
- Build laboratories and purchase of high technological climate change equipment for use in universities, hospitals and by the EPA



## **8. Constraints, Gaps and related Financial, Technical and Capacity Needs**

### **8.1. Introduction**

The Environmental Protection Agency (EPA) through the United Nations Development Program (UNDP) obtained funding from the Global Environment Facility (GEF) to support the preparation of Liberia's Second National Communication (SNC) in fulfillment of its obligations to the UNFCCC. This project will support the Republic of Liberia in the preparation of its Second National Communication to the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). Effort will be made to use the 2006 IPCC guidelines and 2000 IPCC good practice guidelines (GPG) and will follow the BUR and the ICA formats of reporting.

In preparation of the SNC, Liberia received a GEF grant of US\$500,004. This amount was preceded with the amount of US\$20,000 which was used in preparing Liberia's SNC project document. The Government of Liberia also provided an in kind grant of US\$25,000.

During implementation phase of SNC, UNEP provided technical backstopping. This entailed the organization of the inception workshop that led to the development of a comprehensive workplan. UNEP also identified international experts to assist in providing technical training as it relates to the usage of the IPCC 2006 guidelines on the GHG inventory. UNEP also provided technical training to the training of national experts in the usage of sectoral software as it relates to vulnerability assessment.

### **8.2. General constraints**

#### **8.2.1. Policy**

The Environmental Protection Agency of Liberia proposed key elements to be considered in the National Policy and Response Strategy to climate change such as; Adaptation Policy, Mitigation policy and Cross-cutting themes Policy (EPA, 2018). The Environmental Protection Agency of Liberia is the institution mandated for the implementation of international environment treaties including UNFCCC to which Liberia is a member. Their proposed developments to integrate climate change into national policies, programs and plans seems to be significantly strong. This includes embedding vision 2030, the Pro-Poor Agenda for Prosperity with visions of supporting adaptation, disaster risk management and mitigation capacity in Liberia. However, a number of important national policies with significant contribution to climate change are lacking. This may include poorly defined and implementation of National Land – Use Policy and Plan (GoL, 2017) that need to control the current irregular housing and urban developments. Also, the policy failed to propose national



disaster management policy which is important in increasing and sustain resilience of vulnerable communities to climate change hazards. In addition, the strong NAPA climate change policy plan left out serious gaps that establish mechanism for successfully implementation of the proposed strategies. There is a need to reveal mechanisms to ensure proposed measures are implemented. Although there is sector – specific strategy for climate change mitigation and adaptation, there is need to include policy that will govern site – specific which will take into account specific vulnerable areas and communities as a result of climate change.

Lack of expertise was major constraints identified by the initial national communication under UNFCCC for assessment of mitigation and adaptation options. Although the government has determined to assess mitigation and adaptation options, the proposed policy plan and strategy will suffer the same setback. For example, the proposed governance structure under NCCSC requires experts to support its successful implementations which will be the major constraints by the EPA.

### 8.2.2. Institutional

NCCSC which was established by the president in October 2010 has strengthened the institutional capacity to oversee climate change activities in Liberia. NAPA report of 2018 presented a well – documented frameworks for climate change adaptation, climate change mitigation and cross cutting themes. However, the institution mandated to oversee their respective category seems to be working in isolation. For example, The National Meteorological Monitoring System planned to be executed by the ministry of Transport and to share its information to assist in planning of agricultural activities. The forest and wildlife institutions may not see the important of meteorological observation in their work.

NAPA strategies in the institutional level for national policy and response strategy on climate change will be constrained by the limited availability of skilled personnel. As a new concept, it will need skilled staff in the science of climate change that will be able to implement policy action, monitor progress and communicate the findings of the research. The proposed climate change govern structure have included NGOs, Private sector and other interested parties as part of the climate change governing institutions. However, currently there is none of the institutes that have shown effective participation in the implementation of the UNFCCC. Majority of the participant members of climate change activities were from the central government (EPA, 2013).

### 8.2.3. Technical

Implementation of the proposed climate change action will be constrained by limited human resources and technical capacity. The energy sector specifically needs technical experts to initiate development of technologies that can mitigate emissions from energy, transport, mining and agricultural sectors. Technology advancement needs high investment due to their high cost.

The existence limited technical capacity also hinders researches and interpretation of national and regional climate change projections. Liberia has not developed technical documentation that consists of written records, photos, videos and data on vulnerability scenarios established as the baseline measures for climate change adaptations and mitigations. As a technical need, Liberia should enact climate change bill into law. This will enhance government capacity to ensure the best practice climate assessments, adaptation approaches and low carbon development strategies at regional, national and individual levels.

#### 8.2.4. Financial

Implementation of specific adaptation and mitigation strategies and options are constrained by financial limitations. National budget is not sufficient to support climate change related activities due to the overwhelming and competing national priorities such as the decline in of the price of rubber, iron ore, low or lack of new investments and above all the shock of Ebola Virus Disease in 2014 that the country is still struggling to recover. Majority of climate change projects are hence sourced from Domestic Public – Private Sources, International Climate Funds and Bilateral and Multilateral Sources. The current inadequate funding limits the development of skilled staff and supporting institution to effectively fulfill their expanded mandates. For example, high cost of new technologies limits the adoption of low – carbon emission technology by the transport and energy sectors. There is lack of funding to expand the coastal defense project in other affected coastal counties across Liberia and funding to improve agricultural technologies to build resilient of poor communities and increase food security. And limited or lack of funding to enhance climate change education at the undergraduate and postgraduate levels at the state – run university (University of Liberia).

### **8.3. Sectoral barriers to implementation of UNFCCC and actions to address the barriers**

#### 8.3.1. Greenhouse gas inventories

Liberia's INC estimated its national and Sectoral emissions of GHG for the year 2000 that excludes actual emissions of HFCs, PFCs and SF6. Since then Liberia has not submitted Biennial Update Report (BUR) to UNFCCC. But, The Environmental Protection Agency (EPA) of Liberia on Wednesday, March 6, 2019 commenced a three – day capacity building workshop on the preparation of National Greenhouse Gases (GHG) Inventories in Liberia. The workshop intended to bridge the gap of Data limitation, Capacity gap, Enhancement Needs, Institutional Networking and Coordination between ministries, organizations and agencies to produce uniform data on GHG emissions in improving GHG inventory estimations.

### 8.3.2. Vulnerability and adaptation

Despite NAPA immense effort in proposing different adaptations strategy in key sectors, there is existing gaps that constrained its effectiveness, here are some of the barriers identified and there propose solutions in this SNC:

- Dependence on global circulation models (GCMs) due to lack of national and regional climatic prediction models and downscaling models that can provide a likely impacts of climate change on different regions and sectors.
- Inadequate financial resources to support the research needs and implementations of adaptation options. NCCSC should highlight addition financial mechanism to support the implementation of the proposed needs by NAPA.
- Hydro - meteorological department do not provide sufficient and accurate information regarding predictions of potential climate change at smaller scales. The information to the end user also remains a gap. The department needs modernization of equipment and extension of monitoring networks to improved forecasting and early warning systems.

Lack of biodiversity database in the country obscure biodiversity monitoring program in understanding their vulnerabilities and adaptation options.

### 8.3.3. Climate change mitigation

Mitigation is an important aspect in preventing or slowing down the increase of atmospheric GHG concentrations by limiting current and future emissions. Liberia's contribution to the global emissions is relatively negligible. However, the country committed itself to enhance its potential carbon sinks. Sectors mandated for this include energy, transport, industry, Agriculture and mining. However, the effort experienced the below barriers;

- Energy; Capacity gap in the energy sector range from technical skills and lack of cheap alternatives for communities. The high cost of adopting renewable energy technologies and technical expertise within relevant sectors will constrained its implementation.
- Transport; Significant investment will be required to adapt to a low carbon emitting transport system. The mass transport systems will also depend on commuters' preferences and cost effectiveness which should be addressed.
- Industry; Adoption and maintaining of modern techniques and production processes will need high investment and higher production cost which will hence affect the price of the final goods for Liberians. The selection of technologies should hence depend on the cost of production.
- Agriculture; before implementing the NAPA proposed sustainable agricultural system, there is need to determine the sensitivity of particular agricultural regions and crops to climate change.

#### 8.3.4. Education, training and awareness

Education, training and Awareness were considered in a cross – cutting themes policy that aimed to impact all specific sectors by NAPA 2018 proposal. However, before concentrating on general public awareness, there is existing weak awareness among decision – makers on climate change needs. This creates an immediate necessity to provide training for various government ministries, agencies and institutions. Even though it might seem an increasing trend of climate change awareness to the public, disseminating message in a local vernacular remains a gap. In the formal sector, there is a need to push for an immediate inclusion of climate change concept in a national curriculum with subjects and content at all levels with the ultimate objectives of improving decision and changing behaviours. The awareness campaign should also be including by companies through different strategies to promote ecological culture and ways of nature sustainability. Climate change awareness campaign should also follow by a perception research to determine changes in behaviours towards climate change actions.

#### 8.3.5. Research and technological transfer

There is need to strengthen the scientific research and improve cooperation and exchange of research findings among all stakeholders. Each sector mandated in climate change action should establish a database and ensure them updating it regularly. This will help in bridging the existing climate change data gap. The policy should also promote and encourage individual scientific researches. This can be done through establishing database portal by which an individual finding can be shared to the authorized institution to check for its accuracy and reliability. The major researches setback in Liberia resulted from lack of analytical skills personnel, modern research equipment, accessing spares for damaged equipment, inadequate funding to support climate change researches and credibility of climate change research findings due to lack of research accredited institutions.

Appropriate technologies are the key commitment to address the climate change impacts. However, Least Developed Countries (LDC) like Liberia is impeded to improve their technology due to the high cost of adopting new technologies. Their proposed technological advancement projects also are restricted to the dependence of foreign investors, lending or international aid. The foreign investors on the other hand delink their investment to the limited market size. Like many African countries, Liberia energy supply sector work in a monopoly environment. This reduces its ability to invest on modern innovations. This creates a need for Liberian government to introduce investment policy that can introduce competitive environment to the energy sector.

#### 8.3.6. Regional and international cooperation

Liberia is already feeling the effects of climate change. Nevertheless, the country has recognized that it can stand alone in combating climate change therefore; it has formed both

regional and international cooperation. **Error! Reference source not found.** is a list of regional and international cooperation.

Table 8-1 List of regional and international cooperation

| Name of cooperation  | Regional | International |
|--|----------|---------------|
| EU-Liberia Climate Change Alliance + CRIS number: ENV/2016/39639 financed under Development Cooperation Instrument   |          | ✓             |
| Climate change / REDD: In September 2014, Liberia and Norway entered into a partnership to improve forest governance, strengthen law enforcement, and support efforts in reducing greenhouse gas emissions from deforestation and forest degradation in Liberia.   |          | ✓             |
| <p>In 2010, GIZ reopened a regional office for Sierra Leone and Liberia in Freetown, the capital of Sierra Leone. GIZ works on behalf of the German Government, the European Union (EU) and other international donors. The GIZ focuses on the following areas:</p> <ul style="list-style-type: none"> <li>• sustainable infrastructure</li> <li>• environment and climate</li> <li>• social development</li> <li>• governance and democracy</li> <li>• natural resource conservation</li> </ul> |          | ✓             |
| Ecowas Centre for Renewable Energy and Energy Efficiency (ECREE)   | ✓        |               |

#### 8.4. Action plans to address gaps and constraints

Liberian Government has since recognized and committed itself on focusing climate change concerns into its development agendas. A number of improvements have been made in its capacity to mitigate and adapt to the extreme impact of climate change. The latest national policy document on climate change, the National Policy and Response Strategy on Climate Change (NPRSCC) focus in ‘building of a firm foundation for mainstreaming climate change actions into all key socio - economic programs in order to bring about an integrated response

across all sectors’ (EPA, 2018). In addition, the government of Liberia through Environmental Protection Agency (EPA) is overseeing many strategic short and medium term actions such as Nationally Appropriate Mitigation Action (NAMA), National Adaptation Plan (NAP), National Adaptation Plan of Action (NAPA), National Climate Change Secretariat (NCCS) and National Disaster Management Agency (NDMA).

The major focus for both long and short term strategies is to move Liberia into a low carbon climate resilient pathway. Also, effective implementation of the strategies will lead to the establishment of climate change policy and law and opening of funding windows that would address issues related to climate Change, the environment and the investment framework.

