Upscaling Lowland Rice Production to Improve Food Security through Improved Solar Powered Irrigation Practices

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SRI Irrigation Report

Prepared for:

Climate Technology Centre & Network (CTCN), MoA & EPA

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Contents

Tables

Figures

Appendices

Acronyms and Abbreviations

AfDB	African Development Bank
AIICO	Agriculture Infrastructure Investment Company
AWD	Alternate Wetting and Drying
CAC	County Agriculture Coordinator
CAO	County Agriculture Officer
CARI	Competitive African Rice Initiative
CHAP	Community of Hope Agriculture Project
CTCN	Climate Technology Centre and Network
DAO	District Agriculture Officer
DOA	Department of Agriculture
EIA	Environmental Impact Assessment
EPA	The Environmental Protection Agency of Liberia
FAO	Food and Agriculture Organization of the United Nations
FED	Food and Enterprise Development Programme
FUN	Farmer Union Network
GAP	Good Agricultural Practices
GIS	Geographic Information System
LIGIS	Liberia Institute of Geo-Information Services
M&E	Monitoring and Evaluation
MoA	Ministry of Agriculture
NDE	National Designated Entity
NGO	Non-Governmental Organisation
PV	Photovoltaic
RAC	Region Agriculture Coordinator
SPIS	Solar Powered Irrigation Systems
SRI	System of Rice Intensification
SWG	Stakeholder Working Group
TA	Technical Assistance
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization (UNIDO)
USAID	United States Agency for International Development
WAAPP	West Africa Agricultural Productivity Program
WARDA	West Africa Rice Development Association
WUA	Water User Association

1. Executive Summary

1.1. Background

Agriculture is a major sector of Liberia employing more than 70% of the population. However, Liberia's agriculture system is predominantly rain-fed, with heavy dependence on consistent rainfall, and climate change is posing serious challenges to all sectors and is threatening the sustainability of agricultural production. This is happening prior to Liberia recovering from 14 years of civil conflict, global recession, Ebola, and now the COVID-19 pandemic.

In response, the adoption of Solar Powered Irrigation Systems (SPIS) and a System of Rice Intensification (SRI) is being investigated to increase rice yields whilst lowering water usage. Potential benefits of adopting irrigation technology includes guaranteeing yields in an increasingly dry climate and where there is a lack of natural moisture; reducing energy consumption as a climate change mitigation; whilst reducing water consumed as an adaptation to climate change.

1.2. Objectives

Against this background, the objective of the Technical Assistance (TA) is to introduce solar powered irrigation technology and practices to intensify rice cultivation and production in one lowland county in Liberia, to be selected between Lofa and Bong, with the intention of upscaling the technology as an adaptation measure to climate change at a national level. To achieve this objective, the TA has been divided into six main outcomes, as follows:

- Outcome 1: Analyse the current irrigation and rice cultivation practices in one county of Liberia
- Outcome 2: Design appropriate irrigation and solar water pumping technologies for SRI based farming in the selected county
- Outcome 3: Select an appropriate SPIS technology
- Outcome 4: Pilot a small-scale implementation of the solar pumping system in the selected county
- Outcome 5: Elaborate and disseminate training materials and workshops
- Outcome 6: Formulate an enabling environment roadmap and a M&E framework.

This report provides an update on work conducted to provide Outcome 1, covering six activities, described in the following sections.

1.3. Activity 1.1: Mapping Stakeholders and Establishing a Stakeholder Working Group

Relevant stakeholders were mapped that were likely to have an interest in the assignment, and the results used to form a Stakeholder Working Group (SWG). A summary of the initial members of the SWG are provided in Table 1-1 below.

Table 1-1 - Details of individuals in the SWG

Name of Individual	Organization / Role
Robert Bimba	CHAP, Executive Director / National Coordinator for Farmer Union Network / RICOWAS Project In-Country Contact
Mohammed Kamara	Liberia Rice Farmers Federation, President / Agriculture Infrastructure Investment Company (AIICO), CEO
Dr. James Dolo	Central Agricultural Research Institute (CARI), Researcher / Plant Breeder
Dr. Akintayo Inoussa	Africa Rice Center, Liberia (previously the West Africa Rice Development Association (WARDA)), Country Director
Olivia K. David	Liberia Land Authority, Gender Coordinator
Anthony Kullie	Ministry of Mines and Energy: Director, Liberian Hydrological Service
Moses Gbanyan	Ministry of Agriculture: Region Agriculture Coordinator (RAC) Bong, Nimba and Lofa
Mariatou Njie	FAO Representative in Liberia
Zipporah Page	CARI Researcher

1.4. Activity 1.2: Conducting a Virtual Inception Meeting

An Inception Meeting was held on the 25 January 2022 and followed a hybrid physical-virtual format to enable participation of key stakeholders without internet facilities. Following a presentation on the TA given by CARES and INTee key issues discussed included the need and potential approaches for equipment security (which focussed on the involvement of beneficiary communities); water sources (i.e., groundwater versus surface water); seasonality (i.e., the need to plan the project considering the timing of the dry and rainy seasons); the main performance indicators - productivity, cropping intensity, and diversity of crops; constraints for adopting SRI in Liberia; existing studies, programmes, projects and data; and SWG establishment.

1.5. Activity 1.3: Diagnose the Current Irrigation System in Bong and Lofa

A desktop review and a series of interviews with stakeholders has been completed to understand the irrigation systems used as well as its limits, technological failures, bottlenecks, opportunities, and advantages.

During the rainy season, irrigation is unnecessary as flooding occurs in low-lying areas. Irrigation practices that have been attempted by government agencies and a few private funding organizations include surface irrigation and very limited pressurized irrigation. The surface irrigation is mostly through open field channels by gravity and subject to various field losses. Most irrigation schemes in Liberia are running short of funding for maintenance and operations, which can be attributed to insufficient budget allocation and poor cost recovery mechanisms (MOA, Liberia 2015).

During USAIDs Food and Enterprise Development Programme (FED), double cropping of rice was achieved through developing irrigation in Lofa, Bong, Nimba, and Grand Bassa. Catchment areas were identified, and head dikes constructed with both-side spillways, with the spillway channels used as irrigation channels and water drawn to the field through gravitation.

The Food and Agriculture Organization of the United Nations (FAO) has focussed on promoting lowland rice production in two places: Foya, Lofa County, and Belamu, Bong County. Whilst boreholes are used for high value crops, rice cropping is supplemented with dry season irrigation by surface irrigation systems.

In summary, there is a lack of functional irrigation systems with most lowland systems being rainfed. Structures like the head dikes and spillways have not been repaired or maintained regularly, and irrigation channels have not been cleaned or weeded properly to maintain the flow of water.

System of Rice Intensification (SRI) techniques were first introduced to Liberia in late 2012 and activities have extended through projects such as the World Bank-sponsored, West Africa Agricultural Productivity Program

(WAAPP), and more recently the Adaptation Fund (AF) project for “Scaling up Climate Resilient Rice Production in West Africa” (RICOWAS) and UNDP investments in commercial rice seed production.

Bong County is the second most productive county for domestic rice production in Liberia, although a greater share of this production comes from upland areas, which are still undertaken through shifting cultivation. In contrast, lowland rice farming has been practised in Lofa County for many decades, either in depressions between hills or on the plains/swamps, where water is available throughout the year.

1.6. Activity 1.4: Select Best Pilot Sites between Bong and Lofa

Reconnaissance site visits were undertaken to Bong County and Lofa County on the 11-13 December 2021 and 17-19 February 2022 respectively. A number of sites in the two counties were preselected by the Ministry and visited by the field reconnaissance team to make an assessment based upon a wide range of site selection criteria. The key parameters identified by the Team to be used in the selection of the site for the SPIS pilot scheme include the following:

- Availability of suitable water source:
  - Surface water; river and existing storage (dam/reservoir)
  - Groundwater:
    - Submersible pumps; existing borehole with adequate yield
    - Surface mounted pumps; shallow water table within Net Positive Suction Head (NPSH) limit
- Existing lowland rice cultivated areas, with potential for increased yields, cropping intensity and/or diversity of crops (i.e. areas out of command for gravity fed irrigation) ~10ha
- Suitable soil types (i.e. limited iron toxicity) and adequate drainage
- Community interest/motivation in new technologies and cultural practices
- Labour availability and organisation, particularly for equipment security
- No land ownership issues
- Location with respect to milling facilities and markets for inputs (i.e. seeds and agro-chemicals) and produce
- Good site access from Monrovia and other parts of the country for construction logistics, demonstration workshop or meetings etc.

Based on the reconnaissance visits and using these criteria, the Team made a comparison of the two counties and recommended that Lofa county be selected for further study, to identify a specific site for the pilot scheme. This will be the subject of further discussion and a participatory Multi-Criteria Analysis (MCA) with SWG members at the inaugural meeting.

1.7. Activity 1.5: Benchmarking International Best Irrigation Practices in SRI

Relevant laws, policies and institutions relevant to the TA, as well as some of the technical reports and studies relating to SPIS and SRI in Liberia have been reviewed and best irrigation practices from countries with similar socio-economic, geographic, and climatic conditions have been identified through a number of interviews with national, regional and international actors. The reviews of relevant literature will continue throughout the course of the TA, to expand the bibliography presented in this report. Stakeholder consultations were undertaken with key proponents of SRI, including CHAP, FAO and Africa Rice; as the TA progresses, further consultations will be undertaken with others involved in projects / programmes in Liberia and internationally to learn the lessons from their experience, and any findings will be recorded in subsequent reports.

1.8. Activity 1.6: Identifying Challenges and Requirements in the Context of Irrigation and Rice Cultivation Practices

Improving cultivation practices with better nutrient management and good quality seeds can visibly increase rice yields. However, the challenges and recommendations for irrigation and rice cultivation customized to the selected county (taking gender and youth into consideration) are detailed in the report.

Environmental challenges include erosion of topsoil during the rainy season, iron toxicity (especially lands in the Bong Mine area after iron ore exploration), blast disease, birds and common pests (i.e., stem borer, caseworm, and gall midge), water management difficulties, and a lack of functional irrigation systems as most lowland systems are rainfed.

Social challenges include the limited uptake and implementation of SRI adaptations by farmers in the lowlands; lack of ownership by locals in some areas; slow response to pest and disease infestation; limited capacity in the areas of nursery management, planting in rows, levelling, weeding, and time available for field work. Farmers insufficiently trained for the uprooting and transplanting of young seedling and water level maintenance during the early stage of the crop growth in SRI - with maintaining alternate wetting and drying a key component of SRI. The high labour needed for land preparation, weeding, and planting of seedlings is an additional challenge, with the planting of seedlings also needing high attention. Poor land preparation can also result in temporary nutrient deficiency.

Farmers not completing follow up work like extending potential areas, irrigation structures not being regularly maintained and repaired, and channels not being cleaned properly / regularly to maintain an easy flow of water present additional challenges. High post-harvest losses can be experienced due to farmers negligence in following post-harvest technologies.

It is necessary for the beneficiary communities to be involved in securing the security of SPIS equipment, but this would likely require a direct financial incentive.

To support easy and timely land preparation whilst reducing labour costs there is a need for the distribution of Power Tillers. Additionally, to ease wedding operations manual drawn mechanical devices should be promoted. However, the poor road network presents difficulties in moving farm machinery between farms, and for staff and extension worker’s travel.

In absence of the Seed Act, there is no regulation of the seed certification process, and challenges with poor quality seed; along with mixed varieties, and limited milling capacity affect the quality of the milled rice.

Economic challenges include that the pricing of paddy and milled rice requires a collaborative approach so that farmers and buyers receive equal treatment, and a lack of access to market and agriculture financing.

2. Introduction

2.1. Background

Agriculture in Liberia is predominantly rain-fed, with heavy dependence on consistent rainfall, yet climate change is posing serious challenges to all sectors and is threatening the sustainability of agricultural production in the country. As a result of prolonged dry seasons, there is a trend to change the farming calendar and many farmers are moving to lowland areas where there is longer access to water resources (The Environmental Protection Agency of Liberia (EPA), 2019). In response, the Government of Liberia is investigating the adoption of Solar Powered Irrigation Systems (SPIS) and a System of Rice Intensification (SRI), to increase rice yields in the country whilst lowering water usage by applying crop-targeted drip irrigation, thereby ensuring sustainable use of the limited available surface and ground water resources. Also, due to the high cost of electricity, and its potential for contributing to climate change, irrigation water pumping is to be powered by solar systems.

2.1.1. Benefits of Irrigation Technology in the Agriculture Sector

Potential benefits of adopting irrigation technology in the agriculture sector include:

- Irrigation serves as an important tool to safeguard yields of agricultural crops in an increasingly dry climate; it ensures resilience in the increasingly dry conditions projected in Liberia and as the future levels of natural moisture in the soil are depleted.
- SPIS reduces water and energy consumption for irrigation needs in agriculture as an adaptation to climate change and as a driver towards more sustainable energy sources and reduced carbon footprint from fossil fuels.

Irrigation is the most climate-sensitive use of water; the yields and profitability of irrigated land relative to dryland farming tend to increase as conditions become hotter and drier.

2.1.2. Liberian Context

Liberia is a small West African state with borders in the north with the republic of Guinea, in east with Ivory Coast, in the west, with Sierra Leone and in the south with the Atlantic Ocean. The total land area is estimated at 11,137,000 ha (Food and Agriculture Organization of the United Nations (FAO), 2002). In 2002, the total cultivated area (arable land and area under permanent crops) was estimated at 600,000 ha. The arable land (annual crops) estimated at 380,000 ha and the area under permanent crops accounted for 220,000 ha. The population estimated in 2008 by Liberia Institute of Geo-Information Services (LIGIS) was 3.5 million people, of which 52% lives in rural communities with the population density of 31 inhabitants per km^2. Agriculture is a major sector of Liberia employing more than 70% of the population.

However, climate change is posing serious challenges to Liberia's predominantly rain-fed agriculture system, threatening sustainable agricultural production in Liberia. Recent data obtained by the EPA shows that warmer temperatures are affecting food crops production and impacting livestock as well[1]. Farmers are complaining about the fluctuation in rain patterns. Observations have shown that May and June are wetter than expected and this carries implication for farm productivity. May and June are predominant planting periods for farmers especially those engaged in upland agriculture in Liberia. Excessive rain during this time of the year washes away plant seeds and sprouting plants thereby causing low productivity (EPA, 2019). This has led to low food production by the

[1] Historical climate change scenarios suggest increased average annual temperatures of 0.8°C throughout the country, and a 15.7% increase of hot nights which lead to a decline in mean annual rainfall.

majority of the rural population of Liberia that depend almost entirely on food crop production as their source of livelihood and income generation.

All of these impacts are happening as Liberia is still recovering from the 14 unbroken years of civil conflict, which ruined some major agricultural infrastructure (e.g. farm electricity supplies), and coupled with the global recession, Ebola and COVID-19. Prior to the war, there were estimates about the irrigation potential in the country (FAO, 2004). Today, there is little or no information about full or partially controlled irrigation in Liberia; surface irrigation, sprinkler irrigation, localized irrigation, percentage of area irrigated from groundwater or from surface water.

The project seeks support to upscale lowland rice production through SPIS irrigation technology, coupled with systems of rice intensification (SRI).

2.1.3. CTCN

The Climate Technology Centre and Network (CTCN) is the operational arm of the United Nations Framework Convention on Climate Change (UNFCCC) Technology Mechanism and co-hosted by the United Nations Environment (UN Environment) in collaboration with the United Nations Industrial Development Organization (UNIDO) and supported by 11 partner institutions with expertise in climate technologies. The mission of the CTCN is to promote accelerated development and transfer of climate technologies at the request of developing countries for energy-efficient, low-carbon and climate-resilient development.

A request for Technical Assistance (TA) was submitted to the CTCN by the National Designated Entity (NDE) of Liberia, Mr. Christopher B. Kabah TNA National Coordinator Environmental Protection Agency (EPA) of Liberia.

2.1.4. Technical Assistance Basic Information

The Technical Assistance (TA) Basic Information is provided in Table 2-1 below.

