

Republic of South Sudan

TECHNOLOGY NEEDS ASSESSMENT

BARRIER ANALYSIS AND ENABLING FRAMEWORK REPORT FOR CLIMATE CHANGE ADAPTATION AND MITIGATION

JUNE, 2024









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DISCLAIMER

This document is an output of the barrier analysis and enabling framework for climate change adaptation and mitigation. It identifies barriers and provides an enabling framework for developing and implementing sustainable technologies for climate change adaptation and mitigation priority sectors. These included agriculture, livestock and fisheries, the water sector, disaster risk reduction and management (DRRM) for adaptation sectors and the energy sector, agriculture, forestry, and other land use (AFOLU), and solid waste management as priority mitigation sectors in South Sudan.

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FOREWORD

South Sudan has a high vulnerability to adverse impacts of climate change and variability, in particular extreme climate stress events (e.g., heat waves, extended drought periods, flooding), indicating that the country is in dire need of sustainable adaptation and mitigation technologies to lessen damage to life, property, natural eco-systems, and the economy of the country. I am confident that the Technology Needs Assessment (TNA) project initiated by the Ministry of Environment and Forestry, Government of South Sudan, in collaboration with the United Nations Environment Programme (UNEP), Copenhagen Climate Centre (UNEP-CCC), will prompt all stakeholders to take timely action in climate change adaptation and mitigation.

I am pleased to note that the entire process to set preliminary targets for the transfer and diffusion of technologies, identify barriers, and suggest an enabling framework for overcoming the barriers in phase-II of the TNA project has been country-driven. Being highly consultative, it involved a number of stakeholders and experts from the government, private sector, and civil society. I strongly believe that the implementation of adaptation and mitigation technologies prioritized in TNA Adaptation Report Phase-I will help the country build resilience to the impacts of climate change. I would like to thank the members of the TNA National Team, my colleagues in the Ministry of Environment and Forestry, and the experts of the Adaptation and Mitigation Working Group for their invaluable contributions to the preparation of this BA&EF Report.

I also thankfully acknowledge the contributions of Dr. Debbie Sparks and Dr. Gordon Mackenzie, Lead-Expert Mr. Bul John Ajak, and other experts of the United Nations Environment Programme Copenhagen Climate Centre (UNEP-CCC) and the University of Cape Town for their constant support and guidance for the implementation of the South Sudan TNA project.

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PREFACE

South Sudan faces a number of natural hazards, including floods and droughts. Climate variability is likely to negatively impact many sectors in the country, while projected increases in rainfall intensity may increase the risk of floods and the spread of waterborne diseases. In order to meet the problems posed by climate change and move toward a sustainable future, South Sudan has committed to remaining carbon neutral while ensuring overall social-economic development.

It is now imperative for South Sudan to develop resilience and climate change adaptation. Luckily, discussions and frameworks adopting sustainable development policies are placing a greater emphasis on environmentally sound technologies. Technology Needs Assessment (TNA) is one of the critical steps towards identifying and assessing climate change adaptation challenges for South Sudan in order to align its adaptation and migration needs and opportunities with the goals and objectives of its sustainable development. As a climate change adaptation and mitigation tool, this TNA would help the country identify the needs for new equipment, techniques, practical knowledge, and skills that are necessary to successfully pursue climate-resilient development.

This report on the 'Barrier Analysis and Enabling Framework' of technology needs assessment is part of the TNA project outputs, funded by the Global Environment Facility (GEF) and implemented by the Ministry of Environment and Forestry (MoEF) in collaboration with UNEP Copenhagen Climate Centre. This report identifies and provides a list of barriers and enabling measures for the adoption of prioritized adaptation and mitigation technologies in the climate vulnerable areas of agriculture, water, disaster risk management, energy, waste, agriculture, forestry, and other land use (AFOLU).

The report is the outcome of a participatory process that was entirely led by the nation. After lengthy consultations with stakeholders and the adaptation and mitigation technology expert team, the opinions and data in this study were developed. I would like to thank all of the stakeholders for their ongoing assistance and insightful feedback as this report was being developed. I anticipate that the nation's advancement of climate change adaptation and mitigation technology will be greatly aided by this BA&EF report.

Lastly, it has been my honour and pleasure to write these introductory remarks and endorse enabling framework for overcoming the barriers in phase-II of the TNA project Republic of South Sudan's second NDC. This document, and the process that it represents, is

the first step on the road to a prosperous and climate-resilient future for all South Sudanese

Hon. Josephine Napwon Cosmas

Minister of Environment and Forestry (MoEF)

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ABBREVIATIONS AND ACRONYMS

AfDB	African Development Bank	
AFOLU	Agricultural, Forestry and Other Land Use	
BAEF	Barrier Analysis and Enabling Framework	
BDC	Boma Development Committee	
CAMP	Comprehensive Agriculture Master Plan 2015-2040	
CVRA	Climate vulnerability and risk assessment	
DRR	Disaster Risk Reduction	
EWG	Experts working groups	
FAO	Food and Agriculture Organization of the United Nations	
FEWSNET	Famine Early Warning Systems Network	
GCF	Green Climate Fund	
GEF	Global Environment Facility	
GHG	Greenhouse Gas	
GHGR	Greenhouse Gas Emission Reduction	
IDMP	Irrigation Development Master Plan 2015-2040	
IDP	Internally-Displaced Person (People)	
IGAD	Intergovernmental Authority on Development	
INC	Initial National Communication (to the UNFCCC)	
INGO	International non-governmental Organization	
IPCC	Intergovernmental Panel on Climate Change	
JICA	Japan International Cooperation Agency	
LEG	Least Developed Countries Expert Working Group	
LULUCF	Land use, land-use change and forestry	
MAFS	Ministry of Agriculture and Food Security	
MARF	Ministry of Animal Resources and Fisheries	
MERL	Monitoring, evaluation, reporting, and learning	
MGCSW	Ministry of Gender, Child, and Social Welfare	
MHADM	Ministry of Humanitarian Affairs and Disaster	
	Management	
MWRI	Ministry of Irrigation and Water Resources	
MoED	Ministry of Electricity and Dams	
MoEF	Ministry of Environment and Forestry	
MoFP	Ministry of Finance and Planning	
MoGEI	Ministry of General Education and Instruction	
MoTR	Ministry of Transport and Road	
MPM	Ministry of Petroleum and Mining	
MWCT	Ministry of Wildlife Conservation and Tourism	
NALEP	National Agriculture and Livestock Extension Policy	
NAP	National Adaptation Plan	
NAPA	National Adaptation Programme of Action	
NATCOM	Initial National Communication to the United Nations	
	Framework Convention on Climate Change	
NBSAP	National Biodiversity Strategy and Action Plan 2018-2027	

NDC	Nationally Determined Contribution (to the Paris
	Agreement)
NDS	National Development Strategy 2018-2021
R-TGNU	Revitalized Transitional Government of National Unity
SDG	Sustainable Development Goals
SFM	Sustainable Forest Management
SSDP	South Sudan Development Plan 2011-2016
SSMD	South Sudan Meteorological Directorate
SSP	South Sudanese Pounds
TNA	Technology Needs Assessment
ТАР	Technology Action Plan
TFS	Technology Fact Sheet
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP CCC	United Nations Environment Programme Copenhagen
	Climate Centre
UNFCCC	United Nations Framework Convention on Climate
	Change
UNOCHA	United Nations Office for the Coordination of
	Humanitarian Affairs
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

The Technology Needs Assessment (TNA) Report II presents the barrier analysis and enabling framework for climate change adaptation and mitigation technologies in South Sudan, which were identified and prioritized in TNA Report I. The Barrier Analysis and Enabling Framework (Report II) identifies the significant barriers that could constrain the acquisition, deployment, and diffusion of the prioritized adaptation and mitigation sectors' technologies. It also outlines appropriate measures to overcome these barriers. Lastly, it suggests an enabling framework for overcoming the identified barriers and successfully implementing these technologies.

The adaptation and mitigation technologies were identified by the Technology Needs Assessment (TNA) stakeholders and the government of South Sudan in line with the sectors identified in the nationally determined contributions (NDCs) to the UNFCCC and the South Sudan National Adaptation Plan of Action as vulnerable sectors to the impacts of climate change and variability. The twelve (12) climate change adaptation and mitigation technologies that were identified and prioritized for BAEF in South Sudan are indicated in the table 1 below.

 Table 1. Identified and Prioritized climate change adaptation and Mitigation technologies

 for Barriers Analysis and enabling framework (BA&EF)

Adaptation Sectors	Mitigation sectors
Agriculture, livestock, and Fisheries	Energy Sector technologies
sector technologies	• Hydropower (mini/micro hydropower)/small
• Micro – Irrigation - Sprinkler and	hydropower
Drip Irrigation	• Off-grid solar mini-grids up to 100 kW -
• Promotion of drought-resistant crop	Solar PV Grid-tied
varieties	
Water sector technologies	Waste management sector
• Solar-powered water supply system	• Reduce, Reuse, Recycle (3Rs)
• Groundwater Abstraction – Water	Transfer waste station
Borehole Drills	
Disaster Risk Management Sector	Agriculture, Forestry, and Other Land Use
Development and introduction of	(AFOLU) sector
monitoring and early warning systems	• Promoting Forest based enterprises e.g.
• Improving disaster response (through	beekeeping/apiary, butterfly farming, fruit
the use of social media)	tree production, and ecotourism
	• Sustainable Forest Management (SFM)
	for reducing emissions from deforestation
	and forest degradation

The second stage of the TNA process entailed analysis and prioritization of potential barriers and measures to overcome the challenges to implementation. The BAEF was conducted following the barrier analysis processes and techniques indicated in the TNA guidelines. Barriers to adaptation

and mitigation technologies were compiled, screened, decomposed and analyzed for root causes through a literature review, key informant interviews, two stakeholder consultation workshops, and meeting with expert sector working groups. Specifically, the barriers compiled from a literature review, interviews, and meetings were screened and ranked to derive essential barriers, by expert judgment-voting and scoring, respectively. The voting was to discard irrelevant, invalid, and non-essential barriers and keep essential barriers only.

Once key barriers were identified, they were decomposed by categorizing barriers, defining barriers within each category, and then using a logical problem tree analysis to map out the root causes of the key barriers. Finally, the analysis results were validated, and consensus was reached by all the key stakeholders, namely the technical workshop, adaptation and mitigation focus group, and stakeholder consultation meetings.

For the prioritized adaptation sectors and technologies for BA&EF, the economic and financial barriers for the technologies were mainly: 1) the high cost of investments and high infrastructure costs associated with the costs of equipment and installation, 2) limited capital and access to finance, and 3) insufficient incentives. Some of the important non-financial barriers for the implementation of the technologies in the adaptations sectors are: 1) weak capacity and limitations in technical knowledge and skills, 2) lack of trained technical staff, 3) inadequate public budget, 4) insufficient legal framework for the diffusion and transfer of adaptation sector technologies, another important barrier is the low level of awareness of economic and ecological advantages.

Similarly, the barriers that hinder effective development and deployment of the mitigation technologies for the Energy, Waste, Agriculture, Forestry, and Other Land Use (AFOLU) sector consist of financial and economic and non-financial and economic barriers. There are three common financial and economic barriers faced by technologies in both the three mitigation sectors, namely: 1) low budgetary allocation for the promotion, development, and management of the technologies; 2) high investment cost; and 3) inadequate financial and economic barriers: 1) limited knowledge and skill for promotion, development, and management of the technologies; 2) limited information and awareness, 3) technical difficulty and utility limitation of the technologies, 4) inadequate reference projects such as successful interventions and best practices; and 5) insufficient policy framework. In addition, there are other specific barriers to specific technologies, such as inadequate raw material supply for solar mini-grids and micro hydropower, as shown in Table 2 below.

In conclusion, to ensure the development, diffusion, and sustainability of the technologies in both adaptation and mitigation sectors, the following enabling environments are also required to deal with barriers and ensure effective implementation, transfer, and diffusion of the technologies.

Common barriers for adaptation and mitigation technologies	Measures	Enabling framework
Low public budgetary allocation for diffusion and transfer of the technologies	Government of South Sudan to strengthen and take full advantage of revenues from oil sector and promote reinvestment in the technologies Government to improve resource mobilization and access to financial and technical supports from external financial institutions and organization	Government of South Sudan policies and regulation on the promotion of environmentally friendly technologies and sustainable practices
	Urgent call for the Government of South Sudan - Ministry of Finance and Planning to improve public budgeting and financial mechanisms including incentives and subsidies for the deployment Improve effectiveness and fiscal transparency of financial aids to support the acceleration of technology diffusion	
High investment cost of technologies	Government of South Sudan can reduce tax, improve cost sharing and transfer mechanism while promoting incentives can use investment subsidy to reduce the new technology firms' investment cost	South Sudan Investment Promotion Act 2009 for promotion and facilitation of investment in South Sudan Existence of National Revenue Authority (NRA) and Ministry of Investment
Limited capital and access to finance	Increase the capacity for financing of technology markets in South Sudan while at the same time	Developing an effective public budget allocation for the development of

Table 2. Enabling framework for overcoming barriers in both climate change adaptation and mitigation sector

	helping local South Sudanese	climate change
	entrepreneurs in the for-profit and	adaptation and mitigation
	not-for profit sectors to build	technologies.
	sound portfolios of climate change	
	adaptation and mitigation projects	Effective and transparent
	for investment.	financial-aid policy and
	Develop and implement policies	management system.
	including warrants for facilitation	
	of access to finance.	
		Policy for promotion of
	Enhancing financial innovation and	investment, business, and
	access with a focus on capital	the development of the
	market inclusion.	private sector, including
	Stimulate public and private	the capital market and
	investment and provide low interest	access to finance.
Limited organizational	rate loans	Education policies
consists and staff	resource development through	publicly funded research
tachnical knowladge	conscity building training and a	and development and
and skills	capacity building plan	training programmes
	technologies expert knowledge	through the University of
	management	Juba and Upper Nile
	management.	University
	Improve high education and	Oniversity
	professional training.	
Insufficient policy	Establishing an appropriate	Law enforcement and
implementation and legal	regulatory and legal framework and	effective implementation
framework	building the capacity of relevant	especially natural
	stakeholders.	resource, environment
		environment regulations
Technical - Insufficient	Inadequate trained local technical	Establish technology
capacity on most of the	expertise to install, operate and	innovation training
climate change adaptation	maintain the technology for	centers to train and
and mitigation technologies	example the hydropower and Solar	accredit human resource
	Mini-grid	specializing in the
		adaptation and mitigation
		technologies

CHAPTER 1 AGRICULTURE, LIVESTOCK, AND FISHERIES SECTOR

1.1 Preliminary targets for technology transfer and diffusion in Agriculture, Livestock, and Fisheries sector

The agriculture, livestock and fisheries sector is an important source of livelihood for most of the South Sudanese population; though, the prolonged conflict has decimated an already weak agriculture and food system. With over two-thirds of the South Sudanese population engaged in agriculture, livestock, and fisheries and 83 percent of households listing agriculture and livestock as their primary source of livelihood, the sector plays a central role in the lives of the South Sudanese people. Most farmers, however, are small-scale, operating at a subsistence level with an average farm size of 0.8 ha (as calculated by FAO and WFP in 2018). Agricultural productivity and production in South Sudan remain low. Producer farmers rely heavily on rain-fed agriculture, meaning that erratic rain patterns can result in poor or no harvests, destroyed stocks, and waterlogged crop farms. Furthermore, farmers are hampered by the limited availability of and access to quality drought resistant seeds and planting materials that constrain yields. The recent climate change projections for the agriculture sector indicate an increase in temperature, changes in rainfall patterns, and changes in wind and solar radiation patterns that will adversely affect crop productivity, with a looming threat to the national food security gains.

The Comprehensive Agriculture Master Plan (CAMP), which was formulated in 2016 and details the Government of South Sudan's plan for expanding the agricultural sector, identifies several issues and challenges to achieving sustainable development through food and water security. One of the most important challenges to the growth of the sector is the slow rate of technological innovation due to the limited use of climate-resilient and sustainable practices and technologies to improve the efficiency of farming systems. Hence, to adapt to the severe impacts of climate change, the agriculture sector needs to adopt environmentally sound technologies to move towards a climate resilient development pathway.

The stakeholders in the TNA project in its Phase-I identified, prioritized, and considered the following two climate change adaptation technologies for BE&EF in agriculture, livestock, and the fisheries sector:

- 1. Micro irrigation sprinkler and drip irrigation.
- 2. Promotion of drought-resistant crop varieties.

These technologies in agriculture, livestock, and fisheries sector are mainly prioritized as adaptation measures to reduce the vulnerability of the population who are dependent on rain fed agriculture in the face of climate change and variability. However, it is underlined from the beginning of the technology prioritization that all the above two technologies are available and used by farmers in South Sudan at different levels, and the only issue is that these technologies are not being well adapted and implemented widely and sustainably by the farmers across the country to bring sustainable production benefits to the agriculture, livestock and fisheries sector.