NPRSCC has identified 3 key elements of the Policy and Strategy on Adaptation and Mitigation (EPA, 2018);

- a) *Adaptation Policy Statements and Strategies*; Focuses on Adaptation to short-term climate variability and extreme events, Adaptation at different levels in society, Adaptation policy and measures assessed in a development context and the adaptation strategy and the stakeholder process.
- b) *Mitigation policy statements and Strategies*; Focuses in ensuring low carbon emission in sectors include forestry and wildlife, agriculture, energy, mining, industry, transport, tourism, and waste management
- c) *Cross-cutting Themes Policy and Strategies*; These are sectors with a strong impact across all other sectors such as communication, education, and awareness, capacity building and training, research and development, technology transfer, gender, HIV and AIDS.

Table 8-2 National strategy documents and measures to mainstream climate change

| Strategy Documents  | Measures to mainstream climate change  |
|---|--|
| <b>National Policy and Response Strategy on Climate Change (NPRSCC), 2018 (EPA, 2018)</b> | The strengthening of national institutions, communities and initiatives so that they have strong capacity for adaptation, disaster risk reduction and mitigation                                     |
| <b>Liberia National Vision 2030 (National Vision, n.d.)</b>                               | Self - sufficient in clean energy through sensible conservation, and through developing the domestic potential for wind, solar energy, and preparing for drawing on the thermal energy of the ocean. |
| <b>Pro-Poor Agenda for Prosperity and Development 2018 to 2023 (PAPD)</b>                 | The Pro-Poor Agenda for Prosperity and Development focuses on strengthening the capacities of the people to thrive and further draws all Liberians into the national development process.            |

|  |   |
|--|---|
| <b>National Action Plan For Disaster Risk Reduction - Liberia 2016 to 2021 (GoL, 2016)</b> | Effectively implement all legal and institutional frameworks and innovative technological approaches to reduce national and local community vulnerabilities and disaster risks within the context of sustainable development.   |
| <b>Land Rights Policy of 2013</b>  | The legal ownership of land will provide security of tenure to land users and holders thus giving those rights to sustainably manage and use their lands.   |
| <b>Climate Change Gender Action Plan (ccGAP), (Aguilar, Rogers, &amp; Bobtoya, 2012)</b>   | Identify possible areas of action/ intervention that could be taken up in an Action Plan on Gender and Climate Change in Liberia  |
| <b>Integrated Water Resources Management Policy (IWRMP 2009)</b>                           | The policy covers two broad areas: water resource management and water resource use. The goals are to ensure: (i) full socio-economic benefits for present and future generations; (ii) access to safe and adequate water for the people; (iii) the availability of quantity and quality of water for the environment and ecology; (iv) the availability of sufficient quantity and quality of water for food security; (v) the availability of water for other uses such as hydropower generation, industry, transportation, recreation. |
| <b>Liberia Agriculture Sector Investment Program (LASIP- 2009)</b>                         | Seeks to transform Liberian agriculture and, in so doing, maximize the sector's contribution to national economic growth, employment and income generation, food and nutrition security, and poverty reduction.   |
| <b>Food and Agriculture Policy and Strategy (FAPS- 2008)</b>                               | The FAPS is developed toward three fundamental orientations: (i) Improving national food and nutrition security; (ii) Enhancing agricultural productivity, competitiveness, and linkages to markets; and (iii) Strengthening human and institutional capacities.  |
| <b>National Energy Policy of Liberia (2007)</b>  | The principal objective of the National Energy Policy is to ensure universal access to modern energy services in an affordable,   |

|   |   |
|---|---|
|   | sustainable and environmentally-friendly manner in order to foster the economic, political, and social development of Liberia.  |
| <b>Liberia National Forestry Policy and Implementation Strategy of 2006</b> | <p>This policy is woven around eight (8) objectives including:</p> <ul style="list-style-type: none"> <li>• to ensure that commercial forestry, community forestry and forest conservation activities are integrated and balanced to optimize the economic, social and environmental benefits from the forest resource;</li> <li>• to conserve a representative sample of forest ecosystems so that important environmental functions are maintained;</li> <li>• to contribute to the national development goals of poverty alleviation and increased food security by increasing the opportunities for forest-based income generating activities;</li> <li>• to grant more equitable access to forest resources so that the potential for future conflict is reduced and the benefits from forestry development are shared throughout Liberian society;</li> <li>• to ensure that all stakeholders participate in the formulation of forestry policies and in the conservation and management of the forest resource;</li> </ul> |
| <b>National Environmental Policy of 2003</b>                                | The aim of the national environmental policy is to ensure the improvement of the physical environment, improvement of the quality of life, and of the people, improvement of the economic and social living conditions of the entire citizenry, and present and future generations.   |



## 8.5. Financial needs and technical support

### 8.5.1. Existing financial assistance and technical support

Liberia is determined to fully compliment to the proposed climate change strategy from UNFCCC and the Kyoto Protocol. It took initiative towards addressing climate change threats through developing its National Adaptation Programme of Action in 2008 followed by its Initial National Communication to the UNFCCC in 2012 and Second National Communication to the UNFCCC in 2021. In 2015, Liberia presented its INDC mitigation and adaptation interventions as a means to support implementations of climate change strategies and measure (GoL, 2015). GEF Projects in Climate Change Mitigation and Adaptation:

Table 8-3 Existing GEF financial support

| Project Title   | Thematic Area                  | Cost                        | Implementing Agency                  | Sources of Funding                            | GEF Period | Status           |
|---|--------------------------------|-----------------------------|--------------------------------------|---|------------|------------------|
| <b>Building and Strengthening Liberia National Capacity to Implement the Transparency Elements of the Paris Climate Agreement</b> | Climate Change                 | \$1,344,495<br>\$1,600,000  | Conservation International           | Capacity-building Initiative for Transparency | GEF - 6    | Project Approved |
| <b>Conservation and Sustainable use of Liberia Coastal Natural Capital</b>  | Land Degradation, Biodiversity | \$3,944,220<br>\$11,194,248 | Conservation International           | GEF Trust Fund                                | GEF - 6    | Project Approved |
| <b>Strengthening National Capacities to Meet Global Environmental Obligations with the Framework of</b>                           |                                | \$1,500,000<br>\$1,500,000  | United Nations Development Programme | GEF Trust Fund                                | GEF - 6    | Project Approved |

| <b>Sustainable Development Priorities</b>  |                               |                             |  |                                |         |                  |
|--|-------------------------------|-----------------------------|--|--------------------------------|---------|------------------|
| <b>Increasing Energy Access through the Promotion of Energy Efficient Appliances in Liberia</b>  | Climate Change                | \$2,639,726<br>\$40,100,000 | African Development Bank                           | GEF Trust Fund                 | GEF - 6 | Project Approved |
| <b>Enhancing Resilience Of Liberia Montserrado County Vulnerable Coastal Areas To Climate Change Risks</b>   | Climate Change                | \$2,000,000<br>\$2,163,540  | United Nations Development Programme               | Least Developed Countries Fund | GEF - 6 | Project Approved |
| <b>Improve Sustainability of Mangrove Forests and Coastal Mangrove Areas in Liberia through Protection, Planning and Livelihood Creation- as a Building Block Towards Liberia's Marine and Coastal Protected Areas</b> | Biodiversity                  | \$963,994<br>\$3,650,000    | Conservation International                         | GEF Trust Fund                 | GEF - 5 | Project Approved |
| <b>Enabling Activities to Review and Update the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (POPs)</b>  | Persistent Organic Pollutants | \$160,000<br>\$235,000      | United Nations Industrial Development Organization | GEF Trust Fund                 | GEF - 5 | Completed        |
| <b>Strengthening Liberia Capability to Provide Climate Information and Services to Enhance Climate Resilient Development</b>   | Climate Change                | \$6,730,000<br>\$11,859,700 | United Nations Development Programme               | Least Developed Countries Fund | GEF - 5 | Project Approved |

|  |                |                            |  |                                |         |                  |
|--|----------------|----------------------------|--|--------------------------------|---------|------------------|
| <b>and Adaptation to Climate Change</b>  |                |                            |  |                                |         |                  |
| <b>GEF National Portfolio Formulation Document</b>   |                | \$0 \$0                    | GEF Secretariat                                    | GEF Trust Fund                 | GEF - 5 | Project Approved |
| <b>Lighting One Million Lives in Liberia</b>   | Climate Change | \$1,454,540<br>\$4,050,000 | The World Bank                                     | GEF Trust Fund                 | GEF - 5 | Completed        |
| <b>Enhancing Resilience to Climate Change by Mainstreaming Adaption Concerns into Agricultural Sector Development in Liberia</b> | Climate Change | \$2,381,400<br>\$6,345,122 | United Nations Development Programme               | Least Developed Countries Fund | GEF - 4 | Project Approved |
| <b>SPWA-CC: Installation of multi purpose mini-hydro infrastructure (for energy &amp; irrigation )</b>                           | Climate Change | \$1,758,182<br>\$4,054,152 | United Nations Industrial Development Organization | GEF Trust Fund                 | GEF - 4 | Project Approved |
| <b>Enhancing Resilience of Vulnerable Coastal Areas to Climate Change Risks</b>  | Climate Change | \$4,900,000<br>\$4,653,420 | United Nations Development Programme               | Least Developed Countries Fund | GEF - 4 | Project Approved |
| <b>SPWA-BD: Biodiversity Conservation through Expanding the Protected Area Network in Liberia (EXPAN)</b>                        | Biodiversity   | \$950,000<br>\$9,288,000   | The World Bank                                     | GEF Trust Fund                 | GEF - 4 | Completed        |
| <b>Capacity Needs Assessment for the Implementation of Liberia's National</b>  | Biodiversity   | \$194,000<br>\$19,000      | United Nations Development                         | GEF Trust Fund                 | GEF - 4 | Project Approved |

|  |                               |                          |  |                                |         |                  |
|--|-------------------------------|--------------------------|--|--------------------------------|---------|------------------|
| <b>Biodiversity Strategy and Action Plan and Country Driven CHM Support</b>  |                               |                          | nt Programme                                       |                                |         |                  |
| <b>Consolidation of Liberia's Protected Area Network</b>   | Biodiversity                  | \$750,000<br>\$6,630,000 | The World Bank                                     | GEF Trust Fund                 | GEF - 4 | Completed        |
| <b>BS: Support the Implementation of the National Biosafety Framework of Liberia</b>   | Biodiversity                  | \$577,679<br>\$530,000   | United Nations Environment Programme               | GEF Trust Fund                 | GEF - 4 | Project Approved |
| <b>Preparation of a National Adaptation Plan of Action (NAPA)</b>  | Climate Change                | \$200,000<br>\$0         | United Nations Environment Programme               | Least Developed Countries Fund | GEF - 3 | Completed        |
| <b>Enabling activities to facilitate early action on the implementation of the Stockholm Convention on Persistent Organic Pollutants (POPs) in Liberia</b> | Persistent Organic Pollutants | \$372,000<br>\$0         | United Nations Industrial Development Organization | GEF Trust Fund                 | GEF - 3 | Completed        |
| <b>National Capacity Self-Assessment (NCSA) for Global Environmental Management</b>  |                               | \$190,000<br>\$0         | United Nations Environment Programme               | GEF Trust Fund                 | GEF - 3 | Completed        |
| <b>Liberia's National Biodiversity Strategy and Action Plan, and Country Report to the COP</b>   | Biodiversity                  | \$256,000<br>\$0         | United Nations Development Programme               | GEF Trust Fund                 | GEF - 2 | Completed        |

|   |                |                        |                                      |                |         |                   |
|---|----------------|------------------------|--------------------------------------|----------------|---------|-------------------|
| <b>Establishing the Basis for Biodiversity Conservation on Sapo National Park and in South-East Liberia</b> | Biodiversity   | \$975,000<br>\$0       | The World Bank                       | GEF Trust Fund | GEF - 3 | Completed         |
| <b>Enabling Activities for the Preparation of Initial National Communication Related to the UNFCCC</b>      | Climate Change | \$275,000<br>\$100,000 | United Nations Environment Programme | GEF Trust Fund | GEF - 2 | Project Completed |

### 8.5.2. Financial needs

Adequate funding is a key need to support the implementations of priority adaptations and mitigation strategies, capacity building and institutional arrangements. As we stated earlier, Liberia's climate change implementation needs depending on sourced funding from international organizations and funds. INDC represented a number of proposed climate change mitigation and adaptation measures which cannot be implemented as a result of financial need. Some of these projects include;

- Promotes private investments in renewable energy (hydro, biomass, solar, etc.)
- Achieving 20% energy efficiency by firewood cook stove distribution
- Biomass project to generate about 30 MW by 2030
- Developing technical and safety standards and the enforcement of policies including emission control
- 5% of Palm oil biodiesel with both gasoline and diesel by 2030 for vehicles
- Implementing and Strengthen policy that promotes private investment In waste management
- Develop and promote drought - resistance, flood - tolerant and early maturing crop species
- Establishment of gene bank of climate resilient varieties of indigenous food crops
- Pest control including fencing of farms against rodent regular weeding and the use of high echoing bells
- Intercropping irrigation and the optimization of lowland/swamp farming
- Develop and implement climate smart fishery system to enhance the adaptive capacity and resilience of fisher communities
- Identification and conservation of endangered species
- Strengthen institutional and local capacity and monitoring system for fishery management
- Strengthen of transmission and distribution infrastructure for public utilities to ensure climate resilience

- Protection of water catchments around hydro – power sources such as St. Paul River Basin
- Develop early warning system for climate – driven infectious disease
- Strengthen integrated disease surveillance response system and emergency preparedness to prevent, mitigate, and respond epidemics.