Table 2-1 - Technical Assistance (TA) Basic Information

Basic Information	
Title of Response Plan	Upscaling Lowland Rice Production to improve food security through improved solar powered irrigation practices
Technical Assistance Reference Number	AFCIA 2021000017
Country / Countries	Liberia
NDE Focal Point and Organisation	Mr. Christopher B. Kabah TNA National Coordinator Environmental Protection Agency of Liberia kabahchristopher@gmail.com
Sector(s) Addressed	Renewable Energy Agriculture
Technologies Supported	Solar Powered Irrigation Systems (SPIS) i.e., solar water pumps with crop-targeted drip irrigation system.
Implementation Period and Total Duration	22/11/2021 - 17/02/2023 (14 Months)
Total Budget for Implementation	USD 233,825
Designer of the Response Plan	CTCN
Implementer of Response Plan	CARES Limited and INTEGRATION environment & energy GmbH

2.2. Objectives

The objective of the TA is to introduce solar powered irrigation technology and practices to intensify rice cultivation and production in one lowland county in Liberia, to be selected between Lofa and Bong, with the intention of upscaling the technology as an adaptation measure to climate change at a national level. To achieve this objective, the TA has been divided into six main outcomes, as follows:

- Outcome 1: Analyse the current irrigation and rice cultivation practices in one county of Liberia
- Outcome 2: Design appropriate irrigation and solar water pumping technologies for SRI based farming in the selected county
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- Outcome 4: Pilot a small-scale implementation of the solar pumping system in the selected county
- Outcome 5: Elaborate and disseminate training materials and workshops
- Outcome 6: Formulate an enabling environment roadmap and a M&E framework.

2.3. Scope of Work

The detailed scope of work is outlined in the following outcomes and activities:

Outcome 1: Analyse the Current Irrigation and Rice Cultivation Practices in Liberia

- Activity 1.1: Map relevant stakeholders and establish a stakeholder working group.
- Activity 1.2: Conduct a virtual inception meeting
- Activity 1.3: Diagnose current irrigation system in Bong and Lofa
- Activity 1.4: Select best pilot sites between Bong and Lofa
- Activity 1.5: Benchmark international best irrigation practices in SRI from countries with similar socio-economic, geographic and climatic conditions
- Activity 1.6: Identify challenges and requirements in the context of irrigation and rice cultivation practices, taking into account specific barriers for women and youth

Outcome 2: Design Appropriate Irrigation and Solar Water Pumping Technologies for SRI Based Farming in the Selected County

- Activity 2.1: Gather data to understand the demand side of the fit-for-purpose SPIS
- Activity 2.2: Collect data to define PV pump system and irrigation infrastructure (supply side)
- Activity 2.3: Define the configuration of the SPIS

Outcome 3: Select Appropriate SPIS Technology

- Activity 3.1: Elaborate fact sheets on appropriate technologies for the SPIS configuration defined
- Activity 3.2: Define cost estimation of the identified technologies under the configuration designed
- Activity 3.3: Organize a one-day workshop with the stakeholder working group
- Activity 3.4: Organize a 3-hours stakeholders' workshop to present the selected technology

Outcome 4: Pilot a Small-Scale Implementation of the Solar Pumping System in the Selected County of Liberia

- Activity 4.1: Choose a plot in the selected county for a small-scale pilot implementation of the selected SPIS
- Activity 4.2: Plan the implementation of the pilot project
- Activity 4.3: Organize an online meeting to discuss the logistics and implementation of the pilot
- Activity 4.4: Route the technology to the selected area
- Activity 4.5: Implement the small-scale project in the pilot area

Outcome 5: Elaborate and Disseminate Training's Materials and Workshops

- Activity 5.1: Redact a detailed manual on the use and maintenance of the technology

- Activity 5.2: Organize a learn by doing workshop
- Activity 5.3: Organize a stakeholder consultation workshop
- Activity 5.4: Organise a training to Municipal and National officers

Outcome 6: Formulate an Enabling Environment Roadmap and M&E Framework

- Activity 6.1: Design a M&E Framework
- Activity 6.2: Formulate an enabling environment roadmap to scale up the use of SPIS
- Activity 6.3: Organize a workshop with municipal and national officers to present the M&E and enabling environment roadmap
- Activity 6.4: Train rice farmers on the M&E framework

In addition, a Monitoring and Evaluation (M&E) Plan has been developed which provide indicators along with quantitative and qualitative estimations that will be revised and compared at the closure of the project to understand if the assignment has overcome / achieved or missed the expected results of the project. The M&E Plan is provided in the appendices.

2.4. CARES/INTee Team

CARES are leading the TA assignment; they are an international engineering, environmental and water resources consultancy with a focus on Africa, and their Team staff involved to date comprise the following members:

- Oliver Taylor (Team Leader / Water Resources Expert)
- Sanco Lysander (Gender Expert)
- Rajendra Uprety (Expert in Rice Production/SRI)
- Pandian Balamurugan (Rice Production Expert)
- George Oboli (Communication Expert)
- Matthew Baker (Environmental Specialist)
- Yaw Asare (Office Manager, Liberia).

Partnered with CARES, INTEGRATION Environment & Energy Team (INTee) provides expertise in technical assistance, training and carrying out consulting assignments in emerging markets and developing countries, focussing on the solar energy and pumping aspects, with the following team members involved to date:

- Yalun Jin (Energy Consultant)
- Muhammad Imran (Expert in Solar Irrigation Pumping System)
- Frankie Eckersley-Carr (Expert in GIS and Data Management)
- Dr Ulrich Frings (Expert in Solar Irrigation Pumping System).

2.5. Report Scope and Structure

This report provides an update on work conducted to provide the first outcome of the Technical Assistance:

Outcome 1: Analyse the Current Irrigation and Rice Cultivation Practices in Liberia

Activities undertaken to provide this outcome and the relevant chapter in this report are provided in Table 2-2.

Table 2-2 - Activities in Outcome 1

Activity		Chapter
1.1	Map Relevant Stakeholders and Establish a Stakeholder Working Group	3
1.2	Conduct a Virtual Inception Meeting	4
1.3	Diagnose Current Irrigation System in Bong and Lofa	5
1.4	Select Best Pilot Sites between Bong and Lofa	6
1.5	Benchmark International Best Practices in SRI from Countries with Similar Socio-Economic, Geographic and Climatic Conditions	6

3. Stakeholder Mapping Report

3.1. Stakeholder List

The Team have identified and mapped all relevant stakeholders at the national and sub-national levels that are likely to have an interest or involvement in the assignment or in the later roll-out of implementation to the entire country. The stakeholders include beneficiaries, potential technical and financial partners, farmers, and Water Users Associations (WUAs). The results of the Stakeholder Mapping are presented in Table 3-1 below.

Table 3-1 - Stakeholder Mapping

No	Organisation	Brief Description of Organisation	Details of Individuals Identified	Inform	Consult	Involve		Collaborate
				Report	Interview	Workshop	1-to-1	Steering Group
1.	Climate Technology Centre & Network (CTCN)	UNFCCC Technology Mechanism - promoting accelerated development of climate technologies (TA Funder)	Nadege Trocellier *(Climate Technology Specialist - Africa, CIS, and West Asia)*	✓	✓	✓	✓	
2.	Ministry of Agriculture (MoA)	Ministry with responsibility for the development of agriculture.	Halala Willie Kokulo *(Director, Division of Land and Water Resources)* Hn. Jeanine Milly Cooper *(Minister)* Hn. Robert Fagans *(Deputy Minister for Planning and Development)* Madam Leelia Andrews *(Deputy Minister for Technical Services)* Williametta Woods *(SA to Minister)* Marcia Smith *(Minister Office Staff)* Thomas Gbokie *(Technical Advisor to Minister)* Sylvester Taylor *(Financial Management Advisor)* Aurelia Harris *(SA Deputy Minister Technical Services)* Dennis Wiagbe *(Head M&E)*	✓	✓	✓	✓	✓

No	Organisation	Brief Description of Organisation	Details of Individuals Identified	Inform	Consult	Involve		Collaborate
				Report	Interview	Workshop	1-to-1	Steering Group
3.	Environmental Protection Agency (EPA)	Regulatory Agency responsible for sustainable management of the environment and natural resources.	Christopher Kabah *(Department of Planning and Policy)* Prof. Wilson Tarpeh *(Director / CEO)*	✓	✓	✓	✓	✓
4.	Selma Agriculture Development Company (SADC)	Rice aggregation and processing company, producing milled rice for marketing to the general public. Maintains a small farming operation growing upland and lowland rice and provides technical and financial support to enhance farming activities for large scale rice production.	John Selma *(CEO)*	✓	✓	✓		
5.	KK Farms Inc., Kakata	Diversified agriculture farming including rice near Bong mine and has the near future plan to install Solar power system	Krishnan (Director of the company)	✓	✓	✓		
6.	Central Agriculture Research Institute, Bong	Semi-autonomous research agency of the MoA, responsible for coordination of the National Agriculture Research Program	Walter Wiles *(Director General)* Dr Victor Sumo *(Director General)*	✓	✓	✓	✓	✓
7.	The Africa Rice Center (AfricaRice)	A CGIAR Research Center / Pan-African Centre of Excellence for rice research, development and capacity building. Contributes to reducing poverty, achieving food and nutrition security and improving livelihoods of farmers and other rice value-chain actors by increasing the productivity and profitability of rice-based agri-food systems, while ensuring the sustainability of natural resources.	Roland Huhu Dr. Issaka *(Land and Water Management Specialist)* Dr. Kazuki Saito *(Principal Scientist)* Harold Roy-Macauley *(Regional Director, East & Southern Africa)* Dr Akintayo Inoussa *(Country Director)*	✓	✓	✓	✓	✓

No	Organisation	Brief Description of Organisation	Details of Individuals Identified	Inform	Consult	Involve		Collaborate
				Report	Interview	Workshop	1-to-1	Steering Group
8.	BRAC Liberia	NGO operating social development programmes in agriculture, food security and livelihood, education, ultra-poor graduation, youth empowerment, health, and microfinance.	Aisha Nansamba *(Acting Country Representative)* Adolphus Doe *(Acting Country Director)*	✓	✓	✓		
9.	Community of Hope Agricultural Project (CHAP)	NGO acting as the focal point organization on SRI in Liberia with support from IFAD, the World Bank, CNS-Riz, SRI-Rice and Abide in the Vine Fellowship.	Robert Bimba *(Founder)*	✓	✓	✓	✓	✓
10.	FAO	UN Agency leading international efforts to defeat hunger.	Mariatou Njie *(FAO Representative in Liberia)*	✓	✓	✓	✓	
11.	Montserrado County	County containing Liberia's national capital, Monrovia.	Jimmy Smith *(Montserrado District Representative)*			✓		
12.	Scaling up Climate Resilient Rice Production in West Africa (RICOWAS) Project	Project to improve climate resilience and increase the productivity of the rice system of smallholder rice farmers in West Africa. Funded by Adaptation Fund (AF).	Erika Styger *(Prof. of Practice, Director - Climate Resilient Farming Systems, Department of Global Development, College of Agriculture and Life Sciences, Cornell University)*	✓	✓	✓	✓	
13.	Liberia Rural Women Association (LIRWA)	Member of the Women Organizing for Change in Agriculture and Natural Resource Management (WOCAN) Network. WOCAN designs and manages award-winning programmes that advance the role of women and gender in agricultural and natural resource management	Kebbah Mongar	✓	✓	✓		
14.	The Fuamah District Multipurpose Cooperative	A cooperative of 526 members active in lowland rice production on 300 acres. Located in Bong Mines, Bong.	James Wonnie *(Chairman)*	✓	✓	✓		

No	Organisation	Brief Description of Organisation	Details of Individuals Identified	Inform	Consult	Involve		Collaborate
				Report	Interview	Workshop	1-to-1	Steering Group
15.	Liberia Rice Farmers Federation		Mohammed Kamara *(President)*	✓	✓	✓		
16.	Ministry of Mines and Energy (MME)	Lead agency in attracting private investment in resources exploration and development through provision of geoscientific information on minerals and energy resources, and management of an equitable and secure titles systems for the mining, petroleum and geothermal industries. Also carries prime responsibility for regulating extractive industries and dangerous goods in the country, including the collection of royalties, and ensuring that HSE standards are consistent with the relevant legislation, regulations and policies.	Gesler Murray *(Minister)*	✓	✓	✓		✓
17.	Liberia Land Authority (LLA)	Autonomous government agency with three key functions: Land Governance, Land Administration, and Land Use and Management.	Hon. J. Adams Manobah *(Chairman)*	✓	✓	✓	✓	✓
18.	World Food Programme (WFP)	World's largest humanitarian organization, saving lives in emergencies and using food assistance to build a pathway to peace, stability and prosperity for people recovering from conflict, disasters and the impact of climate change.	Karla Hershey *(Country Representative)*	✓	✓	✓		

No	Organisation	Brief Description of Organisation	Details of Individuals Identified	Inform	Consult	Involve		Collaborate
				Report	Interview	Workshop	1-to-1	Steering Group
19.	Welthungerhilfe (WHH) Liberia	WHH is a non-denominational and politically independent non-profit and non-governmental aid agency working in the fields of development cooperation and humanitarian assistance. WHH goal is to end hunger and poverty	Troken Bryant *(Head of Program)*	✓	✓	✓		
20.	Ministry of Gender, Children and Social Protection (MoGCSP)	Responsible for policy formulation, coordination, and M&E of gender, children, and social protection issues within the context national development agenda.	Williametta Saydee-Tarr *(Minister)*	✓	✓	✓		
21.	College of Agriculture and Forestry, University of Liberia	Faculty within the University of Liberia with departments in General Agriculture, General Forestry, Agronomy, Home Science and Community Development, Wood Science and Technology, and Agricultural Extension.	Leroy Cegbe *(Dean, College of Agriculture and Forestry)*	✓	✓	✓		
22.	Cuttington University	Private University issuing degrees in the liberal arts and technical studies.	Washington Willie *(Dean, College of Agriculture and Forestry)*	✓	✓	✓		
23.	Bong County Ministry of Agriculture	Bong County arm of the MoA.	Gasoni Watson *(Dept of Agriculture, DOA)*	✓	✓	✓	✓	✓
24.	Regional Agriculture Coordinator	Ministry of Agriculture	Moses Gbanyam *(RAC, Bong, Nimba, and Lofa)*	✓	✓	✓	✓	✓
25.	County Agriculture Coordinator	Ministry of Agriculture	Henry Darkor *(CAC, Lofa County)*	✓	✓	✓	✓	✓
26.	Liberia National Meteorological Centre	Meteorological department under the Ministry of Transport providing meteorological data for 29 cities		✓	✓	✓		

No	Organisation	Brief Description of Organisation	Details of Individuals Identified	Inform	Consult	Involve		Collaborate
				Report	Interview	Workshop	1-to-1	Steering Group
27.	Ministry of Public Works	Engineering ministry responsible for surveying, drafting and designing construction contracts, and the maintenance of roads, bridges, and public buildings.		✓	✓	✓		
28.	Ministry of Commerce and Industry	Ministry responsible for promoting and regulating commerce, trade and industry.		✓	✓	✓		
29.	USAID Liberia	USAID carries out U.S. foreign policy by promoting broad-scale human progress at the same time it expands stable, free societies, creates markets and trade partners for the United States, and fosters good will abroad.		✓	✓	✓		
30.	Forestry Development Authority (FDA)	Semi-public autonomous corporation, with the mandate to sustainably manage and conserve Liberia's forests and related resources.		✓	✓	✓		
31.	Fuamah District Police	Police force in Fuamah District	*(Police Commander, Fuamah District)*	✓	✓	✓		
32.	Ministry of Internal Affairs	Ministry with mandate for development of rural communities, and urban centres throughout the country. Some of the projects are undertaken directly on government funding, while others are funded by development partners, such as: schools; roads and bridges; local administrative buildings; clinics; peace huts; markets; latrines; commissioners' residences; wells; etc.		✓	✓	✓		
33	Liberia Institute of Statistics and Geoinformation Services	Responsible for collating all data related to climate change in Liberia		✓	✓	✓		

3.2. Stakeholder Working Group

The results of the Stakeholder Mapping were used to form a Stakeholder Working Group (SWG). The list of initial SWG members is provided in Table 3-2 below.

The budget limits the number of members to eight and the membership will need to be flexible to meet the needs of the TA, with both the capacity and authority to make decisions of the design of the SPIS and ensure that these align with Liberian strategic priorities. As the work progresses and focusses more on a specific site, the SWG membership may need to change to a more suitable balance and diversity of skills, including members representing women and vulnerable groups from the selected county and site, therefore a number of names have been included as provisional at this stage.

The SWG will hold their first meeting on Wednesday 30 March 2022, and the minutes of this meeting are included in the Appendices, with key discussion points and decisions incorporated in the final version of the report.