The preliminary targets identified according to national aspirations for the transfer and diffusion of these technologies in agriculture, livestock, and fisheries sectors are:

Micro – Irrigation - Sprinkler and Drip Irrigation

South Sudan's irrigation potential is around 1.5 million hectares (ha) (AfDB 2013) that could be brought under sprinkler; and drip irrigation by smallholders and commercial farming. This potential is divided into the Nile-Sobat River Basin (with a potential of 654,700 ha); the Western and Eastern Flood Plains in Warrap, Unity, and Jonglei States; the Mangalla region, which is 45 kilometers (km) from South Sudan capital city Juba, at the convergence of the White Nile and one of its tributaries in Central Equatoria State; and the Green Belt zone, but, because of political instability, the development of micro-irrigated agriculture was constrained except for a few formal irrigation schemes constructed as pilot agro-industrial projects. These have never been fully operational. They were neglected during the periods of civil conflict and war and are now largely nonfunctional, but plans do exist to revive them given the availability of water both from surface and underground sources.

South Sudan's Irrigation Development Master Plan targets installation of drip/sprinkler irrigation systems on 4,987 hectares under micro-irrigated agriculture, mainly in Wau (1000 ha), Rejaf (960 ha), Jebel Lado (1330 ha), and Aweil (1,691 ha). This will mainly be an investment in sprinkler and drip irrigation systems to reduce vulnerability to the effects of climate change by increasing crop yields and minimizing losses. The sprinkler and drip irrigation systems will fall under the micro-medium scale systems, and although no specific target is mentioned for this technology, it is likely to dominate given the demand by a large number of farmers in the drought prone areas. The sprinkler and drip irrigation technology will be established across the country to provide many adaptation benefits: With projected decline in rainfall and freshwater availability, the technology will provide efficient use of water supply, especially in drought prone areas or those with seasonal rainfall, and the target for the drip/sprinkler irrigation technology is the introduction of 3000 drip/sprinkler irrigation systems to individual farmers and institutions, respectively, by the year 2030. It will reduce the demand for water by reducing water evaporation losses.

Under this technology, sensitization and awareness programmes across the 10 states in South Sudan will be implemented and provide support for vulnerable smaller farmers operating 2- 4 feddans farms to install "starter" drip and sprinkler irrigation systems for 100 farmers per year and expand to include larger farms 5-10 feddans or even more per year thereafter. The technology will be implemented in conjunction with other ongoing schemes, such as the promotion of drought-resistant crops and rainwater harvesting to better adapt to climate change and variability, and training of farmers on efficient irrigation techniques and water management.

Promotion of drought-resistant crop varieties

The target for diffusion of promoting drought-resistant crop varieties technology in South Sudan has been primarily based on the national strategy developed by the Ministry of Agriculture and Food Security (MAFS-GOSS). The South Sudan Country Programming Paper (CPP), 'Drought Disaster Resilience and Sustainability Initiative', identifies climate change as one of the major threats of food security in the country and thereby includes the South Sudan National Agriculture, Food and Security Investment Plan (NAFSIP) and Comprehensive Agricultural Development Master Plan (CAMP), which include a specific target for the development and promotion of drought and pest resistant crop varieties like maize and sorghum. This program has the overall goal of: addressing the causes of structural natural resource-based conflict and insecurity as an underlying expander of the impact of drought and strengthening the livelihoods, coping, and adaptive capacity of households and communities in drought-prone areas.

Under this program and plan, a South Sudan Resilient Agricultural Livelihoods Program has been prepared with the goal of increasing crop production through the promotion of improved drought-resistant varieties, breeds, and management technologies. The project covered the testing of drought-resistant hybrids, the production of early generation drought tolerant seed, and linkages with the seed companies. One of the key strategies to achieve this goal is through the promotion and dissemination of improved drought-tolerant crop varieties that aim at enhancing the resistance of maize and sorghum varieties to a variety of stresses that could result from climate change, such as water and heat stresses and the emergence of new pests. Varieties that are developed and promoted to resist these conditions will help to ensure that agricultural production can continue and even improve despite uncertainties about future impacts of climate change. Based on the national strategy of the Ministry of Agriculture and Food Security and in line with the Comprehensive Agriculture Master Plan (CAMP), the TNA consultations agreed on the targets for the diffusion of the technology:

- 1. Development and promotion of drought-resistant and early-maturing crop varieties for agricultural households in all the agro-ecological regions of the ten states of South Sudan.
- 2. Supporting farmers to access drought-resistant and early-maturing seed varieties of maize, sorghum, bean, and cassava. The total investment cost of cultivation of drought-resistant sorghum or maize varieties using hand hoes on a 1 ha plot of land is US\$16.
- 3. Increasing generation, uptake, and use of improved certified and quality climate resilient declared seed by 60% of the farmers through seed multiplication by 2030.

1.2 Barrier Analysis and Possible Enabling Measures for Micro Irrigation – Sprinkler and Drip Irrigation Technology

1.2.1 General Description of Micro Irrigation – Sprinkler, and Drip Irrigation Technology

Irrigation is an agricultural operation involving supplying the need of a plant for water. Irrigation is necessary in a dry climate where natural rainfall does not meet plant water requirements during all or part of the year. In South Sudan, land and water resources are becoming scarce, and arable land has decreased tremendously due to population increases, unreliable rainfall caused by periodic droughts, and a lack of appropriate technologies to cope with the situation. Persistent droughts and dry spells due to climate change have led to a persistent threat to household food security and exacerbated poverty in the country. The importance of irrigation and efficient use of water due to

water scarcity is being addressed through the development of more efficient irrigation systems and methods, such as drip irrigation.

Drip Irrigation, is a technique for the application of specific and focused quantities of water to soil crops and the application of water at a determined rate to the root zone of crops. This greatly reduces water run loss through deep percolation or evaporation. Required minerals can also be added to the water, thus allowing for increased efficiency, minimized oversaturation, and improved productivity. The system uses pipes, valves, and small drippers or emitters to transporting water from the sources to the root area and apply it under particular quantity and pressure specifications. Drip irrigation can provide as much as 90 percent water-use efficiency in contrast to surface irrigation and sprinkler systems, which provide 60 percent 75 percent efficiency, respectively, and can therefore enable farmers to adapt to climate change in crop production under erratic rainfall patterns (Irmak Suat et al., 2011). Micro-sprinkler irrigation involves a type of pressurized aerial irrigation that consists of applying water to the soil surface from above using mechanical and hydraulic devices that simulate natural rainfall.

The benefits of each of these technologies include: - supply of water to farms whenever required by crops, thereby reducing dependence on rainfall, efficient drawdown on water, thereby minimizing loss and conserving resources. Where groundwater is the source, sprinkler and drip irrigation systems can reduce withdrawal, particularly during more sensitive dry months, thus minimizing depletion of groundwater levels.

Status of drip irrigation in the country

In South Sudan, the technologies are well known, and local supply chains are present for the supply and installation of sprinkler and drip irrigation technologies. However, there is generally low uptake by small and medium-sized farmers. Farming remains primarily rain-fed; irrigation farming is still limited; this can be attributed to the high capital investment cost, and to some extent, the low technical knowhow of the farmers regarding the use of the technology (IDMP, 2015).

Technology Category and Market Characteristics

During the stakeholder consultation, micro-Sprinkler and drip irrigation have been categorized as 'consumer goods. It was justified as a consumer good because it involves small and medium-scale farmers and local retailers - a full service for the supply, installation, and maintenance of the sprinkler and irrigation systems. However, many of the components can be accessed from local retailers and hardware stores. These imports are subject to all local taxes, duties, and fees. Despite these opportunities, there has been a very low user adoption of sprinkler and drip-irrigation technology in medium and small-scale farms in South Sudan. This barrier analysis aims to identify direct and indirect contributors in the categories of financial and non-financial barriers for microsprinkler and drip-irrigation technology transfer and diffusion.

1.2.2 Identification of Barriers for Micro Irrigation – Sprinkler and Drip Irrigation Technology

The process of barrier identification includes barriers compilation, screening, decomposition, and root cause analysis by literature review, key stakeholder interviews, and consultation workshops. The consultation result showed that, despite many barriers hindering the diffusion of micro irrigation in South Sudan, there are 11 important barriers that are hindrances to micro irrigation: – sprinkler and drip irrigation technology (Table 3). The barriers and scores are given in Table 3-2. The financial-economic barriers include: 1) low profit on the investment in feed development, 2) high investment cost, i.e. high cost of initial installation, 3) inadequate public financial support, e.g., incentives and subsidy; and 4) limited capital and access to finance. Non-financial are: 1) small market, 2) insufficient technical knowledge and capacity on sprinkler and drip irrigation technology, 3) inadequate information and lack of awareness on sprinkler and drip irrigation technology, suitable types and feasibility, 4) low level of trust for financial and banking institutions; and 5) insecurity: fear of theft if the system is installed far from the house.

1.2.2.1 Economic and financial barriers

Economic and financial barriers were identified from stakeholder consultations and were scored and ranked to determine which barriers were most significant. The barriers and scores are given in Table 3 below.

Barrier Category	Identified economic and financial barriers
Economic and Financial Barriers	High initial investment and maintenance cost. The high initial investment cost is for mini-sprinkler and drip irrigation systems as compared to traditional irrigation methods. This includes small and medium-sized farmers' lack of financial resources to cover the operating and maintenance costs, of sprinkler and drip irrigation systems.
	There is a limited access to credit for farmers. Producers in the country are unable to access financing for the initial capital to purchase the hardware for sprinkler and drip irrigation systems. The majority of farmers and entrepreneurs are small sized medium with limited financial capital. Many of them have not even had enough financial resources to explore optimal irrigation technology and invest in irrigation inputs for the improvement of existing irrigation technology. Access to finance, in the meantime, is challenged. Interest rates and requirements for borrowing loans provided by domestic financiers are high and complicated.

Table 3. Identified economic and financial barriers to the deployment and diffusion micro sprinkler and drip irrigation technology

Loans for the purchase of equipment for sprinklers and drip irrigation are
generally high risk and sometimes have a high interest rate. Micro- finance
banks in South Sudan provide loans to farmers at a rate of interest as high as
15%, making it extremely difficult for producers to avail these loans, making
the diffusion of these technologies difficult in the country because it requires
a higher return on investment (ROI), which is not typical for small and
medium-sized farms.
Capital for investment in Sprinkler and drip irrigation systems is difficult to
obtain for producers. This is due to a lack of required documentation, such as;
land titles, financial records, and financial references.
Absence of lending agencies. In South Sudan, most commercial banks shy
away from lending to startup individuals or companies due to the absence of
stable cash flows and transaction history with the bank. The best places to get
a startup technology implementation loan are the less traditional types of
lenders, such as family and friends.

1.2.2.2 Non-financial barriers

The non-financial barriers were identified from stakeholder consultations and scored to determine which non-financial barriers were most significant. The barriers are given in Table 4 below.

Barrier Category	Identified measures to address economic and financial barriers
Technical Barrier	Limited technical skills in drip and sprinkler irrigation. Many farmers are unaware of the proper use of the technology; how to install and maintain the systems for the efficient collection and use of water; and the application for optimizing production. In addition, the inadequate number of sprinkler and drip irrigation professionals in the country is a major impediment to the development and diffusion of micro-Sprinkler and drip irrigation programs. The Ministry of Agriculture and Food Security (MAFS) has inadequate staff and professionals who are experienced in designing and maintaining new systems and are familiar with drip and sprinkler irrigation techniques, which act as a major impediment. This coupled with the poor efficiency of the existing infrastructure for irrigation in the country. Private sector institutions and their human capacity are further constrained to cater to the after sales service needs of such sprinkler and drip irrigation systems.

Table 4. Identified non-financial barriers for sprinkler and drip irrigation systems

	There are limited hands-on training and capacity building programmes by the
	government of South Sudan and international organizations for farmers in
	operating micro-sprinkler and drip irrigation water management technology
	suitable for small or medium-sized farms.
Doliov Logol	In South Sudan, there is no single policy legal, and regulatory instrument
roncy, Legal	that is supportive and encourages individual investment in micro sprinkler
and regulatory.	and drip irrigation systems. There is no special focus in current policies on
	and drip infiguron systems. There is no special focus in current poncies on
	schemes and community based models like the Awail rice scheme in
	Northern Behr al Chazal
	Furthermore, the leak of fiscal incentives by the government in form of tax
	Furthermore, the fack of fiscal incentives by the government in form of tax
	exemptions of subsidies further discourages producers from adopting and
Institutional	Limited good knowledge and practical experience are necessary to install and
and	constantionalize such water saving systems, as each system needs to be site
allu	specific for optimal use. Despite strong policy frameworks for integrated
organizational	specific for optimiar use. Despite strong policy frameworks for integrated
capacity and	(MWPI) aspecially the Directorate of Water Management Research suffers
numan skins	(WWRI) especially the Directorate of water Management Research suffers
Darrier:	and infrastructure leading to a rather slow development and diffusion of new
	technologies such as drip and sprinkler. Implementation of irrigation systems
	suffers due to a lack of technical staff at awail Rice Irrigation schemes
	suffers due to a fack of technical start at Awen Rice infigation schemes.
	In addition, water management responsibilities are distributed across several
	institutions and entities, both at the national and subnational level, but roles
	and responsibilities are not clear or aligned. Because South Sudan is a
	relatively new country, institutions are nascent, and progress in the
	implementation of efficient irrigation methods or technologies including the
	advanced irrigation systems like sprinkler irrigation and drip irrigation has
	been slow.
Market	Currently, in South Sudan, there are no dealers dealing with sprinkler and
Condition:	drip irrigation technology and equipment's. This is largely because there has
	been no demand for such systems by the Micro-, Small-, and Medium-
	Enterprises (MSMEs) engaged in farming; thereby, the supply could not be
	developed. Most of these systems are currently being imported from East
	Africa (Uganda and Kenya). No after sales support to these systems further
	reduces their uptake.
	The local market for Sprinkler and drip irrigation is underdeveloped, small,
	and has a weak supply chain. According to the South Sudan Agriculture

	Producers Union (SSAPU), there are a limited number of suppliers and no
	pre-qualified registered supply and service companies, that are responsible
	for the installation of drip and sprinkler irrigation systems and for the
	provision of post installation support to micro-, small-, and medium farmers
	in the country.
Information	Due to limited institutional capacity both at the research implementation
and awareness	levels for new irrigation systems, there is a real dearth of information on
on the Micro	better water management techniques, including drip and sprinkler. This lack
Sprinkler and	of information translates into a lack of awareness, both at the level of
drip Irrigation	researchers, irrigation engineers, and farmers, of new technologies and their
technology	associated costs and benefits.
	Inadequate and ineffective R&D and information dissemination regarding
	the advantages of sprinkler and drip irrigation technology.
Social, cultural	Typically, producers in South Sudan tend to have a low level of trust for
and behavioral	financial and banking institutions. They always do not trust the banking
	system and government.
	Also, communal use and sharing of water sources in most parts of South
	Sudan is difficult to break and therefore, some people believe that
	technologies are likely to create problems as the number of individual
	sprinkler and drip irrigation installation increase.
Others	Insecurity: fear of theft if the system is installed far from the house. The
	safety and security of the systems for sprinkler and drip irrigation have been
	a concern for farmers, as well as for lending and donor agencies. There have
	been many reports that equipment is often stolen from farms. Therefore,
	additional resources are required to safeguard these systems

One of the most significant barriers identified for the technologies is related to economics and financing of the technologies. Farmers are unable to access financing for the initial capital to purchase the Sprinkler and drip irrigation system hardware. There are loans and grants available to few farmers through various entities such as Sudan Microfinance Institution, Finance Sudan Limited, Rural Finance Initiative and Rural Finance Initiative (RUFI). Consultation with stakeholders and the sector expert working group indicates that farmers do not meet the criteria to access loan opportunities. This is because they lack the required documentation, such as land titles, financial records, and financial references. This limits them from conducting agriculture production business with financial institutions and lending agencies. Getting documentation such as land titles is a very difficult, lengthy, and expensive process in South Sudan. Individual producer loans for the purchase of sprinkler and drip irrigation are mostly seen as high risk and sometimes have a high interest rate. Therefore, it requires a higher return on investment, which is not typical for small and medium-scale agricultural producers.