## **9. Networking, Knowledge and Information Sharing**

### **9.1. Introduction**

Sub-Saharan Africa (where Liberia is located) faces more extreme climate variability than other regions of the world (Tatlock, 2006). Climate change effects are disproportionately impacting the continent through, for example, changing rainfall patterns, floods, droughts, rising sea levels, coastal erosion and etc. These events have severely affected local and vulnerable communities, their economic activities and as well as their livelihoods (Cohn et al., 2017).

Hence, the Republic of Liberia being located in Sub-Saharan Africa is not exempted from the above mentioned climate change impacts. Currently, Liberia is faced with climate change vulnerability and risks; and these current observed impacts of climate change in the country have negative results as they impose significant challenges on the sustainability of the country's social-economic and environmental assets.

Moreover, the diversity of stakeholders involved in adaptation processes (from policymakers to CSOs, researchers and local communities), the insufficient governance-related skills and the wide-spread institutional fragmentation present substantial obstacles among institutions to effectively coordinate and cooperate as it relates to climate change knowledge and information sharing. These challenges are furthermore noted by the lack of effective synergies between policy, research, private sector and the civil society in climate change relevant knowledge and technologies transfer.

As knowledge sharing is relatively limited among climate change actors, it is highly recommended that fruitful interactions among these relevant stakeholders are of central importance when trying to generate, increase and exchange climate change knowledge, innovation and information. Therefore, to increase the resilience of climate change vulnerable communities and sectors in Liberia, the need to ensure that they have access to information and knowledge on appropriate adaptive practices is significantly important.

### **9.2. Knowledge sharing and climate change in Liberia**

As climate change has become a major threat to Liberia's social-economic and environmental sustainability, Liberia has taken some initiatives to address the limited knowledge and information sharing among climate change actors and also the inadequate coordination among institutions. With many local communities already affected and struggling to adapt or cope with climate change impacts; the measures taken by the government of Liberia and its partners aim to increase the resilience of these vulnerable communities by ensuring that they have access to information on appropriate adaptive practices and knowledge sharing.

In so doing, the government of Liberia has along with its partners developed national networks, platforms, programs and groups that are exclusively dedicated to sharing climate change national adaptation/ mitigation knowledge and information. Some of these networks are listed and discussed below.

#### 9.2.1. Climate Change Knowledge Sharing Platform of Liberia (CCKSP)

The government of Liberia and its climate partners has established a national Climate Change Knowledge Sharing Platform (CCKSP, <http://ccksp.gnf.tf>). The design of the website was completed in December of 2019 and funded under the United Nations Development Programme (UNDP) through the Green Climate Funds (GCF). The platform uses a technology powered by the Drupal and DKAN projects. The CCKSP has been designed and produced by a French group called RESALLIENCE.

Through the CCKSP, the Liberia government aims at facilitating the expansion of knowledge and the building of capacities. The website serves as an online hub for sharing knowledge among researchers, policy makers, and NGOs in particular. It features adaptation and mitigation projects and hosts climate documents, discussions. As such, the objectives of the CCKSP are the following:

- Creating knowledge repository and enhancing knowledge environment;
- Improving knowledge access and transfer;
- Managing knowledge as an asset;
- Strengthening the Research & Development capacity within climate change field in Liberia;
- Mainstreaming climate change concerns in the policies and programs.

#### 9.2.2. Environmental Knowledge Management System (EKMS)

The EKMS was funded by the Global Environmental Facility (GEF), through the United Nations Development Programme (UNDP). The Environmental Knowledge Management System (EKMS) is a web-based platform which provides free and open access to information from key government and partner institutions relating to the implementation of Rio Conventions in Liberia. The EKMS is created to bridge the knowledge management gaps between the Environmental Protection Agency (EPA) and Partner governmental institutions as well as non-governmental organizations that have direct linkages with environmental policies and development. According to the EPA, the system is developed on a dedicated web-server using Word-Press, a popular and user-friendly open-source Content Management System.

In an effort to bridge knowledge management gaps as climate change information and knowledge sharing become more and more important and demanding, the EKMS was created to strengthen institutional coordination between the Environmental Protection Agency (EPA) and Partner governmental institutions as well as non-governmental organizations that have



direct linkages with environmental policies and development. According to the EPA, it was also created to increase access and dissemination of key information and promote adequate public awareness and education. The EKMS was created to serve as a repository for all natural resource management institutions, data, information, and knowledge.

In so doing, it is indeed important to note that the EKMS is an output of the Cross-Cutting Capacity Development project (CCCD). A project funded by the GEF and implemented by the EPA in partnership with the UNDP in collaboration with Natural Resources Management Agencies of Liberia. The project is in line with GEF-6 CCCD Strategy objective 1, 3, and 5 which call for countries to:

- Integrate global environmental needs into management information systems and monitoring;
- Integrate MEA provisions into national policy, legislative, and regulatory frameworks; and
- Update NCSAs

This project is part of a portfolio of capacity building interventions in Liberia that encourages regional cooperation and knowledge and information exchanges. Partnerships and collaboration will also catalyze the transfer of knowledge and competencies among actors and stakeholders. As such, some long term benefits of this platform include but not limited to the following:

- It eases data retrieval;
- It enhances decision making and collaboration;
- It improves institutional agility;
- It provides quicker problem-solving;
- It supports employee growth and development of line ministries and agencies;
- It enhances planning, policy, and legislation;
- It improves research capabilities for students, teachers, planners, and policy makers.

### 9.2.3. Environmental Studies Master's Degree Programs at the University of Liberia (UL)

Based on the current and future threats of climate change to national development, the Government of Liberia has been undertaking initiatives aimed at addressing the impacts of climate change. In 2008 Liberia developed its National Adaptation Program of Action (NAPA) to combat climate change and environmental issues in the country. The NAPA was further structured to the National Adaptation Plan (NAP) with its function to identify Liberia's medium-term adaptation needs. Part of the NAP function was to train Liberians and Line Ministries or Institutions to engage in environmental sustainability and climate change activities since these sectors have capacity gaps.

Relative to the NAP's 2015 preliminary project and to help Liberians and land ministry or institution meet this critical need, the project title: Advance the NAPs process for medium-term investment planning in climate-sensitive sectors (i.e. agriculture, energy, waste Management, forestry, and health) and coastal areas in Liberia was implemented. The medium-term planning identified the University of Liberia as the academic and research arm for the program. In this light, part of the University of Liberia's function is to establish graduate and undergraduate programs in Environmental Studies & Climate Change. In so doing, the University of Liberia, supported by the National Adaptation Plans (NAPs) project at the United Nations Development Program (UNDP) established a Master Degree Program in Environmental Studies, including Climate Change.

The establishment of this master degree program is a major achievement to Liberia due to the lack of adequate climate change experts in the country. The approved master curriculum provides an integrated design of courses to prepare students to address the social and biophysical complexities of environmental problems facing Liberia and as well as to supply the expertise required to support sustainable development in the country. The Environmental Studies curriculum is designed to offer two types of degrees, Master of Arts (M.A.) and Master of Science (M.Sc.) in various disciplines in environmental studies. The MSc or MA stresses the importance of understanding the interrelationships between the humanities, social sciences, climate change, and natural science Engineering, Agriculture, and Forestry disciplines.

a) The program

The Environmental Studies Master's Programs are categorized into three degree-granting programs that were tailored to the Environmental Issues of Liberia. Some of the issues that are impacting the environment of Liberia include and not limited to: coastal erosion, mining pollution, biodiversity loss, waste management, land use, climate change, wetlands, wastewater treatment, environmental social impact assessment, environmental laws & policy, remote sensing, environmental economics, disaster risks management, amongst other.

The degree-granting programs are:

- Master of Science Degree in Climate Change & Biodiversity
- Master of Arts in Environmental Management
- Master of Science Degree in Environmental Science

b) Strategic goals of the program:

- Provide students with demand-driven education, research and other approaches that meet Liberia's National Adaptation Plan and EPA development priorities and provide hands-on training and skills development.
- Develop human capital that is to transform the country by providing the necessities as environmental management and environmental protection services that result in the reduction climate change problems

- Prioritize environmental education to address issues in climate change, global warming, Liberia Ecosystem, Coastal Zone and, environmental sustainability, science education, vulnerable population
- Foster leadership skills in environmental management and protection, critical thinking skills, and environmental issue information literacy, while facilitating students’ personal and professional development for lifelong learning
- Students will have the opportunity to earn either an M.A. in Environmental Management & or MSc. in Climate Change & Biodiversity and Environmental Science.

c) Objectives of the program

- To prepare graduates for professional careers or to continue their education in Ph.D. programs.
- To ensure that graduates are proficient and competent in all core competencies of at least one of the following concentrations: Climate Change & Biodiversity, Environmental Management, and Environmental Science.
- To produce graduates who will pursue life-long learning and professional development.

The overall goal of the program is to establish outstanding environmental Studies that will contribute significantly to Liberia’s Environmental Protection Agency’s program and to solve environmental issues in Liberia and its surroundings.

9.2.4. Other climate change knowledge and information sharing groups, networks/programs

Presented in table 9-1 below is a summary of some other climate change knowledge and information sharing groups or networks founded by youth groups, CSOs and local communities that are also dedicated in disseminating climate knowledge and information to those climate change affected, vulnerable and at-risk population. The initiatives taken by these groups highly complement the efforts of the national government on the networking and climate information sharing.

Table 9-1 Climate change networks and their objectives and activities

| Climate groups/<br>networks |  | Objectives and activities   |
|-----------------------------|--|---|
| 1                           | Talk the Environment (Environmental awareness radio program) | <i>Talk the Environment is an every Saturday radio program produced by the Environmental Protection Agency of Liberia (EPA), about 2 years ago. Its objective is to create and promote awareness of national environmental issues. This program has been successful in disseminating and giving opportunities to the local communities to directly engage climate change experts, technicians, and key stakeholders on issues</i> |

|   |  |  |
|---|--|--|
|   |  | <i>concerning their wellbeing in finding adaptation or mitigation measures.</i>  |
| 2 | Knowing Your Environment (KYE)               | <i>Knowing Your Environment (KYE); the KYE was established in 2015 by the planning and policy department of the Environmental Protection Agency of Liberia (EPA). It is an environmental knowledge and information sharing program aims at promoting climate change knowledge sharing amount the staffs of the EPA to adequately enable them to efficiently diffuse climate change knowledge in vulnerable communities. The KYE program activities are designed to directly engage an affected or vulnerable community “face-to-face” once a week (every Wednesday) to disseminate and educate climate residents about some important environmental regulations, adaptation / mitigation measures. It also creates the medium to build synergies which enable environmental experts to share climate change knowledge in addressing specific problems affecting the environment.</i> |
| 3 | Inter-sectoral awareness campaign of the EPA | <i>The inter-sectoral awareness campaign is the EPA’s motherly climate change environmental awareness and knowledge sharing program. The sole purpose of this program is to educate the Liberian population on issue confronting the environment. Key objective of the program is to also educate and provide the required tools and methodologies to enable students, youth and local community groups champion environmental issues. The program has been successful in reaching out to more than 60 schools and 20 vulnerable communities in Monrovia and its environs.</i>   |
| 4 | Climate Saturday                             | <i>The climate Saturday is run by the Action for Climate Empowerment focal point of the EPA. The aim of this program is to buttress national efforts aim at promoting initiatives to enhance action to combat climate change at the national level by taking discussions that borders on climate change to local community dwellers in local languages. This is a monthly exercise which has been successful in Montserrado county, Margibi Country, Bomi, Grand Bassa County, Rivercess County, Bong County, Cape Mount County and Nimba County.</i>  |

|  |  |
|--|--|
|  | <p><i>The Climate Saturday program has helped many local community dwellers to have a behavioral change in the way they take care of the environment. The Climate Saturday has also given birth to “CLIMATE BEAT”, which is a platform that is used to expand the public outreach through the production of video skits for YOUTUBE channel, television and other social media forums.</i></p> |
|--|--|

#### 9.2.5. Climate change networks

The impacts of climate change in Liberia have become issues of national concern in regards to the limited or inadequate climate change adaptation / mitigation information and knowledge sharing among affected or vulnerable communities. In an effort to address these concerns, the republic of Liberia and her partners have taken many initiatives to nationally improve, promote and facilitate climate change adaptation and mitigation networking, knowledge and information sharing in vulnerable areas through many mediums.