Table 3-2 - List of Proposed Initial Members in the Stakeholder Working Group

No.	Name of Individual	Organization / Role	Mobile No.	Email Address	Reason for Engaging	Gender
1.	Robert Bimba	CHAP, Executive Director	0886543735/ 0770155844	robertbimba@yahoo.com r.bimba@chap-lr.org	Pioneer in rice production and research in indigenous technologies. National Coordinator for the Farmer Union Network (FUN) and country contact for RICOWAS project.	M
2.	Mohammeh Kamara	Liberia Rice Farmers Federation, President	0777848010/ 0886620185	mkamara902002@yahoo.com	Rice farmer and processor. (CEO for the Agriculture Infrastructure Investment Company (AIICO))	M
3.	Dr. James Dolo	CARI, Researcher / Plant Breeder	0776333586/ 0881302181	dolo.james@gmail.com	Researcher based at CARI	M
4.	Dr. Akintayo Inoussa	Africa Rice Center, Liberia, Country Director	0770750547/ 0880946266	i.akintayo@cgiar.org	Africa Rice was previously the West Africa Rice Development Association (WARDA)	M
5.	Olivia K. David	Liberia Land Authority, Gender Coordinator	0777912393/ 0886796512	oliviadavid@gmail.com	Advisor on the process and issues relating to gender and land acquisition, and avoiding conflict	F
6.	Anthony Kullie	Ministry of Mines and Energy, Director Liberian Hydrological Service	0886603638/ 0777000838	mrkullieson@yahoo.com	Advisor on the process on issues relating to the availability of potential water sources	M
7.	Moses Gbanyan	Ministry of Agriculture, Region Agriculture Coordinator (RAC) Bong, Nimba and Lofa	0776390617	Robertmoses1977@gmail.com	For regional coordination	M
8.	Mariatou Njie	FAO Representative in Liberia	0776737524/ 0776737530	FAO-LR@fao.org / Mariatou.Njie@fao.org	Co-ordination with other agricultural development activities in Liberia	F
9.	Zipporah Page	CARI Researcher	0777272723		Researcher at CARI	F
Provisional/Alternate Members						
10.	Gasoni Watson	Ministry of Agriculture, District Agriculture Officer (DAO), Bong	0778625911		For extension purposes and farmer's outreach	M
11.	Henry Darkor	Ministry of Agriculture, County Agriculture Coordinator (CAC), Lofa	0770075946/ 0886521357	htdarkolon77@gmail.com	For extension purposes and farmer's outreach	M
12.	Tewa L. Blama	Executive Director; Mayor River Women Initiative	0778326376	tewal.blama@yahoo.com	Farmer and director of Women's group at Ndama in Lofa County	F

4. Inception Meeting Report

The Inception Meeting was held on the 25 January 2022; it was originally planned to be undertaken on a virtual basis, however, following requests, a hybrid physical-virtual meeting was held to enable participation of key stakeholders without internet facilities. Those participants attending physically gathered at conference room of the Ministry of Agriculture, Monrovia, with other attending virtually via MSTeams.

On behalf of the Deputy Minister of the Department of Technical Services, Ministry of Agriculture, invitations were circulated to the stakeholders by Halala Kokulo. The invitation letter and circulation list are provided in the appendices.

4.1. Presentation Materials

The Agenda for the Inception Meeting and the associated presentation materials covered the following key points:

- Introductions
- Context
- Project Aims & Objectives
- Methodology
- Workplan
- Questions & Answers
- Initiating the Stakeholders Working Group

A copy of the PowerPoint presentation is provided in the Appendices.

4.2. List of Participants

The list of the Inception Meeting participants is provided in Table 4-1 below.

Table 4-1 - Inception Meeting Participants

No.	Name	Institution	Physical / Online	Gender
1	Sanco Lysander	CARES	Physical	M
2	Isaac Yaw	CARES	Physical	M
3	Robert Bimba	CHAP SRI	Physical	M
4	Mohamed Kamara	NRFL	Physical	M
5	Henry Darkolon	MoA Lofa	Physical	M
6	Moses Gbanyan	MoA	Physical	M
7	Garsonide Watson	MoA	Physical	M
8	James Wonkie	FDMCS	Physical	M
9	Leelia Andrews	MoA	Physical	F
10	Halala Kokulo	MoA	Physical	M
11	Fester Tiah	MoA	Physical	M
12	Oliver Taylor	CARES	Online	M
13	Matthew Baker	CARES	Online	M
14	Yalun Jin	INTee	Online	F
15	Balamurugan Pandian	CARES	Online	M
16	Jobson Momo	Guest	Online	M
17	Nadege Trocellier	CTCN	Online	F
18	Rajendra Uprety	CARES	Online	M
19	George Oboli	CARES	Online	M
20	Adolphus	Guest	Online	M
21	Frankie Eckersley-Carr	INTee	Online	F
22	James Dolo	Guest	Online	M
23	Akintayo Inoussa	AfricaRice Liberia	Online	M
24	Chris Kabah	EPA	Online	M
25	Dagnoko Mariatou	FAOLR	Online	F
26	DMT	Guest	Online	M
27	Theophilus Baah	Guest	Online	M
28	Anthony Kullie	Guest	Online	M
29	Roosevelt Reeves	MoA	Online	M
30	Tom-Wesley Korkpor	Guest	Online	M

4.3. Summary of Meeting

The Minutes of the Inception Meeting are provided in the Appendices.

The Inception Meeting included welcome remarks, introductions of invited stakeholders, and a presentation by CARES and INTee on the project context, aims and objectives, and work plan.

Following the presentation, the key issues discussed included:

- **Equipment Security** - Discussions were held over security measures that may need to be implemented to protect the equipment on site**.** Security approaches discussed focussed upon the involvement of beneficiary communities. Discussions included the need to consider providing a financial incentive.

- **Water Sources** - Issues surrounding water sources (i.e., groundwater versus surface water), and the likelihood that existing water sources will be utilised.
- **Seasonality** - The need to plan the project considering the timing of the dry season and rainy season (starting in June and ending in October).
- **Performance Indicators** - Productivity, cropping intensity, and diversity of crops will be the three main indicators of performance. The scheme will aim to intensify production by greater yields, extending cropping seasons (up to 3 times a year), and including vegetables in addition to rice.
- **Constraints** - Causes of low yields in Liberia identified to include limited uptake and implementation of SRI adaptations by farmers in the lowlands, limited inputs, and topsoil erosion during the rainy season. Whilst challenges for SRI adoption identified to include cost of inputs, labour, technology, adoption of planting methods.
- The following existing studies, programmes, projects and data were mentioned, with attendees noting their willingness to share information with the Team:
    - CHAP study on pests and diseases of SRI in different ecological zones of Liberia.
    - Yield data available from 2012 for 1,800 farmers implementing SRI Technologies in Lofa County.
    - Report on SRI yields across plots in all areas of the country is available, based on funding by African Development Bank (AfDB).
    - GIS information held by FAO Liberia.
    - A project funded from Dubai is testing salinity resistant varieties for 12 crops, including rice, and is using SPIS technologies to irrigate.
- **SWG Establishment** - 8 SWG members with a suitable balance of skills to provide both capacity and authority, including vulnerable groups and women, were identified. It was agreed that the MoA would finalise the membership and that the election of the SWG Chair and Co-chair would be on the agenda of their inaugural meeting.

5. Irrigation and Rice Production in Liberia

This chapter presents a diagnosis / assessment of the current irrigation systems used in Liberia for rice production and the adoption of SRI practices. Two complementary approaches have been used to achieve this: a literature review and stakeholder consultation, to provide an assessment of SRI and rice production systems currently used in Liberia.

5.1. Literature Review

This section provides a summary of relevant laws, policies and institutions relevant to the TA, as well as some of the technical reports and studies relating to SPIS and SRI in Liberia. These have been reviewed in the course of the studies to date and will be further expanded on throughout the course of the TA, to develop a detailed bibliography of relevant literature.

5.1.1. Legislative Framework

5.1.1.1. Environment Protection Agency Act of Liberia (2002)

The Environment Protection Agency Act of Liberia (2002) establishes the Environmental Protection Agency of Liberia (EPA) as the main agency and principal authority for environmental management within Liberia, thereby establishing the overall institutional framework for sustainable management of the environment in Liberia (USAID, 2008). The EPA was created by a legislative Act on the 26 November 2002. This established the EPA with authority to protect and manage the environment and tasked EPA as the authority responsible for monitoring, coordinating, and supervising sustainable management of the environment.

5.1.1.2. Environmental Protection and Management Law (EPML)

The Environmental Protection and Management Law of Liberia (EPML) provides the legal framework for sustainable development, management and protection of the environment and natural resources by EPA in partnership with relevant ministries, autonomous agencies, and organisations, as well as in a close and responsive relationship with the people of Liberia. It addresses a wide range of environmental issues, including environmental impact assessment, guidelines and standards, international obligations, education, and awareness (EPA, 2021).

5.1.1.3. The Land Rights Act

The Land Rights Act was passed into law on August 23, 2018 by the Liberia National Legislature and signed into law by President George Weah on September 19, 2018. The new law is progressive and was shaped from the grassroots. However, there are still challenges to its successful implementation which would help to minimize land conflicts between local communities and agricultural and forestry concessions (IFAD, 2019).

5.1.1.4. United Nations Framework Convention on Climate Change (UNFCCC)

Liberia joined the United Nations Framework Convention on Climate Change (UNFCCC) in 2002 (IFAD, 2019).

Liberia is one of the first recipients of the Green Climate Fund and a signatory to the 2015 Paris Climate Change Agreement. Africa's first Green Climate Fund-financed project to support National Adaptation Plans was launched in Liberia in August 2018. The National Adaptation Plans project kicked off on 12 March in Monrovia and benefits from US$2.3 million in financing from the Green Climate Fund (GCF) (IFAD, 2019).

5.1.1.5. The Paris Agreement

The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016. Implementation of the Paris Agreement requires economic and social transformation, based on the best available science. The Paris Agreement works on a 5- year cycle of increasingly ambitious climate action carried out by countries. By 2020, countries submit their plans for climate action known as nationally determined contributions (NDCs) (UNFCCC, 2022).

Liberia's NDC categorizes the country as a net carbon sink and emphasizes the importance of the agriculture sector for climate change mitigation and adaptation. Mitigation actions focus on renewable energy and energy efficiency, whilst adaptation options include the development of climate-resilient crop species and sustainable forest management (IFAD, 2019).

Liberia's revised NDC addresses nine key sectors: agriculture, forests, coastal zones, fisheries, health, transport, industry, energy, and waste - as well as cross-cutting targets for urban green corridors (EPA, 2021).

The mitigation target related to agriculture is to reduce agricultural GHG emissions by 40% below Business As Usual (BAU) levels by 2030 (reduction of 13 $GgCO_2e$), through promoting low-emissions rice cultivation and reducing the burning of field residues. Mitigation actions and policy measures for agriculture include:

- Roll out incentives and programs to promote low-carbon agriculture practices, e.g., conservation agriculture, no / low tillage, agro-silvopastoral systems, improved lowland rice cultivation, multi-cropping, organic fertilizers, fertigation, composting, crop rotation, and sustainable agricultural waste management.
- Implement sustainable, low-carbon development of 150,000 ha of lowland crop systems, 500,000 ha of upland sedentary crop systems, and 500,000 ha of pastureland by 2030;
- Ensure 1,500 agricultural households adopt sustainable agriculture, animal husbandry, soil conservation, and organic / manure management practices by 2030 *(Link to Health sector);*
- Allocate $400,000 per year in funding for research on sustainable agricultural production and GHG mitigation potential from the agriculture and livestock sectors in Liberia by 2025, conditional upon international support;
- Increase training and capacity building of farmers and agricultural extension agents to implement mitigation actions in the agriculture sector
- Establish 100 farmer field schools and train at least 5,000 farmers to implement conservation agriculture, soil carbon sequestration methods, and low-emissions livestock systems by 2025 *(Linked to Adaptation target)*
- Train at least 3 agricultural extension agents per district yearly to support implementation of conservation agriculture, soil carbon sequestration, and low-emissions livestock systems by 2025 *(Linked to Adaptation target)*
- Deploy at least 1 solar water pump and/or spring irrigation system for crop irrigation for communal farms with land constraints in each county by 2030.
- Develop programs and policies to incentivize the establishment of new agricultural areas on open and / or degraded lands by 2025 (Link to Forest sector).
- Develop policy and incentives frameworks to implement low-emissions practices in the production and processing systems of key commodity agriculture and tree crop value chains, e.g., oil palm, rubber, cocoa, rice, sugar cane, cassava, bananas by 2030.
- Link agricultural development with the National REDD+ Strategy by 2025.

The relevant adaptation targets for agriculture include developing incentives and programs to promote crop and livestock diversification, climate resilient seeds, Integrated Pest Management (IPM), water harvesting, irrigation systems, increased soil fertility. Adaptation actions and policy measures for agriculture include:

- Increase training and capacity building of farmers and agricultural extension agents to implement climate adaptation actions in the agriculture and livestock sectors, especially by increasing support for education and training on agricultural climate risks and adaptation solutions for vulnerable groups
- Establish 100 farmer field schools and train 5,000 farmers in climate-resilient agricultural and livestock practices by 2025 (*Linked to Mitigation target*)
- Train 150 agricultural extension agents per year to support implementation of climate-resilient agricultural and livestock practices, with 45 agents receiving additional support for increased implementation with vulnerable groups by 2025 (*Linked to Mitigation target*)
- Roll out a "Women in Agriculture" program with 4 training sessions per year (with at least 45 women trained per year) to support implementation of climate-resilient agricultural and livestock practices and increase women's access to agricultural inputs and labour-saving devices by 2025.
- Increase finance for agriculture and livestock diversification by $3,000,000 dollars by 2025.

- Strengthen the Environmental Knowledge Management System platform to increase the integration of local and indigenous knowledge of climate-resilient agricultural and livestock practices by 2025.
- Establish or strengthen crop and livestock insurance systems by 2025
- Strengthen agricultural climate services and early warning systems by 2025.
- Develop national dietary guidelines to support climate-resilient, food secure livelihoods by 2025 (*Link to Health sector*)
- Establish a national research institution focusing on new climate smart seed varieties and improving livestock breeding by 2030 (EPA, 2021).

5.1.2. Policy Framework

5.1.2.1. Integrated Water Resources Management Policy (2007)

This policy covers two broad areas: water resources management, and water resources use.

- Water Resources Management: The policy covers the water resources management framework including policy objectives, principles and strategies for the monitoring, assessment, allocation and protection of water resources.
- Water Resources Use: Covers the policy objectives, principles and strategies for the development and use of water for people (domestic water supply), water for food security (agriculture), water for industry and other water uses such as hydropower, recreation, Non-Revenue-Water (fire hydrants and trucks) and water for maintenance of productive ecosystems.

5.1.2.2. National Environmental Policy (NEP)

The National Environmental Policy (NEP) sets the policy framework for environmental management in Liberia (USAID, 2008). The objective of the NEP is to ensure sound management of resources and the environment, and the need to attempt to avoid resource exploitation in a manner that may cause irreparable damage to the environment (UN-Habitat, 2018). It seeks to ensure reconciliation and coordination between economic development and growth with the sustainable management of natural resources (EPA, 2021).

Liberia formulated the NEP to recognize the severe impact of human activities on all components of the natural environment, especially the influences of population dynamics, high density urbanisation, and resource exploitation, as well as recognizing the critical importance of restoring and maintaining environmental quality for the welfare and development of the people (EPA, 2021).

The NEP states that the Government of Liberia will:

- Commit itself to the sound scientific and sustainable use of natural resources
- Create environment awareness among all sections of the community
- Develop procedures for the utilization of land resources so as to ensure the maximum degree of economic value
- Require prior environmental impact assessments for all investments that may impact the environment
- Institute appropriate measures to control pollution and the importation and use of potentially toxic chemicals
- Take appropriate measures to protect critical ecosystems against harmful effects, or destructive practices
- Develop and maintain a professional agency to supervise, coordinate, implement and enforce procedures and legislation essential for safeguarding the environment
- Oblige all concerned to provide the relevant information needed for environmental protection and for the enforcement of environmental regulations and legislation
- Promote and support environmental research programs
- Establish an adequate legislative and institutional framework for monitoring, coordinating and enforcing environmental programs and issues.

The policy specifically calls for the creation of the EPA as an independent authority for the management of the environment.

5.1.2.3. National Gender Policy

The National Gender Policy aims to mainstream gender in national development (Feed the Future, 2017). The policy provides the framework and guidelines for mainstreaming gender and empowering women and vulnerable groups in national development processes (UN-Habitat, 2018). Other policy objectives are to enhance the empowerment of women and girls for sustainable, equitable development; and creating and strengthening gender responsive structures, processes, and mechanisms for development so that women and men participate equally, and have access to, and benefit from all of Liberia's resources (UN-Habitat, 2018).

5.1.2.4. National Health Policy

The National Health Policy aims to improve health through improved nutrition; the increased equitable access to quality health care services; improvements in prevention, control, and management of major diseases; and, increased access to quality social welfare services (UN-Habitat, 2018).

5.1.2.5. National Disaster Management Policy

The National Disaster Management Policy aims to enhance national and local capacity to minimise vulnerability and disaster risks; and to prevent, mitigate, and prepare for adverse impacts of hazards within the context of sustainable development (UN-Habitat, 2018).

5.1.2.6. Water Supply and Sanitation Policy

The Water Supply and Sanitation Policy aims to provide guidance and direction in institutional, economic, and legal reforms that will lead to improved water governance at national, local and community levels, and improved access to safe water supply and adequate sanitation, in an affordable, sustainable, and equitable manner, to all the peoples of Liberia (UN-Habitat, 2018).