A problem tree analysis was carried out to determine the root cause why small and medium-scale agricultural producers lack the required capital for the sprinkler and drip irrigation (Annex 1.1 A and 1.2A). The root cause analysis indicated the following: -

- 1. There is limited use of production technology in subsistence farmers' farms, therefore, they generally produce on a small scale for sale on local markets. This makes them susceptible to environmental and economic impacts.
- 2. Small and medium-sized farmers have limited access to or opportunities for further education to learn finances, economics, and banking. Therefore, they lack the knowledge required to understand and appreciate the banking system and apply for financing options or grant opportunities.
- 3. Small and medium-sized farms also lack the required documentation to access and obtain grants and loans. In many cases, the farmers do not have official titles for their properties or other documentation such as birth certificates and so on. The process for obtaining many of these documents are sometimes lengthy and expensive, particularly regarding land valuation and titles.

1.2.3. Identified Measures for the Micro irrigation technology (Sprinkler and Drip Irrigation Systems)

Based on intensive discussions with Sector experts and secondary research, the following measures for building an enabling environment for the development and diffusion of the micro sprinkler and drip technology have been identified:

1.2.3.1 Economic and financial proposed measures

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Table 5. Identified ed	conomic and financial measures to the deployment and diffusion Micro
irrigation technology	(Sprinkler and drip irrigation)

Barrier Category	Measures to Overcome Barriers
Economic and financial	Introduction of financial incentives to overcome the high costs associated Sprinkler and drip irrigation systems
	The existing financial barriers for the transfer and diffusion of sprinkler and drip irrigation system could be overcome through the introduction of financial incentives to overcome the high costs associated Sprinkler and drip irrigation technology. Financial support is crucial to enhancing uptake of sprinkler and drip irrigation technology by micro-, small-, and medium sized farmers and helping them understand the benefits. Such provisions will ensure sprinkler and drip irrigation pilot projects are replicated on large scale in different parts of the country. In the long term, once the business case is established such support can be phased out.

Financial incentives could be provided by introducing a scheme for the installation of drip and sprinkler irrigation systems. Such a scheme could offer a certain percentage of the total cost of the installation of the sprinkler and drip irrigation systems as a capital subsidy, and the remaining cash could be sourced through low interest debts and small-scale farmer contributions. Also, the provision of special grants or subsidy on initial cost of installation to promote the use of micro sprinkler and drip irrigation technology by small and medium-sized farmers.

Provision of low interest or interest free loans for purchase and installation of Sprinkler and drip irrigation equipment's

In order to improve the access to finance of farmers one of the essential financial measures would be to provide loan at low interest rate or interest-free loans for the purchase and installation of sprinkler and drip irrigation equipment through formal financial services such as the agricultural bank of South Sudan's rural and microfinance institutions. For this, Rural microfinance institutions such as the Rural Finance Initiative (RUFI) and the agricultural bank providing such loans could be identified. The rural microfinance institutions could be sensitized on the importance of scaling up and disseminating climate change adaptation technology. Further incentives could be provided to microfinance institutions to provide such loans by introducing credit risk guarantee schemes.

Provision of Tax incentives or liberal tax on sprinkler and drip irrigation equipment. The provision of tax incentives and the reduction of import duties on component parts for systems to reduce capital costs for adoption and installation of sprinkler and drip irrigation technology. Stakeholder during the consultation recommended the implementation of tax incentives and exemption provisions for agricultural equipment's as set forth in Chapter 6 of the South Sudan Customs Service ACT 2013. Irrigation helps to increase productivity even in low rainfall areas; thus, the government of South Sudan should regularly enact exemption and reduction of import duties on sprinklers and drip irrigation equipment's agricultural production and productivity in the country.

Establishment of a funding policy/financial framework for example the creation of Small and medium-sized farmer's irrigation development fund that would enable the Government of South Sudan, through Ministry of Agriculture and Food Security (MAFS) both at national and sub national level to provide guarantees to selected lending institutions for providing credit to private entities to supply sprinkler and drip irrigation systems to small and medium-sized farmers who meet the determined criteria. The

government should fit this technology as the part of a larger investment in
horticultural production to improve production and market access and thus
increase investment in promotion of efficient micro-irrigation systems.

1.2.2.2 Non-financial Measures

Various measures that could be implemented in South Sudan to overcome some of the impending non-financial barriers include:

Barrier Category	Identified economic and financial barriers
Institutional and organizational capacity	Strengthening institutional support and building technical Capacity through training of farmers, extension workers and service providers in design, installation, operation, and maintenance of sprinkler and drip irrigation
	Capacity Building of Ministry of Agriculture and Food security (MAFS) and the Ministry of Water Resources and Irrigation (MWRI) staffs and extension both at national and sub national level in term of human resources and technical expertise on sprinkler and drip irrigation system focusing on operation and maintenance of Sprinkler and drip irrigation system beside irrigation and fertigation scheduling. This helps micro-, small-, and medium- farmers in finding a better way to learn about the drip and sprinkler fertigation technology along with the periodical maintenance.
	It is Vital to overcome the shortage of professionals and strengthen institutions in South Sudan to promote effective development, management and implementation of irrigation programs and activities. This could be done by first assessing the resource requirement in different level of institutions, designing and conducting training programs on drip and sprinkler irrigation and water management, designing institutional structure for smoother implementation of micro sprinkler and drip irrigation schemes.
	Develop institutional and organizational capacity on Sprinkler and drip irrigation
	Government through the Ministry of Agriculture and food security (MAFs) and the Ministry of Water Resources and Irrigation (MWRI), may provide necessary financial support to its directorate of research and Development other relevant institutions to undertake needed micro

Table 6. Identified non-financial barriers for sprinkler and drip irrigation systems

	sprinkler and drip irrigation research and pilot demonstration projects. There may also provide institutional capacity building by undertake active information and awareness campaigns about the usefulness of sprinklers and drip irrigation technologies in the face of climate change and variability. In additional, The Ministry of Agriculture and Food security including it implementing partners could include adoption of sprinklers and drip irrigation technologies in their agricultural investment projects so as to enhances crop productivity and ensures higher yields. It saves energy and reduces the carbon footprint associated with excessive water pumping and waste of energy that can directly contributes to an increase in CO2 discharge
	Also, the capacity building should include the training of Water User
	Associations (WUAs) and service providers in design, installation,
	operation, and maintenance. This kind of training can increase the knowledge, skills, and confidence of water users' committee members so they can train farmers to operate, manage, and make the investment decisions needed to maintain and improve the on-farm drip and sprinkler irrigation and drainage system
Technical	Strengthening micro-Sprinkler and drip Irrigation Advisory
	Services (IAS) to farmers. The Ministry of Agriculture and Food Security both at the national and sub national level should prioritize the
	provision of micro sprinkler and drip irrigation extension services to the farmers in various aspects such as design, installation, operation, and maintenance and irrigation advisement. Irrigation advisory services for the farmers are powerful management instruments aiming to achieve the best efficiency in irrigation water use. The barriers related to information and awareness for adaptation and diffusion of technologies such as sprinkler and drip irrigation system is caused by the inadequate advisory services provision and approach hence appropriate communication and extension approaches should be selected.
	provision of micro sprinkler and drip irrigation extension services to the farmers in various aspects such as design, installation, operation, and maintenance and irrigation advisement. Irrigation advisory services for the farmers are powerful management instruments aiming to achieve the best efficiency in irrigation water use. The barriers related to information and awareness for adaptation and diffusion of technologies such as sprinkler and drip irrigation system is caused by the inadequate advisory services provision and approach hence appropriate communication and extension approaches should be selected. Develop guidelines, best practice and reference on sprinkler and drip irrigation

Information & awareness	Develop a public awareness campaign and information dissemination on sprinkler and drin irrigation system to increase	
	support for the adaption through Public Outreach Campaigns	
	Conducting awareness campaigns on drip and sprinkler irrigation techniques for state level agricultural engineers, County directorate of agriculture (CAD), farmers and extension agents. It is important to introduce training and capacity building programmes as there is lack of skilled personnel for installation and operation of Sprinkler and drip technologies so that technical staff's capacity is built.	
	Awareness raising to farmers about the importance of rationalizing water consumption through the adoption of modern, water saving and higher income generating irrigation methods. Disseminating information on modern drip and sprinkler methods can help farmers' meet their water needs and enable them to work without depleting water resources.	
	Promote outreach programs to provide intensive information for awareness and sensitization: booths, brochures, open days, etc.	
Social, cultural and behavioral	Enhancement of information and awareness to reduce social and cultural barriers and enhance community participation in the adoption of sprinkler and drip irrigation technology	
	Provide adequate training Social, Cultural and behavioral issues by taking into account cultural and social aspects in promoting the technology and educate the farmers about the financial benefits of the use of sprinkler and drip irrigation technologies. Behaviors sensitization and awareness should be in a way that it highlights how the technology is going to contribute towards the well-being/ empowerment of both male and female farmers engaged in agriculture.	
	Reduce Sprinkler and drip irrigation user's perception of risk through demonstration plots, and identification or creation of markets.	
Policy, legal and regulatory	Government of South Sudan should fit this technology as the part of a larger investment in horticultural production to improve production and market access and thus increase investment in promotion of efficient micro sprinkler and drip-irrigation system	

Research and	Agricultural training entities should be encouraged to include in its	
Development	curriculum research and development (R&D) as it relates to the	
	application and benefits of the climate-smart technologies for water	
	management such as the sustainable use of drip and sprinkler irrigation	
	in the face of climate change	
	-	

1.2.4 Cost Benefit Analysis for Sprinkler and Drip Irrigation system for small scale farmer.

A cost benefit analysis was done in order to assess the economic benefits associated with adoption and diffusion of Sprinkler and Drip Irrigation technology compared to the existing scenario. Small scale farmers in South Sudan practicing rain-fed agriculture, a practice that leads to crop failure and low yield due to unreliable rainfall associated with climate variability. This result in economic loss and food insecurity, and associated malnutrition for children and the aged famers.

The sprinkler and drip irrigation cost-benefit analysis was conducted by first identifying both direct and indirect costs and benefits associated with the implementation of the either Sprinkler or Drip Irrigation technology. The cost benefit analysis was based on costs for installing a sprinkler or drip irrigation kit for irrigating one acre of land. The costs and benefits for technology application are per year.

Cost	Items Description	Amount SSP
1.0 Existing actions		
1.1	Cost of hybrid vegetable seeds	76, 780
1.2	Agrochemicals	150,819
1.3	Labour (Land preparations, weeding, planting and harvesting)	258, 225
1.4	Crop failure	384,686
1.4	Food insecurity and associated malnutrition for children and aged	70, 780
1.5	Poverty associated Environmental destruction (deforestation, overgrazing)	97, 248
	Total Cost	535,505
2.0 Cost of Technology		
2.1	Sprinkler or Drip irrigation kits	810,400
2.2	Tanks (1 m3) and installation	121, 560
2.3	Water pump and accessories	63, 819
2.4	Fencing (for security and animals)	450,000
2.5	Labour	374,810
2.6	Agro-chemicals	81,040
2.7	Capacity building	121,500

Table 7. Elements of costs and benefits of the existing situation and of adopting Sprinkler and Drip Irrigation Technology

2.8	Cost of water	31,403
2.9	Environmental degradation	31,000
	Total Cost	1,819,113
Benefit		
1.0	Existing situation	405,200
1.2	Crop harvest	34,000
1.3	Existing human capacity (traditional knowledge)	3, 403
	Total Benefits	473,500
2.0 Technology		
2.1	Increased yield per acre	1,114,300
2.3	Food security and improved health	63,819
2.4	Environmental conservation	97,248
2.5	Employment creation	709,100
	Total Benefits	1,984,467

Net benefits for existing situation = SSP (473,500 - 535,505) = - SSP 62005.....(1) Net benefits for technology = SSP (1,984,467 - 1,819,113) = SSP 165,354.....(2) Net Benefits for the technology = (2) - (1)

= 165,354 - (-62005) = SSP 227,359Net present values for the technology (NPV) $=\sum \frac{NetBenefit t}{(1+i)t}$ Where t is the year and i is the discount rate (10%)
NPV for year 1 $= 227,359/(1+0.1)^{1} = SSP 206,690$ NPV for year 2 $= 227,359/(1+0.1)^{2} = SSP 187,900$

Similarly, calculations were done for the next 5 years (total 7 years) and the NPV values are presented in Table 8.

Table 8. Seven (7) years NPV values for Sprinkler and Drip Irrigation Technology

Year	Calculation	Net Benefits, 10% Discounted
		(SSP)
1	227,359/ (I+0.I) ¹	206,690
2	227,359/ (1+0.1) ²	187,900
3	227,359/ (1+0.1) ³	170,818
4	227,359/ (I+0.I) ⁴	155,289
5	227,359/ (1+0.1) ⁵	141,172
6	227,359/ (1+0.1) ⁶	128,338
7	227,359/ (1+0.1) ⁷	116, 671
NPV, SSP		990,207

It is clear from the above total, 7 years, NPV value that the Sprinkler or Drip Irrigation technology has positive cost benefits and it is therefore viable since the main identified barrier is initial cost associated with high cost of installation

1.3 Barrier Analysis and Possible Enabling Measures for the Promotion of drought resistant crop Varieties Technology

1.3.1 General Description of Drought resistant crop Varieties Technology

Drought tolerant seeds, also known as drought-resistant seeds, are specially developed plant seeds that have the ability to withstand prolonged periods of drought or water scarcity. These seeds are bred and selected for their ability to survive and thrive in environments with limited water availability, allowing farmers and gardeners to cultivate crops even in arid or semi-arid regions. Drought-tolerant crop seeds provide a solution to minimize crop losses and ensure food security in water-stressed regions.

Promotion of drought resistant crop varieties that withstand climate-related stresses and are suitable for cultivation in innovative cropping systems are key to maximize risk avoidance, productivity, and profitability in the face of climate variability of short rainfall periods and prolonged dry spells. In South Sudan, small, medium, large-scale producers are vulnerable to such climatic hazards because of their dependence on rain-fed agriculture and long maturing crops varieties. Yield losses differ according to severity and category of drought. Prolonged drought at any phase will result in crop failures. The main advantage of this adaptation technology option is that it permits both small, medium and large agricultural producers to plant crops varieties that demonstrate the distinctive attribute of early maturity, resilience to disease and reduces the risk of total crop failure and provides the producers with chances of dealing with the uncertainty created by climate variability and change.

The technology has been developed and adopted by few agricultural producers in the country. Producers are already using the drought tolerant varieties in drought prone areas to improve crop production under drought conditions especially Sorghum and Maize drought resistant varieties. National Ministry of Agriculture and Food Security and State Ministry of Agriculture, FAO and Both INGO and NNGOs are promoting drought tolerant sorghum and Maize for food security. However, the extent of adoption of drought-tolerant crop varieties in the country is still not known.

The drought tolerant sorghum varieties such as IESV 92043 DL, IS 8193, ICSR 160 and GE 17/1/2013A, (of which the first three were developed at ICRISAT Nairobi, while the last was acquired from Purdue University, USA) possess critical traits such as resistance to drought, diseases and maize hybrid varieties that were developed by Alliance for a Green Revolution in Africa (AGRA) include SC0923, SC719, Longe 6H, Longe 10H, KH500- 136·Plant Breed. Biotech. 2021 (June) 9(2):124~138 22A and KH500-46A, PALOTAKA-2H, PALOTAKA-3H, NAMA-18H and PIITA-6H – are expected to improve yields and food security. During the consultation with sector expert working group, it was estimated that it costs SSP162,000 – Equivalent to US 162 US \$ per hectare for the adoption of the drought tolerant sorghum and Maize seeds by a producer per 1 hectare of farm land, but this sum does not include the research and

development of the drought tolerant Maize and sorghum variety by Ministry of Agriculture and Food Security which is estimated to cost about US \$ 4 million over a period of about 5 years.

Technology Category and Market Characteristics

Promoting drought tolerant crop varieties technology is non-market public good. The promotion of drought tolerant crop seed is transferred and diffused by Government, private or non-profit institutions, international donors and research institutions. It is a public good because it is not transferred as part of market but within public non-commercial domain. At the initial stage of promoting drought tolerant seeds, promotion and awareness creation is normally done by both National and state Ministry of Agriculture and Food Security (MAFS), therefore, at this stage the promotion of drought tolerance crop variety is a non-market public good.