However, there are some challenges that are serving as hindrances to the efforts of the government in promoting climate change knowledge and information sharing in areas of national concern. The observed challenges to said efforts are, but not limited to the following:

- a) Limited technical experts in climate changes related professions to facilitate networking and knowledge sharing;
- b) Insufficient or limited financial support to facilitate and disseminate climate change adaptation / mitigation information and knowledge in vulnerable local communities;
- c) Inadequate institutional or organizational collaboration to mainstream and share climate change information;
- d) Limited capacity to facilitate climate change networking and knowledge sharing in terms of infrastructures, platforms and higher learning institutions (universities/ collages).
- e) Limited sustainable manage of the already existing climate change information and knowledge sharing platforms, networks, youth or local community groups and programs.

#### 9.2.6. Measures identified to address climate networking, knowledge and information sharing barriers in Liberia.

In order to address the above identified national barriers to climate change networking, knowledge and information sharing in Liberia, the following measure are recommended to directly and adequately improve the existing efforts of the government and as well address the concerns thereof.

- a) To address the barrier of limited technical experts, it is indeed recommended to conduct / provide an intensive capacity building in respect to hands-on training, university studies, workshops, scholarships in climate change adaptation and mitigation related fields so as to increase national climate experts.
- b) To overcome the concerns of limited or insufficient financial support, it is highly recommend that agencies and ministries involved with the management of climate change related issues allocate budgets when preparing their yearly budgets to support climate networking, knowledge and information sharing.
- c) To address the inadequate institutional or organizational collaboration among national climate change stakeholders, it is important to improve institutional and organizational coordination by organizing technical working sessions, workshops to enable them mainstream and share climate change information;
- d) To address the limited infrastructural capacity to facilitate climate change networking, knowledge and information sharing, it is recommended to encourage the establishment of more adequate climate data, knowledge and information sharing networks or platforms. This could be done by providing physical (materials, tools, equipment, etc.), financial and institutional supports.

To overcome the limited sustainable manage of the already existing climate change information and knowledge sharing platforms and networks, it is important to support and facilitate the development of a long-term and medium-term sustainable management plans for these groups.

### **9.3. Conclusion**

As Climate change has become a major threat to Liberia's social-economic and environmental sustainability, Liberia has taken some initiatives to address the limited knowledge and information sharing among climate change actors and also the inadequate coordination/ collaboration among institutions. With many local communities already affected and struggling to adapt or cope with climate change impacts; the measures taken by the government of Liberia and its partners aim to increase the resilience of these vulnerable communities by ensuring that they have access to information on appropriate adaptive practices and knowledge sharing.

In so doing, the success and sustainability of the developed national networks, platforms, programs and groups that are exclusively dedicated to sharing climate change national adaptation/ mitigation knowledge and information can only be achieved if the related identified barriers and their recommended measures are taken into consideration.

# 10. Capacity Building

## 10.1. Introduction

At the 1995 Conference of Parties (COP) in Berlin, Decision 1/CP.1, known as the Berlin Mandate, launched the process of strengthening the commitments of the Annex I Parties to Article 4.2(a) and (b) of the UNFCCC, which led to the development of the Kyoto Protocol. Article 10(e) of the Protocol encourages all parties to cooperate in and promote the development and implementation of education and training programs, including the strengthening of national capacity building, in particular for developing countries, and to facilitate public access to information on climate change. At the 2001 COP in Morocco, Decision 2/CP.7, part of what is known as the Marrakesh Accords, adopted the Capacity Building Framework (CBF) for developing countries and decided that this framework should guide capacity building activities related to the implementation of the convention and effective participation in the Kyoto Protocol process. The objective of the CBF in developing countries is to build, develop, strengthen, enhance, and improve their capabilities to achieve the objectives of the convention and its Kyoto Protocol. The scope of needs and areas for capacity building in developing countries included institutional capacity building, enhancement and/or creation of enabling environments to implement the convention, research and systematic observation, including meteorological, hydrological and climatological services; development and transfer of technology, education, training, and public awareness; and information and networking, including the establishment of databases. Under CBF, it is the prerogative of developing countries to identify their specific needs, options, and priorities for capacity building on a country-driven basis; to promote the coordination and sustainability of activities undertaken within this framework, and to facilitate the dissemination and sharing of information on capacity-building activities conducted by them. To effectively implement the CBF, the developing countries should be supported through bilateral and multilateral efforts using the Special Climate Change Fund (SCCF), Adaptation Fund (AF), and bilateral and multilateral financial sources.

The Republic of Liberia, through the Environment Protection Agency (EPA) as the National Climate Focal Agency, has coordinated the building of capacities at the national, regional, and international levels through facilitating the participation of experts in climate change projects embedded with capacity-building components, in climate change enabling activities such as the development of National Capacity Self-Assessment (NCSA), National Adaptation Program of Action (NAPA), the National Adaptation Plans (NAPs) and the National Communication (NATCOM) process, in the negotiation process, and also through technical support and special programs for Least Developed Countries (LDCs) under the UNFCCC processes.

## 10.2. Assessment of Existing Capacity

The EPA has coordinated and collaborated with national experts and international consultants to develop the NAPA under the LDC Program of the UNFCCC as well as begin the implementation of the National Adaptation Plans (NAPs). In the preparation of the Second National Communication (SNC) of Liberia to the UNFCCC, the capacities of national experts have been developed in the assessment of GHG emissions, or regional-specific emission factors with the ultimate objective of reducing uncertainties in the national inventory statistics. For a comprehensive undertaking and involvement in the mitigation of greenhouse gases and adaptation to climate change, the capacity of the members of the national team needs to be enhanced through continuous training, especially on the economic assessment of mitigation and adaptation measures and project development. Members of the national team have limited expertise in influencing the source codes of biophysical models to fine-tune them to the Liberian environment. For a comprehensive vulnerability assessment, the technical capacities and skills of experts need to be developed and enhanced beyond those acquired through workshops. The experts need to be trained on modelling at institutions of higher learning through fellowships and/or internships. Already appropriate curricula and degree programs, both graduate and undergraduate programmes in Environmental Science, Climate Change and Biodiversity is being institutionalized at the University of Liberia and two other tertiary institutions (Cuttington University and Stella Maris Polytechnic to enable development of a critical mass of experts on climate change. Institutional reforms are necessary. Currently, coordination on climate change related activities seems to be improved. This makes the coordinating role of the EPA better improved. The development of relevant policies and the connection of said policies to climate change in order to and influence decision making processes is much more improved at this stage but there is an urgent need of understanding and prioritizing climate change in Liberia. It is necessary to realign current practices, programs, and policies to take into account climate variability and climate change. Hence, one of the key areas of research is to initiate a process that will re-orient most of the present policies, particularly those related to finance and natural resources management, in the direction of sustainable economic and environmental development and management. This will also lead to mainstreaming climate change into the national development agenda of Liberia.

### **Systematic Observation**

The Liberian National Meteorological Service (NMS) is gradually being improved in the country though a lot of efforts need to be exerted to get it very functional. Major equipment and installations were destroyed. It is unreliable, unsafe, and a security breach for meteorological products generated from other sovereign states to be used in Liberia, but this appears to be the case, especially in the aviation and maritime transport sectors. Hence, the following institutional and human capacity-building priority activities need to be implemented in Liberia:



- Upgrading of Liberia’s meteorological equipment to digital equipment to minimize human interaction and also to provide continuous recording of meteorological, hydrological, and climatological elements and phenomena;
- Rehabilitation and expansion of the existing station networks for more representative monitoring of weather, climate, and other aspects of the environment;
- Provision of better and bigger capacity for data processing and storage and for the upgrading, networking, and interconnectivity of the data base systems of the NMS and other collaborating national and regional institutions;
- Rebuilding and strengthening the human resources and capacity of the institutions involved in collecting, processing, and maintaining data and information related to meteorology, hydrology, and climatology.

### **Technology Development and Transfer**

In Chapters 3 and 4 of this Second National Communication (SNC), mitigation and adaptation measures have been determined as the means to implement the Climate Change Convention in Liberia. In Chapter 5 appropriate technologies to support the implementation of these measures have been determined and discussed. These include solar usage, clean cook stoves, and efficient and clean energy, of which Liberia is aware and receptive because of the opportunities these technologies represent for the sustainable development of the country. It is most urgent that the capacities of institutions and their personnel are built and strengthened for the sustainable uptake of these technologies.

### **Information and Networking, Including the Establishment of Databases**

Climate change management is a science- and technology-intensive process requiring a considerable body of scientific information and technologies. In Chapter 9 appropriate networking and information sharing avenues, tools, and technologies have been identified and discussed. The ability of the Environmental Protection Agency of Liberia and collaborating stakeholder institutions and agencies to effectively implement the Climate Change Convention and its Kyoto Protocol depends on the nature and level of scientific and technical capacity that they acquire and utilize. This level of scientific and technical capacity is limited in Liberia, and its elevation to an appreciable level depends very much on cooperation and collaboration with regional and assessment of mitigation measures, vulnerability and adaptation assessment, and the technology and capacity needs assessment. The implementation of these programs and studies has enabled Liberia to acquire some level of institutional and human capacity on climate change.

## **10.3.Capacity Needs for future Implementation of the Climate Change Convention**

### **10.3.1. Enhancement and/or creation of an enabling environment**

As the science and politics of climate change progress, the mandate of the EPA and national experts broadens and becomes more challenging in its scientific and technical capacity needs.

For effective implementation of the Climate Change Convention and its Protocol, it will be necessary for Liberia to enhance, as appropriate, the enabling environment for capacity building through:

- Reviewing and strengthening the appropriate policy, regulatory, and institutional frameworks to identify and remove barriers to capacity building and create supportive backup for enactment and implementation;
- Strengthening the technical and human resources capacity of the Environmental Protection Agency of Liberia and collaborating stakeholder institutions to implement the UNFCCC effectively and efficiently.
- Strengthening existing and, where needed, establishing i) Systematic observation and monitoring networks (sea level rise, meteorological and hydrological monitoring networks, land degradation, floods, and droughts) ii) Strengthening institutions for the provision of research, training, education, and scientific and technical support in specialized fields relevant to climate change, and utilizing information technology as much as possible and iii) Research programs on climate variability and climate change oriented towards improving knowledge of the climate system and scientific capability
- Supporting education and training in and public awareness of climate change related issues.

#### 10.3.2. Institutional capacity building, including strengthening the EPA

Cross-sectoral measures such as public awareness and education, research, technology development and transfer, and capacity building are vital in addressing climate change issues of any nation or region. These measures are required to ensure a coherent approach to implementing the adaptation and mitigation actions and strategies contained in this NC, NDC, NAPA, and the National Climate Change Policy and Response Strategy. The EPA Outreach Unit and the National Focal Point, Action for Climate Empowerment (ACE) have and continue to undertake outreach activities, which include public meetings to solicit support and collaboration, educational campaigns, and media events. However, the Outreach Unit and the EPA and the Action for Climate Empowerment initiative have funding challenges. It is necessary for the EPA to be adequately resourced. The EPA should be facilitated through support for a National Multi-Donor Trust Fund (MDTF) for mobilization of the domestic and international financial resources necessary to meet the cost of implementation of multilateral environmental agreements (MEAs) including climate change. It is a high priority to strengthen the capacity of the EPA to participate effectively in the implementation of the convention and its Kyoto Protocol process.

This will involve:

- The implementation of a comprehensive Climate Change Action Plan (CCAP) and integrated strategy that takes into account the capacity building needs, particularly in research and training, of the institutions participating in climate change activities;

- The development of education and training programs, specialized skills and expertise, and scientific institutions with the necessary equipment and scientific information;
- Enhancement of public awareness at all levels with the ultimate objective of improving decision and policy making through re-orientation and development of appropriate policies.