5.1.2.7. National Forestry Policy

The National Forestry Policy aims to conserve and sustainably manage forests to ensure that they continue to produce a complete range of goods and services for the benefit of all Liberians, thereby contributing to poverty alleviation whilst maintaining environmental stability and fulfilling Liberia's commitments under international agreements and conventions (USAID, 2008).

5.1.2.8. National Energy Policy

The National Energy Policy aims to lay the foundation for creating an enabling environment for attracting private sector capital to the energy sector, restructuring and reforming energy institutions, decentralising energy service administration, full utilisation of domestic energy sources, and ensuring access to affordable and modern energy (UN-Habitat, 2018).

5.1.2.9. National Nutritional Policy

The National Nutritional Policy (NNP) was a five-year policy that was created in 2008 with the aim to create an enabling environment to facilitate the implementation of nutrition interventions. In 2018, the NNP was revised and updated based on new developments in the field of nutrition and best practices. The revised NPP emphasises multi-sectoral approaches to nutrition where relevant sectors collaborate to implement nutrition interventions to address both immediate and underlying determinants of undernutrition, along with the forming of new partnerships between government and key stakeholders (communities, development partners, private sector) that are critical for addressing the undernutrition problem (IFAD, 2019).

5.1.2.10. National Capacity Development Strategy

The National Capacity Development Strategy aims to integrate effective approaches to assess current capacities, identifying required capacities, and investing in collaborative initiatives to capitalise upon and further develop capacities in a sustainable manner across the core work of all sectors in Liberia (UN-Habitat, 2018).

5.1.2.11. The Liberian Poverty Reduction Strategy

The Liberian Poverty Reduction Strategy provides a framework for addressing the widespread poverty in Liberia. It proposes four pillars of action: ensuring secure and peaceful environment; revitalising pillar industries such as forestry, manufacturing, agriculture and fisheries; building efficient and effective institutions and systems; and,

providing better infrastructure and basic services (UN-Habitat, 2018). To oversee implementation of the framework, the Liberia Reconstruction and Development Committee chaired by the president was formed with members ranging from ministries to international development partners (UN-Habitat, 2018).

5.1.2.12.Pro-Poor Agenda for Prosperity and Development (PAPD) (2018 - 2023)

The Pro-Poor Agenda for Prosperity and Development (PAPD) Medium-Term Plan (PAPD 2018-2023) is a five-year national development plan that aims to address the basic needs of income security, access to basic services, and greater self-improvement opportunities, through an enabling environment that is inclusive and stable (EPA, 2021).

Its long-term goal is to raise the per capita income levels and economic status of Liberia to a middle-income country, as outlined under the Vision 2030 framework. The PAPD aligns with the African Union Agenda 2063 and Sustainable Development Goals (SDGs) across all three sustainability dimensions – economic, social, and environmental – with a special emphasis on human development and peace (EPA, 2021).

PAPD prioritizes: i) human capital development as cross-cutting foundation for the various social sectors; ii) reducing out of school rates and increasing retention and completion rates for girls and boys; iii) ensuring appropriate responses to Gender-Based Violence, as major thrusts under human capacity development; iv) reducing the maternal mortality rate in under five malnutrition of girls and boys; v) malnutrition prevention; and, vi) reducing women inequality in political, social, and economic life (IFAD, 2019).

PAPD recognizes the importance of the agriculture sector in the structural transformation of the economy, including by moving from subsistence to commercial farming in important value chains such as rice, cassava, horticulture, cocoa and oil palm (IFAD, 2019).

5.1.2.13.Liberia Agriculture Sector Investment Program (LASIP)

The Liberia Agriculture Sector Investment Program (LASIP), finalized in 2010, identifies priority for investment projects aligning national objectives with the Comprehensive African Agriculture Development Programme (CAADP). CAADP is an African-led program bringing together governments and diverse stakeholders to reduce hunger and poverty and promote economic growth in African countries through agricultural development (IFAD, 2019).

Under LASIP the government committed to increasing its budget share for agriculture from the current level of 3 percent to 10 percent over five years. The LASIP / CAADP Agriculture Sector Investment and Development Program has four major sub-programs including land and water development, food and nutrition security, competitive value chains and market linkages, and institutional development (IFAD, 2019).

5.1.2.14.The Second-Generation Liberia Agricultural Sector Investment Plan II

The Second-Generation Liberia Agricultural Sector Investment Plan II (LASIP II) covers the period 2018-2022 and has five major interrelated strategic components and policy objectives: (i) food and nutrition security; (ii) competitive value chain development and market linkages; (iii) agricultural extension, research and development; (iv) sustainable production and natural resource management; and (v) governance and institutional strengthening. LASIP II focuses on seven value chains: rice, cassava, horticulture, oil palm, cocoa, rubber and livestock (IFAD, 2019).

5.1.2.15.National Policy and Response Strategy on Climate Change

The National Policy and Response Strategy on Climate Change guides Liberia's efforts to address climate change. The policy aims to ensure that a qualitative, effective, and coherent climate change adaptation process takes place, and that can also serve as the pillar for comprehensive sectoral strategies and action plans.

The policy supports climate change adaptation, disaster risk management, and mitigation capacity in Liberia. It focuses on the implementation of Liberia's commitment to achieving the SDGs - especially SDGs 13, 14, and 15 which focus upon combating climate change and fostering sustainability. The policy also focuses on achieving Africa's vision for promoting positive socio-economic transformation over the next 50 years - as detailed in Agenda 2063 (adopted in 2013), which recognizes climate change and natural disasters as major threats to Africa's development now and in the future (EPA, 2021).

5.1.2.16.National Adaptation Program for Action

The National Adaptation Program for Action (NAPA) for prepared by EPA in 2008 to address manifestations of climate change such as coastal erosion, erratic rainfall patterns, flooding, and temperature increases (IFAD, 2019).

5.1.2.17.National Adaptation Plan (NAP)

The National Adaptation Plan (NAP) is a two-year project (supported by UNDP) to invest in climate sensitive sectors including agriculture and fisheries. The strategic priorities are to mainstream climate change adaptation into development policies, plans, and strategies; to build long-term capacities of institutions involved; implement effective and sustainable funding mechanisms; advance research and development in climate change adaptation; and improve knowledge management (IFAD, 2019).

5.1.2.18.Liberia Rising Vision 2030

Liberia's Vision 2030 is an overarching vision of the government to direct the country to a developed society which includes a range of Pillars, Sector Goals, Strategic Objectives and Outcome Indicators, which together support the development of adaptation and mitigation capacity in Liberia (EPA, 2021). Under the vision Liberia aims to achieve middle-income status by 2030 (Feed the Future, 2017).

5.1.2.19.National Food Security and Nutrition Strategy

The National Food Security and Nutrition Strategy (MOA, 2008), aims to ensure the availability and accessibility of food. It recognises the need to strengthen public-sector research and extension to enhance their capacity to contribute to achieving food security.

5.1.3. Institutional Framework

The key relevant institutions for the introduction of solar powered irrigation technology and practices to intensify rice cultivation and production in Liberia are:

- Ministry of Agriculture (MOA)
- Environmental Protection Agency of Liberia (EPA)
- Ministry of Mines and Energy (MME)
- Liberia Land Authority (LLA)
- Ministry of Gender, Children, and Social Protection (MoGCSP)
- Ministry of Public Works (MPW)
- Ministry of Commerce and Industry (MoCI)
- Forestry Development Authority (FDA)
- Ministry of Internal Affairs (MIA)
- National Climate Change Steering Committee (NCCSC)

Further details are provided in the following sections.

5.1.3.1. Ministry of Agriculture (MOA)

The Ministry of Agriculture (MOA) leads the agricultural sector with its mandate to formulate policies and strategies to guide the growth and development of the agriculture sector (MOA, 2016), encompassing crops agriculture, livestock, and fisheries (Feed the Future, 2017)

The MOA is responsible for the formulation, development and implementation of policies, plans, programs and projects to enhance sustainable agriculture. The MOA sets standards, rules and regulations governing the establishment, licensing and accreditation of individuals, public, private agencies and commercial organizations, in order to safeguard sustainable development of the agriculture sector (MOA, 2014).

The MOA Minister of Agriculture heads four departments, each led by a Deputy Minister, who is assisted by an Assistant Minister. The four departments are:

- Department of Planning and Development (DPD) - responsible for providing policy advice and facilitating strategic planning.

- Department of Administration
- Department of Technical Services (DTS) - responsible for providing technical information and support for all agricultural production across Liberia. The department accumulates, synthesizes, and evaluates technical information and packages it for dissemination through the Extension Department
- Department of Regional Development, Research and Extension (DRDRE) - responsible for oversight of regional development in agricultural production, research in socio-economic programmes and extension services within the framework of the demand-driven, farmer-based pluralistic system (MOA, 2016; Feed the Future, 2017).

5.1.3.2. Environmental Protection Agency of Liberia (EPA)

The EPA is the Regulatory Agency responsible for sustainable management of the environment and natural resources. Section 5 of the Act Creating the Environment Protection Agency of the Republic of Liberia of 2002 mandates the Agency to:

- Collaborate with key line ministries and agencies to coordinate, integrate, harmonize, and monitor the implementation of environmental policy and integrate environmental concerns in overall national development planning.
- Collect, collate, and analyse basic scientific data and other information pertaining to pollution, degradation of ecosystems and on environmental quality and resource use.
- Train and build the capacity of line ministries and agencies.
- Ensure the preservation and promotion of important historic, cultural, and spiritual values of natural resource heritage; and,
- In consultation with local authorities, enhance effective natural resource management plans and activities (EPA, 2021).

To achieve its statutory mandate and other obligations, the EPA collaborates with several key entities including the Ministry of Finance and Development Planning which serves as chair of the EPA's Board, Forestry Development Authority, Ministry of Agriculture, National Disaster Management Agency, Ministry of Mines and Energy, Ministry of Internal Affairs, among others. This collaboration extends to the fulfilment of Liberia's commitment to the Paris Agreement including the development of the NDC (EPA, 2021).

The EPA is the National Designated Entity (NDE) for the UNFCCC and has the mandate as the national regulatory agency for sustainable environmental management, including climate change (EPA, 2021).

5.1.3.3. Ministry of Mines and Energy (MME)

The Ministry of Mines & Energy (MME) was established by an act of legislature to administer all activities related to mineral, water and energy resource exploration, coordination, and development. Key functions performed by the Ministry are summarised as:

- Conduct evaluation of mineral applications and grant mineral rights
- Promote geo-scientific collection and dissemination about the nation's mineral and water resources
- Engage in scientific investigations for the proper assessment of mineral and water resources
- Promote research programs and activities favouring the development of new and alternative renewable sources of energy
- To monitor and enforce compliance of all policies, laws and regulations pertaining to research, exploration, development and exploitation of mineral, waters and energy resources in Liberia
- Promulgate new regulations to guide and govern the mineral and energy sectors (MME, 2019).

5.1.3.4. Liberia Land Authority (LLA)

The Liberia Land Authority (LLA) is an autonomous government agency with three key functions: Land Governance, Land Administration, and Land Use and Management. LLA was created through the Lands Rights Act, thereby removing from the Ministry of Lands, Mines, and Energy the land component of the ministry - now the MME.

5.1.3.5. Ministry of Gender, Children, and Social Protection (MoGCSP)

The Ministry of Gender, Children and Social Protection (MoGCSP) is the national machinery for promoting gender equality, women's advancement and children's welfare in Liberia. The primary objective for its establishment was to have a Ministry responsible for policy formulation, coordination and monitoring and evaluation of Gender, Children, and Social Protection issues within the context of the national development agenda.

The Ministry is mandated to coordinate and ensure gender equality and equity; promote the survival, social protection, and development of children, vulnerable and excluded and persons with disability and integrate fulfilment of their rights, empowerment and full participation into national development.

The Objectives of MOGSCP are to:

- Promote Gender Mainstreaming and Gender Responsive Budgeting (GRB) in MDAs and MMDAs through capacity building
- Improve the socio-economic status of the vulnerable and the excluded through targeted interventions
- Enhance evidence-based decision making on gender equality, the empowerment of the vulnerable and excluded by collecting disaggregated data
- Protect and promote the development and the rights of children, the vulnerable and the excluded through awareness creation and effective implementation of National and International Policy frameworks and legislations
- Assess progress on implementation of gender related programmes and projects and evaluate policy outcomes and impacts through effective monitoring and evaluation framework to provide inputs for gender, children and social protection policy review and planning
- Integrate and coordinate the rights of the vulnerable, the excluded and persons with disabilities into national development through social protection programmes (MoGCSP, 2022).

5.1.3.6. Ministry of Public Works (MPW)

The Ministry of Public Works (MPW) is the government's engineering arm created to administer the country's engineering is terms of surveying, drafting / designing, construction and supervision to improve and maintain (direct or by contract) all highways, bridges, roads, streets, airports, seaports, and all other public infrastructure (MPW, 2020).

5.1.3.7. Ministry of Commerce and Industry (MoCI)

The Ministry of Commerce and Industry (MoCI) is the ministry responsible for promoting and regulating commerce, trade, and industry. The roles and functions of MoCI include to: establish and regulate commodity and trade standards; collect, evaluate, and publish data pertaining to commerce and industry; establish and enforce standards for business practices; promote sound dev elopement of foreign and domestic trade; issue import and export permits; control quality of goods and commodities imported into and exported from the country; implement efficient and effective trade management system including pre-shipment Inspection of imports and exports; and, monitoring and regulating prices of essential goods (MoCI, c2022).

5.1.3.8. Forestry Development Authority (FDA)

The Forestry Development Authority (FDA) is a semi-public autonomous corporation, with the mandate to sustainably manage and conserve Liberia's forests and related resources. The mandate of FDA includes (but is not limited to) the following broad responsibilities: formulation and enforcement of forestry law, policy objectives and regulations in collaboration with the relevant and concerned ministries and agencies; enhancement of the sustainable management, conservation and utilization of the forest and related resources, taking into consideration their various benefits to the people and the nation; controlling and monitoring of concessions operations to ensure that concessionaires carry out activities in line with prescribed guidelines; assessment and collection of revenue from forestry activities; conduct of research and training; provision of technical assistance to operators engage in the forestry sector; implementation and supervision of reforestation programs and projects; encouraging and promoting the involvement and participation of rural dwellers in forestry programs and projects; and, protection and extension services for the sustainability of the forest estate (FDA, 2020).

5.1.3.9. Ministry of Internal Affairs (MIA)

The Ministry of Internal Affairs (MIA) has the mandate to develop rural communities and urban centres. Some of the projects are undertaken directly on government funding, while others are funded by development partners, such as: schools; roads and bridges; local administrative buildings; clinics; peace huts; markets; latrines; commissioners' residences; wells; etc. (MIA, c2022).

The administrative structure is in two tiers: Central Administration (personnel at the headquarters of the Central Office of the Ministry with specific duties and functions of administering the affairs of the political subdivisions of the country); and, Local Administration (personnel who run the various political subdivisions of the country as local government).

5.1.3.10. The National Climate Change Steering Committee (NCCSC)

The National Climate Change Steering Committee (NCCSC) is the supreme institutional body responsible for coordinating and supervising the implementation of climate change policy and other related activities in Liberia. The NCCSC is chaired by the office of the President of the Republic of Liberia, or his/her designate, and supported through a National Climate Change Secretariat seated at the EPA to ensure the implementation of its daily activities (EPA, 2021).

5.1.4. Reports and Studies on SPIS and SRI

A summary of some key reports and studies on SPIS and / or SRI reviewed is provided in Table 5-1 below, with findings and lessons learned from others included in later sections and recorded in the bibliography in the Appendices.