1.3.2 Identification of Barriers to the promotion of Promoting Drought Crop Varieties Technology in South Sudan

The following barriers were randomly identified by the consultants through literature review, expert knowledge, consultation with the stakeholders and Sector working during workshops and brain storming sessions:

- Inadequate early involvement of farmers in drought resistant varietal selection.
- Delayed release of drought-tolerant varieties.
- Inadequate government commitment to rapid multiplication and effective dissemination of high-quality drought -tolerant seed.
- Inefficient drought-tolerant seed production, distribution and delivery system.
- Inaccessibility of the drought-tolerant seeds by farmers.
- Insufficient capital to buy drought Tolerant seeds from commercial companies.
- Undeveloped of a functional drought-tolerant seed market.
- Uncertainty in demand for seed hence reluctance by commercial stockiest to stock seeds.
- Non-integration between formal and informal seed systems dealing in drought-tolerant crop seeds.
- Inadequate training on drought-tolerant seed multiplication.
- Inappropriate communication /extension approaches in regard to the promotion of drought-tolerant crop seeds
- Inadequate of agricultural credit /loans for small scale farmers to purchase drought-tolerant crop seeds.
- Inadequate institutional capacity on drought-tolerant crop seeds dissemination.
- Inadequate capacity and basic legislation and institutional factors.
- Non-promotion of unreleased drought-tolerant varieties by private sector.
- Inadequate training and education in regard to the important of adapting drought-tolerant crop seeds.
- Inadequate financial resources to procure drought-tolerant crop seeds by individual farmer

The barriers were then categorized into broad categories and described in order to enable further analysis

1.3.2.1 Economic and financial barriers

Economic and financial barriers were identified from stakeholder consultations and were scored and ranked to determine which barriers were most significant. The barriers and scores are given in Table 9 below

Barrier Category	Identified Economic and Financial Barriers	
Economic and	Inadequate access to appropriate drought tolerance seed varieties	
Financial Barriers	due to high prices of drought tolerance hybrid crop seed and limited	
	number of outlets supplying genuine drought-tolerant crop seed varieties	
	Poor markets for drought-tolerant crop seed. In South Sudan the	
	drought tolerant seeds market is week, with no major players that has a	
	strong presence in the market.	
	High cost of production and distribution of drought-tolerant crop	
	seed varieties	
	In South Sudan there are about 14% of farmers who are using improved	
	drought-tolerant and certified crop seed mainly because of insufficient	
	availability of affordable high-quality seed and lack of trust in the	
	certified seed available in the market (Subedi, A.et al 2022). The process	
	leading to variety release is expensive and lengthy due to use of old	
	methods. Modern technology such as marker-assisted selection, which	
	may potentially cut down time taken and costs, is not yet adopted due to	
	lack of funds to establish the necessary set-ups and inadequate capacity	
	to promote the drought-tolerant crop seeds. The Ministry of Agriculture	
	and food Security (MAFS-GOSS) is the sole provider of drought-	
	tolerant crop seed, but due to low budget allocations, it is too financially	
	constrained to satisfy the demand (AGRA, 2022).	
	Limited access to credit for farmers is another barrier identified for	
	the technology. Farmers in the country are unable to access financing	
	for the initial capital to purchase drought tolerance crop seeds. Only	
	about three percent of the population in the country has access to	
	financial services. As per the World Bank (2019) Ease of Doing	
	Business report, South Sudan ranks 178 out of 189 economics in ease of	
	getting credit because of an inadequate regulatory infrastructure, weak	
	investor protection legislation, undeveloped credit bureau, and inexistent	
	collateral registry.	

Table 9: Identified economic and financial barriers to	the promotion of drought crop	
varieties technology in South Sudan		
	L	oans for the purchase of drought tolerance crop seeds. Micro-
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fii		nance banks in South Sudan provide loans to farmers at a rate of
	in	terest as high as 15%, making it extremely difficult for producers to
	av	vail these loans making the diffusion of these technologies difficult in
	th	e country because it requires a higher return on investment (ROI)
	w	hich is not typical for small and medium-sized
	Li	imited number of outlets supplying genuine drought tolerance seed
	as	s well as little involvement of private sector. In South Sudan, only12
	Se Se	red companies are involved in drought tolerance seed production seed
	m	arketing and are registered in South Sudan such as PRO Seed. Seed
		row Afroganias Magwi Sood Company Groop Horizon Sood Smart
		Tow, Alloganics, Magwi Seeu Company, Oreen Holizon Seeu, Smart
		ed, Guilloo Glow Seed, TEFCO Seed, Sinart Farmer. These have
		nited ability to generate sufficient quantities of genuine certified
	dr	ought resistant improved crop seed varieties.
	A	lmost all the above companies do not have proper production and
	sto	orage facilities and rely on contracted seed growers from East Africa
	(U	Jganda and Kenya). This makes supervision very difficult resulting in
	pr	oduction of seed of mixed quality and quantity where supply is not
	su	stained. Seeds imported from other countries is also not sufficiently
	m	onitored at seed distribution stage.

1.3.2.2 Non-financial barriers

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The non-financial barriers were identified from stakeholder consultations and scored to determine which non-financial barriers were most significant. The barriers and scores are given in **Table 10** below

S/No	Barriers Category	Identified Non-economic and Financial Barriers		
1	Technical Barriers:	Lack of technical skill in developing new drought crop varieties are not available and there is country is heavy reliance on institutes outside the country for		
		germplasm . The research and breeding centers are not functioning and there is a need for upgrading the laboratories. Inadequate manpower and technical skills in breeding drought resistant crop and germplasm utilization remain a serious barrier. There is also a need to build		

Table 10. Identified non-financial barriers for promoting drought-tolerant crop varieties in South Sudan

		institutional capacity within the South Sudan in the long run to be able to breed new drought varieties of seeds within the country.There is also lack of awareness among the stakeholders engaged in germplasm development and utilization on
		recent technology trends and also international treaties and agreements such as Standard Material Transfer Agreements, and International Treaty on Plant Genetic Resources. Information dissemination and sensitization on significant of drought resistant varieties is week as well as research and development of more drought new varieties.
2	Policy, Legal and	Counterfeit seed in circulation . An estimated 30% of the
	regulatory:	to the National Bureau of Standards (NBS), certified seeds
		from the genuine companies contribute to only 5% of the
		seed demand, and an estimated 95% of seeds traded on the
		market substandard or counterfeit. The circulation of
		counterfeit seed in the market has greatly weakened
		and low farmer confidence in drought tolerant improved
		seed (MAF.2022) leading to reliance on home saved seed.
		Surveillance and enforcement of the seeds to ensure seed
		standards are very weak due to limited capacity (Subedi, A
		et al,2022. This has hindered the promotion of drought
		tolerance seed varieties for farmer's production. Also,
		Inadequate enforcement of regulations on the promotion
		and distribution of hybrid crop seeds that are drought-
		tolerant. The government of South Sudan through the
		developed seed regulation on promotion of climate-
		resilient crops seeds and the process for dissemination and
		implementation is yet to be cascaded to lower government
		through development and passing of ordinances and bylaws
		to control the sale or supply of counterfeit seed (Agriculture
		Sector Policy Framework (ASPF) 2012-2017).
3	Institutional and	Limited human capacity to provide effective extension
	organizational	support for the promotion of drought tolerant crop
	capacity and human	seeds. Estimates from 2014 showed each of the 86 counties
	skills Barrier:	III South Sudah had about 8-14 extension agents, which
		would be between oso to 1204 extension agents in the

		country. If every one of those agents is still working today,
		it would mean that each would be trying to serve between
		900 and 1500 farming households. Assuming four people
		per household working in agriculture (average household
		size is 7) the ratio would be one agent to between 3600 and
		6300 people that need training and information. This is
		based on population estimates of 2.05 million households
		in mid-2018 of which an average of 53 percent is farming
		households ($FAO/WFP = 2019$) Alternative forms of
		extension_including radio_ICT_lead farmers_farmer field
		schools and community resource persons can create an
		diffusion and transfor of drought tolerant crop variaties
		information that can source and move knowledge to
		forman when they need it
A	Maulast Condition	Tarmers when they need it.
4		Weak arought tolerant seen supply chain and
		distribution mechanism in the Country, madequate
		accessibility to improved drought tolerance seed by
		farmers. Inaccessionity of drought tolerance seeds by
		farmers and the insufficient drought tolerant seed
		diffusion and transfor of the technology in South Sudan
		Unreliable supplies Additional Unreliable supply of
		drought tolorent souds variation uncertainty on demand for
		and and low good demand also provide berrier to the
		diffusion of drought tolorent grop
5	Information and	Incloque to knowledge regarding new variation that
5		madequate knowledge regarding new varieties that
	awareness	the appropriate variaties due to poor funding of extension
		and Inadequate linkages between P&D and extension
		This arose from inadequate information being provided to
		farmers with respect to what varieties they should plant
		and the required management interventions at various
		stages of the production cycle
6		Social cultural and behavioral. In many parts of South
U		Sudan producers have been traditionally developing their
		own crop seeds for a decade and hence most of them area
		always reluctant to adopt new drought tolerant varieties
		aspecially if they require different forming practices and
		additional investments from the farmers
		additional investments from the farmers.

1.3.3 Identified Measures

South Sudan needs sustainable access to quality drought-tolerant seeds of a variety of crops to not only improve their incomes, food, and nutrition security, but also to help them absorb climatic shocks, adapt to shocks, and build transformative capacity. The formal seed system is often unable to meet the demand for quality drought-resistant seeds. This study attempts to better understand how seed companies could be incentivized to broaden their crop portfolio to increase access to quality seeds at the last mile. Based on the study findings, the following recommendations are suggested:

1.3.3.1 Economic and Financial Measures

Table 11. Identified economic and financial measures for the deployment and diffusion of promoting drought-tolerant crop varieties in South Sudan

Barrier Category	Measures to overcome economic and financial barriers
Economic and financial	Incentivizing Seed Companies to Expand drought-tolerant Crop-Seed Portfolio. Government should reduce nontariff barriers (NTB) that restrict trade such as licenses, embargoes, roadblocks, sanctions (long clearing procedures at the port and levies etc.). There is need for favorable government policies in reducing long bureaucratic importation process of climate-smart seeds into South Sudan. Seed companies can diversify their crop-seed portfolio to increase access to quality drought-tolerant seeds at the last mile with appropriate incentives. The seeds companies would be motivated to expand their portfolio if varieties are able to respond to the needs of the farmers in the face of climate change e.g., availability of early maturing, drought resistant/tolerant, highly nutritious varieties, and resistance to emerging pests.
	Provision of Subsidized credits and favorable loan products from financial institutions. Inadequate access to financial instruments, including credit services, especially among farmers, is one of the greatest obstacles to scaling up diffusion and transfer of drought-tolerant crop seed varieties. It is expected that local communities will adopt the technology if measures for provision of credit facilities with low interest rates and improved institutional and organizational capacity are taken place. Governments can engage with the private sector and empower them to provide long-term, inexpensive credit to producers so that they can invest in drought tolerant seed varieties supply and to enable more

farmers adopt the technologies. In general, medium- and long-term
finance is needed to cover the up-front investment in drought tolerant seed
varieties technologies that over the long-term will increase productivity,
improve the efficiency in the use of resources, build resilience to climatic
shocks and reduce emissions.

At the household level, financial incentives need to focus on supporting the adoption of drought and heat resistant crop varieties. Farmers need support on-market development to help them to efficiently market their climate-smart seeds and reach smallholder farmers cross the ten states in the country, incentivizing farmers to use certified seeds through training, extension services. Partnership with NGOs and government ministries to support seed companies with scaling, extension, training services, and breeding of drought tolerant crop seeds.

At the national level, policies and actions are needed to **reduce the financial risks associated with the shift to drought resistant crop seeds, lower transaction costs, facilitate monetary transactions, enable access to financial services and facilitate long-term investments**. This can be done by promoting mechanisms, such as safe-savings deposits that provide incentives to save, low-priced credit (e.g. joint-liability group lending), and insurance schemes (e.g. index-based weather insurance). The financial needs of smallholder farmers for working capital expenditures e.g. quality drought tolerant crop seeds.

1.3.3.2 Non-Financial Measures

The non-financial measures are intended to deal with a wide range of issues in institutional organization capacity and policy, legal and regulatory. These include promotion of quality declared drought tolerance crop Seed (QDDTS) to farmers, promotion of value addition and consumption of hybrid crops and lobby government to encourage public-private supplying genuine seed.

Table 12. Identified non-financial barriers for the promotion of drought tolerant cr	rop
arieties	

Barrier Category	Identified economic and financial barriers	
Institutional and organizational	Develop domestic capacity and ability to develop and produce new drought tolerance crop varieties domestically, without external	
capacity	dependence. Currently, South Sudan is too much of reliance on international germplasm and on conventional methods of crossing are practices domestically to produce new seeds.	

	Provision of adequate training will improve farmers' skills in adoption and diffusion of drought tolerant crop variety technology. It will also enable effective communitarian between farmers, extension staff and researchers. Also, more trained farmers with improved skills who are capable of using technologies.
	Government and humanitarian agencies' seed programming should broaden their drought tolerant crop variety portfolio such as Sorghum, maize, groundnut and even drought resistant vegetables. This can be done by promoting farmer-preferred and climate-resilient local crops & drought-tolerant crop varieties, in particular crops such as sorghum, groundnut and cassava. The government can play their role by creating an enabling environment for the INGOs/NGOs and monitor the interventions carried out. Government should also monitor the agro- dealers so that they import affordable agricultural inputs and good quality seeds; available and accessible to the farmers.
Technical	Strengthen technical capacity of crop and seed technical specialists. Capacity building of County agricultural extension, seed specialist to undertake drought-tolerant crop seeds extension services to farmers. Currently, both national and sub national Ministry of agriculture and food security (MAFS) have limited fund to undertake large scale drought tolerant sees production and information dissemination in regard to climate smart seed varieties to farmers. Capacity of national and state level Directorate of Extension can be built by designing and conducting training and capacity building activities for extension workers and outreach centers focusing on drought-tolerant sales representatives and extension officers and undertaking exposure visits for extension officers sensitizing the existing and new officers to benefits of new technology. Also, the promotion of drought-tolerant crop seed extension can be strengthened by recruiting and training the extension workers to ensure efficient technology transfer and diffusion
	Strengthening Farmer-Based drought tolerance crop Seed Systems. Government and international partners should support the strengthening of farmer-based seed systems by broaden local seed producers' crop/variety portfolios with locally preferred and climate-resilient crops and varieties, potentially through community seed banks and facilitate participatory plant breeding/variety selection to support farmers' access to locally preferred drought tolerance crop diversity.

Information & awareness	Designing and conducting awareness campaigns to spread information about challenges with existing crops and the need to develop and disseminate new varieties of crops that are drought tolerance as well as crop pest and disease.	
	Strengthening agricultural extension services disseminate appropriate information, knowledge and create awareness about the potential of drought-tolerant crop in the face of climate change . Agricultural extension services may be geared to disseminate appropriate knowledge and awareness about the availability and potential benefit of the use of drought resistant seeds varieties. Also, there is a need for establishing drought tolerant seed quality testing labs in agricultural areas and appropriately equipped to provide required drought tolerance varieties testing service and information to farmers.	
Social, cultural and behavioral	Taking into account cultural and social aspects in promoting the technology Wider acceptance of the technology. Training and awareness among farmers to reduce social and cultural barriers and enhance community participation in the promotion of drought-tolerant crop. Taking into account the farmers' perception of reluctance of adoption of drought-tolerant crop variety, the training on awareness raising will reduce social and cultural barriers and enhance community participation. It will also include providing adequate trainings to government staffs and farmers for drought-tolerant seed production and multiplication techniques for the local farmers.	
Policy, legal and regulatory	Strengthen enforcement of regulations to reduce counterfeits. Create awareness about the existence of counterfeit seeds and ensure private sector actors need to work with government to track and trace their products along the value chain using scanners or smartphones to verify barcodes. The South Sudan National Bureau of Standards (SSNBS) and the Directorate of Seed Certification Services in the Ministry of Agriculture and Food Security needs to be sufficiently funded to recruit enough climate smart seed inspectors, train and equip them ensure all improved drought tolerant seeds are tested and certified before they are sold to farmers Formulate and enact appropriate legislations and regulations on good agricultural practices and the provision of drought tolerant seed varieties	

Market	Encourage seed companies to use cheaper methods of seed production and support supply of drought resistant seed varieties to delivery and expand options to reach farmers at the last mile e.g., supporting establishing seed kiosks in remote rural areas, targeting youth and women entrepreneurs for job and income opportunities. Seed companies and other seed industry stakeholders should strive to remove barriers to expand crop-seed portfolio and increase access to quality seeds at the last mile. Major barriers include high cost of seed certification, lack of enforcement of regulations and policies, poor business environment and limited internal capacity of the seed companies, as well as seed companies' internal capacity and costs to conduct market research.
Research and Development	 Promote use of Quality Declared drought tolerance crop Seed (QDDTS) to farmers. The capacity of local seed producers (technical expertise and seed testing laboratories) should be strengthened to produce Quality Declared drought tolerance crop Seed (QDDTS) as governed by the seed regulation Support agricultural universities and public-sector research centers for plant breeding, seed research and business management for seed enterprises as well as training in seed production, quality control and seed certification.

1.3.4 Cost Benefit Analysis for the promotion of drought-tolerant crop varieties

A cost benefit analysis was done in order to assess the economic benefits associated with adoption and diffusion of promoting drought tolerant crop varieties technology compared to the existing scenario. Existing scenario involves the use of local traditional seed varieties which have low yields and are less tolerant to drought and disease and pest leading. This result in crop failure and low yields which results in food insecurity, malnutrition and associated health problems and social instability in the face of climate change and variability.