### 10.3.3. Institutional strengthening for research and systematic observations

The team of national experts of Liberia is need capacity building strengthening in the development of sectoral and national GHG inventories, vulnerability analysis, economic analysis of mitigation and adaptation measures, and project development. In developing the inventory of national GHG emissions, the members of the team of experts will be effectively capacitated in the use of the 2006 IPCC Guidelines. Extensive training of the team will be necessary for the development of the next round of inventories in the third National Communication. The team of experts should be capacitated and involved in the development of national and global scientific and technical institutions and networks. Science networks exist at the regional and global levels that can play important roles in the development of the scientific and technical capacities of Liberia. These roles include mobilization and provision of scientific and technical skills and information, and training of Liberian scientists in specific aspects of climate change. Another role that some of the science networks could play in the development of national scientific and technical capacity relates to the procurement of relevant equipment and technologies such as specialized computer hardware, software, and models. These would be particularly useful in the development of databases, websites, and electronic communications systems at the EPA for data and information acquisition and exchange and the development and sharing of media and outreach materials. Included in this category of networking and information sharing is the ability of members of the team of experts and staff of the EPA to participate in on-line training programs, webinars of the UNFCCC and other networks.

## 10.4. Technical, Technological and Financial Requirements for Capacity Building

Implementation of the Climate Change Convention and its Kyoto Protocol at the national level in Liberia is technically, technologically, and financially expensive. However, it is also agreed that lack of action is irreversibly more expensive. Through the identification of mitigation and adaptation activities and the development of project cost profiles, the national experts and consultants involved in the development of this SNC of Liberia have estimated that the technical, technological, and financial requirements for addressing climate change in the country, especially for the required capacity building efforts needs to be heavily invested into.

# 11. Conclusions and Recommendations

## 11.1. Conclusion

A good climate is important as it satisfactorily affects nearly every aspect of human lives. Generally, climate has a huge effect on people's livelihoods, health and future. But our climate is changing due to anthropological actions and these changes are already having a big impact on our lives and our biodiversity.

The effects of climate change have caused humans and biodiversity to face new challenges for survival. More frequent and intense storms, heat waves, rising sea levels, melting glaciers and warming oceans directly harm humans and other life forms on earth, destroy the places they live, and wreak havoc on people's livelihoods and habitats.

A lot of research work is required to generate data for intervention in the above circumstances and to put early warning system in place. However, as mentioned in the Second National Communication (SNC), there is lack of adequate support for research in government institutions in Liberia for roughly three decades, a situation resulting to lack of systematic updates of information on the energy sectors, poor institutional capacity and loss of historical data due to destruction of important records, and inconsistency of data obtained from government institutions.

The SNC mentions that high reliance on climate-sensitive activities renders Liberia vulnerability to climate variability and change. The key climate impacts .., among others, in Liberia: the SNC suggests are:

- Increased in crop loss and / or crop failure as a result of extreme weather events; such events can lead to increased pests, weeds, and likelihood of widespread pathogen outbreak.
- Rising temperature in the climate which leads to reduction in underground water level and diminishing water quality. Rise in temperature in Liberia can lead to shifts in distribution of aquatic fauna species, loss of biodiversity and negative impacts on people's livelihoods. The occurrence of coastal zone flooding often leads to erosion of the coastline, damage to houses and infrastructure, and poor sanitation of land and aquifers.

More research is required to obtain reliable/quality data for planning and policy purposes. Unfortunately, the SNC mentions that support for research in government institutions have been inadequate over the past few decades, and there is a lack of systematic updates of information in the IPPU sector.

The SNC also touches on national mitigation measures. We humans can't stop climate change but can reduce the amount of GHG emissions being released due to anthropological activities around the world. To reduce the risk climate change poses on the vulnerable population, the TNA process involving major stakeholders in key sectors in Liberia prioritized three adaption and mitigation technology areas through stakeholders' Multi-Criteria Analysis workshops. It

further created the opportunity for each sector to prioritize technologies deemed necessary to address the effect climate change poses in their respective sectors.

Moreover, the SNC mentions that many policy documents have been crafted that could be used as instruments in the fight to reduce the risks climate change is posing on the livelihoods of the Liberian population and some projects with funding from government and international organization have been implemented to address this growing problem.

In the case of waste, the SNC emphasizes the challenges facing the waste management sector in Liberia as being immense. With increasing population growth, changing consumption patterns and economic growth, it is likely that waste generation will continue to increase. Government, having recognized this, has made waste management one of its reconstruction priorities. Some of the key policy responses required as indicated by the SNC include:

- A clear definition of the roles and responsibilities of the principle agencies involved in waste management and sanitation. Their activities should be coordinated so as to avoid overlapping and duplication of functions.
- Specific policies relating to waste management are either non-existent or inadequate. In adherence to the 1973 Municipal Act of Liberia, all policies and legislative provisions on waste management should be reviewed and revised, where possible..
- It should be mandatory for all facilities that produce a lot of wastes, such as factories and hospitals, install and operate incinerators for burning their combustive waste fractions.
- The official waste disposal site in Fiamah and filled and should be abandoned. A new dumpsite should be gazetted in an appropriate location.
- There is need for thorough environmental and public health impact study of solid waste and sewage on the environment.
- A well-coordinated public awareness and education on waste management and sanitation must be organized, backed by intensive capacity building initiatives.
- An integrated waste management strategy for Liberia should be developed.
- Waste management-related laws and regulations should be formulated and existing laws and regulations updated to meet the demand of present realities.
- Guidelines for disposal of wastes from villages and rural communities should be developed.

Regarding knowledge and information sharing on climate change, the SNC mentions that:

As climate change has become a major threat to Liberia's social-economic and developmental sustainability, Liberia has taken some initiatives to address the limited knowledge and information sharing among climate change actors and also the inadequate coordination among institutions. With many local communities already affected and struggling to adapt or cope with climate change impacts the measures taken by the government of Liberia and its partners aim to increase the resilience of these vulnerable communities by ensuring that they have access to information on appropriate adaptive practices and knowledge sharing. They have developed national networks, platforms, programs and groups exclusively dedicated to sharing climate change national adaptation and mitigation knowledge and information including climate change knowledge sharing platforms (CCKSP), environmental knowledge management system (EKMS), environmental studies master degree program at the University

of Liberia as well as other climate change knowledge and information sharing groups, networks/programs.

Capacity issues are lengthily discussed in the SNC. The 14-year civil war in Liberia contributed greatly to capacity gap in Liberia. To a minimum extent, the outbreak of Ebola also made some contribution in that direction. The government of Liberia, through the EPA, has coordinated the building of capacities at the national, regional and international levels through facilitating the participation of experts in climate change projects embedded with capacity building components in climate change enabling activities such as the development of National Capacity Self-Assessment (NCSA), National Adaptation Program of Action (NAPA), the National Adaptation Plans (NAPs) and the National Communication (NACOM) process, in the negotiation process, and also through technical support and special programs for Least Developed Countries (LDCs) under the UNFCCC processes.

Despite progress, Liberia's recovery remains fragile and key challenges must be addressed for the country to embark on a sustainable development path. Based on this, several identified barriers and measures to reducing climate change impacts regarding the prioritized technologies are highlighted in each of the sectors' Technology Needs Assessment report.

Finally, there are huge climate change challenges in Liberia. However, the Liberian Government is placing emphasis on economic growth as part of its national strategy for development and prioritizes the implementation of appropriate strategies for meeting climate change challenges in the development process. Successful national development may result in expansion of urban sector as well as agricultural and industrial activities. The demands placed on the environment to provide resources (e.g. timber) and funds from the industrial sector (mainly the extractive industry sector) for development and to absorb wastes will continue to grow as national population grows. This will present increasing challenges for both authorities and communities. in the country.

## **11.2.Recommendation**

Following are recommendations for improving the climate change data collection strategy in data quality in Liberia based on the results provided by the SNC:

- a. A data collection plan is required to meet data quality objectives regarding timelines, consistency, completeness, comparability, accuracy and transparency. The plan will focus on providing guidance for efficiency in data collection and should provide for identifying data gaps and strategies towards filling these gaps. It should put in place data collection activities that will lead to the continual improvement of data sets.
- b. It is important to review data collection methodologies and activities on a regular basis to ensure ease in data collection, collection (as well as maintenance) of quality data, and progressive/improvement in national inventory . Data collection procedures should iteratively improve the quality of the inventory in line with the data quality objectives; Such methodologies should be developed within the framework of the IPCC methodology. An improved data collection plan is necessary to improve the quality of data collected.

- c. Adequate support be provided for research activities in government institutions to avoid situations such as lack of systematic updates of information on key sectors, poor institutional capacity, loss of historical data due to destruction of important records, and inconsistency of data obtained from government institutions.
- d. Improve the institutional arrangement for data collection to ensure availability of reliable data and appropriate reporting format for GHG inventory and other climate change data collection purposes.
- e. To effect recommendation above, the government of Liberia, through the EPA, should organize a national data collection team (NDCT). The team's function will purposely be to collect and manage data on climate change but may also be requested to collect data on other environmental issues. The team should be trained in data collection, analysis and management.
- f. Develop and implement a public awareness strategy for maintaining data supply, overcoming barriers during data collection and minimizing difficulties in data collection procedures; the strategy should consider making agreements with data suppliers to ensure consistent and continuing information flows. Generally, the collection of climate change related data proved difficult because of a weak GHG management system and poor institutional arrangement, lack of official information in some sectors of Government, fear that the data could be used against the data supplier, and the supplier's lack of knowledge about GHG emissions reporting procedure. Hence, the awareness strategy should consider these situations.
- g. Specific policies relating to waste management are needed in Liberia. Existing policies linked to waste management should be reviewed and revised in accordance with the 1973 Municipal Act of Liberia; all such policies and legislative provisions on waste management should be reviewed and revised, where possible.
- h. In particular, the following recommendations for waste management need immediate attention:
  - Specific policies relating to waste management are either non-existent or inadequate. In adherence to the 1973 Municipal Act of Liberia, all policies and legislative provisions on waste management should be reviewed and revised, where possible..
  - It should be mandatory for all facilities that produce a lot of wastes, such as factories and hospitals, install and operate incinerators for burning their combustive waste fractions.
  - The official waste disposal site in Fiamah and filled and should be abandoned. A new dumpsite should be gazetted in an appropriate location.
  - There is need for thorough environmental and public health impact study of solid waste and sewage on the environment.
  - A well-coordinated public awareness and education on waste management and sanitation must be organized, backed by intensive capacity building initiatives.
  - An integrated waste management strategy for Liberia should be developed.
  - Waste management-related laws and regulations should be formulated and existing laws and regulations updated to meet the demand of present realities.

- Guidelines for disposal of wastes from villages and rural communities should be developed.
- i. The following three climate change adaptation technologies identified by the TNA project should be diffused in the agriculture sector of Liberia as good adaptation practices. According to the TNA Liberia Agriculture Report, 2019; the three technologies are:
    - Value addition to agriculture products (rice, cassava, vegetables and fruits): establishing 3 major facilities for value addition of agricultural products in rice, cassava, vegetables and fruits;
    - Improved Storage (drying and freezing of agriculture products): building of 3 storage facilities for seed, grain and vegetables in 3 agro-ecological zones of Liberia; and
    - Integrated Soil Fertility Management: introducing and running at least 4 Integrated Soil Fertility Management facilities in four agro-ecological zones of Liberia
  - j. Most of the Liberian population, especially those whose activities are significantly contributing to climate change factors, are limited in accessing information shared through modern technology such as website, while others have limited exposure to some established platforms/programs. To reach the masses with climate change information, simple strategies for sharing climate change knowledge and information must be developed and used. An example is posters/fliers depicting pictorial on climate change situations/actions and mitigation/adaptation activities.



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# Appendix

## Appendix A.1: Keywords of Liberia's Energy Sub-Sectors

### 1. *Energy Industries*

Public electricity by LEC generation and petroleum refining operations are considered under Industries for the Energy Sector. There is no oil or natural gas production in Liberia at this point in time. Diesel/Gas Oil and Residual Fuel Oil used for electricity production are counted under Energy Industries. A small percentage of the electricity is also produced from gasoline.

### 2. *Industries and Construction*

The Industrial Sector of Liberia is very small. Most of the industrial activities relied on electricity from the public utility company in 1986 although in recent years most of the industrial activities rely on the use of small-medium size electric generators using gasoline and diesel oil as oil.

This sector includes light industries, semi-autonomous and government/public corporations. Petroleum use for construction, cement production, breweries, small and medium scale industries, and road construction are included under Industrial Energy sub-sector.

Energy used for transport by industry is not reported under Industrial Sector but under Transport. Energy used for rubber processing by rubber companies is included under agriculture energy sub-sector.

Energy emissions arising from off-road and other mobile machinery in industry are included under industry emissions.

- (a) Iron and Steel Works – this is primarily for small-scale welders and metal smiths in Liberia. Most of them use either electricity from small generators or oxygen torches.
- (b) Food processing, beverages, or tobacco – those included in this category are club beer factory, USTC soft drinks factory, and NICOM gin distilleries.
- (c) Others include remaining emissions from fuel combustion industry.