Table 5-1 - Reports and studies on SPIS and / or SRI reviewed

No.	Title	Author	Countries	Date	Reference	Summary Findings	SPIS	SRI
1	Assessing and improving water productivity of irrigated rice system in Africa	Sander J zwart	Benin	2013	Africa Rice Center, Cotonou, Benin	New research is proposed for irrigated rice system focusing on testing promising water saving techniques such as intermittent irrigation, Alternate Wetting and Drying (AWD) and SRI. High involvement of stakeholders through on interdisciplinary and participatory research, which involves farmers, irrigation managers, developmental organisation and NGOs are recommended.	✓	✓
2	An opportunity for increasing factor productivity for the rice cultivation in the Gambia through SRI	Ceesay.M	Gambia	2010	Paddy and water Environment, 9(1), 129-135	SRI activities resumed in 2019 with SRI trainings in the Central River Region which were sponsored by the Gambia Commercial Agriculture and Value Chain Management Project (GCAV), in partnership with Department of Agriculture (DoA).In October 2021, the Adaptation Fund approved the “Scaling up Climate Resilient Rice Production in West Africa” (RICOWAS) project which includes Ghana and 12 other countries in the region.		✓
3	Adapting the SRI in Tanzania. A review	Katambara, Z. et al	Tanzania	2013	Agricultural Sciences, 4(8), 369-375	"SRI practices have been reported of using less water, producing high yields and healthy grains which have stronger aroma. It has been positively accepted by subsistence rice growers and has shown positive results."		✓
4	Adoption, constraints and economic returns of paddy rice under the system of rice intensification in Mwea, Kenya.	Ndiiri, J.A et.al	Kenya	2013	Agricultural Water Management, 129, 44–55	The yield under SRI management increased by 1.6 t/ha (33%), with seed requirements reduced by 87% and, water savings of 28%. SRI required 9% more labor than normal planting on average, but this factor of production showed great variability; in three Mwea units of Kenya, labor costs were reduced by an average of 13%.		✓

No.	Title	Author	Countries	Date	Reference	Summary Findings	SPIS	SRI
5	Application of system of rice intensification practices in the arid environment of the Timbuktu region in Mali.	Styger, E. et.al	Mali	2011	Paddy and Water Environment, 9(1), 137–144.	Average SRI yield for all farmers reached 9.1 t/ha, with the lowest being 5.4 t/ha and highest being 12.4 t/ha. The SRI system allowed for a seed reduction of 85–90%.		✓
6	Soil management : The key factors for higher productivity in the fields utilizing the system of rice intensification (SRI) in the central highland of Madagascar.	Tsujimoto. Y, et.al	Madagascar	2009	Agricultural Systems, 100(1–3), 61–71.	The set of management practices at the early SRI-adopters' fields indicated that smallholder farmers could realize relatively high yields with less irrigation water. The results indicated that the high yields at the fields of those who were early to adopt SRI were mainly due to the soil fertility associated with great nitrogen-supplying ability, rather than 'synergetic effects' of the SRI components		✓
7	Solar Water Pump Technology Roadmap	Efficiency for Access Coalition	Global	2019	https://efficiencyforaccess.org/publications/solar-water-pump-technology-roadmap	Cost reductions in solar water pumps have the potential to make modern irrigation more accessible and cost-effective for nearly 500 million small-scale farmers globally. This document identifies a series of technology improvements for remote monitoring systems and brushless DC motors that, if adopted, could improve the efficiency and performance of solar water pumps.	✓	

5.2. Stakeholder Consultations

This section summarises the direct discussions held with individuals involved in other projects / programmes in Liberia and in other countries with similar socio-economic, geographic, and climatic conditions as part of a lessons learned / benchmarking experience. Topics for discussion included limits, technological failures, bottlenecks, opportunities, advantages etc. and included engineering aspects (photovoltaic (PV), pump and irrigation systems, and SRI practices employed to complement and raise yields.

A summary of those consulted is provided in Table 5-2, with a summary of discussions and key findings provided in the following sections. Further consultations will continue throughout the TA, as the studies continue, and any findings will be recorded in subsequent reports.

5.2.1. CHAP (Community of Hope Agricultural Project)

CHAP is a Liberian owned national initiative specialized in working in urban and rural communities since 2008. Currently, they are active in Lofa, Montserrado, Nimba, Bong, Gbarpolu, Grand Gedeh, River Gee Bassa, and Cape Mount. They have experience in construction and rehabilitation of irrigation schemes, waterways and dams and distributed certified seeds to smallholder farmers in their operated counties. The seeds distributed for the purpose of adopting SRI have increased the farmers' rice yields from 1.3 ton to 3-8 tons per hectare. CHAP also developed a map of pest and diseases for rice crops in Lofa, Bomi, Basaa, Monstserrado, Cape Mount and Grand Gedeh counties.

The objectives of CHAP are as follows:

- To empower urban and rural communities to use available resources to promote climate-smart and nutritional-sensitive agricultural production and processing, as well as health education for sustainable peace and development,
- To build sustainable farming practices by improving farmer's productivity in the areas of rice and other crops (System of Rice Intensification, System of Crop Intensification), vegetable and livestock production embedded with efficient water, sanitation and hygiene practices,
- To introduce user-friendly labor-saving implements and equipment,
- To improve quantity and quality of local rice production as a result of the training and equipment received,
- To increase farmer's income and expand the cycle of rice production, processing and marketing and
- To provide efficient advisory services to farmers using life-changing innovations and technology

A call with the Director of CHAP, Robert Bimba, on 8 February 2021 provided the following insights:

- The selection process is key to the success of the project; selection should be done with farmers that are already growing rice and not wanna-be farmers.
- SRI method was introduced in 2012 and has been successful since; 10,000 farmers trained with method being replicated using photos and video across farmers' fields; every success story is documented to showcase for learning for other farmers.
- CHAPS are currently working with 21,000 lowland farmers providing technical and advisory supports.
- Women and youth are fully participatory without and traditional barriers.
- The major constraints and challenges noted by CHAPS were:
    - Site selection process
    - Land ownership
    - Land preparation
    - Water management
    - Birds that eat and damage the crop.

Table 5-2 - Details of individuals involved in discussions as part of lessons learned / benchmarking

No.	Organisation	Brief Description of Organisation / Relevance	Details of Individuals Consulted			Consultation Date
			Name	Position	Gender	
1.	CHAP	CHAP is a national own program working in urban and rural areas in Liberia since 2008 and Focal Organization for System of Rice Intensification in Liberia	Robert Bimba	Director	M	8/2/2022
2.	Food and Agriculture Organization of the United Nations (FAO)	FAO office in Liberia works to fight hunger and poverty in Liberia, with assistance focused on revitalizing the agriculture sector, crucial for the consolidation of Liberia's progress from post-conflict stabilization to sustainable economic development and food security.	Dagnoko Mariatou	Liberia head	F	9/2/2022
3.	Africa Rice Center (Liberia)	CGIAR rice research institute working for Africa	Dr. Inoussa Akintayo	Liberia head	M	10/2/2022
4.	United States Agency for International Development USAID-FED	The Food and Enterprise Development Program (FED) helped Liberia achieve increased food security, in terms of food availability, utilization, and affordability	Dr.Pandian Balamurugan	STTA, Liberia	M	12/2/2022
5	Balamah Community/Farmer Group	Farming community located in Bong County that relies on low land rice farming for the majority of its members.	Ruth Suah	Town Chief of Balamah	M	11/12/2021
			Daniel	Group Head	M	
6	Africa Rice Center (Madagascar)	CGIAR Rice Research Institute working for Africa	Kalimuthu Senthilkumar	Sr.Scientist	M	6/2/2022
7	Sergeant Kollie Town (SKT) Farming Group	Farming community located in Bong County that predominantly produces rice, utilising rainfed methods and with a dam for irrigation in the dry season.	Martin George	Group Head	M	12/12/2021
8	Fuamah District Multipurpose Cooperative	A community that was once a mining concession area (Bong Mines) with most of the inhabitants now involved in rice and vegetable farming in the community.	James Wonnie	Chairman	M	13/12/2021
			Francis F. Tamba	Secretary	F	
			S. T. Nyakpoar	Co-chair	M	
9	Magona Rice Farm Production	Rice farming group in Solomba Community	Harris Domah	Co-chair	M	17/2/2022
10	Youmtornor Enterprise and Developmental Services, Inc.	Farming group in Dundu Community	Daniel S. Samoi	CEO	M	18/2/2022
11	Mayor River Women Initiatives	Rice farming group in Ndama Community	Taiwah Pokuah	Chairlady	F	19/2/2022
			Damie Tumbey	Co-chair	F	

12	Regional Centre for Energy and Environmental Sustainability of the University of Energy and Natural Resources (UENR)	Involved in developing SPIS systems and providing training to farmers in Ghana under the Green People's Energy (GPE) Project under the GIZ Sustainable Energy and Climate Cluster (SECC) At time of consultation had installed three irrigation systems namely, drip, sprinklers and spray tube - for a total farm size of approximately 3 acres, and with two training sessions completed.	Eric Ofosu Antwi	Associate Professor, Department of Civil and Environmental Engineering	M	28/1/2022
13	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)	The GPE project in Ghana is part of a global programme to improve conditions for supplying rural regions in selected African countries, including Ghana, with decentralised renewable energy. The project in Ghana focuses on the promotion and capacity development of skilled experts of solar companies, credit and financial institutions and public technical universities; the use of decentralized renewable energy systems for small-scale rural enterprises in the agricultural sector and social institutions such as farmers and health facilities for income-generating activities through technical and financial support schemes; the development of business support services for investment in decentralized RE systems for project developers and other investors as well as the improvement of framework conditions.	Ernest Ohene Nkansah	Technical Advisor, Training in Solar Pumping and Irrigation System, GPE Project	M	31/1/2022

5.2.2. USAID's FED (Food and Enterprise Development programme)

This five year programme ran from 2011-2016 with a mission to increase production and productivity of four major components in agriculture and allied sector. The Food and Enterprise Development programme (FED), latterly renamed as 'Feed the Future', was a USAID funded project that aimed to increase productivity, profitability and access within the rice, cassava, vegetable and goat value chains; improve nutrition; and strengthen food security. The project concentrated on four priority counties (Grand Bassa, Bong, Nimba and Lofa) and two secondary counties (Margibi and Montserrado). Rice had been taken as a major component with an aim to increase productivity of lowland and upland farmers by introduction of cost-effective technologies.

Discussions with past members of the team revealed that this programme started with the objective of increasing rice production in lowland areas through double cropping the rice crop by developing irrigation facilities. It started in four counties (i.e. Lofa, Bong, Nimba and Grand Bassa) and aimed to work with more than 11,000 ha of rice farms and beneficiaries including 10,000 rice farmers. Catchment areas were identified for the sizable farm areas and head dikes were constructed with side spillways; these spillway channels were also used as irrigation channels and the water supplied to the field by gravity. Farmers in 42 water management sites and FED extension staffs received refresher training on double cropping techniques. Lowland rice production manuals and guidelines were developed and disseminated. Appropriate technologies for mechanization and SRI were identified, tried and tested on lowland demonstration sites to determine the adaptability to Liberian conditions. Labour saving implements like drum seeders, cono weeders (especially for SRI) and threshers were introduced and adopted for the lowland rice.

5.2.3. Food and Agriculture Organization of the United Nations (FAO)

FAO operates various agricultural programmes and allied activities in Liberia, including support to vegetable, corn, rice and poultry farming and helping the establishment of business hubs, especially for rice. In some areas, they combine these agro allied entities as integrated farming systems. In the main, the focus for lowland rice production under FAO projects is in two places; Foya in Lofa and Belamu in Bong county.

Under the FAO programme, boreholes have been drilled mainly for high grade crops, like vegetables, but also for rice, since the crop requires supplementary irrigation water during the dry season; this is applied by surface/flood irrigation techniques. In total, FAO operate in 6 counties for lowland rice production, mainly in the rainy season only.

FAO has a partnership with the Central Agricultural Research Institute (CARI) and Africa Rice for the seed multiplication programme. The seeds from seed multiplication trials go for various screening tests before being distributed to farmers.

Regarding their experience of problems in the field, FAO have worked closely with the farmers operating on 300 ha in Bong Mines area, which were developed after the exploration of iron ore and which are subject to iron toxicity that impacts the yields of rice produced. They also have experience of stem borer pests and birds causing problems, particularly during the milky stage of the crop's development.

FAO has plans to use solar energy for post-harvest handling of the harvested produce especially for rice mills and cold storage for vegetables.

A meeting with representatives of FAO Liberia was held on 9 February 2022, raised the following key insights:

- Programmes build capacity of farmers in rice production and provide support in mono gardens (piloting in vegetable production); currently working in Nimba, Bong, Lofa, Montserrado, Gbarpolu and Bomi using SRI methods.
- Irrigation has been piloted but not yet fully in operation; the methods are only being used for vegetable production with boreholes used as the source of water.
- Village saving loans have been introduced as a means to sustain the facilities by the farmers.
- Women and youth participation is encouraged.
- The major constraints and challenges noted by FAO were:

- Pilot plots have been delayed due to the difficulties in commissioning boreholes with adequate water supply volumes.
- Adoption rates for new SRI practices are slow due to farmers being used to traditional methods.
- The availability of labour at key times is a major concern.

Case Study:

Japan/FAO Project to Use SRI for Seed Rice: A group of 65 farmers in Panta District, Bong County, from the "Kwapaigei Farmers Development Cooperative Society (KFDCS)", harvested 15 ha of NERICA L-19, an improved, short-duration, lowland rice variety as part of the initiative "Integrated Sustainable Rice System Development in Liberia" for which the Government of Japan provided funding to FAO to support the Government of Liberia's efforts in enhancing the capacity of smallholder farmers to sustainably increase productivity and incomes. FAO has been working with the Ministries of Agriculture and Internal Affairs to ensure that the most urgent and needed support is provided to farmers in Bong and Lofa counties. Beneficiaries replant their farms with seed rice using the System of Rice Intensification (SRI) and are assisted by FAO and partners with the installation of agro-machinery and the construction of post-harvest technology centres.

5.2.4. Africa Rice

Africa Rice Centre has been working for the rice research and development for African continent. They also collaborate with different government and non-governmental organizations in Liberia. During discussions, iron toxicity, blast disease, and some common pests (like stem borer, caseworm and gall midge), water management and availability of good quality seed of appropriate varieties were the main problems highlighted as responsible for the low yields of rice in Liberia. However, demonstrations of rice fields using good quality seeds, improved cultivation practices and better nutrient management have been shown to increase rice yields.

5.2.5. Summary of Lessons Learned

During discussions with other organisations in Liberia and the region, the following key lessons learned were drawn from the wide range of experiences:

- Limited milling capacity to handle bulk paddy; there was a high volume of paddy rice for milling in Liberia during the 2021 season, due mainly to the increase in harvests in counties supported by external projects.
- Mixing varieties of seed has a negative effect on the quality of the milled rice.
- Most lowland rice farms are rainfed, with a lack of functional irrigation systems.
- Farmers' responses to pest and disease infestation, which affect many farmers' fields, is too slow.
- The pricing of paddy and milled rice requires a collaborative approach so that farmers and buyers receive equal treatment.
- Farmers have limited capacity and little time for work in nursery management, planting in row/lines, levelling and weeding.
- Bad roads, particularly in the rains, create difficulties to move farm machines from farm to farm, and limit the transport of fresh produce to markets.
- In the absence of a Seed Act or similar legislation in Liberia, there is no body with the mandate to regulate a seed certification process in the country.
- Some areas lack land, machinery and scheme ownership by locals.
- Many farmers are unable to access lucrative markets in Monrovia and therefore cannot afford the payment terms for agricultural financing.
- Existing structures used for water management, like head dikes and spillways, are not well managed, with little regular repair work and maintenance, with the following examples:
  - Irrigation channels are not cleaned properly to remove weeds and maintain the flow of water
  - Field bunds and canal embankments are not cleaned regularly

- Farmers have not made efforts to extend schemes into potential areas.

- Poor SRI techniques; particularly farmers are not well trained in the following:
  - Land preparation, including the improper incorporation of crop residues - This leads to a temporary deficit of nutrients and poor crop growth
  - Uprooting and transplanting young seedlings; planting of single seedlings needs attention and high levels of labour
  - Maintenance of water levels to maintain alternate wetting and drying during the early stage of the crop growth.
- Quality of seed is not of a high standard and is often mixed with admixtures, ill filled grains and weed species.
- Post-harvest losses, especially in storage, are high due to farmers negligence and lack of knowledge of proper post-harvest technologies.
- The poor road network, especially in north-west of the country, does not enable easy travel for ministry staff and extension workers to access rural sites.
- Availability of more labour needs improvement, especially for land preparation and weeding.
- Power tillers could be distributed for easy and timely land preparation and to reduce the cost on labour.
- Finally, manual-drawn mechanical devices may be promoted to improve the efficiency of weeding operations, instead of spending money for labour.

5.3. SRI and Rice Production Systems Currently Used in Liberia

Based on the findings of the literature reviews and stakeholder consultations, this section assesses SRI and rice production systems currently used in Liberia and the two counties.

5.3.1. Assessment of Rice Farming and Irrigation in Liberia

5.3.1.1. Rice in Liberia

Rice has become the staple food crop in most of the West African countries and this is also the case for Liberia; rice has become an everyday food and Liberians are proud to eat it. The type of rice grown in Liberia is a medium and slender type and very much preferred by Liberians. Generally, rice is grown in Liberia for sustenance, but recently has been promoted with more commercial intentions because of the fluctuating price of rice in international markets and the growing demand for locally grown rice.

It is estimated that Liberia consumes an average of 450,000 tons milled rice per year, but only 150-250,000 tons are produced in the country (See Figure 5-1). The deficit is made up through subsidized rice imports, although the National Rice Policy also promotes local production with the aim of reducing importation and to become self-sufficient (Ministry of Agriculture (MOA), Liberia 2012).