The cost-benefit analysis was done by first identifying both direct and indirect costs and benefits associated with current seeds sources and the promotion of drought tolerant crop varieties technology. The elements of costs and benefits of growing traditional and drought tolerant crop varieties in a one-acre plot of land per year are presented in **Table 13** and were used as input during cost-benefit analysis

Cost	Items Description	Amount SSP	
1.0 Existing actions			
1.1	Cost of drought-tolerant Sorghum or maize (5kg)	120,000	
1.2	Agrochemical (Pesticides and insecticides)	220,000	
1.3	Labour (Land preparations, weeding, planting and	298, 225	
	harvesting)		
1.4	Crop failure	284,686	
1.4	Food insecurity and associated malnutrition for children	90, 780	
	and aged		
1.5	Poverty associated Environmental destruction	120, 448	
	(deforestation, overgrazing)		
	Total Cost	624,686	
2.0 Cost of Tech	nology		
2.1	Cost of promoting drought-tolerant technology – Public awareness	90,000	
2.2	Labour (Land preparations, weeding, planting and		
	harvesting	78000	
2.3	Fertilizers	45, 819	
2.5	Labour	174.810	
2.6	Agro-chemicals	81.040	
2.7	Capacity building	70.500	
2.8	Cost of water	31 403	
2.9	Purchase of drought-tolerant crop seeds	65,000	
2.9	Total Cost	509 713	
Benefit		000,110	
1.0	Existing situation	205.200	
1.2	Crop harvest	44.000	
1.3	Existing human capacity (traditional knowledge)	2,800	
	Total Benefits	249.200	
2.0 Technology			
2.1	Increased yield per acre	904,000	
2.3	Food security and improved health	60,400	
2.4	Environmental conservation	86,200	
2.5	Employment creation	60,900	
	Total Benefits	1,111,500	

Table 13. Elements of costs and benefits of the existing situation and of adopting droughttolerant crop varieties technology

Net benefits for existing situation = SSP (249,200 - 509713) = - SSP 260,513.....(1) Net benefits for technology = SSP (1,111,500 - 509713) = SSP 601,787(2) Net Benefits for the technology = (2) - (1)

 $= 601,787 - (-260,513) = SSP \ 862,300$ Net present values for the technology (NPV) $= \sum \frac{NetBenefit t}{(1+i)t}$ Where t is the year and i is the discount rate (10%)
NPV for year 1 $= 862,300/(1+0.1)^1$ $= SSP \ 783,909$

NPV for year 2 = $862,300/(1+0.1)^2$ = SSP 853,

Similarly, calculations were done for the next 5 years (total 7 years) and the NPV values are presented in Table 14.

Year	Calculation	Net Benefits, 10%
		Discounted (SSF)
1	862300 / (1+0.1)1	783,909
2	862300/ (1+0.1) ²	853762
3	862300/ (1+0.1) ³	861438
4	862300/ (1+0.1) ⁴	862213
5	862300/ (1+0.1) ⁵	862291
6	862300/ (1+0.1) ⁶	862299
7	862300/ (1+0.1)7	862210
NPV, SSP		5,948,122

Table 14. 7 years NPV values for adapting drought-tolerant crop varieties Technology

It is clear from the above 7 years, NPV value that the promotion of drought tolerant crop varieties technology has positive cost benefits and it is therefore viable.

1.4 Linkages of the Barriers Identified

This section looks at linkages of different barriers that hinder the diffusion and transfer of Sprinkler and drip Irrigation and drought resistant crop varieties technology in the agriculture sector and is presented in the table below 15. Overall, the barriers for the two prioritized technologies in the agriculture, Livestock and fisheries sector were related to the following themes.

Barrier Category	Barriers	
Economic and Financial	Insufficient financial resources	
	Inadequate credit and loans	
	Inadequate training	
Human skills	Inadequate training of farmers, government agricultural	
	extension workers	
	Farmers and small and medium-sized farmers low	
	adoptive capacity	
Information and Awareness	Limited knowledge and awareness; - inadequate	
	awareness of the existence of technology	
	Inappropriate communication and extension approach as	
	well as limited communication among technology	
	developer, supplier, and users	
Policy, legal and regulatory	Inadequate policy implementation and enforcement;	
Institutions	Weak institutional capacity building	

Table 15. Linkages of barrier faced by different prioritized technologies in the Agriculture, Livestock and fisheries sector.

The above-mentioned barriers are common and inter-linked in the two technologies within the agriculture sector. Therefore, overcoming these barriers would immensely help in adoption and diffusion of all three prioritized agriculture sector technologies. It is expected that local communities can adopt both the two technologies in the agriculture sector. If measures for provision of credit facilities, reduce interest rates and tax rebates are undertaken. Undertaking of adequate training will enhance farmer's skills. On barriers related to information and awareness for adaptation and diffusion of technologies will target inadequate awareness of the existence of the technologies and inappropriate communication, technologies dissemination and extension approaches. Overcoming one barrier for a Sprinkler and drip irrigation technology would translate into resolving some bottlenecks in the promotion of drought resistant crop Varieties Technology, that would eventually lead to quick and more sustained adoption and diffusion of all these technologies in the agriculture sector of South Sudan.

1.5 Enabling framework for overcoming the barriers in the diffusion and transfer of agriculture, livestock and fisheries sector

Despite measures that are in place, without favorable environments, implementation might be a challenge, ineffective and inefficient. Common measures of overcoming the barriers on micro sprinkler and drip irrigation and the promotion of drought-resistant crop varieties technologies and expected outcomes in the agricultural sector are listed on Table 16 below.

Table 16. Enabling framework for overcoming the barriers in the diffusion and transfer of agriculture, livestock and fisheries sector

Porrier Cotegory	Darriara	Enchling	Deeponsible
Darrier Calegory	Barriers		Responsible
T ''''' 1 1	TT' 1 ' ',' 1 '	environment	Institution
Financial and	High initial investment	Subsidies to support	Ministry of
economic Barriers	and maintenance cost -	progressive small	Agriculture and
	Small and medium-sized	and medium-sized	food Security
	farmers rarely have	farmers and	(MAFS)
	enough capital required for	organized farmer	directorate of
	the initial investment for	groups to set up	Mechanization and
	micro sprinkler and drip	micro sprinkler and	the Ministry of
	irrigation.	drip irrigation	Water Resources
		schemes (The CAMP	and Irrigation
	Lack of financial resources	Support the	(MWRI),
	to cover the operating and	implementation of	Cooperative
	maintenance costs, for	irrigation	society,
	sprinkler and drip		international
	irrigation as well as	Existing structures	NGOs and
	provision of drought	such as the Ministry	agricultural banks.
	resistant crop	of agriculture,	
		Ministry of livestock	
		and MIWR and	
		agricultural	
		cooperatives	
	Unable to access financing	Existing structures	MAFS; MLF
	for the initial capital to	such as the Ministry	MIWR
	purchase the hardware for	of Finances; Ministry	
	sprinkler and drip	of Agriculture,	
	irrigation systems.	Ministry of	
		Livestock.	
	Loans for the purchase of	Existing structures	MAFS; MLF
	equipment for small	such as the Ministry	MIWR, NGOs
	farmers are high risk and	of finances; Ministry	
	high interest rate.	of agriculture,	
	Higher return on	Ministry of livestock,	
	investment (ROI)	Agricultural Bank	

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		actors and private	
		sector	
Institutional and	Weak policies and	Existing structure	MAFS and MLF
organization	regulatory framework	such as MAFS;	
capacity		MIWR	
Human Skills	Inadequate skills	Existing structure	MAFS; MLF
		such as MAFS;	
		MIWR and	
		Universities	
Cultural/Behavioral	Farmers tend to have a low	Existing structure	MAFS and MLF
	level of trust for financial	such as MAFS; MLF	
	and banking institutions	and agricultural	
		cooperatives	
Information and	Inadequate information	MAFS; MIWR and	MIWR
awareness	and lack of awareness	MLF	
Others	Lack of environmental	MAFS; MEF	MAFS and MLF
(environmental	impact assessment		
impact assessment,			
Physical			
infrastructure)			

CHAPTER 2: WATER SECTOR

South Sudan has abundant water resources, with generally low over-abstraction and water quality risks. Total annual renewable water resources per person are estimated to be 3,936 m3, which is higher than the Falkenmark Index threshold for water stress. Water resources are not evenly distributed across the country and inter-seasonal variability is high, which leads to extreme flooding and dry season shortages. South Sudan is highly dependent on surface water resources that originate in neighboring countries for both human use and for their livestock. Although the country has a large livestock population, without a secure and sustainable dry season water supply, livestock management is a critical source of social and economic conflict.

In 2011 South Sudan's Ministry of Water Resources and Irrigation reported that 30-50 percent of boreholes were non-functional at any point. Financing the water sector is a long-term committee that must be consistently secured. Indeed, its effectiveness requires significant investment in producing skilled, knowledgeable, and trained human resources; obtaining specialized equipment, building infrastructure, providing access/logistical equipment; producing and implementing policies, legal frameworks, and regulations. Technological development and innovation could play a critical role to achieving sustainable water resource management amidst uncertain climatic conditions cast by climate change in South Sudan. Among the different technologies identified, two were prioritized based on their importance in reducing vulnerability of communities and individuals to the severe impacts of climate change. These include: -

- 1. Solar powered water supply system
- 2. Ground water abstraction- water borehole drills

2.1. Preliminary targets for technology transfer and diffusion in the Water Sector

The preliminary targets for deployment and diffusion of the prioritised water sector technologies are as follows.

South Sudan has made steady progress in increasing access to improved water sources, with the national rate increasing from 65 percent in 2011 to 78 percent in 2020. However, the rate of access to basic water service has remained at 41 percent over the last ten years (WHO/UNICEF, 2020). The national rate of progress also masks significant inequalities between urban and rural areas with 70 percent of urban households having access to basic water in comparison to 34 percent of rural households (Borgomeo, Edoardo, *et al.*, (2013).

Surface water, which includes rivers and lakes, is a common water source for the population but is also at high risk of contamination from human and animal faeces and industrial effluent from mining and oil extraction. On the other hand, Groundwater is the main source of drinking water for rural areas; however, groundwater extraction is not well regulated, and there is a potential risk of over exploitation (USAID, 2021).

South Sudan as a nation is preparing for a sustainable energy future by reducing electricity deficit through clean power investment that targets up to 80MW of additional power from renewable energy sources. In addition to our hydrocarbon proven reserves.

With regard to Solar powered water supply, about 0.5% of all households in the country are equipped with solar water heating systems. As per the Energy Master Plan, 30% of all households are expected to be equipped with solar powered water supply system by the year 2020. Under the South Sudan - Strategic Urban and Rural Water Supply and Sanitation Improvement Project (SURWSSIP), the Government of South Sudan plan to supporting the installation of solar water pumping system across the major state towns in South Sudan and 450 Solar Water Pumping system for agricultural application to provide irrigation facility for various crops in Aweil, Northern Bahr el Ghazal state.

Numerous projects with a total capacity of 260 MW were already allocated in two 200-megawatt tender rounds. The project is being developed by Elsewedy Electric T&D and is currently owned by South Sudan Electricity with a stake of 100%. Juba Solar PV Park is a ground-mounted solar project which is planned over 25 hectares. The project is expected to generate 29,000MWh electricity and supply enough clean energy to power 58,000 households. The project is expected to offset 12,000t of carbon dioxide emissions (CO2) a year.

Moreover, Aptech Africa Ltd, a solar energy and water pumping company signed a plan to designed, built and installed a 6KW solar water pump system project in in Juba. This system will have the capacity to pump 40,000 litres of water per hour, and has two 210,000 litre tanks that deliver water 2.8 kilometres to service 6,000 people within the suburb of Juba City. This system will have the potential to prevent 9,600 Kg of CO2 emissions per day, or almost 3800 tons of carbon emissions per year.

The Ministry of Irrigation and Water Resources – GOSS together with development plant target to construct groundwater recharge systems in all the ten states in South Sudan and more particularly in drought and dry spell prone areas to improve ground (aquifer) water and to store water underground in times of surplus for use during times of shortage and high demand. During the second phase of barrier analysis and enabling framework preliminary targets were set for the transfer and diffusion of the ground water technologies in water sector which are as below

- Construct groundwater recharge systems in Eastern Equatoria state, Upper Nile state and in other dry areas in the country to improve ground (aquifer) water situation
- Conduct groundwater resource assessment and monitoring cross the country and carry out information surveys on (ground) water demand and use in different sectors (agriculture, domestic, urban, industry), and produce reports and maps;
- Dialogue with groundwater users including women and vulnerable groups to assess groundwater use scenarios for different sectors; develop and provide custom-made practical guidelines, training to attain sustainable use.

Compile and integrate all collected data into the online information portal; develop and implement best ground water management equipment and measures to each pilot area for vulnerability reduction and/or GW supply improvement by 2030.

Some of the major constrains to closing the gap in water supply system in South Sudan include inadequate capacity development and poor financing. Financing the water sector is a long-term

committee that requires significant investment in producing skilled, knowledgeable, and trained human resources; obtaining specialized equipment, building infrastructure, providing access/logistical equipment; enacting and implementing policies, legal frameworks and regulations that will enable the system to run. To improve on water supply system, substantial investment in solar powered water supply system is required.

2.2 Barrier Analysis and Possible Enabling Measures for Solar Powered Water Supply Technology

2.2.1 General description of solar powered water supply system.

South Sudan is the world's least electrified country, and solar power is a great solution. The solarpowered water systems are easy for communities to maintain, rarely break down and don't require expensive fuel supply. Most importantly, they are a green technology, with minimal environmental impact. Solar-powered water systems can keep children healthy while reducing emissions from diesel systems. They can reduce the impact of declining water levels and extreme weather events by enabling pumping from deeper levels below the ground – even during droughts or when many shallow wells go dry. Most importantly, they can continue operating after storms, when other electrical systems are no longer operational.

Unlike traditional hand pumps, solar-powered systems can be used for water storage and can supply water for multiple purposes, making water available to a larger population. This reduces walking and waiting times, and can make water readily accessible to schools, health-care facilities, and entire communities.

The solar panels used in solar water pump systems produce electricity by using the photovoltaic effect by absorbing the sun's photons and convert them into energy. The energy is then transmitted through the inverter to the pump, the pump is the piece of equipment that draws water from the source to the storage tank or it can be used for different purposes. Inverters are used to convert direct currents (DC) output into an alternating current (AC), which can be used to power the pump. This conversion is necessary for many electrical devices, including the water pumps, making inverters an important part of the solar pump system. The inverter also acts as a backup power during cloudy or low-light days, an inverter helps to keep water pump running, even without solar. Solar pump systems are important in maximizing pump performance and controllers are used to essentially control the water pump. Controllers are used to set a pumping schedule, turn the pump on or off, and help maximize the life of the pump. When pumping from a well or water source with low water levels or dry situations, controllers with water sensors help turn off the pump when water is low and on when the water level rise. Installation of solar powered technology for water extraction has a potential in South Sudan dry zone region where the sun shine hour is sufficient and the use of solar power will reduce the air pollution and GHG emissions to the environment.

- 2.2.3 Identification of barriers for solar powered water supply system technology
- 2.2.3.1 Economic and financial barriers

Table 17. Identified economic and financial barriers for Solar Powered	Water System
technology	

Barrier category	Identified economic and financial barriers
Economic and Financial	High cost of capital invested in securing equipment (Solar panels, pumps, installation, Maintenance) and low expected rate of returns. While solar-powered water pumps have long-term cost advantages, the initial investment can be substantial. The costs of solar panels, batteries, pumps, and installation may deter some potential users, especially in low-income countries like South Sudan. This is the main obstacle to implementing solar energy in an emerging economy like South Sudan. It's difficult for individuals or organizations to afford the initial investment required to install and maintain solar powered water systems. This is especially challenging in South Sudan since it's not economically developed with limited access to financing.
	High cost of capital invested in securing equipment (Solar panels, pumps, installation, Maintenance) and low expected rate of returns. While solar-powered water pumps have long-term cost advantages, the initial investment can be substantial. The costs of solar panels, batteries, pumps, and installation may deter some potential users, especially in low-income countries like South Sudan. This is the main obstacle to implementing solar energy in an emerging economy like South Sudan. It's difficult for individuals or organizations to afford the initial investment required to install and maintain solar powered water systems. This is especially challenging in South Sudan since it's not economically developed with limited access to financing.
	Limited access to financing and lack of awareness about financial support. Stakeholder consultation shown that limited access to financing is a significant barrier to implementing solar energy in emerging economies because of underdeveloped financial systems, which makes it difficult for individuals and businesses to secure loans or other forms of financing for solar projects. Additionally, there is high levels of poverty and income inequality, which means that many people lack the financial resources to invest in solar water system (MWRI, 2022).