### 3. *Mining*

Iron Ore Mining Companies constitute the main sources of emissions from energy of the mining sector included under the Industrial sector. Prewar year's data is available on the Mines Energy Sector and includes iron ore mining companies' operations and not the gold and diamonds mining operations which are basically alluvial mining operations included under fugitive emissions.

Presently, the gold and diamond mining sector of Liberia is predominantly alluvial mining operations utilizing mainly manual labor. Energy use in this sector is mainly for transportation of workers, and minimum small-scale electricity for residential purposes. A few of them may use water pumping equipment during the mining process but this is relatively very small.

### 4. *Transport*

This category includes energy for Road, Air, Marine and Rail Transport.

Energy used by Commerce, Industrial, Mines, Agriculture and Forestry sectors, etc. for transport purposes where disaggregating is possible, is accounted for under transport.

Off-road and other mobile machinery in other sectors is not reported under transport but reported under the sector where it is used.

Domestic passengers and freight traffic inside the country (not used as international bunkers) are reported under transport.

The Transport Energy Sector is further sub-divided into three as defined below:

*(a) Road Transport*

This comprises fuel use by roads and highway vehicles for transporting goods and people, including the use of agriculture vehicles such as tractors on highways for transporting goods and people (for example in the rubber plantations).

*(b) Air Transport*

The Transport Sector of Liberia is predominantly Road Transport through domestic air transport which operated a small fleet of air planes in the 1980s. This air transport is no longer in existence. The small amount of domestic air transport emission is attributed to the fuel used by the United Nations Mission in Liberia (UNMIL).

Air transport consists of small domestic airlines (commercial, private, agricultural, missions, etc.) This includes all civil domestic passengers and freight traffic inside a country (not used as international bunkers). Data on landing and take-offs (LTO) cycles are not available.

It excludes the use of fuel at airports for ground transport which is reported under road transport, and also excludes fuel for stationary combustion at airports for electricity generation; this information is reported under the appropriate stationary combustion category.

Domestic aviation fuel data is available only for the postwar years. LTO cycles data is not available.

International Aviation (International Bunkers) and jet fuel used for International Air Transport are classified as Export. Almost all Jet Fuel used currently in the country by commercial airlines is attributed to international aviation. Energy Export (also classified as memo items) for Liberia includes direct export of petroleum products in the form of bunker and aviation fuel used for international commerce. However, for the pre-war period, it was not possible to distinguish between the domestic uses of Jet Fuel from that for international use. Furthermore, since the war, Liberia does not have any domestic air transport system. The only domestic air traffic in the country at this time is the UN Mission in Liberia (UNMIL) activities (mainly helicopters) but data on fuel consumption could not be obtained at the time of finalizing this document.

*(c) Rail Transport*

During the pre-war years, for which data is available, rail transport in Liberia comprises Bong Mines, LAMCO and NIOC railroads. At present, only the Bong Mines old train is operated by a local company "Geo-services" for transport. The other two railroads ceased operations since the 1990s.

The rail transports in the 1980s was operated by LAMCO Iron Ore Mining Company (from Yekepa to the Buchanan Port) and Bong Mines Iron Ore Mining Company (from Bong Mines

to the Freeport of Monrovia). These railroads were basically used for the transport of iron ore to the port. Currently, mining operations have significantly reduced. In some cases, small trains with passengers and agricultural goods are used by the companies.

#### *(d) Marine Transport*

Marine Transport includes boats, fishing vessels, and barges used for domestic sea transport along the coast of Liberia but exclude Bunker Fuel and fuels used for international ships and vessel.

International Marine (Bunkers) – fuels burned by sea-going ships of all flags that are engaged in international transport as far as possible, are excluded from national totals and reported separately under International Bunkers.

#### **5. Commercial and Institutional Sector**

This sector consists of service activities such as restaurants, stores, hotels, hospitals, institutions, such as universities and colleges, etc.

Business or commercial vehicles used to transport cargo and passengers are included under the Transport Sector.

The Commercial and Institutional Sector also includes all Government (GOL energy use for office activities (for example, lighting and air conditioning equipment). Public corporations are listed under this sector as well. Fuel used to electrify an office, school, hospital, or business center is under Institutional Sector.

Fuel used by government for transportation is included in the Transport Sector.

#### **6. Residential Sector**

Residential Sector refers to fuel combustion activities in households such as the use of kerosene, wood, charcoal, and electricity.

Gasoline and Diesel fuel used for private vehicles are included under transport, but those used for generating electricity for household is considered residential energy.

#### **7. Agriculture / Forestry / Fishing**

This sector includes fuel combustion for agriculture activities, including the production of process or electricity generation for the production and processing of agriculture and forestry products, particularly in Liberia for rubber, logging, and timber production. This sector also includes fuel combustion in coastal and deep-sea fishing. Highway agricultural transportation is excluded.

The agricultural sector in the country is mainly rain-fed water regime which depends solely on production. In Liberia, irrigated water pumping energy systems are virtually nonexistent at present and very small if any. The system of manure use for fuel is not in significant use in Liberia to impact N<sub>2</sub>O generation at the moment.

## **1** Appendix A.2: Overview of Energy Resources in Liberia

The term **energy resources**, is defined as concentrations of naturally occurring solids, liquids, or gaseous materials on the earth in such forms that their economic extraction is potentially feasible for energy purposes. Energy resources are divided into two major groups.

They are:

- (a) Conventional energy resources – also known as non-renewable energy resources. They mainly consist of fossil fuels such as coal, crude oil, and petroleum products derived from crude oil (i.e. fuel oil, diesel oil, gasoline, kerosene, jet fuel, liquefied petroleum gas, liquefied natural gas, etc.)
- (b) Non-conventional energy resources – or non-renewable energy resources. Clean renewable energy resources, as suggested by the Union of Concerned Scientists, are wind power, solar power, biomass, geothermal energy, and hydroelectric power.

### ***1. Energy Sources of Liberia***

While there are many sources of energy, the part will focus on those predominantly use or have the potential to make a major national economic and climatic impact in Liberia. These include petroleum, biomass (i.e. fuel-wood and charcoal) and hydroelectric power.

Liberia is not refining crude oil. This means that all of our petroleum products used in Liberia are imported, while wood, charcoal, and hydroelectric power are produced locally.

### ***2. Categories of Fuel Applicable to Liberia***

Common terms and definitions of fuels are discussed here for consistency in the description of emissions from fuel combustion activities. For example, a list of fuel types that are applicable is provided below.

#### ***(a) Liquid (Petroleum Products)***

Gasoline

Jet fuel

Kerosene

Gas oil / diesel fuel

Fuel oil (includes HFO)

#### ***(b) Solid fuels***

Charcoal

Wood/Wood Waste



***(c) Gaseous fuels***

Liquefied Petroleum Gas (LPG):- LPG imported to the country comes in about 15–50 kg pressure tanks, and are used mainly for cooking gas and small scale commercial activities such as welding, metal smiths, etc. There is no pipeline distribution of gas in the country.

***(d) Cement production***

Liberia has a small cement processing and packaging factory that produces approximately several tons of cement per year. It consists mainly of klinka.

***(e) Road payment with Asphalt***

Liberia is in need of massive road paving activity. This activity is yet to begin. A number of road projects have been completed by Government in recent time, such as the Suacoco Road, Gbarnga-Ganta highway, etc. The use of cement, instead of asphalt, is used mainly for filling potholes.

***(f) Chemical industry***

The chemical industry in Liberia mainly comprise candle and paint factories in Monrovia. In addition, ammonia used in the rubber tapping and processing in Liberia is also part on local industry.

***(g) Metal production***

Metal production includes iron ore and small-scale metal work industries.

***(h) Food and drinks***

Facilities producing food and drinks are beer factory, USTC soft drinks factory, NICOM distilleries, RITCO, ISI drinks, etc.

***(i) Refrigeration and air conditioning equipment***

This consists mainly of room air conditioners and very few central a/c systems. There is no space heating in Liberia, being a hot tropical country.

***(j) Degreasing and dry-cleaning chemicals***

Degreasing and dry-cleaning chemicals are imported to the country

***3. Burning of Savannas***

Burning of savannas poses a relatively significant source of emissions of CH<sub>4</sub>, CO, N<sub>2</sub>O, and NO<sub>x</sub> in Liberia. Savannas described as tropical and subtropical formations with continuous grass cover, occasionally interrupted by trees and shrubs, exist in two regions of Liberia, namely: the Southeast (from Rivercess to Sinoe counties) and the Northwest (upper Lofa, from Kolahun to Foya districts).

Savannas are burned to control the growth of vegetation, remove pests and weeds, promote the nutrient cycle and encourage the growth of new grass for animal grazing. Carbon dioxide from savanna burning has not been assessed in Liberia. It should be noted for information purposes

although it is not included in the national total, as it is assumed that an equivalent amount of CO<sub>2</sub> is removed by re-growing vegetation in the following year.

#### ***4. Field Burning of Agricultural Residues***

The burning of agricultural waste for energy as well as field burning of agricultural and cereal residues, e.g. coconut shells, rice husk and maize stalks, etc. is not a significant activity in Liberia. Because wood and charcoal are relatively available, they are not used in fuel combustion activities. There are no data available for emissions from the on-site burning of residue to the harvesting of cereal crops.

#### ***5. Sugarcane***

Emissions from the on-site burning of sugarcane crop residue could constitute a significant activity in the Liberian cane juice production by rural farmers. Crop residue emissions occur from the on-site burning of sugarcane husk during cane juice distillation.

#### ***6. Changes in Forest and Other Woody Biomass Stocks***

These include emissions and removals of CO<sub>2</sub> from decreases or increases in biomass stocks due to forest management, logging, fuel-wood collection, etc. The category is either a net source of biomass if biomass harvest/destruction exceeds re-growth in the inventory year, or a net sink if re-growth exceeds harvest/destruction.

In Liberia, some logging companies and rubber plantations have utilized their wood waste for energy production. This constitutes a source of emission of non-CO<sub>2</sub> greenhouse gases from burning (in the field) of wood waste and other agricultural wastes on site. Carbon dioxide from vegetable or biomass burning is noted for information purposes and not included in the national total, since it is assumed that a measure of CO<sub>2</sub> is removed by re-growth of the next crop.

Other emissions and removals of CO<sub>2</sub> from other biomass categories include village and farm trees chopped down for fuel wood.

### Appendix A.3: Scope of Work and Timeline

| <b>No.</b>                      | <b>ACTIVITY</b>  | <b>TIMELINE</b>       | <b>DURATION</b> |
|---------------------------------|--|-----------------------|-----------------|
| 1.                              | Literature Review  | August 2016           | 1 months        |
| 2.                              | Presentation of Detailed Workplan                                    | September 2016        | 1 month         |
| 3.                              | Gathering and compilation of Activity Data                           | October–November 2016 | 2 months        |
| 4.                              | Processing of Data using 2006 IPCC Software                          | December 2016         | 1 month         |
| 5.                              | Submission of Initial Draft  | January 2017          | 1 month         |
| 6.                              | Revision of draft by incorporating relevant comments and suggestions | February 2017         | 1 month         |
| 7.                              | Submission of the FINAL GHG Inventory Report for the Energy Sector   | March 2017            | 1 month         |
| <b>Duration of the Contract</b> |  |                       | <b>8 months</b> |

## Appendix D.1: Scope of Work (SOW) and Methodology

| No. | ACTIVITY                                     | ESTIMATED DURATION IN MONTHS |   |   |   |   |   |   |   |
|-----|--|------------------------------|---|---|---|---|---|---|---|
|     |  | 1                            | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1.  | Literature Review                            | ■                            |   |   |   |   |   |   |   |
| 2.  | Preparation of Detailed Workplan             |                              | ■ |   |   |   |   |   |   |
| 3.  | Gathering and compilation of Activity Data   |                              |   | ■ |   |   |   |   |   |
| 4.  | Processing of Data using 2006 IPCC Software  |                              |   |   | ■ |   |   |   |   |
| 5.  | Submission of Initial Draft                  |                              |   |   |   | ■ |   |   |   |
| 6.  | Draft revision by incorporating suggestions  |                              |   |   |   |   | ■ |   |   |
| 7.  | Submission of the FINAL GHG Inventory Report |                              |   |   |   |   |   | ■ |   |
|     | <b>Duration of Contract</b>                  | ■                            | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