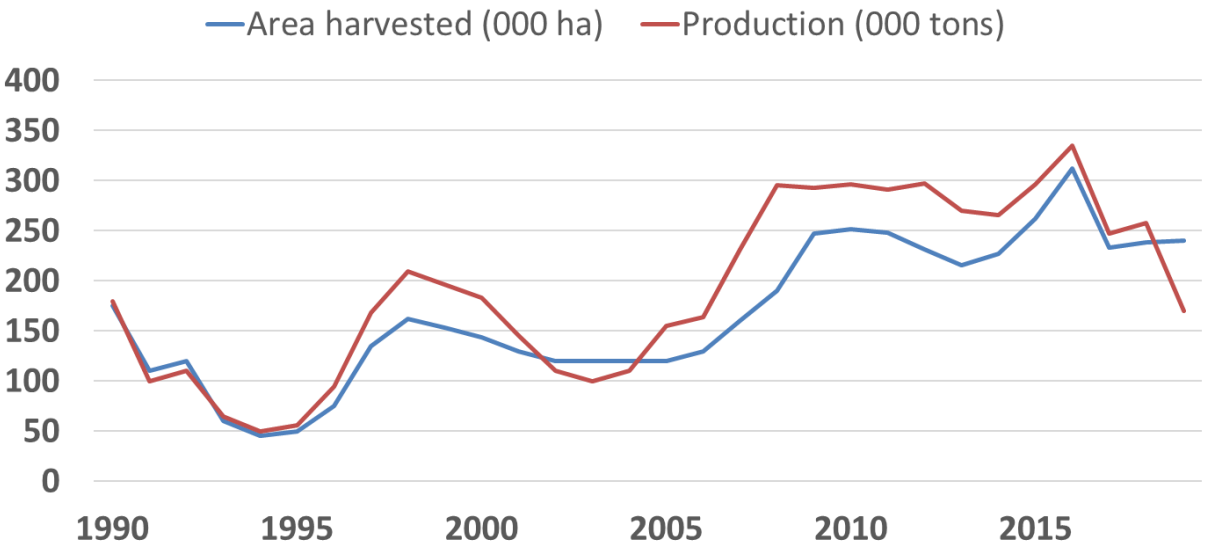

Figure 5-1 - Area of Rice Production in Liberia (1990-2019)

Source: FAO

In recent years, there are schemes both by the government and NGOs with a common objective of increasing rice yield and the area under rice cultivation in the potential areas of various counties. There are two approaches to increase production; firstly, by increasing the area under cultivation or the cropping intensity (i.e. the number of crops per year) or, secondly, by increasing the productivity per unit area. Most development projects focus on the first category, since developing irrigation facilities can bring significant untapped potential areas under production and increase cropping intensity. The second approach is being followed in more isolated areas, by increasing the productivity per unit area via SRI techniques and its location-specific modifications. In Liberia, although blessed with adequate rainfall, the average productivity of rice is low, approximately 2t/ha (FAO, 2010), and needs greater focus on this productivity aspect, by implementing SRI technologies.

5.3.1.2. Climate and soils

Liberia has a hot and humid climate, with abundant annual rainfall ranging from more than 4500 mm in coastal areas to about 2000 mm in the northern interior of the country. Most precipitation falls between May and November, with the peak monthly rainfall in the months of July and August. Whilst the rainy season is lengthy and the volumes of water are sufficient to grow rice, the uni-modal pattern allows only one crop per year without any supplementary irrigation.

Four key soil types are prevalent in the country:

- **Latosols** occur in areas of rolling countryside, covering about 75% of the total land area, and are low to medium fertility.
- **Lithosols** are found in hilly and rugged terrain, covering approximately 12.5% of land area, but are generally shallow and coarse.
- **Regosols** or sandy soils are found along the coastal plains and are mostly infertile due to a lack of organic content and free draining texture.
- **Alluvial soils** are present in a small percentage of the land area, along valleys and floodplains, but they are highly fertile and the most utilized for agriculture.

All top soils can be subject to severe erosion due to the intensity of rainfall in the rainy season and because of the steep and undulating terrain. Generally, rice is grown in the lowland areas and very rarely in upland locations; the yield potential of upland varieties is relatively low due to the soils and limited water.

5.3.1.3. Shifting cultivation

In the past, between 50-100 years ago, the population in Liberia was so low that shifting agriculture practices could be used by farmers, without significant negative impacts on forests; people were able to clear farm lands to farm

for one or more seasons, allow the area to go fallow, and come back 10-15 years later when the area would be fully reforested, and they would be able to farm there again. Deforestation and shifting cultivation still occurs in the upland areas, but with a growing population there is increased pressures on the relatively small areas of lowland farms to produce more food.

5.3.1.4. General irrigation systems in Liberia

Most rice in Liberia is grown as a rainfed crop, but predominantly in low-lying "swamp" areas where farmers are able to capture the water and that may be subject to flooding. Supplemental irrigation during the rainy season has therefore not been required, for all crops not only for rice, but during the last decade, government agencies and a few private funding organizations have tried different irrigation practices, mostly gravity-fed, surface irrigation, to grow rice, maize and other cereals, with some very limited areas of pressurized irrigation for highly remunerative crops like vegetables, greens etc.

The surface irrigation systems in Liberia are mostly a combination of a dam reservoir or river diversion, distributed to the fields by gravity through open field channels, which are subject to various losses that significantly reduce the efficiency of water use. These irrigation systems were designed to operate during the dry season (i.e. from November to March), drawing water from the water storage, but most have run short of funding for maintenance and operating costs, which in turn has increased losses in the systems and the water storage has become insufficient for full-time irrigation. The failings are often attributed to insufficient budget allocation for maintenance and poor cost recovery mechanisms for the farmers to pay for water service provision.

Whilst this picture of irrigation systems in Liberia is at a primitive stage, with similar challenges to many countries across the region, the basics of good soils and available water do exist and there is optimism for the future (MOA, Liberia 2015).

5.3.1.5. System of Rice Intensification in Liberia

SRI was first introduced to Liberia in late 2012, through Robert Bimba, National Coordinator for the Farmer Union Network (FUN) of Liberia and President of the Community of Hope Agriculture Project (CHAP). Later that year, following encouraging initial trials with his family and a few farmers in Zubah Town, Paynesville, Monrovia, the SRI activities were extended and, when the World Bank-sponsored West Africa Agricultural Productivity Program (WAAPP), SRI program was approved in late 2013, CHAP organized the first training of trainers in collaboration with the Ministry of Agriculture. The SRI workshop, brought together 84 participants from different parts of Liberia, as well participants from Sierra Leone and Mali, and led to further meetings and workshops about SRI, bringing together the government, multi-lateral and bilateral partnerships, donors, NGOs, farmer organizations and the private sector.

More recently, the Adaptation Fund (AF) approved a 4-year project for "Scaling up Climate Resilient Rice Production in West Africa" (RICOWAS) to emphasize SRI across 13 ECOWAS countries, with CHAP in charge of executing the project in Liberia. The overall purpose is to improve climate resilience and increase the productivity of smallholder rice farmers in West Africa[2].

The UNDP has very recently granted funds to develop a commercial rice seed production farm in Montserrado and Lofa counties, using SRI methods to produce climate-smart seeds that will increase local rice production and reduce the reliance on imports.

[2] RICOWAS is overseen regionally by the Sahara and Sahel Observatory (OSS), with the Rice Regional Centre of Specialization, hosted by the Institute of Rural Economy (IRE) in Mali, working in partnership with the Climate Resilient Farming Systems program at Cornell University, USA.

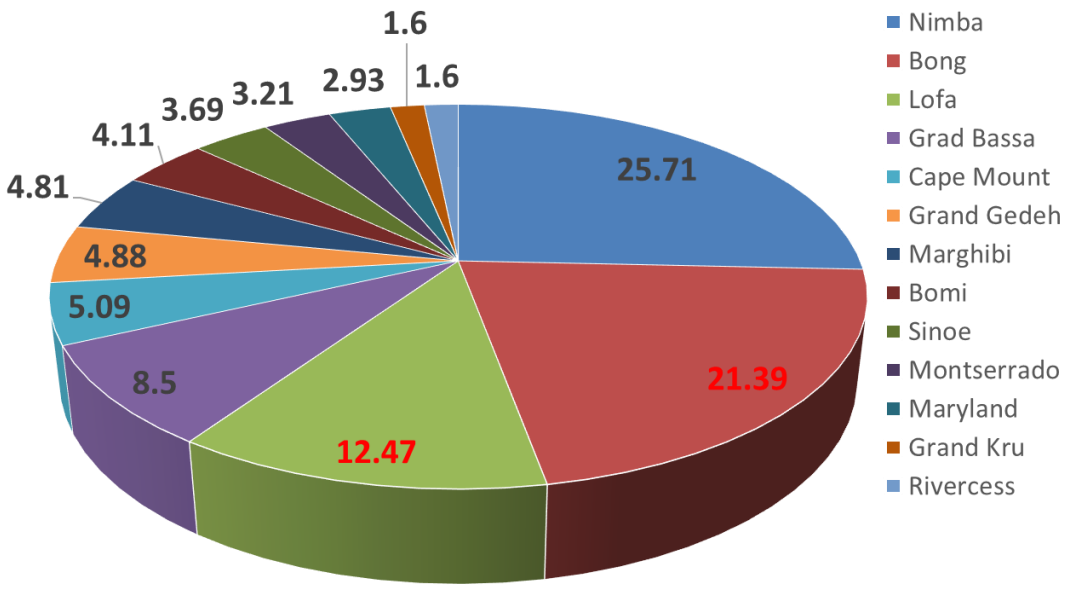

Figure 5-2 - Harvested rice area (% total harvested area) in different counties

Source: FAO

5.3.2. Bong County

Bong County is situated in the north-central portion of Liberia and has twelve districts, with Gbarnga as its capital; the area of the county is 8,772 km^2, as shown in the Figure 5-3 below.

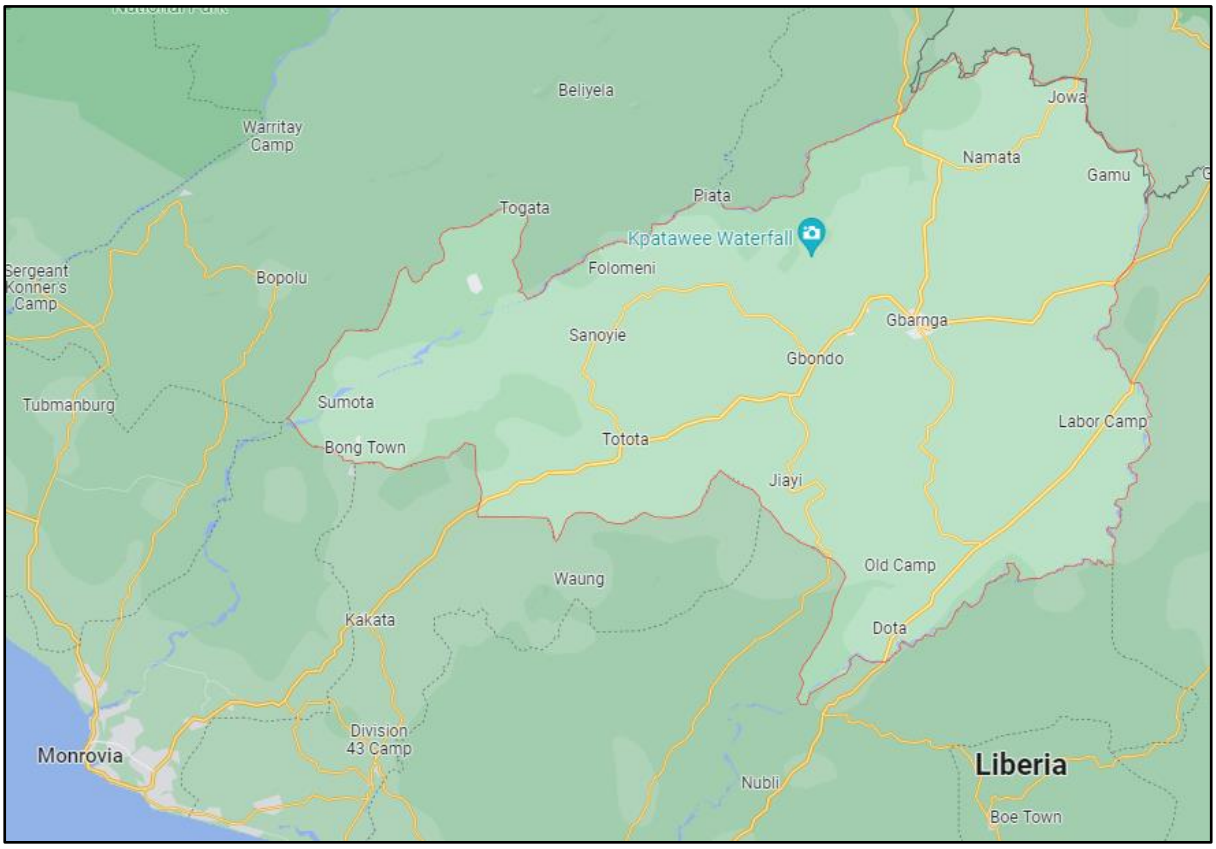

Figure 5-3 - Location of Bong County

Bong County is the second most productive county for domestic rice production in Liberia (See Figure 5-2), although together with Nimba County, a greater share of this production comes from upland areas, which is still sometimes undertaken through shifting cultivation. Lowland rice production has been practiced more in the last two decades and the areas cultivated are slowly increasing.

5.3.3. Lofa County

Lofa County is located in the northernmost portion of Liberia, with nine districts and Voinjama as its capital, and a total area of 9,982 km^2, see Figure 5-4 (over page). The county is bordered by Bong County to the south and Gbarpolu County to the west. The north-western border is formed with Sierra Leone and the north-eastern side borders with Guinea. Mount Wuteve, the highest mountain in Liberia, lies in the north-central part of the county. As of the 2008 Census, it had a population of 276,863, making it the third-most populous county in Liberia.

Being further inland, the county experiences lower rainfall compared to other counties and, whilst the lowland areas are flat floodplains, drainage occurs naturally creating some ideal locations for rice production. Though the percentage share of total rice production from Lofa county is lower than Bong (See Figure 5-2), the percent share of lowland rice production is higher, making it the predominant system of production in the county.

Rainfed lowland rice farming has been practised in Lofa County for many decades, either in depressions between hills or on the plains/swamps, where water is available throughout the year. Lowland farms, developed through the 1940-70s by the United States, an Israeli “Agricultural Mechanization Company” (AGRIMECO) and the World Bank funded Lofa County Agricultural Development Project (LCADP), involved the construction of water control structures (i.e. headworks and dykes), with main and distribution canals to feed the layout of farm plots. This lowland technology gradually spread and built the capacity of smallholder farmers.