2.2.3.2 Non-financial barriers

Table 18. Identified non-financial barriers for solar powered water supply syst	em
technology	

Barrier Category	Identified non-financial barriers
Technical	Limited capacity / technicians who can install the solar powered water supply technology properly. Farmers and extension agents (public and private) have limited skills and trainings of solar powered water supply systems technology especially technical skill in the installation and maintenance of solar power equipment's.
Institutional and organizational capacity	Inadequate solar powered water supply extension services due to insufficient capacity and numbers of extension staff both at the national and sub national to support in the transfer and diffusion of the technology.
Market	Lack of easy availability of solar powered water supply system technology. Solar panels and other peripherals required for installing systems are not easily available in many part of the country especially in the remote areas. They need to transported through the rugged terrain which increases the cost, making the installation more expensive.
	Lack of local manufacturing and supply chain infrastructure. The lack of local manufacturing and supply chain infrastructure is also a contributor to the high cost of solar system in emerging economies. This barrier is aggravated by lack of appropriate financing mechanisms to facilitate the development and promotion of solar powered water supply systems. Most of the commercial banks are not providing long-term lending required for solar businesses since most consumers, especially the rural population find them unaffordable.
	In addition, the private sector's engagement is a must for the viability and sustainability of any system. However, in remote areas, few companies and entrepreneurs prioritise solar irrigation systems due to perceived low return of investment. Most of the time, the system is used only for pumping drinking water and not linked to a viable business models such as providing water to irrigate orchards and commercial farms.
Information & awareness	Lack of appropriate education and training can be a barrier as without proper training and expertise it can be difficult for

	individuals and businesses to acquire the knowledge and skills needed to install, operate, and maintain solar pumps, panels, solar systems. This can also limit the development of a skilled workforce needed to support the growth of solar powered water generation in the country (Musa Kose & Kuyu Kongas,2023).
	Awareness and understanding of climate smart technology can be a barrier as without proper education and outreach, people may not be aware of the potential and benefits of solar powered water system as compared to using diesel engines, and therefore citizens may not be motivated to adopt it. Limited awareness and understanding can also make it more difficult to secure support from government, businesses, and utilities for the development of solar energy investment by potential investors. This can also make it difficult to attract private investment in the sector as investors may not be familiar with the technology and its potential benefits (Moorthy, 2019).
Policy, legal and regulatory	Government policies and regulations are a big hindrance as without clear and supportive policies and regulations in place, it is difficult for individuals and businesses to navigate the process of procuring, installing, and operating solar powered water systems. Without policies in place the issue of standardization and quality of solar panels, solar pumps, and inverters entering South Sudan is a big barrier as lack of quality control can lead to unreliable equipment, poor installation, and maintenance, which can result in low water generation and high maintenance costs. Besides this, a lack of standardization and quality control can also lead to the proliferation of counterfeit or substandard products, which can further undermine confidence in the
	 technology and make it difficult to expand the adoption of solar powered water systems in South Sudan. Limited policies and guidelines to encourage the use of water efficient use solar water pump technology. In South Sudan there is generally limited legal instrument that encourage people to use water efficient technologies.
Insecurity	Political instability and lack of government support in South Sudan is a barrier as without security and a stable government, it can be difficult to establish and implement policies and regulations that support the development of the solar energy systems (Solangi, 2021). Political instability can make it difficult for businesses and investors to plan for

the long term and make investments in the sector due to uncertainty.
Also, insecurity can cause the installed equipment to be vandalised,
looted, and destroyed (Pathak, 2022).

2.2.4 Identified measures

2.2.4.1 Economic and financial measures

Growth of solar powered water supply system around the world has been aided by a range of financing mechanisms, including tax credits and leasing schemes that have allowed solar developers, businesses, and individuals to pay down the cost of solar system over time. Such credit or leasing facilities do not exist in South Sudan or in most other conflict-affected societies. Most investors, humanitarian agencies and South Sudanese citizens do not have the resources to buy solar powered water supply system at once (Choudhary, 2017).

Government of South Sudan, Non-governmental Organisations (NGOs) and Donors could help fund a pivot toward solar powered water system by creating a funding pool for equipment purchase, rationalizing such a large one-time up-front cost. Also extending multiyear payment options to local investors and individual could seek their own financing (Mozersky, 2018).

To enhance the sustainability of a solar powered water supply initiative, and to ensure that South Sudanese benefit from the outset of a transition to clean energy, new investment in renewable energy should be coupled with a significant commitment to fund local capacity building and training technical personnel in solar energy. Government support for such a transition would help bring foreign solar technology developers to the country, create opportunities for South Sudanese to get into the business of manufacturing, installing and maintaining solar systems, and provide a critical economic building block through solar powered water supply. This massive investment from the different actors will in turn create competition among the different players and bring a variety of benefits, including lower prices for the equipment making it affordable to the citizens (Peter Alstone, 2015).

2.2.4.1 Non-financial measures

South Sudan Bureau of Standards and other government agencies must develop and strictly enforce appropriate manufacturing standards and specifications. This can be achieved by introducing policy instruments and incentives that can encourage local assembling of solar system equipment. Likewise, for the purpose of sustainability, government of South Sudan needs to also make efforts to introduce domestic manufacturing industry for solar equipment, thus reducing the reliance on the imported products. With the implementation of these standard production procedures, the quality and quantity of solar water equipment output will yield increases. This will be a step in the right direction that would entirely empower the water sector. Creating a

standardized certification for units would help keep customers informed of what they are buying, hence increasing trust in the market.

Developing a skilled workforce to operate and maintain the solar powered water supply system such as solar panels, pumps, invertor is essential for successful deployment and development of the technologies in the country. deployment of this technology requires skilled manpower in different fields that may include physics, materials science, chemical, mechanical, and electrical engineering, business management and social science (Wilkins, 2010). It is also essential that technology users understand the availability and explicit operational features of solar system. Training such artisans and ensuring that they have ready access to spare parts require the establishment of new infrastructure that can provide a quality training platform for technical and engineering personnel.

Government, development partners, importers, distributors, and suppliers should foster community participation in deploying solar powered water supply projects and initiatives and strive to promote knowledge of and greater acceptance by the public of prospective renewable energy solutions for water supply that are appropriate for their locations. This involvement should start at an early stage in the planning process. These developments should consider the socioeconomic set up of the concerned community, including the needs of the poor. The development of deploying solar powered water generation system should lead to employment creation and poverty alleviation. This will create a sense of ownership in the public and will increase acceptance and uptake of the same technology in their own homes and communities.

Reinforce inter-agency collaboration among partners, in order to build up internal technical capacity. Tap into the private sector to organize workshops and trainings and raise technical expertise among relevant NGOs and government technical staff. Coordinate solar work (possibly through a solar working group) in order to, among others, provide technical guidance for the standardization of solar pumping design, installation, care and maintenance for all WASH actors in South Sudan

2.4 Barrier analysis and possible enabling measures for Ground Water Abstraction-Water borehole drills

Many parts of South Sudan experience more variable surface water flows, a prolonged dry season and intensifying droughts and a growing demand for water resources including groundwater. Despite relatively abundant surface water resources, a considerable number of low-income groups and urban/rural communities rely on low-cost groundwater for their domestic, agrarian and industrial use. Several groundwater reserves are transboundary and it is recognized that there is limited capacity to manage these shared resources and limited knowledge about the sustainable yields of these transboundary aquifers. Recent and predicted population dynamics will put more pressure on limited water resources, accelerated by consumption and behavioral patterns, unless serious awareness, education, and science-based information flow will balance this trend (MacAlister C, et *al*, 2013). Groundwater exploitation is not well managed or regulated by water management entities and there is limited information on abstraction rates and changes in water. Communities are generally

responsible for their own wells but non-governmental organizations have also played a significant role in borehole drilling and providing access to groundwater in certain areas of the country.

South Sudan has three main aquifer types: unconsolidated, basement, and consolidated. Spanning 365,268 km2, the Umm Ruwaba unconsolidated geological formation is located within the Sudd Basin and is the largest source of groundwater (Kwai Malak *et al*, (2019). Water tables are shallow, ranging between 10-25m, although they can reach over 300m in the central and northern parts of the aquifer.6,8 Heavy seasonal rainfall and river flooding recharge the Umm Ruwaba aquifer with approximately 341 MCM per year.

2.4.1 General description of Ground Water Abstraction-Water borehole drills.

According to sustainable water partnership, groundwater is the main source of drinking water in rural areas and in key cities like Juba. Boreholes and wells provide an estimated 65 percent of the total water supply (Sudan, 2013). Between 2014 and 2020, South Sudan's volume of groundwater produced remained stable at around 4 billion cubic meters. This resource can be developed for various climatic adaptation strategies including water supply for domestic use, irrigation, livestock watering, aquaculture, industry, and health. The technology of ground water abstraction involves drilling the ground and drawing water from 30 metres or more underground using containers or pumping it through sunk pipes (Sloots, 2010). Inside a vertical borehole, an extraction pipe is placed that has a perforated section (filter) and sand trap, surrounded by a filter gravel. Wells can be hand pumped or co-installed with smart energy technology including solar sources (SPR MWE, 2019).

The vertical borehole of most wells is drilled to an average depth of 60 m and up to 90 m and about 100 to 600 mm in diameter (Manuela Lasagna, 2020). Alternatively, deep water extraction can be developed for large diameter (1-2 metres) high-yielding projects for municipal water supply. These use an inbuilt mechanised pump supplying water to an elevated reservoir that works as a distribution point to a network of pipes. Large-diameter wells are less costly than multiple small wells in the long run (Nsubuga, 2009).

2.4.1.2. Technology category and market characteristics.

The groundwater recharge technology can be categorized as a non-market public good when established at a community level and requires state level support to develop and manage the system. The technology option in this report is community or state managed technology and thus considered as a non-market public good.

2.4.2 Identification of barriers for ground water Abstraction-Borehole drill

2.4.2.1. Economic and financial barriers

Table 19. Identified economic and financial barriers to the ground water Abstraction Borehole drill technology

Barrier category	Identified economic and financial barriers
Economic and Financial	High initial investment and maintenance cost. High costs especially related to equipment, drilling operation & maintenance and low access to spare parts associated with ground water abstraction are the main barriers to extending water supply to the population of South Sudan. Personnel costs including hydrogeologists, technicians, and casual labour, are quite high (Fagan et al 2015). When sites suitable for water drilling are distant from settlements and uneven, steep, or bushy, then costs include access development including clearance and maintenance of roads that lead to them (Asaba et al. 2015).
	Low budget allocation by government to the water sector: Many times, due to low budget allocation by government to the water sector, it is difficult for the sector to motivate and retain expertise. At local government level, the water officers are too few and not adequately skilled in deep well extraction and therefore cannot provide sufficient extension advice for community water users. Sometimes the issue of transport, fuel, reagents for testing water quality, and equipment such as cameras, GPS and computers to fulfil their duties hinder the lower-level officers from executing their duties because of low budget allocation.
	High cost of the construction and high cost of technology components, most of which are imported. Borehole maintenance is challenging and costly because spare parts and technical skills are difficult to access. The functioning of Water User committees is also constrained with hidden costs of meetings, fee collection, mobilisation, and supervision of service providers, which are often not taken into consideration (SPR MWE, 2019)
	Inadequate private – public partnership engagement. Private sector investment in the supply of necessary accessories and spare parts is also inadequate. The functionality of the boreholes depends heavily on the organisational strength of the water user committees to keep up the mobilisation, fee collection and deployment of skilled personnel for ensuring

that the equipment and the area around the wells is kept in good repair, yet
these committees are not adequately facilitated

2.4.2.2 Non-financial barriers

Table 20. Identified non-financial barriers for the ground water Abstraction-Borehole drill technology

Barrier Category	Identified non-financial barriers			
Technical	Inadequate technical capacity for constructing operating and maintaining deep wells.			
	There is inadequate hydrogeological knowledge making estimates of quantity of underground water and physical delineation and dynamics of aquifer systems in relation to precipitation uncertain and not readily available (MWRI, 2021). Due to inadequate knowledge, private companies sometimes abstract groundwater from restricted less endowed areas such as the cattle corridor, which tend to dry up during drought conditions. Cases of faulty infrastructure at construction and operation stages are quite common owing to inadequate competence of service providers and lack of means of verifying the genuine from the impostors. Limited functionality of boreholes comes from limited access to personnel to do repairs and maintenance (MWRI, 2021).			
Institutional and organizational capacity	Training in deep well extraction is expensive and no institution provides training on deep well extraction because it requires specialised equipment and expertise which are limited in South Sudan. Therefore, only very few people can access the training from East African institutions which provide training on water. There are no specific courses on groundwater extraction at the universities in the country.			
Information & awareness	Institutional weaknesses. Ground water is a publicly owned resource with common access, therefore requiring legislation, awareness, and motivation to ensure equitable access and good quality while avoiding irresponsible abstraction and conflict. Awareness and implementation of the policies and legislation governing groundwater abstraction is low. Drilling and abstraction activities are poorly monitored, and some abstraction companies operate without permits or supervision Various sectors including irrigation, livestock farming, energy, industry, and fisheries are potentially key stakeholders, but they are not			

	well coordinated. Deep well drilling projects by government are sometimes poorly coordinated with those of NGOs leading to concentration of wells in some locations, which in turn results in drying up of some wells as they turn into aquifers for others nearby.			
Policy, legal and	The lack of strategies and plans in the water resources sector can be			
regulatory	attributed to the lack of comprehensive water resources assessment.			
	Knowing when and how much water is expected to be available in the underground is fundamental to effective planning for water resources management, development, and use. In the absence of data, there is a lack of analytical tools, and information management systems, making it difficult to conduct assessments of availability and demand for water supply.			
Research and	Water Ouality concerns. Inadequate water quality monitoring			
Development	systems as well as limited data on water resources impede effective integrated water resources management and a comprehensive understanding of risks related to water quality. Oil extraction in the central floodplains of Jonglei, Lakes, and Upper Nile has contributed to surface and groundwater quality risks. There are high concentrations of heavy metals such as lead, barium, and chromium in groundwater near oil fields. Groundwater shows a high overall salt content and persistently elevated chloride, sodium, potassium and sulphate, likely caused by the seepage of saline water from oil field basins and mud pits (Garang Kuch S, 2019).			

2.4.3 Identified measures

2.4.3.1 Economic and financial measures

Table 21. Identified economic and financial barriers to the ground water Abstraction Borehole drill technology

Barrier	Identified economic and financial measures
category	

Economic and Financial	Reduce costs of ground water extraction. Because costs are mainly related to use of imported drilling equipment, the country needs to identify ways of reducing importation costs possibly by removing importation duties in the short term, but also work on a long-term strategy of fabricating the parts locally. This may increase accessibility of spare parts and enable water users to maintain ground water abstraction in functional condition.		
	The government of South Sudan should provide subsidies on the use of efficient irrigation technologies to achieve actual water saving . There is also need of incentives to reduce geochemical discharge in order to control groundwater pollution with subsidies targeted toward chemicals. Also, government should keep taxes on construction material low as well as levying fee directly for water abstraction that would vary according to area, volume, source and location.		
 Partnership with private sector is also needed by creating aware business incentives for profitable commercial enterprises regroundwater resource development including supplying of the requand equipment both for national and state level. Training more technical service providers would enhane availability and lower costs of hiring them. Emphasis should be sinking more large-diameter and mechanised boreholes, which are the long run and supply many people. 			