## 2 Appendix D.2: General Demographic and Economic Information

| ITEM                                    | DATA  |
|---|---|
| <b>Location:</b>                        | Western Africa, bordering the North Atlantic Ocean, between Cote d'Ivoire and Sierra Leone            |
| <b>Geographic Coordinates:</b>          | 6° 30' N, 9° 30' W  |
| <b>Area: Total</b>                      | 111,370 sq. km  |
| <b>Area: Water</b>                      | 15,050 sq. km   |
| <b>Area: Land</b>                       | 96,320 sq. km   |
| <b>Land boundaries: Total</b>           | 1,585 km  |
| <b>Guinea (northern border)</b>         | 563 km  |
| <b>Cote d'Ivoire (eastern border)</b>   | 716 km  |
| <b>Sierra Leone (western border)</b>    | 306 km  |
| <b>Coastline</b>                        | 579 km  |
| <b>Maritime claims: territorial sea</b> | 200 NM  |
| <b>Climate: tropical</b>                | Hot, humid dry season with hot days and cool to cold nights; rainy season with frequent heavy showers |
| <b>Terrain</b>                          | Mostly flat to rolling coastal plains rising to rolling plateau and low mountains in the north        |
| <b>Elevation extremes</b>               | Lowest point: Atlantic Ocean 0 m<br>Highest point: Mount Wuteve 1,380 m                               |
| <b>Principal natural resources</b>      | Iron ore, timber, diamond, gold, bauxite, rubber, hydropower  |
| <b>Land use</b>                         | Arable land: 1.97%; Permanent crops: 2.08%; other: 95.95% (1998 est.)                                 |

|                                     |   |
|-------------------------------------|---|
| <b>Irrigated land</b>               | 30 sq. km (1998 est.)   |
| <b>Natural hazards</b>              | Dust-laden harmattan winds blow from the Sahara (December to March)   |
| <b>Environment – current issues</b> | Tropical rainforest deforestation, soil erosion, loss of biodiversity, pollution of coastal waters from oil residue run-off from iron ore mines                             |
| <b>Geography – note</b>             | Facing the Atlantic Ocean; the coastline is characterized by lagoons, mangrove swamps and river-deposited sandbars; the inland grassy plateau supports limited Agriculture  |
| <b>Demography:</b>                  |   |
| <b>Population</b>                   | 3,288,198   |
| <b>Age structure</b>                | 0–14 years (43.3%; 714,563 male & 709,582 female)<br>15–64 years (53.2%; 854,324 male & 894,753 female)<br>65 years and above (3.5%; 57,925 male & 57,051 female) 2002 est. |
| <b>Population growth rate</b>       | 1.91% (2002 est.)   |

### 3 Appendix D.3: General Demography and Economic Information on Liberia

| ITEM                            | DATA  |
|---------------------------------|---|
| <b>Birth rate</b>               | 45.95 births/1,000 population (2002 est.)   |
| <b>Death rate</b>               | 16.05 deaths/1,000 population (2002 est.)   |
| <b>Net migration rate</b>       | 10.8 migrations/1,000 population  |
| <b>Life expectancy at birth</b> | Total population: 51.8 years; Female: 53.33 years; Male: 50.33 years)   |
| <b>Infant mortality rate</b>    | 130.21 deaths/1,000 live births (2002 est.)   |
| <b>Nationality</b>              | <i>Noun:</i> Liberian(s); <i>Adjective:</i> Liberian  |
| <b>Ethnic groups</b>            | <i>Indigenous Africa tribes</i> 95% (including Kpelle, Bassa, Gio, Kru, Grebo, Mano, Krahn, Gola, Gbandi, Lorma, Kissi, Vai, Dei, Belle, Mandingo, and Mende)<br><i>Americo-Liberians</i> 2.5% (descendants of immigrants from the US who had been slaves)<br><i>Congo people</i> 2.5% (descendants of immigrants from the Caribbean who had been slaves) |
| <b>Religions:</b>               | Indigenous belief: 30%; Christianity: 50%; Islam: 20%   |
| <b>Languages</b>                | Official: English; Others: Some 16 major ethnic group languages, of which few are written and used in correspondence  |

|   |   |
|---|---|
| <b>Literacy (age 15, ability to read and write)</b> | Total population: 38.3%<br>Male: 53.9%<br>Female: 22.4% (1995 est.)   |
| <b>Government</b>                                   |   |
| <b>Country name</b>                                 | <i>Conventional long form:</i> Republic of Liberia<br><i>Conventional short form:</i> Liberia   |
| <b>Government type</b>                              | Republican  |
| <b>Capital</b>                                      | Monrovia  |
| <b>Administrative Divisions</b>                     | 15 counties (Bomi, Bong, Gbarpolu, Grand Bassa, Grand Cape Mount, Grand Gedeh, Grand Kru, Lofa, Margibi, Maryland, Montserrado, Nimba, Rivercess, River Gee, and Sinoe) |
| <b>Independence</b>                                 | 26 July 1847  |
| <b>National Day</b>                                 | Independence Day, 26 July   |
| <b>Constitution</b>                                 | 1847 (first), 1986 (revised)  |
| <b>Legal system</b>                                 | Dual system of statutory law based on Anglo-American common law and native customary law based on tribal practices  |
| <b>Suffrage</b>                                     | 18 years of age; universal  |
| <b>Executive branch</b>                             | President is Chief of State, Head of Government, and Commander-in-Chief of the Armed Forces   |
| <b>Legislative branch</b>                           | Bicameral national legislature comprising Senate (30 seats); and the House of Representatives (64 seats)  |
| <b>Judicial branch</b>                              | Five-member Supreme Court and subordinate courts  |
| <b>Political parties</b>                            | Multi-party democracy (more than 20 political parties)  |

#### 4 Appendix D.4: General Demography and Economic Information on Liberia

| ITEM                           | DATA   |
|--------------------------------|--|
| <b>Flag description</b>        | 11 equal horizontal stripes of red (top and bottom) alternating with white; there is a white five-pointed star on a blue square in the upper hoist-side corner |
| <b>Economy</b>                 |  |
| <b>GDP</b>                     | Purchasing power parity (\$3.6 billion) 2001 est.  |
| <b>GDP – real growth rate</b>  | 5% (2001 est.)   |
| <b>GDP – per capita</b>        | Purchasing power parity (\$1,100) 2001 est.  |
| <b>GDP – agriculture</b>       | 60%  |
| <b>Composition by industry</b> | 10%  |
| <b>Sector: services</b>        | 30% (2001 est.)  |

|   |  |
|---|--|
| <b>Inflation rate (consumer prices)</b> | 8% (2001 est.)   |
| <b>Labor force by occupation</b>        | Agriculture: 70%; industry: 8%; services: 22% (2000 est.)            |
| <b>Population below poverty line</b>    | 80%  |
| <b>Unemployment rate</b>                | 70%  |
| <b>Budget: revenues</b>                 | \$85.4 million (2005); \$129 million (2006)                          |
| <b>Budget: expenditures</b>             | \$90.5 million (2005)  |
| <b>Industries</b>                       | Rubber processing, palm oil processing, logging, mining              |
| <b>Electricity production</b>           | 450 million kWh (2000 est.)  |
| <b>Electricity – fossil fuel</b>        | 100%   |
| <b>Production by source</b>             | Hydro: 0%; other: 0%; nuclear: 0% (2000 est.)                        |
| <b>Electricity consumption</b>          | 418.5 million kWh (2000)   |
| <b>Agriculture</b>                      | Rubber, coffee, cocoa, rice, cassava (tapioca), palm                 |
| <b>Products</b>                         | Oil, sugarcane, banana, sheep, goat, timber                          |
| <b>Exports</b>                          | \$55 million f.o.b. (2000 est.)                                      |
| <b>Exports – commodities</b>            | Rubber, timber, iron ore, gold, diamond, cocoa, coffee               |
| <b>Exports – partners</b>               | Major European countries, the U.S. and China                         |
| <b>Imports</b>                          | \$170 million f.o.b. (2000 est.)                                     |
| <b>Imports –</b>                        | Fuels, chemicals, machinery, transportation                          |
| <b>Imports – commodities</b>            | Equipment, manufactured goods, rice and other foodstuffs             |
| <b>Imports – partners</b>               | France, Germany, South Korea, Japan, Singapore, China, U.S. and U.K. |
| <b>Debt – external</b>                  | \$2.1 billion (2000 est.)  |
| <b>Economic aid recipient</b>           | \$94 million (1999 est.)   |
| <b>Currency</b>                         | Liberia Dollars  |
| <b>Currency code</b>                    | LRD  |

## 5 Appendix D.5: General Demography and Economic Information on Liberia

| ITEM                                    | DATA  |
|---|---|
| <b>Exchange rates:</b><br><b>note</b>   | Until December 1997, rates were based on 1:11 relationship with the US dollar; beginning January 1998, rates are market-determined. Presently: 110:1  |
| <b>Fiscal Year</b>                      | Calendar year   |
| <b>Communication</b>                    |   |
| <b>Telephones – main lines in use</b>   | 6,700 (2000)  |
| <b>Telephone system</b>                 | <i>General assessment:</i> telephone and telegraph service via microwave radio relay network, main center in Monrovia<br><i>Domestic:</i> NA<br><i>International:</i> satellite earth station – 1 intelsat (Atlantic Ocean).<br>By 2006, four GSM cellphone companies are in operation competitively reaching nine of the fifteen counties  |
| <b>Radio broadcast stations</b>         | AM 0, FM 9, SW 2 (2004 est.)  |
| <b>Television broadcast stations</b>    | 30,000 (1997 est.)  |
| <b>Internet country code</b>            | .lr   |
| <b>Internet service provider (ISPs)</b> | 2 (2004)  |
| <b>Internet users</b>                   | 2 (2004)  |
| <b>Transportation railways</b>          | <i>Total:</i> 490 km (328 km single-track); <i>standard gauge:</i> 345 km 1.435-m gauge <i>note:</i> in 1989, Liberia had three rail systems owned and operated by foreign steel and financial interests in conjunction with the Liberian Government; one of these, the LAMCO railroad, closed in 1989 after iron ore production ceased; the other two were shut down by the civil war; large sections of the rail lines have been dismantled; approximately 60 km of railroad track was exported for scrap <i>narrow gauge:</i> 145 km 1.067-m gauge |
| <b>Highways</b>                         | <i>Total:</i> 10,600 ( <i>paved:</i> 657 km; <i>unpaved:</i> 9,943 km)<br><i>Note:</i> there is a major deterioration on all highways due to heavy rains and lack of maintenance (1996 est.)  |
| <b>Waterways</b>                        | None  |
| <b>Ports and harbors</b>                | 4 (Buchanan, Greenville, Harper, and Monrovia)  |
| <b>Merchant marine</b>                  | <i>Total:</i> 1,513 ships (1,000 GRT or over) totaling 51,912,244 GRT/79,297,046DWT   |



## 6 Appendix D.6: General Demography and Economic Information on Liberia

**Merchant marine (cond't)** *Note:* includes some foreign-owned ships registered here as a flag of convenience: Argentina, 9; Australia, 2; Austria, 15; Belgium, 9; Brazil, 5; Canada, 4; Cayman Islands, 1; Chile, 7; China, 39; Croatia, 11; Denmark, 4; Ecuador, 1; Estonia, 1; Germany, 437; Greece, 154; Hong Kong, 69; India, 5; Indonesia, 1; Israel, 1; Italy, 5; Japan, 90; Latvia, 20; Isle of Man, 5; Monaco, 56; Netherlands, 12; New Zealand, 1; Nigeria, 1; Norway, 103; Pakistan, 1; Portugal, 5; Russia, 66; Saudi Arabia, 21; Singapore, 20; Slovenia, 1; South Africa, 1; South Korea, 10; Spain, 2; Sweden, 9; Switzerland, 17; Taiwan, 29; Turkey, 3; Ukraine, 4; United Arab Emirates, 12; United Kingdom, 39; United States, 113; Uruguay, 3; Vietnam, 1 (2002 est.)