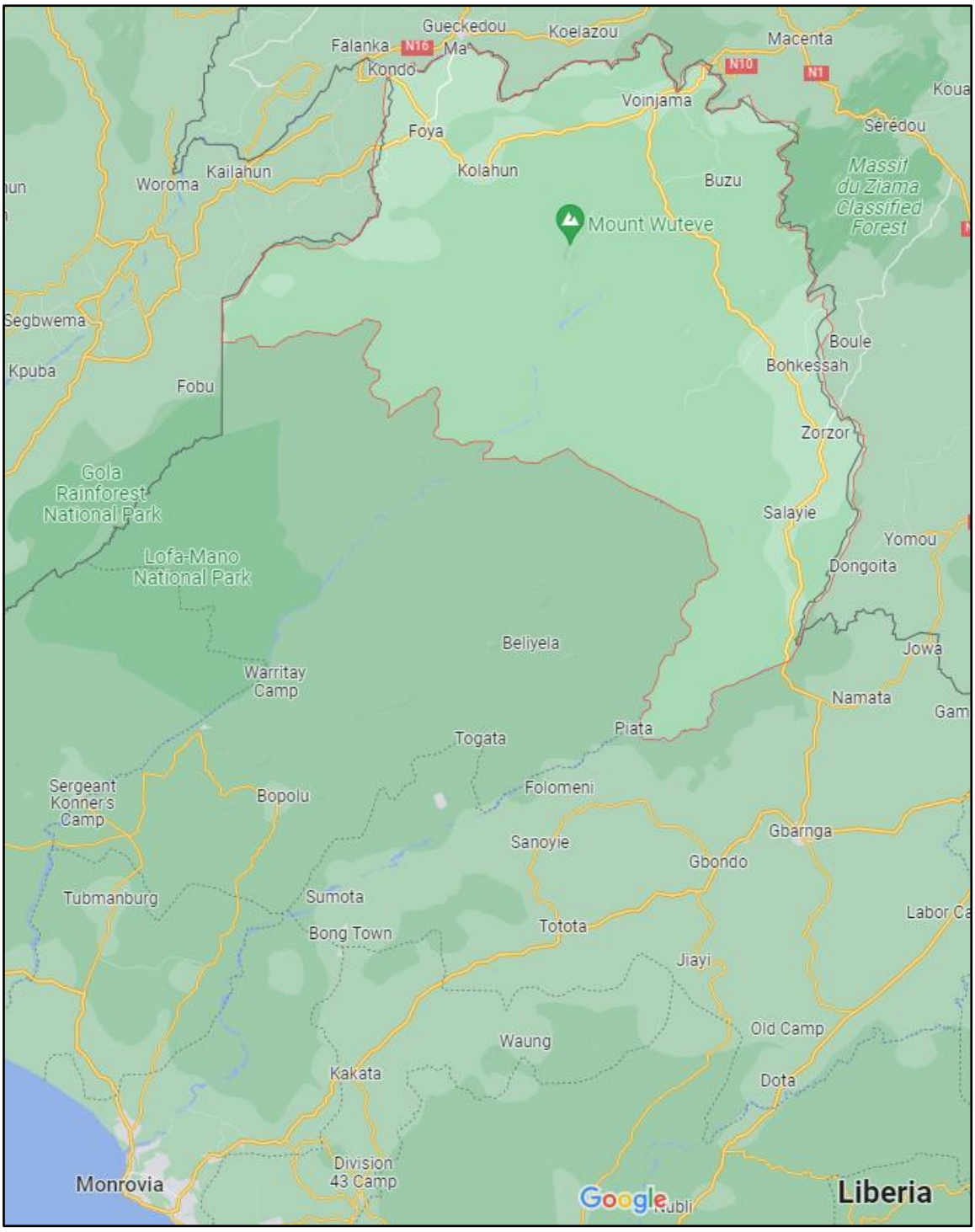

Figure 5-4 - Location of Lofa County

The reasons for the dominance of lowland rice farming in Lofa County are as follows:

- Available water resources to meet the dry season demands
- Farmers have knowledge and experience in good agricultural practices in lowland cultivation, they are generally enthusiastic, innovators and progressive farmers.
- There are sufficient numbers of functioning rice mills in the local area to meet production demands.

One negative is the poor road network to access the county from Monrovia and other parts of the country (average drive from Monrovia takes 6 hours), especially during the rainy season (9 hours or longer); this may negatively impact the availability of agricultural inputs and transportation of produce to markets.

6. Pilot Project for SPIS and SRI

6.1. Commentary on Feasibility of Using GIS in the Selection Process

The level to which Geographic Information Systems (GIS) may support the site selection process depends largely on the availability of suitable datasets. An initial scoping of data available publicly online has been made and Table 6-1 summarises these datasets and their location:

Name	Short description	Link to resource
Irrigated areas	Higher spatial resolution dataset showing current and potential irrigated areas. Made from data modelling (not ground truth data).	http://waterdata.iwmi.org/applications/irri_area/
Farmed rice areas	A lower spatial resolution dataset for farmed areas. Made from data modelling (not ground truth data).	https://www.mapspam.info/data/
Livelihood zones	Categorisation of livelihood zones.	https://fews.net/west-africa/liberia
Water points	A list of water points and pumps, each pump with a photograph attached.	https://data.humdata.org/dataset/liberia-water-point-data
Health sites	Health sites in Liberia.	https://data.humdata.org/dataset/liberia-healthsites
WASH in schools	Water & sanitation supply in schools.	https://wash-liberia.org/raw-water-point-data/
Groundwater resources	A low-resolution modelled ground water resource map, giving Liberia ground water between 0 and 25 meters in depth.	https://ggis.un-igrac.org/view/groundwater-resources-africa
Grid datasets	Energy and grid datasets – useful for understanding potential of grid connectivity for SPIS.	https://energydata.info/

Table 6-1 - Summary of publicly available GIS datasets

Based on this level and breadth of available data, GIS cannot fully replace the benefits of on-the-ground surveys at potential locations, primarily because of the lack of detailed, high resolution hydrological, groundwater, soils and geological datasets. With the available GIS data, the selection of the pilot site is more effectively undertaken by travel and surveys of the handful of shortlisted locations identified by the Ministry of Agriculture. However, the following recommendations are given:

1. GIS can support the assessment to create a national plan of potential SPIS locations, based on the selection criteria and if collection of the most relevant datasets is conducted and combined with existing geospatial data and data collected as part of this assignment.
2. GIS can support the design of the SPIS if specific geospatial data is collected or other existing datasets are identified and made available to the consultants, for example on soil types and location of existing farmed areas (as noted in discussions with CHAP[3] and FAO[4]). GIS can give a remote calculation of the area of existing farmed areas as well as a remote assessment of the potential for further extension with SPIS. Further in-depth analysis can be done with imagery spanning many years, but quick remote assessments of site locations before a site survey will enable better planning and potentially save time and effort in the field.

[3] CHAP indicated they had data on approximately 1000 lowland rice farmers, including GPS locations/ maps.
[4] FAO Liberia indicated they had data on 8 groundwater pumping systems and information on farming groups in Bong and Lofa county.

3. GIS data collected throughout the assignment and from the site visits may be used and shared to support future scaling up of the SPIS in Liberia.

6.2. Details of Site Visits

A team of 4, including Christopher Kabah (EPA), Kokulo Halala (MoA), Isaac Asare (CARES) and Sanco Lysander (CARES), travelled to Bong and Lofa counties for two reconnaissance visits and an assessment of a number of sites identified by the Ministry.

6.2.1. Bong County

The team visited three communities in Bong County between 11-13 December 2021.

6.2.1.1. Balama Community

Balama community is situated along the Kpatawe Waterfall highway with a population size of approximately seven hundred to nine hundred (700 to 900) and relies on farming as a major source of livelihood along with petty trade. Lowland rice farming is the common farming practice but with the major constraint of the flow of water during the dry season. The farming is done by 15 persons in a group represented by family members and supervised by a chairperson. Any cash proceeds from the farm are usually saved to support members and empower other developments.

The Balama farm plots total about 4-5 ha, most of which are used for rainfed rice production. In addition, there is an existing irrigation scheme, comprising a water body with spillway constructed to supply the surrounding fields of approximately 2-3 ha. From here, if there is a constant flow of water during the year there is potential for two harvests each year, but due to the shortage of water during the dry season these fields are not irrigated.

Figure 6-1 - Google satellite imagery and potential area at Balama

Note the land highlighted is an approximation based on Google satellite imagery and may vary significantly, depending on the age of the imagery, or at what time of the year the imagery was taken.

Figure 6-2 - Pictures from Balama fields

6.2.1.2. Sergeant Kollie Town

Sergeant Kollie Town (SKT) has a large farming area with a dam close by, to supply water to the fields by gravity; it has not been known to run short of water during the dry season.

Figure 6-3 - Google satellite imagery and potential area at SKT

However, the farm area is located right outside the Central Agricultural Research Institute (CARI) and was claimed to be owned by an individual, who indicated that he had previously had many farmers working for him, but they had left to work on the Africa Rice project located at CARI, because the pay was better (This was refuted by Africa Rice during the Inception Meeting).

Figure 6-4 - Pictures from Sergeant Kollie Town fields

6.2.1.3. Bong Mines

Bong Mines Community is a community that was once a mining concession area, with most of the inhabitants working for the mining company in the past, or involved in trade or other activities for their livelihood. The civil war left the area devastated with the community left to find new ways for survival. There have been post-war operations of the mining concession, but these were discontinued either for none compliance issues or other reasons. However, the former employees, their dependents and the wider community have managed to develop rice and vegetable farming in the area.

The farmers in this area are organised in a group; each member registers with an amount of 200 Liberian dollars (equivalent to 1 US$) and the group's governing body provides oversight, settles disputes and seeks opportunities through other local and international organizations. It has a total membership of 986, with 500 women and 486 men. Those members provide labour to undertake activities in the fields, so that they do not have to hire labour for any activity.

The Bong Mines farm is much larger compared to Balama and SKT. There are water storage facilities in three water bodies, with constructed spillways, to supply water via the existing irrigation infrastructure to the members in the group. There is also a warehouse available for storage of tools and machinery, agricultural inputs and produce from the farms.

Figure 6-5 - Google satellite imagery and potential area at Bong Mines

Despite the existing storage, it was reported that the flow of water during the dry season is a major constraint for rice farming and they resort to growing smaller plots of vegetables until the next rainy season. Also, since the area is an old mining site, some concerns regarding remnant toxicity levels were raised, although testing has been conducted to prove the soils are toxic free.

Figure 6-6 - Pictures from Bong Mines fields

Of the three sites visited in Bong County; Balama, SKT and Bong Mines, it was Bong Mines that was considered to have the greatest potential for the SPIS pilot scheme.

6.2.2. Lofa County

The team visited four communities in Lofa County between 17-19 February 2022.

6.2.2.1. Solomba Community

This community is located in Foya and the farming area is owned and managed by the Magona Rice Farmers, with a total membership of 96 farmers (of which 51 are males). The farm size is estimated at about 43 ha and is traditionally rain-fed.

Figure 6-7 - Google satellite imagery of Solomba

The Bakia river is the main source of water situated nearby to the rice fields; however, due to its very low flows during the peak of the dry season, rice is only grown once per year, during the rains. To provide the additional water storage required to expand the production would involve the construction of a dam.

Average yields have been almost 100 bags of rice from the farm and there is a storage facility that can store up to 500 bags. Proceeds from the harvest are used to pay the farmers and other expenses.

Figure 6-8 - Pictures from Solomba fields

6.2.2.2. New Foya

New Foya farm is privately owned and operated by a farmers' group called Wokanjah. The area comprises about 26 ha that could produce up to 1,500 bags of rice, if there was a constant flow of water to the fields. The existing dam is only functional during the rains, suggesting that there are structural leaks or major seepage losses.

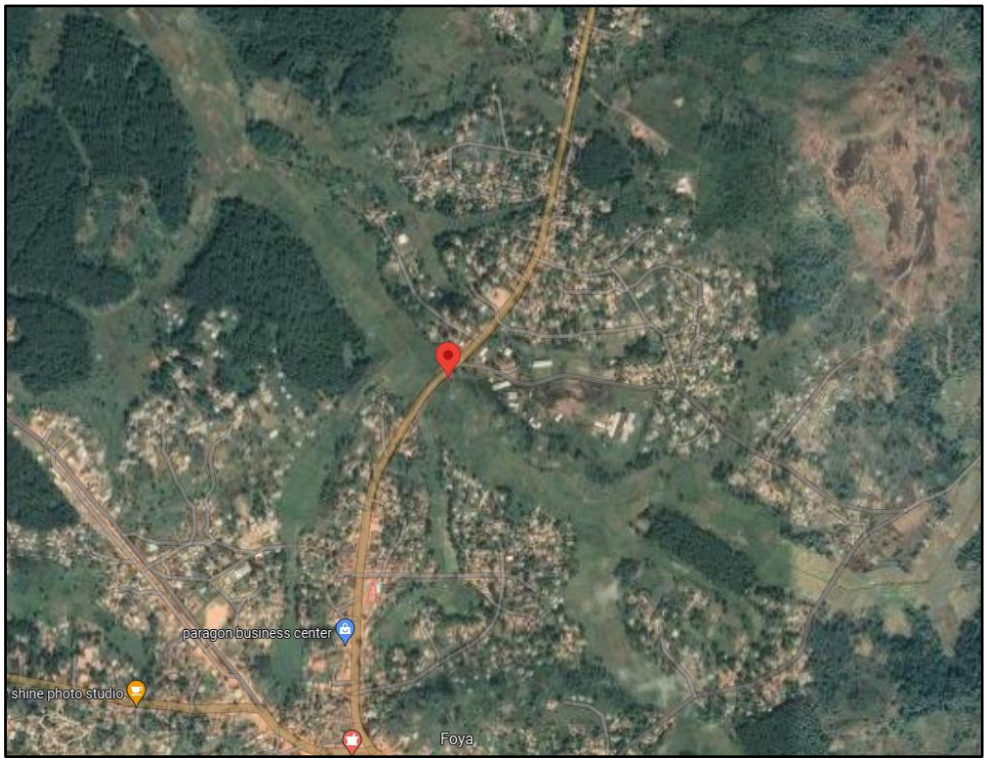

Figure 6-9 - Google satellite imagery of New Foya

Figure 6-10 - Pictures from New Foya fields

The farmers' group totals 26 members (16 female and 10 male) and they have produced 200-300 bags of rice per season from the farm.

6.2.2.3. Dundu Community

At Dundu, there is an 80 ha privately owned farm operated by individual farmers and enterprises. Farmers have been supported by FAO, WFP and the MoA. One of the groups operating on the farm is Youmtornor Enterprise and Development Services, which leases an area of about 8 ha with 61 farmers. They operate a dam that is functional during all seasons and average yields are about 250 bags. There is ongoing work to improve the flow of water from the dam to the fields and their seasonal production could reach to 2-3 t/ha if this is successful in supplying water throughout the seasons.

Figure 6-11 - Google satellite imagery of Dundu

The dam in Dundu could supply water throughout the seasons, as a potential source for the SPIS pilot scheme, extending the cultivated areas beyond those already commanded by gravity supply from the dam.

Figure 6-12 - Pictures from Dundu fields

6.2.2.4. Ndama

The site at Ndama is operated by the Mayor River Women's Initiative, with a membership of 77 farmers. The group is predominantly female, with only 7 males. They operate a farm of 10 ha, which they lease by paying a percentage of production to the private owner (12%) and have recorded about 400 bags at harvest. Though sometimes challenged by issues, their initiative has been a motivation to many and their efforts in this endeavour has not gone unnoticed as they received an award by the Ministry of Agriculture.

The fields are currently rain-fed, but with some flow remaining in the Mayor River running by the scheme. The site doesn't have any pumps to raise water to the fields during the dry season or when water levels are low.

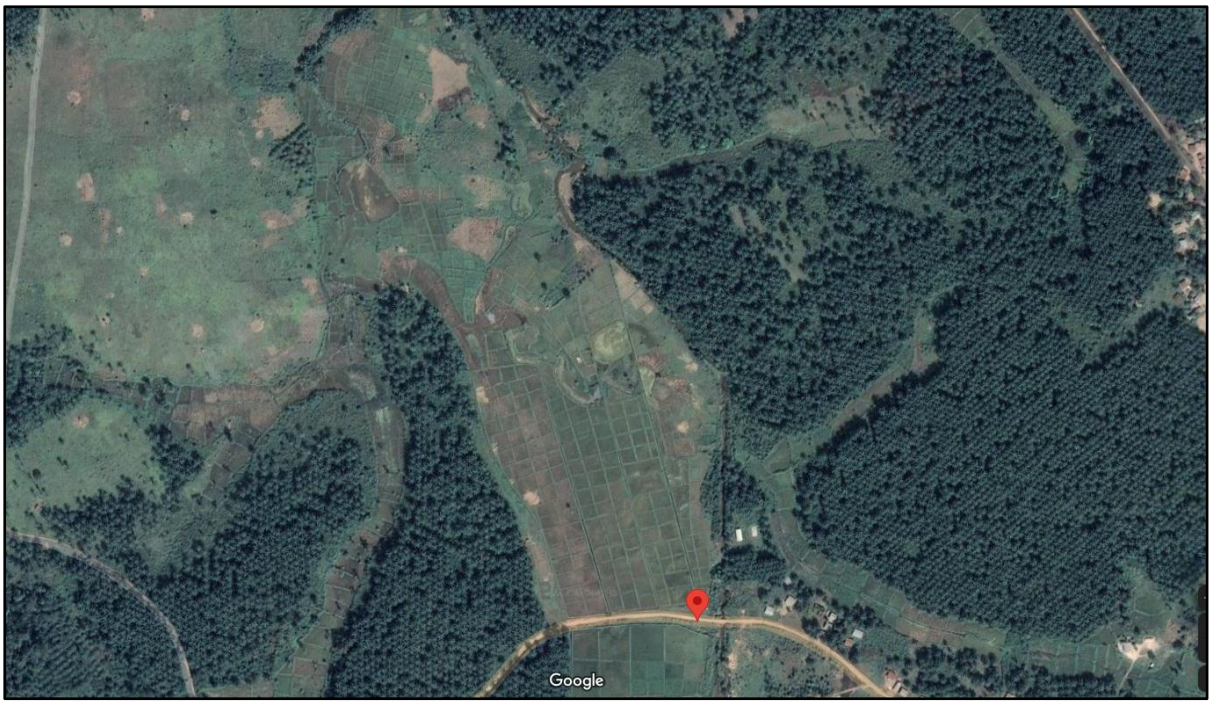

Figure 6-13 - Google satellite imagery of Ndama

There is also a storage building that could be used for mounting solar panels, providing better security, and labour availability does not appear to be an issue.