2.4.3.2 Non-financial measures

 Table 22. Identified non-financial barriers for the ground water Abstraction-Borehole drill

 technology

Barrier Category	Identified economic and financial barriers			
Technical	Strengthen technical skills for borehole installation and			
	management. Programs should be developed for up-skilling the			
	existing administrative staff and technical advisors at lower			
	government level, private sector, and NGOs to monitor and supervise			
	abstraction and use. Community training is also needed in borehole			
	operation and maintenance to ensure sustained functionality of existing			

	wells. Hydrogeological courses are also needed at tertiary institutions			
	to enable an increase in skilled manpower in surveying, and monitoring			
	of ground water sources for deployment to every district			
Institutional and	Strengthen institutions for groundwater management. Institutional			
organizational	and administrative structures and law enforcement need to be			
capacity	strengthened to build concerns of recharge of ground water and			
	prevention of contamination into water catchment management			
	planning. Sustaining ground water extractions requires coordination			
	between key government sectors including water, agriculture, and			
	energy, also between government and private or non-government			
	entities.			
	Water user association and committee members need to be			
	sufficiently facilitated with budgets for management, mobilisation,			
	and supervision to ensure efficient fee collection and sustained			
	functionality of installations. They also need to be trained in			
	developing and enforcing byelaws to govern groundwater use.			
Information &				
awareness	Strengthening awareness raising and generating dialogue on			
	responsible groundwater abstraction for climate adaptation. Media			
	including radio, newspapers and television should be engaged in raising			
	awareness and generating dialogue on responsible groundwater			
	abstraction for climate adaptation and its potential benefits for example			
	infigation and increased access to safe water.			
	An information catalogue needs to be created on the national			
	hydrogeological status showing the status of groundwater,			
	quantities available, quality, potential opportunities it offers for			
	climate adaptation, farming modernization and enterprise development.			
	The catalogue can also include laws and guidelines in groundwater			
	abstraction and potential options for groundwater resource			
	development. This needs to be made readily available in digital format			
	to inform and guide issuance of water abstraction permits and			
	supervision.			
	Encoding and in the line			
	Engaged in raising awareness and generating dialogue on			
	including radio, nowspapers and television should be engaged in reising			
	awaranass and generating dialogue on responsible group durate			
	awareness and generating dialogue on responsible groundwater			

	abstraction for climate adaptation and its potential benefits for example				
	irrigation and increased access to safe water.				
Policy, legal and	Implementation of strong and effective underground water				
regulatory	 utilization, land rule, and property rights. Land surface zoning can be used as a policy instrument to protect quality of groundwater and control abstraction. Strategies should be developed for commercial producers and for subsistence farmers who are totally dependent on groundwater for protecting their livelihoods. Another sustainable measure could be aquifer and land use planning that involve long-term groundwater planning through participatory decision-making. 				
Research and	Strongthoning hydrogoology research Research in hydrogoology				
Development	Strengthening hydrogeology research. Research in hydrogeology needs to be strengthened to establish the current groundwater status and the potential impact of climate change and water use practices under different scenarios. Feasibility studies for different options for groundwater resource development need to be made and piloted (MWRI). Research also needs to be strengthened in exploring the business potential for local fabrication of equipment for increased access to parts.				
	Improve water quality assurance. Groundwater from below 30m requires little or just basic treatment (MWRI,2021). However, with rising oil exploitation, urbanisation and threats of pollutants, water treatment technology needs to be installed to ensure safety especially in the oil rich state of Unity, Upper Nile and Jonglei state.				

2.5 Linkages of the barriers identified

Barriers that are common for all technologies include high cost of establishment of infrastructure, inadequate technical capacity, limited facilitation of water user committees and inadequate information. Given that most beneficiaries of these projects are small scale farmers, infrastructure installation costs can be prohibitive, even for seemingly simple technologies like ground water abstraction using boreholes. The bulk of infrastructure development cost is commonly borne by government, but while this enables installation even in remote areas, the functionality of installations remains a challenge due to various reasons.

Water user associations who are put in charge of these facilities do not have direct access to extension support and information. Information transfer and advisory support through mobile phone has not been sufficiently developed in the extension system. The affordable access to internet and the culture of browsing available sources for technical information are also yet to

develop. This owes to low literacy levels and the language barrier as most information is provided in English.

Another related challenge is the low access to spare parts and inadequate skills for local fabrication. Investment in community capacity to mobilize, manage and repair these facilities will increase the efficiency of their operation and maintenance. Private sector engagement needs to be strengthened by identifying avenues that motivate investment in installation, supply of technical services and spare parts.

The low coverage of extension staff is a key barrier in ensuring diffusion of water technologies among small-scale farmers. This is due to inadequate offering of courses covering this subject matter in the learning institutions.

There is also inadequate motivation of engineers to specialize in such courses because they perceive limited prospects of demand for such services. The limited ability of small-scale farmers to pay also demotivates private entities from developing technical advisory companies. Existing extension services also require refresher courses to understand these technologies and the skills of social and community engagement to enable community uptake and ownership of facilities.

The below-mentioned barriers are common and inter-linked in water sector technologies. Therefore, overcoming these barriers would immensely help in transfer and diffusion of both water sector technologies.

Barrier Category	Barriers		
Economic & Financial	High capital and maintenance cost		
	Limited financial allocation to local		
	governments		
	Inadequate loan and donor funding		
Policy, legal and regulatory	Lack of sound comprehensive cross-sectoral		
	policies for resource protection, development		
	and management		
Information & awareness	Limited information and awareness about the		
	existence and usefulness of the solar water		
	pump and underground water technology		
Institutional & organizational	Limited institutional capacities both at the		
capacity	national and sub national level in integrating		
	climate change risks into water and		
	development planning		
	Limited human skills and maintenance		
	specially at sub national level (state)		

Table 23. Common barriers identified in different prioritized technologies in water sector

2.6 Enabling framework for overcoming the barriers in the Water Sector

A key component of the enabling framework for overcoming the barriers to the diffusion of prioritized technologies in the water sector is the operationalization of the existing national water and climate change policy and its implementation framework recommendations.

The next step should include the increased budgetary allocation for increasing the resilience of the vulnerable communities from the impact of climate change on water resources, so that the diffusion of above-mentioned prioritized technologies can be facilitated through the mobilization of external donor agencies and getting access to international climate finance funds' specifically Green Climate Fund (GCF) and Adaptation Fund. For that to happen we may need to devise effective technology-based adaptation projects that would promise to deliver the potential benefits of these technologies to the resource managers, users, and other beneficiaries alike.

The next important component of sustainable water sector management in South Sudan is the need to ensure that social, economic, and environmental aspects of water are integrated into sectoral policies and plans. While these plans and programs should be taking guidance from the cross-cutting themes of water access, equity, and hazards.

Based on this theme, the prioritized technologies' implementing strategy needs to be focusing on alternative water resources, ground water sustainability and hydro-disaster risk reduction in the form of flash floods specifically inundating and damaging infrastructure and risking human lives in the rural areas. Further, though several measures are proposed to improve diffusion of water sector prioritized technologies, but it is important to address the most fundamental, practical, and urgent ones first.

In this category, we easily can place institutional capacities' enhancement, strengthening laws and regulations, ensuring climate informed decision making and planning, promoting research and technology awareness, and implementing pilot demonstration projects. In addition, ensuring the required investment will continue to be the fundamental enabling factor across all water sector technologies implementation in South Sudan.

Table 24: Enabling Environment to the deployment and diffusion of technologies in the water sector

Barrier	Measures	Enabling environment	Responsible
Category			Institution

Economic and	Reduce custom expenses	Developing facilities	Ministry of Water
Financial	/Taxes.	under public private	Resources &
	Enable local investment to	partnerships (PPP)	Irrigation (MWRI)
	produce the equipment by	arrangement where	
	giving incentives and tax	private companies can	South Sudan Urban
	holiday to manufactures.	acquire technology	Water Corporation
		construction equipment at	(SSUWC)
	Partnership with private	a subsidized price.	
	sector is also needed by		Ministry of
	creating awareness and	Many NGOs promoting	Finance and
	business incentives for	Maintenance.	Planning - GOSS
	profitable commercial	The existing water	
	enterprises related to	development strategy for	
	groundwater resource	public-private	
	development	partnerships in all stages	
		of the development of	
		water projects	
Market	Build capacity of local	Lobby for funds from	Ministry of Water
Conditions	suppliers.	International NGOs, UN	resources and
		Agencies, International	Irrigation, South
		Banks, Faith Based	Sudan Urban
		Organizations	Water Cooperation
Legal and	Enact the water bill that	Implementation of the	The National
Regulatory	has been developed.	policies that have been	Assembly
	Provide security to the	developed	Ministry of
	investors and service		Electricity and
	providers. Approve		Dams
	special attention to water		
	conservation and		
	sustainable water		
	management		
Network	Improve the technology	Public Private	Ministry of Water
	required.	Partnerships	resources and
	Build skills/capacity for		Irrigation (MWRI)
	the services providers in		
	the water sector.		
	Partnerships with local		
	private sectors to provide		
	the materials		
Technical	Partnerships with Private	Consultations with	Ministry of Water
	sectors	International NGOs to	resources and
	Develop Training	improve technical skills.	Irrigation
	Modules	Improve the educational	
		systems by providing the	

		necessary modules on	South Sudan Urban
		best practices	Water Corporation
		Formation and training of	
		Water user committees	
Institutional	Strengthen institutions for	Recruit and motivate new	Ministry of Water
and	water management	staff to participate at their	resources and
Organizational	Institutional and	best capacity.	Irrigation, South
Capacity	administrative structures	Government effort to	Sudan Urban
		mainstreaming climate	Water Corporation
	Strengthen Institution	change considerations	
	Management of Water	into water sector polices,	
	Supply systems and	plans and	
	administration.	Strategies.	
Human Skills	Train service providers	Improve sustainability on	Ministry of Water
	Introduce training	operation and	resources and
	Institutions.	maintenance and	Irrigation.
	Develop training modules	Development.	
~ ~	and short courses		
Social, Cultural	Create awareness on	Reaching out to	The National
and Behavioral	social behavioral change	community leaders,	Ministry, The State
		Women groups, the	Ministry and the
		youth, religious leaders,	Local Government.
T. C	Dura and and the size	WASH clubs in school	The NGOs Ministers of
Information	Prepare extensive	The high demand of	Ministry of
and Awareness	information and	The existing of Water	The abuse of a set
	awareness material about	The existing of water	Veter Institutions
	usefulness of water sector	Institutions such as The	NGO ₂
	technologies and	Lirban Water	NUUS
	disseminate them through	Existing of Media houses	
	workshops	to disseminate	
	and training sessions	information	
	Create awareness on the		
	importance of solar water		
	pumps		

CHAPTER 3 DISASTER RISK MANAGEMENT SECTOR

3.1 Preliminary targets for technology transfer and diffusion in Disaster Risk Management sector

Increased disaster risks have resulted into high degree of vulnerability of local communities, households, and ecological systems in South Sudan. There is evidence that natural catastrophes, particularly floods, are becoming more and more devastating in the country, putting millions more individuals' lives at risk (Disaster management strategic plan (2018-2020). The increase in flood events has exposed more populations to disaster risks and has unveiled socioecological systems to various vulnerabilities. The vulnerabilities to flooding risks are most in 6 states of South Sudan (RRC, 2023). In South Sudan, floods are unquestionably the most frequent disaster triggered by natural hazards. Between 1970 and 2020, the country suffered an average of two floods yearly. The country has seen the deadliest floods in the last 6 years (2014, 2017, 2019, 2020, 2021, and 2022) and drought 2011–2015 (Edoardo Borromeo, et al., 2023. In 2021, the country was hit by the biggest floods in its history (till now), which affected 800,000 million people, destroyed over one million hectares of standing crops and cost the economy estimated billions of dollars (UN Women,2022). The increased impact of the 2021-2022 floods highlights the importance developing and introducing early warning system to ensure continuous monitoring, preparedness, and response efforts to minimize the risks and impacts of future disasters. It is important for communities and disaster response organizations to work together to improve their capacity to respond to and recover from disasters to protect vulnerable populations and reduce the impacts of future events.

The overall preliminary target for South Sudan is to develop end-to-end early warning systems (EWS) to provide timely, accurate and effective warnings and enhance the adaptive and response capacity of national and sub national levels (County, Payam and Boma) that are at risk of floods, drought, pest infestation (Second Nationally determined Contribution, 2021). Specific targets defined in the South Sudan vision (2040) and in the National Disaster management strategic goal include:

- 1) Development, rehabilitation and introduction of 5 early warning system for monitoring, weather forecasting and hydrology.
- 2) Introduction and improvement of flood and drought warning systems in all the ten states of South Sudan
- Development of hazard maps and disaster risk reduction plan cross the ten states in South Sudan
- 4) Development and Establishment of a sub national emergency coordination and command center including ICT system for the EWS.

The government of South Sudan target to strengthen the information and communication technology (Facebook, WhatsApp, messenger) and telecommunication sectors to enable the provision of timely warning and improved disaster response to relevant stakeholders including key

disaster management institutions, private sector players and the local communities in all the state in South Sudan.

3.2 Barrier Analysis and Possible Enabling Measures for Development and Introduction of Monitoring and Early Warning Systems

3.2.1 General description of development and introduction of monitoring and early warning systems

An early warning system (EWS) is a system of hazard monitoring and forecasting, risk assessment and informing people at risk, relevant organizations and stakeholders to be prepared and enabled to take timely action to reduce disaster risks in advance of hazardous events. Early warning systems (EWS) are key elements of climate change adaptation and disaster risk reduction, and aim to avoid or reduce the damages caused from hazards. To be effective, early warning systems need to actively involve the people and communities at risk from a range of hazards, facilitate public education and awareness of risks, disseminate messages and warnings efficiently and ensure that there is a constant state of preparedness and that early action is enabled. The significance of developing and introducing an effective early warning system lies in the recognition of its benefits by the local communities.

Early warning systems for climate-related risks must rely on a sound scientific and technical basis and focus on people or sectors mostly exposed to risk. This implies the adoption of a system approach incorporating all relevant risk factors, whether arising from the climate-hazards or social vulnerabilities, and from short-term or long-term processes. Early warning systems include detection, analysis, prediction, and then warning dissemination followed by response decisionmaking and implementation. Such systems are in place, in many parts of the world, to monitor, forecast, and warn people about e.g. tropical cyclones, floods, storms, tsunami, avalanches, tornadoes, severe thunderstorms, volcanic eruptions, extreme heat and cold, forest fires, drought, etc. To be effective and complete, an early warning system needs to comprise four interacting elements namely: (i) risk knowledge, (ii) monitoring and warning services, (iii) dissemination and communication and (iv) response capability. In South Sudan a fully functioning system with all four interactive elements of an effective early warning system is not yet developed due to several barriers such as insufficient financing for early warning development and introduction in all the states.

Technology Category and Market Characteristics

An EWS is a non-market and publicly provided technology that requires wider cooperation from and participation with the private sector and local people, especially those who reside in hazard prone areas. In South Sudan, floods, drought and insect pests' distribution EWS are currently not developed to be able to provide timely and accurate forecast, warning, and response (FAO. 2020). This barrier analysis, apart from revisiting the overall problem, investigates the underlying barriers that impede the development and introduction of monitoring and early warning systems and their performances.

3.2.2 Identification of barriers for the development and introduction of monitoring and early warning Technology

The identification of the barriers to the development and introduction of monitoring and early warning technology was carried out in accordance with the barrier analysis process, for which barriers were initially compiled, screened, decomposed and then analyzed causes and effects, by literature review, key informant interviews, information analysis and stakeholder consultations. Results showed that 15 barriers were initially listed as the obstacle. However, following decomposition of the barriers and problem analysis using logical problem tree, screening and revising; it was found that there are 11 important barriers that restrict the development and introduction of monitoring and early warning technology.

3.2.2.1 Economic and financial barriers

Economic and financial barriers were identified from stakeholder consultations and were scored and ranked to determine which barriers were most significant. The barriers and scores are given in table 25 below

Barrier	Identified economic and financial barriers
category	
Economic and	High investment cost. The cost for development and introduction of an end-
Financial	to-end monitoring and early warning systems technology for South Sudan is estimated to be round \$15 million for a stand-alone EWS system and \$10 million for an integrated regional system in which, the weather observation and forecast system including radar, ground observation station, hardware and software (model) may cost about 60% of the total cost, and operation and management may account for about 20% of the total cost (USAID, 2014). The cost of strengthening hydromet service ranges from \$5 million to \$10 million. This has resulted in very limited infrastructure (buildings,
	biser varion sites, instruments, etc.) for early warning systems in the country.
	National and sub national budget deficit and ineffective public
	budgeting. The national budget deficit and ineffective public budgeting are
	also the main barriers causing early warning system under infancing and then underdevelopment. The national budget deficit between 2001 and 2022
	resulted in no implementation of disaster response activities. For example
	the MHADM budget for $2021 - 2022$ financial year was about SSP 8 27
	billion (5%) compared to the budget of other sectors in South Sudan. The
	public budget allocation has been either imbalanced or ineffective.

Table 25. Identified economic and financial barriers to the Development and introduction
of monitoring and early warning systems technology
A lack of resources and a lack of strong and robust evidence also
--
contribute to decision makers' reluctance (internally and externally) to
commit the funds they do have. Financing challenges are compounded when
roles and responsibilities are not clearly defined.