|   |  |
|---|--|
| <b>Merchant marine (cond't)</b>         | <i>Ship by type:</i> barge carrier, 3; bulk, 313; cargo, 89; chemical tanker, 167; combination bulk, 16; combination ore/oil, 32; container, 318; liquefied gas, 99; multi-functional large-load carrier, 4; passenger, 23; petroleum tanker, 302; refrigerated cargo, 69; roll on/roll off, 20; short-sea passenger, 3; specialized tanker, 13; vehicle carrier, 42 |
| <b>Airports – with paved runways</b>    | <i>Total:</i> 2<br><i>Over 3,047m:</i> 1<br>1,524 to 2,437 m : 1 (2002)  |
| <b>Airstrips – with unpaved runways</b> | <i>Total:</i> 45<br>1,524 to 2,437m : 4<br>914 to 1,523 m : 7<br><i>Under 914 m:</i> 34 (2002)   |

| Emergency Monrovia Urban Sanitation Project (EMUS) |               |               |               |                |                |                |         |
|--|---------------|---------------|---------------|----------------|----------------|----------------|---------|
| Tonnes   |               |               |               |                |                |                |         |
| PERIOD   | MCC A         | MCC B         | MCC C         | Total          | Project Target | Variance       | Backlog |
| Sep-14   | 6,124         | 326           | 5,367         | 11,816         | 12,233         | -417           | -417    |
| Oct-14   | 4,776         | 40            | 4,429         | 9,245          | 12,233         | -2,988         | -3,405  |
| Nov-14   | 3,029         | 172           | 4,434         | 7,634          | 12,233         | -4,599         | -8,004  |
| Dec-14   | 4,247         | 497           | 4,001         | 8,745          | 12,233         | -3,489         | -11,493 |
| Jan-15   | 3,639         | 275           | 2,843         | 6,757          | 12,233         | -5,476         | -16,969 |
| Feb-15   | 3,646         | 718           | 3,567         | 7,931          | 12,233         | -4,303         | -21,271 |
| Mar-15   | 6,219         | 1,913         | 2,027         | 10,158         | 12,233         | -2,075         | -23,346 |
| Apr-15   | 4,365         | 3,291         | 2,507         | 10,164         | 12,233         | -2,070         | -25,416 |
| May-15   | 3,688         | 7,025         | 6,365         | 17,078         | 12,233         | 4,845          | -20,572 |
| Jun-15   | 4,928         | 8,582         | 5,850         | 19,360         | 12,233         | 7,127          | -13,445 |
| Jul-15   | 6,587         | 4,374         | 2,110         | 13,071         | 12,233         | 838            | -12,607 |
| Aug-15   | 6,956         | 9,154         | 0             | 16,110         | 12,233         | 3,877          | -8,314  |
| Sep-15   | 7,348         | 15,388        | 0             | 22,736         | 12,233         | 10,503         | 2,189   |
| Oct-15   | 6,730         | 8,333         | 0             | 15,063         | 12,233         | 2,829          | 4,602   |
| Nov-15   | 3,578         | 5,839         | 3,632         | 13,049         | 12,233         | 816            | 5,417   |
| Dec-15   | 4,808         | 3,878         | 4,393         | 13,078         | 12,233         | 845            | 6,262   |
| <b>TOTAL 2015</b>                                  | <b>80,667</b> | <b>69,804</b> | <b>51,524</b> | <b>201,995</b> | <b>195,733</b> | <b>6,262</b>   |         |
| <b>%</b>   | <b>40%</b>    | <b>35%</b>    | <b>26%</b>    | <b>103%</b>    | <b>100.00%</b> | <b>3%</b>      |         |
| Jan-16   | 3,062.80      | 3,061.17      | 3,810.88      | 9,934.85       | 12,233         | -2,298         | -2,298  |
| Feb-16   | 1,957.91      | 2,435.82      | 2,072.73      | 6,466.46       | 12,233         | -5,767         | -8,065  |
| Mar-16   | 3,022.18      | 3,292.81      | 3,073.78      | 9,388.77       | 12,233         | -2,845         | -10,910 |
| Apr-16   | 2,583.11      | 3,573.53      | 2,563.58      | 8,720.22       | 12,233         | -3,513         | -14,423 |
| May-16   | 3,552.19      | 3,346.57      | 2,109.68      | 9,008.44       | 12,233         | -3,225         | -17,648 |
| Jun-16   | 2,919.33      | 4,081.37      | 3,530.75      | 10,531.45      | 12,233         | -1,702         | -19,350 |
| Jul-16   | 3,905.30      | 4,917.60      | 2,581.78      | 11,404.68      | 12,233         | -829           | -20,178 |
| Aug-16   | 2,024.87      | 2,572.07      | 2,691.35      | 7,288.29       | 12,233         | -4,945         | -25,123 |
| Sep-16   | 1,104.05      | 1,559.91      | 2,804.04      | 5,468.00       | 12,233         | -6,765         | -29,590 |
| <b>TOTAL 2016</b>                                  | <b>24,132</b> | <b>28,841</b> | <b>25,239</b> | <b>78,211</b>  | <b>110,100</b> | <b>-31,889</b> |         |
| <b>%</b>   | <b>31%</b>    | <b>37%</b>    | <b>32%</b>    | <b>71%</b>     | <b>100.00%</b> | <b>-29%</b>    |         |

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**Note: September covers the period Sept 1-20, 2016. These are tentative tonnages pending CJ Report**

## Appendix E: LULUCF

### 8 Appendix E.1: Condensed Source data by definition

**Dark Green:** Closed Canopy forests due to minimum human interventions

**Lemon Green:** Open Canopy Forests partly as a result of human interventions

**Sky Blue:** Indicating forests affected by agriculture activities of one kind

**Yellow:** indicating forests under several agriculture activities

**Red:** Indicating High Priority forests, especially in the case of contract allocations **Gray:** Is also used here to underscore topic features of this document

### 9 Appendix E.2: Total Forest Cover Land of Liberia

- ❖ 4.5 million hectares (42 % host to the remaining Upper Guinea Forest Belt) approximately 11.25 million acres **Distribution:**
  - **Closed Dense Forest:** 2.4 million hectares (approximately 6 million acres)
  - **Open Dense Forest:** 1.02 million hectares (approximately 2.55 million acres)
  - **Agriculture Degraded Forest:** 0.95 million hectares (approximately 2.375 million acres)
  - **Mixed Agriculture Forest:** 1.28 million hectares (approximately 3.2 million acres)

### 10 Appendix E.3: Production Forest

- ❖ 7 FMCs (Forest Management Contract)
  - FMC –A : 119,240 hectares (approximately 298,100 acres) Lofa County
  - FMC-B: 57,262 hectares (approximately 143,155 acres) Rivercess County
  - FMC-C: 59,374 hectares (approximately 148,435 acres) Rivercess County
  - FMC-F: 254,583 hectares (approximately 636,457.50 acres) River Gee & G.Gedeh Counties
  - FMC-I: 131,466 hectares (approximately 328,665 acres) G.Gedeh & Sinoe Counties

- **FMC-K: 266,910 hectares (approximately 667,275 acres) Nimba, Rivercess & G.Gedeh Counties**
- **FMC- P:119,344 hectares (approximately 298,360 acres) G.Kru, Maryland & River Gee Counties**
- ❖ **10 TSCs (Timber Sale Contract)**
  - **TSC-A 2: 5,000 hectares (12,500 acres) G.Bassa County**
  - **TSC-A 3: 5,000 hectares (12,500 acres) G.Bassa County**
  - **TSC-A 6.9: 5,000 hectares (12,500 acres) Gbarpolu & G.Cape Mt. Counties**
  - **TSC-A 7: 5,000 hectares (12,500 acres) Gbarpolu County**
  - **TSC-A 11: 5,000 hectares (12,500 acres) G.Cape Mt. County**
  - **TSC –A 15 &A 16: 5,000 hectares (12,500 acres) G. Cape Mt. County**
  - **TSC-A8: 5,000 hectares (12,500 acres) G. Cape Mt. County**
- ❖ **Community Forest: Land under forest cover set aside (under the Community Right Law of Liberia) for the use of bordering communities of the specified forest as may be required for their livelihood activities**
  - **Neezonnie : 42,424 hectares (106.06 acres) Grand Gedeh County**
  - **Zor : 1,140 hectares (2,850 acres ) Nimba County**
  - **Bluyeama: 44,444 hectares (111.11 acres) Lofa County**
  - **Nitrian: 958 hectares (2,395 acres) Sinoe County**
  - **Blandon: 40, 862 hectares (102,155 acres) Nimba County**
  - **Blouquia : 43, 796 ( 109,490 ) Grand Gedeh County**
  - **Nimopoh : 7,320 hectares ( 18,300 ) Sinoe County**
  - **Dore : 36,912.98 hectares (922,782.45 ) Nimba County**
- ❖ **NATIONAL PROTECTED FOREST AREAS : Gazette and endorsed through Legislative enactment**
  - **Sapo National Park : 180,436 hectares ( 451,090 acres ) Sinoe county**
  - **Lake Piso Reserve: 97, 159 hectares ( 242,897.5 acres ) Grand Cape mount County**

- **East Nimba Nature Reserve :13,574 hectares ( 33,528 acres )**

## 11 Appendix E.4: National Proposed Reserves

- **Kpo Mountain: 83,709 hectares ( 209,272.5 acres ) Bong County**
- **Gola Forest: 88,873 hectares ( 219,605 ) Gbarpolu / G. Capemount County**
- **Wologizi Mountain: 99,538 hectares ( 245,958 acres ) Lofa County**
- **Bong Mountain : 24,822 hectares ( 61,335 acres ) Bong County**
- **Grebo Forest : 97,136 hectares ( 240, 023 acres ) G. Gedeh / River Gee**
- **Margibi Mangrove : 23,818 hectares ( 58,842 acres acres ) Margibi county**
- **Sankwehn Proposed Reserve : 80, 348 ( 198,540 acres ) Sinoe county**
- **Gbi Forest : 88,409 hectares ( 218,459 ) Nimba County**
- **Wonegizi Range :37979 ( 93,846 acres ) Lofa County**
- **Grand Kru/ River Gee Forest : 135,100 hectares (333,832 acres ) Grand Kru County**
- **West Nimba National Forest: 10,482 hectares ( 25,901 acres ) Nimba County**
- **Foya Forest: 164,628 hectares ( 406,796 acres ) Lofa County**
- **Cavalla Reforestation Project : 978.39 hectares ( 2,445.975 acres )**
- **Glaro Reforestation Project : 1008.89 ( 2,524.725 ) River Gee County**
- **Industrial Trial Pulpwood Plantation: 1026 hectares ( 2,565 acres ) Grand Cape mount County**
- **Bomi Reforestation Project: 3,276.75 hectares ( 8,097 acres ) Bomi County**
- **Kpaytuo Reforestation Project: 64.79 ( 160 acres ) Nimba County**
- **LTPC Reforestation Project : 154.2 ( 385.5 acres ) Mile 20 Sinoe County**
- **SIGA Reforestation Project : 247.2 hectares ( 618 acres ) Grand Gedeh County**
- **EAC Reforestation project : 59.2 hectares ( 148.0 acres ) Grand Gedeh County**
- **WATRACE Reforestation Project: 58. 4 hectares ( 146 acres ) Grand Gedeh County**
- **Tappita Reforestation Project :139.62 hectares ( 345 acres ) Nimba County**

- **FDA /OTC Reforestation Project: 276 hectares (690) River Cess County**
- **Foya Afforestation Project: 9,062.4 hectares (2,656.0 acres) Lofa County**
- **LPC Reforestation Project: 330.28 hectares (825.7 acres) Bong County**
- **LETSCO Reforestation Project: 70.4 hectares (176.0 acres) Grand Bassa County**
- **LAMCO Reforestation Project: 776.0 hectares (1,940.0 acres) Nimba County**
- **YEKEPA Reforestation Project: 271.55 hectares (671.0 acres) Nimba County**

*Table E.4.1: West African Land Use Study (Harmonized Classification System)*

|    | <b>IPCC Category</b> | <b>Land use/land cover??</b>          |  |
|----|----------------------|---------------------------------------|--|
| 1  | <b>Forest Land</b>   | Forest                                |  |
| 2  |                      | Gallery Forest/Riparian Forest        |  |
| 3  |                      | Degraded Forest                       |  |
| 4  |                      | Swamp Forest                          |  |
| 5  |                      | Plantation                            |  |
| 6  |                      | Mangrove                              |  |
| 7  | <b>Cropland</b>      | Agriculture                           |  |
| 8  |                      | Irrigated Agriculture                 |  |
| 9  |                      | Agriculture in shallows and recession |  |
| 10 |                      | Cropland and fallow with oil palms    |  |
| 11 | <b>Grassland</b>     | Woodland                              |  |
| 12 |                      | Thicket                               |  |
| 13 |                      | Savanna                               |  |
| 14 |                      | Herbaceous savanna                    |  |
| 15 |                      | Sahelian Short grass savanna          |  |
| 16 |                      | Bowé                                  |  |

|    |                   |                        |  |
|----|-------------------|------------------------|--|
| 17 | <b>Settlement</b> | Steppe                 |  |
| 18 |                   | Settlements            |  |
| 19 |                   | Open Mine              |  |
| 20 | <b>Other Land</b> | Sandy Area             |  |
| 21 |                   | Rocky Land             |  |
| 22 |                   | Bare soil              |  |
| 23 | <b>Wetland</b>    | Bottomland and Wetland |  |
| 24 |                   | Water Bodies           |  |