Figure 6-14 - Pictures from Ndama fields

From the reconnaissance visits to the sites in Lofa County, the field team considered the Ndama Site to be the most suitable for the SPIS pilot scheme.

6.3. Site Selection Criteria

The key parameters identified by the Team to be used in the selection of the site for the SPIS pilot scheme include the following:

- Availability of suitable water source:
  - Surface water; river and existing storage (dam/reservoir)
  - Groundwater:
    - Submersible pumps; existing borehole with adequate yield
    - Surface mounted pumps; shallow water table within Net Positive Suction Head (NPSH) limit
- Existing lowland rice cultivated areas, with potential for increased yields, cropping intensity and/or diversity of crops (i.e. areas out of command for gravity fed irrigation) ~10ha
- Suitable soil types (i.e. limited iron toxicity) and adequate drainage
- Community interest/motivation in new technologies and cultural practices
- Labour availability and organisation, particularly for equipment security
- No land ownership issues
- Location with respect to milling facilities and markets for inputs (i.e. seeds and agro-chemicals) and produce
- Good site access from Monrovia and other parts of the country for construction logistics, demonstration workshop or meetings etc.

Other factors that may also be considered include the following:

- Availability of agri-tools and machinery for land preparation.
- Detailed weather parameters of the particular location (if available), to understand rainfall patterns, temperature, humidity, wind speed and sun shine hours etc.
- Detailed soil test reports determining the condition of the soil (if available), including the physico-chemical properties (particularly hardness, iron toxicity and zinc deficiency), texture and organic content of the soils.
- Capabilities of extension officers or agriculture service providers and the levels of farmers/community involvement and training received on lowland rice farming and SRI agronomic practices.
- Experience and/or interest in diversifying to other crops.
- Prevalence of major pests, including birds, diseases and weed categories.
- Topography and land slopes to avoid soil erosion.
- Facilities for post-harvest operations, like winnowing, drying and storing of produce.
- Presence of community hall or venue to conduct meetings.

6.4. Selection of Best Sites between Bong and Lofa Counties

Based on the reconnaissance visits to Bong and Lofa counties, and the preselected sites identified by MoA, and using the key selection criteria and knowledge gained from all the studies to date, the Team made a comparison of the two counties to propose which is most suited to implementation of the SPIS pilot project. Each criteria was scored from 1-4 (1 = Poor, 4 = Good), with equal weighting for each category, and the scores totalled. Based on this comparison, it is recommended that Lofa county be selected for further study, to identify a specific site for the pilot scheme. The comparison is summarised in Table 6-2 below and, to ensure the process of selection is both transparent and informative, will be the subject of further discussion and a participatory Multi-Criteria Analysis (MCA) with SWG members at the inaugural meeting.

Criteria	Lofa	Bong
Availability of suitable water sources: • Surface water; river and existing storage (dam/reservoir) • Groundwater: ° Submersible pumps; existing borehole with adequate yield ° Surface mounted pumps; shallow water table within Net Positive Suction Head (NPSH) limit	 3 2	 2 2
Existing lowland rice cultivated areas, with potential for increased yields, cropping intensity and/or diversity of crops (i.e. areas out of command for gravity fed irrigation) ~10ha	4	4
Suitable soil types (i.e. limited iron toxicity) and adequate drainage	3	2
Community interest/motivation in new technologies and cultural practices	4	2
Labour availability and organisation, particularly for equipment security	3	2
No land ownership issues	3	2
Location with respect to milling facilities and markets for inputs (i.e. seeds and agro-chemicals) and produce	3	3
Good site access from Monrovia and other parts of the country for construction logistics, demonstration workshop or meetings etc	2	3
Total	**27**	**22**

Table 6-2 - Comparison of Bong and Lofa counties

At the SWG, the members will discuss the context of rice production in the counties and the proposed selection criteria, considering others that may be included, such as the benefits for women or particularly vulnerable groups, economic, legal and political differences between the counties that may have an impact on implementation and operation of the scheme. The SWG members will also consider the weighting assigned to each criterion, before completing the MCA and making their recommendation.

The site selection criteria and selected county were approved / revised by the SWG on the 30 March 2022 and the minutes of this meeting are included in the Appendices. The final county selection is confirmed as Lofa/Bong county.

6.5. Challenges and Requirements for Future Irrigation and Rice Cultivation

Summarising the findings of the studies to date, this final section of the report identifies some of the challenges faced in the selected county in the context of irrigation and rice cultivation, and based on the lessons learned from other local and international SRI projects provides recommendations on the most successful practices that could and should be replicated for the success of the SPIS pilot. In particular, consideration has been given to the vital importance of women and youth in the agricultural production system.

The Liberian rice industry, including both its production farms and milling facilities, have had to face and overcome a number of challenges. The main focus has been to move towards commercialization of local production, which has been hampered by farmers' lack of motivation to produce beyond their consumption needs, to move away from traditional, upland production systems and to adopt improved techniques and higher productivity strategies in lowland rice. Other major challenges are the availability of labour for the intensive production activities and the capital investment required for clearing lowland areas and constructing dikes, bunds and canals for irrigation. However, these challenges can be addressed and the following sections provide some further details that will guide the technical and social design of the SPIS pilot as well as identifying possible changes in legal, institutional and financial arrangements that will create a more positive environment for future irrigated rice cultivation in Liberia.

6.5.1. Policy related issues

Agricultural policies in Liberia have been inconsistent, often made more complex by the multiple policies that exist at national and local levels, which can run counter to one another. In particular, unfavourable pricing policies for agricultural inputs and produce reflect an inefficient value chain and marketing system.

6.5.1.1. Availability of inputs

The quality of seeds and their availability, as well as the consistent and timely supply of agro-chemicals and fertilizers are difficulties facing all farmers, in particular the lack of choice of high yielding rice varieties and specific resistant varieties that can cope with site specific problems, such as iron toxicity, pests and diseases.

6.5.1.2. High cost of cultivation

Liberia's rice value chain has seen worsening profitability in rice cultivation, due to the rising prices of chemicals and fertilizers, and the cost of agricultural labour.

6.5.1.3. Price fluctuations

Rice price fluctuations create a significant risk to farmers, which is outside their control and a major hindrance to decisions on investment, new technology or extending farms to larger areas, and the adoption of improved cultural practices. Farmers face difficulties getting their produce to the right market at the right time and with poor commercial linkages of marketing agents and little guidance on selling, their rice production fetches low prices. Inadequate modern storage and processing facilities, and the absence of precise scale systems for determining rice quantity and quality add to this problem.

6.5.1.4. Quality standards

The farmers' lack of awareness of quality control (i.e. generation of impurities at each stage of harvesting, threshing, drying, sorting, storing, parboil processing, drying and milling) and the absence of rice grading standards (i.e. inappropriate determinants to pricing, focusing more on quantity than quality) are big challenges in improving the market for rice.

6.5.2. Infrastructure

The poor infrastructure in Liberia discourages private sector investment in the rice sector, particularly in areas distant from the capital. The national road network does not effectively reach all smallholder farms, hindering the development of efficient trucking and transportation of agricultural inputs and for marketing of produce. These deficiencies contribute further to the production cost and further undermines the profitability of agriculture and agricultural business developments.

6.5.3. Maintenance of irrigation infrastructure

Existing rainwater harvesting structures, spillways and irrigation infrastructure are not being adequately maintained, either by government or by the community users. Over time, these structures become inefficient or useless, farmers see a diminishing return on any fees or labour provided for their upkeep and eventually they are abandoned. In particular, a lack of maintenance of earth channels leads to increased water losses and insufficient water supplies to the crop, leading to falling yields and generated income; and the cycle of decay continues.

6.5.4. Land preparation

Land preparation is mostly undertaken by manual labour and can lead to poor conditions for rice growth, especially in the early stages of the crop. Poor levelling leads to non-uniform spreading of water in the field and a short duration between land preparation and planting means the decomposition of plant roots and residues is delayed, with fewer nutrients available in the soil and some proportion of any applied nutrients from fertilisers effectively wasted on the survival of microorganisms involved in the decomposition process.

6.5.5. Rainfall intensity

The high intensity of rainfall in Liberia, exacerbated by climate change, can lead to increased runoff that may cause soil erosion, damage to crops and flooding.

6.5.5.1. Soil erosion

Intense rainfall and runoff can strip fields of fertile top soil or create gullies through farms and infrastructure. There are limited water management structures, like check dams, stilling ponds or emergency spillways, in Liberia that could provide protection against such occurrences.

6.5.5.2. Yield loss

Heavy downpours during the rainy season also lead to reduction in yield due to problems of drainage that cause waterlogging. Alternate wetting and drying is a major principle of irrigation technology, which fails due to improper drainage and leads to poor ear-bearing and tillering, and ends in reduced yields.

6.5.5.3. Flooding

Flooding of farm infrastructure, stores and housing close to the waterways adds risk and costs to the farmers budget that may impact his/her decision-making on investments and/or the adoption of new practices.

6.5.6. Location specific problems

Location specific problems should be considered when planning rice farming, including the use of appropriate varieties and problems like iron toxicity, salinity, problematic soil management and endemic pests. Some areas in Liberia are rich in iron ore and there is increased risk of iron toxicity that will impact rice yields. Individual packages of seed varieties, fertilisers and cultural practices should be formulated to combat the specific problems in the area.

6.5.7. Crop protection

High weed pressures coupled with pest and diseases will reduce the eventual yield. For example, the dominance of grass and sedges competing with rice in the early stages of its growth will increase the loss of yield due to subsequent pest and disease attack. The availability of inputs and timely use of appropriate crop management practices and plant protection measures are lacking for particular weeds, pests and diseases, and these then becomes a prominent issue for the farmer.

6.5.8. Adoption of technologies

Liberian rice farming is at a relatively primitive stage when compared with other major West African rice producing countries, especially in terms of the usage of machinery for land preparation, harvest and post-harvest operations, as well as the usage of labour-saving implements, and the adoption monetary and non-monetary inputs.

6.5.8.1. Adoption of SRI

System of Rice Intensification (SRI) is the emerging low cost, eco-friendly and sustainable technology being adopted in many African countries, following its development and success across the world. With the support of CHAP, FAO and other agencies, SRI practices are being followed in small pockets across Lofa and Bong counties. However, there are a number of hindrances to adopting these practices:

- Poor nursery management
- Untrained labour to transplant young seedlings
- Initial high weed pressures due to the wider gap between plants
- Lack of context-specific innovation/modification of SRI methods
- Lack of knowledge on appropriate plant protection measures.

Yet the transfer of technologies to mitigate these challenges are still in their infancy and meagre levels of adoption (CHAP, 2014). In addition, SRI practices should not be offered as a fixed package, since they are not always

suitable for all agro-ecological and socio-economic contexts. Because of diversities in the rice cultivation areas, the practices and technologies need to be adjusted according to the precise situation.

6.5.8.2. Harvest and post-harvest

Rice harvesting in Liberia is predominantly done manually with little or no mechanization; labour costs can be unaffordable to many smallholder farmers and many farmers use traditional threshing methods because of cost. However, the problem with these traditional threshing methods is that they are inefficient, incurring significant losses[5], and there is high tendency for stones and dirt to become mixed into the rice. Such inefficient and ineffective post-harvest processes, coupled with poor storage and transport logistics, are the main challenges to maximising price and incomes for farmers, processors and wholesalers of rice.

6.5.9. Involvement of Women and Youth

Agriculture can be an important engine of growth and poverty reduction, but the sector is underperforming in many countries, in part because women and youth, who are often a crucial resource in agriculture and the rural economy, face constraints that reduce their productivity.

In general, the labour burden of rural women exceeds that of men and includes a higher proportion of unpaid household responsibilities related to preparing food and collecting fuel and water. The contribution of women to agriculture and food production in Liberia is significant but it is impossible to verify the share empirically. Women's participation in rural labour markets varies considerably across regions, but invariably women are over represented in unpaid, seasonal and part-time work, and the available evidence suggests that women are often paid less than men, for the same work.

In the livestock sector, both women and men participate in small-scale animal production, but it is also worth noting that since women and men manage different livestock, they may experience different health and economic risks; the same is true in rice farming.

Women are experienced agricultural agents, but they suffer from limitations in farming cash crops and trading their produce effectively. Given the extensive evidence on the gender division of labour in value chains, strengthening women's capacity in this sector could increase women's gains in agriculture, leading to empowerment in other areas. Enabling women to participate in development processes is not only beneficial for the well-being of women, their families and rural communities, but it has an overall impact on economic productivity nationally.

The prevalence of high illiteracy rates, especially among women, often makes it difficult to reach rural people through extension services using conventional communication channels. Alternative models should therefore be employed to enable women to access extension services.

Social protection is crucial for women to improve their families' health and nutritional status, school attendance of their children and reduce hunger. Therefore social protection packages should be comprehensive and not limited to food/cash-for-work and school feeding programmes.

The issue of women's access to financial services is critical, since women are usually the poorest of the poor. However, financial service facilities are not readily available to rural women. Those available to rural women are predominantly microfinance-based and the percentage of rural women who access them is uncertain.

Liberia's Community Rights Law aimed to increase the role of forest communities in forest governance and management. The law should be strengthened to ensure equal representation of men and women on committees involved in the management of agriculture and natural resources, similar to the Community Forest Development Committee.

[5] Harvest and post-harvest losses in Liberia have been found to be close to 25% of the total yield.

6.5.10. Consumer aspects related to SPIS adoption

Whilst SPIS technologies are quite mature, early adoption in the Liberian context might prove to be challenging. Farmers who still depend on rainwater and do not have experience with any other form of irrigation will require support to adopt to the new methods of irrigation via pump and pipes. Furthermore, perceptions about inadequate water supply or access to groundwater may result in early bad experiences and can negatively impact adoption and further upscaling.

6.5.11. Technical aspects related to SPIS design and system sizing

SPIS tends to optimise performance when they are above a certain minimum capacity; experience in other countries shows that pumps of 15kW or higher are generally preferred, due to their ability to provide adequate water over several hours of the day. In Liberia, this may require several farmers to either group together to use the same pump or an installer might need to make contracts with several farmers around a pump to secure the viability of that individual pump. In addition, sufficient water storage would also need to be accounted for based on the cropping seasons and irrigation patterns.

6.5.12. Financing challenges and viability of SPIS

Any new system that is to be offered to the farmers would need to be cost competitive to their existing expenses for irrigation. SPIS do require significant upfront investments (CAPEX) and subsidies should be considered to ensure that the market is attractive enough for suppliers and service providers to enter the market with minimum equity injection. At the same time, water supply contracts would need to be drafted to offer competitive rates to farmers but also cover the operating costs (OPEX) and recover equity (and possibly any debt) investments. In depth assessments and financial due diligence would be needed to identify the conditions at which the projects can operate viably and also support market growth and uptake.

Farmers might also find it difficult or impossible to commit to purchase of certain minimum quantities of water per month or cropping season. This uncertainty results in direct financial insecurity for the supplier and investors. This situation can be further aggravated during rainy seasons when the farmers do not need water from the pumps at all. While secondary use of SPIS might be explored for powering other machines (e.g., milling, forced drying etc), the dispersed locations of the SPIS do not normally allow for such adaptations. Therefore, system costing and financial planning would need to be done based on realistic assumptions of water sales that can be realised in a year, depending on local cropping pattern, water demand and rainy seasons.

6.5.13. Procurement, supply chain and O&M structures needed for SPIS deployment

A substantial upscaling of SPIS would require adequate supply chains to be set up to ensure that the systems are available for installers and service providers at reasonable prices. At the same time, after sales and O&M services would need to be established across the country. Fortunately, the technological aspects are not the main challenge, since existing expertise on pumping and solar PV can be leveraged upon. However, specialized technicians and service providers might be needed for a sustainable market development and growth.

6.5.14. Security of SPIS equipment

Due to prevailing conditions in Liberia, security of deployed equipment has been identified as a major concern for farmers, suppliers and service providers. Working with local farmers to participate in the maintenance and security of equipment on ground will need be to ensured. However, social dynamics will need to be considered as well. It has been observed that sometime if one of the farmers hosts the SPIS and takes care of its maintenance or security, it may cause social issues with other farmers who may feel that they are now dependent on the host farmer. To address this, adequate communication and confidence measures with time and capital investments in social mobilization and onboarding of recipient farmers would need to be made.

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8. Appendices

Appendix A	M&E Plan and Impact Statement
Appendix B	Inception Meeting Invitation and Circulation List
Appendix C	Inception Meeting Minutes (including PowerPoint Presentation)
Appendix D	Minutes of inaugural Stakeholder Working Group Meeting

Appendix A - M&E Plan and Impact Statement

Appendix B - Inception Meeting Invitation and Circulation List

Appendix C - Inception Meeting Minutes (including PowerPoint Presentation)

Appendix D - Minutes of inaugural Stakeholder Working Group Meeting