3.3.2.2 Non-financial barriers

The non-financial barriers were identified from stakeholder consultations and scored to determine which non-financial barriers were most significant. The barriers and scores are given in Table 26 below

Table 26. Identified non-financial barriers for the development and introduction of
monitoring and early warning Technology

S/No	Barrier category	Identified economic and financial barriers
1	Technical Barriers	Inadequate knowledge and skills. Inadequate knowledge and skills to effectively and sustainably operate an early warning system have resulted in no development and introduction of climate change early warning system. South Sudan lack adequate EWS professionals who are trained to support the diffusion and transfer of early warning system.
		Currently, there is no comprehensive flood and drought EWS learning and training curriculum provided by any educational and government institutions in South Sudan.
		Some staff from the Ministry of Environment and forestry and Ministry of humanitarian affairs and Disaster management staffs were trained on the use of some flood modelling such as MIKE flood Mode but they are not able to apply it on the ground.
2	Policy, Legal and regulatory	Lack of legal framework and policies: The development and introduction of early warning involves multi-sectors and requires concrete information for effective legal framework coordination for the development and operation of an effective early warning system (EWS). Inexistence of specific early warning system policies that provide guidelines on how EWS should be developed and managed means insufficient legal framework. The law on telecommunication and media also fails to provide details

		about responsibilities amongst the ministries on the development and management of the telecommunication and media network in specifically disaster-prone areas and for the EWS. The specific legal framework or decree to provide principles, practical guidelines, organizational arrangement and responsibilities on this affair in detail has not been developed.
		The insufficient legal framework is a main barrier hindering an effective EWS. As a result, responsibilities among key institutions to manage and operate EWS, for example, between MoEF and MHADM including the MWRI are duplicated. These have undermining effectiveness of the EWS development, introduction and functioning.
3	Institutional and organizational capacity and human skills Barrier:	In South Sudan, there is no experience with high resolution data, models and new generation equipment. There is a lack of qualified personnel to ensure the prevention of natural disasters, deciphering images and techniques (for example lack of personnel to operate the hydro meteorological and forecasting services). The warning system of extreme events is not very familiar to the general public, including the dissemination of extreme hydro meteorological phenomena.
4	Information and awareness	Inadequate data and lack of climate information for EWS and actions is one of the more acute barriers to the development and introduction of an early warning system in South Sudan. Forecasts and actions both have time periods that need to be considered and aligned. Examples of successful early warning system development and introduction include prepositioning stocks and cleaning drains.
		Weak information management and content of particular concern were issues related to internal capacity to collect the data necessary to complete the development of early warning indicator dashboards, dealing with contexts affected by a chronic issue or multiple hazard profiles, and

		effectively turning early warning into relevant actions across responsible departments in the country.
		Data and information about hazards, response capacity of local communities. EWS technologies and best practices
		(financial and economic) of an EWS are not enough for
		effective EWS development and operation. Although South
		Sudan faced yearly constant floods, research and
		development of information about floods and drought,
		sudan bazard profiles and maps are not yet developed
_	~	Sudan nazard promes and maps are not yet developed.
5	Social, cultural and	Typically, producers in South Sudan tend to have a low
	behavioral.	level of trust for financial and banking institutions. They
		Also, communal use and sharing of water sources in most
		parts of South Sudan is difficult to break and therefore.
		some people believe that technologies are likely to create
		problems as the number of individual sprinkler and drip
		irrigation installations increase.
6	Political instability	Political instability in South Sudan is one of the most critical
		key barriers that hindered the implementation, diffusion and
		deployment early warning system in all the ten states in
7	Inadaquata hasic	Inadequacy of the infrastructure has undermined
,	early warning system	dissemination and communication of warning and facilitate
	infrastructure	response to the warning and disaster in effective and timely
		manner. For example, in the event of flood in Jonglei state
		in 2021, several payam and villages did not receive any
		hazard information and alerts because of dysfunction of
	T 00 /1	telecommunication and media network
8	Ineffective	Ineffective coordination amongst key government and
	coordination amongst stakeholders	international institutions that are implementing early
	amongst stakenolders	warning to manage and operate EWS, and between the key
		organizations and other stakeholder who support EWS
		partner are ineffective.
		Dissemination and communication on warnings in the event
		of disaster is not end-to-end and lacks feedback mechanism.
		These caused by the lack of clear responsibilities and SOP.

		In addition, it is because of the absence of EWS operation center.
9	Absence of the	Inadequate reference project and best practices on the
	reference project and	early warning systems
	the best practices	In South Sudan, the absence of the reference project and the
		best practices have hindered early warning development and
		deployment. This is due to limited research and exchanges,
		which resulted from budget, skills, knowledge barriers. A
		reference project and a best practice on how to effectively,
		efficiently and sustainably develop, introduce and manage
		an early warning system of different types of hazards are
		limited; there is a lack of wide-ranging studies and
		dissemination.

3.3.3. Identified measures

3.3.3.1 Economic and financial measures

Securing adequate financial resources and investment is the main measure for early warning system development, introduction and sustainability. At least, the government needs to secure US\$ 15 million for the development and establishment and US\$ 5 million for the operation and management of a stand-alone EWS system for South Sudan. Investment in an EWS is worthwhile. Financially and economically, for each US dollar invested in EWS US\$ 5.51 will be saved (stand-alone EWS) as a result of loss and damage reduction (Rogers David and Vladimir Tsirkunov (2010). These demonstrate positive cost-benefit ratio (CBR) and the integrated EWS has an even higher CBR compared to the CBR rate 1:7 defined by WMO (ISDR et al., 2012). To secure financial resources and investment in EWS, there are five important measures to pursue as follows.

- 1. Enhancing macroeconomic and national revenue as it would have an overall positive impact on EWS financing. This can be fulfilled by effectively implementing and revising the South Sudan National Disaster Management Strategic Plan that was intended for execution between 2018-2020 Sudan and recommendations in the Revised National Development Strategy (R-NDS) which emphases the need to secure enough financial resources to ensure effective and sustainable development, introduction and implementation of climate change early warning system cross
- 2. **Improving the effectiveness and efficiency of public budgeting**: particularly increasing the capacity building of the Ministry of Finance and Planning to re-define the optimal public investment and budget allocation model which optimizes economic growth and reduces financial deficit while balancing investment in the social and environmental sectors. This

means, there is a need to evaluate the effect of the existing public investment model, following this with studies and adopt best practices on the public investment and budgeting model. In addition, during financial constraint, the government may focus on financial economically viable and critical projects such as the development, introduction and the implementation of early warning system to reduce loss and damage as a public investment target.

- 3. Strengthening the capacity of Ministry of Environment and Forestry and the Ministry of humanitarian affair and Disaster management and stakeholders to mobilize, access and manage financial resources from all sources in effective, efficient and accountable manner. Realizing this, MoEF and MHADM at national and sub national needs to increase awareness and justification for convincing the government including Ministry of Finance on investment in EWS. In any case, MoEF and MHADM needs to increase efforts to cooperate with relevant institutions and partners to improve capacity and carry out the following activities.
 - Assessment of financial needs for Early Warning Development;
 - Development of resource mobilization strategy and plans;
 - Strengthen the availability, access and use of accurate, timely and disaggregated climate and risk information for MHADM and the MoEF;
 - Increase capacity to develop financeable project proposal including adequate financial and economic analysis;
 - Enhancement of the financial aid management system, especially financial support and investment record, tracking and reporting system, and feedback mechanism in order to ensure effectiveness, efficiency and transparency of the financial aids related to the development of climate change early warning system. This will be done by improving coordination of bilateral early warning climate finance, as well as support to the Government of South Sudan to increase access to all sources of early warning system finance, building on a country-owned programmatic approach to climate finance.
- 4. Promote investment and contribution of private sector, especially investment and development of the social media and telecommunication including the development of hydro-met observation stations and floods detection system. In addition, the government may incentives including tax reduction and exemption to import of EWS equipment's.

3.3.3.2 Non-Financial Measures

Various measures that could be implemented in South Sudan to overcome some of the impending non-financial barriers include

1. Development of law, regulation and policy on disaster management and EWS is a must for effective EWS development, operation and sustainability. Strengthening law enforcement especially by mainstreaming disaster risk and EWS and enhance enforcement of the Environmental and Social Impact Assessment (ESIA) of development projects such as hydropower projects. South Sudan needs to be committed by developing and implementing national strategies and plans of action for early warning system as key instruments for the diffusion and deployment of the technology. At least, following law, regulation and policies shall be developed and enforced by the government. For example, the government needs to work with development partners to start the drafting of National Disaster Risk Management Policy endorsed by the Re-vitalized Transitional Government of National Unity in February 2022 and the National Disaster Risk Management Bill; which emphases the promotion and incentives on operation of business and activity on disaster prevention including import of equipment for disaster prevention and control, and EWS.

- 2. Develop strategy and action plan on disaster risk reduction and management including EWS Strategy and action plan on disaster risk reduction and management, and EWS including emergency response plan should be developed to clearly define risk reduction and EWS targets, methods and resources needs for an effective and sustainable EWS development national and local levels. However, to be more effective and practical, inclusive stakeholder participation and comprehensive studies should be pursued to support the development. With the strategy and action plan in place and effective implementation, more resources, effective and advance EWS development could be expected. Investing in the development the strategies deem efficient, especially in long-term. There are only some costs involved such as research and consultation, but may be worthwhile compared to positive impacts that may be generated following implementation of the strategies.
- **3.** Strengthening information for early warning system (EWS). Information on hazards, technologies, financial and economic feasibility of EWS need to be developed and made available for decisions on the investment and development of the EWS. Research needs to be carried out to improve: 1) hazards and risks, 2) best suitable EWS technologies and best practices, 3) adaptive and resilient capacity of disaster-prone communities, 4) EWS technical, financial and economic feasibility including financial needs, financial and economic returns on investment or cost and benefits, 5) financing models and mechanism, and 6) funding sources for EWS development.
- 4. Raising public risk awareness and education on the significance of development and introducing strong climate change early warning system. Risk knowledge is the fundamental requirement of each user-oriented early warning system. Without widespread education on risks, warnings, and how to react to them, EWS lose their fundamental mandate to prompt a mitigating action by endangered communities. For this reason, increasing public risk awareness is an activity often included in the development plan of community-based climate change early warning system.
- 5. Develop strategies for last-mile communication and dissemination of information on early warning system. Government and implementing partners to strengthen early warning communication strategy specifically targeting communities through well-tailored dissemination mechanisms. Early warning system should be disseminated using local (community) radio stations in the local language. Strengthening community radio initiative and mobile VHF radio operation to co-ordinate early warning system intervention during the

severe climatic stresses such as flood and drought. The mobile station can be used to collect and delivery early warning date to remote communities.

- 6. Enhancing organizational and capability skills to deal with a lack of capacity in developing and introducing an effective early warning system in the country. The development and introduction of an early warning system require training and capacity-building exercises for the various linked government and nongovernment officers. Since the early warning system is a multi-organization effort, it emphasizes training in execution and coordination as well. Therefore, a wide range of trainings related to management skills are highly required for potential officers in order to equip them for specialized climate change early warning system-related tasks. Therefore, there is a need to develop an HR and capacity development plan, put in place early warning staff knowledge management and capacity needs assessment, and develop short-term EWS training modules, including specific courses on floods and droughts.
- 7. Enhance disaster awareness and preparedness by promoting behavioral change and linking disaster management with recovery period by developing disaster management manuals or guidelines, developing curriculum on early warning system, educate communities and create awareness initiatives.

3.4 Barrier Analysis and Possible Enabling Measures for the improving disaster response (through the use of social media) Technology

3.4.1 General Description of Improving disaster response (through the use of social media) Technology

Social media (SM) are socio-technical systems that have the potential to provide real-time information during disaster crises and thus to help protect lives and property. Yet, South Sudan disaster management agencies do not extensively use them to disseminate (send out) climate change disaster related messages and information. Technological advances have resulted in social media becoming a significant tool to improve disaster response. The ease-of-use and relatively low cost makes social media applications an effective way to disseminate information during or following a disaster, and allows for those affected by a disaster to be in touch with disaster relief organizations, friends and family. Information transmitted via the use of social media applications can also be used by emergency teams to determine the scale of the disaster and pinpoint specific locations in affected areas, resulting in swift and effective action. It can also be used to quickly notify a large number of people about distribution sites, shelter areas, evacuation zones, etc. Facebook, messenger, WhatsApp are three commonly used social media technologies used during disaster situations, while new micro-blogging applications are emerging as effective platforms for volunteers to organize relief efforts.

Data received from social media can provide important information about the behavior of affected citizens and can be used to improve disaster risk management in the future. The use of social media in disaster response is relatively new in DRM. Platforms such as Twitter, Facebook, and, by extension, Google Maps can help in sending out alerts, tracking the effects of disasters, gathering

and distributing aid and relief supplies, coordinating logistics and volunteer efforts, and improving information sharing after disasters. This technology has already been used in disaster response worldwide and can also be applied in South Sudan.

Technology Category and Market Characteristics

Technology Category and Market Characteristics Improving disaster response by using social media technology can be categorized as a nonmarket public good when improved at both national and sub national state-level. The technology option being considered in this report is a state-run and state-provided improved disaster response social media service which is a non-market public good.

3.4.2 Identification of Barriers for Improving disaster response (through the use of social media) Technology

The following barriers were randomly identified by the consultants through literature review, expert knowledge, consultation with the stakeholders and Sector working during workshops and brain storming sessions:

- Inadequate budget for Improving disaster response (through the use of social media) Technology
- Social media application for improving disaster response requires the necessary technical equipment, knowledge, electricity and an adequate
- Network and internet coverage, which is often limited or lacking in remote states in South Sudan
- Lack of experience with social media for improving disaster response
- In South Sudan, many individuals are unaware of the proper use of the social media technology for disaster response;
- Social and culture brief False information on social media can lead to the rapid spreading of rumors or misinformation
- Certain demographic groups, particularly older generations, may not be familiar with social media or even the internet.
- Literacy is required to use social media for disaster response
- Data and information for good designing and decision about using social media for improving disaster response
- Lack of time and personnel
- Lack of available staff to use these social media tools for disaster response
- Lack of trust in the accuracy of information posted by SM users.
- Lack of formal policies for using social media for improving disaster response
- Inappropriate communication /extension approaches in regard to the promotion of social media application in disaster responses
- Inadequate institutional capacity on application of social media for improving disaster response

- Inadequate capacity and basic legislation and institutional factors.
- Inadequate training and education in regard to the important of using social media for effective disaster response.
- Inadequate financial resources to procure social media application equipment's

The barriers were then categorized into broad categories and described in order to enable further analysis

3.4.2.1 Economic and financial barriers

Economic and financial barriers were identified from stakeholder consultations and were scored and ranked to determine which barriers were most significant. The barriers and scores are given in Table 27 below

Table 27. Identified economic and financial barriers for improving disaster response (through the use of social media) Technology

S/No	Identified economic and financial barriers
1	Inadequate public budget for strengthening the use of social media technologies to improve disaster response . The amount of budget allocated for social media application for disaster management is very short for improving disaster response through social media. Ineffective and imbalanced public investment prioritization and budget allocation greatly hinder the diffusion and deployment of social media application in disaster response and management in South Sudan.
2	High initial investment cost of building a dense social media network for improving disaster response. Setting-up an advanced social media system that is efficient and effective may require high investment forecasting and efficient early warning system. Social media use requires system support. There is a financial cost to having and maintaining computer equipment and systems, and the staff to operate the equipment
3	Limited financial resources for deploying social media technology for disaster response in South Sudan. This barrier is due to ineffective resources mobilization by the government and private sector for the deployment of social media application as a tool for effective disaster response and management.

3.4.2.2 Non-financial barriers

The non-financial barriers were identified from stakeholder consultations and scored to determine which non-financial barriers were most significant. The barriers and scores are given in Table 28 below.

S/No	Broad Category	Identified non-financial barriers
1	Technical Barriers:	Limited technical skills in social media applications for
		disaster response and mapping. The technology use
		requires the necessary technical equipment, knowledge,
		electricity and an adequate solar power for charging. In
		South Sudan, many individuals are unaware of the proper use
		of the social media technology for disaster response;
		The Ministry of humanitarian affair and Disaster
		management (MHADM) have inadequate staffs and
		professionals who are experienced to send information to
		specific reporters' social media accounts. Consultation with
		stakeholder during the barrier analysis workshop indicated
		that staff from the Ministry of Humanitarian affair and
		Disaster management had not been trained in the use of
		social media, or they simply did not have enough staff to
		manage the response adequately during and after disaster
		such as flood and drought.
2	Policy, Legal and	Lack of guidance/policy documents. In South Sudan, there
	regulatory:	is a lack of rules/regulations/ laws on the use of social media
		for disaster management and response, because of which
		there is a misuse of freedom of speech/ freedom of
		expression. Social media in the country is not fully develop
		and introduced as tool for disaster management.
		Incomplete law or deeree on disaster and disaster reduction
		fund. The application of social modia in improving disaster
		response is not yet available in South Sudan. The draft law
		on disaster response is not yet approved by the parliament
3	Institutional and	A lack of skilled/trained professionals to handle social
5	organizational	media application for disaster management Lack of
	canacity and human	knowledge and skills to develop, sustain as well operate and
	skills Barrier	manage social media for improving social media application
		manage soonal meana for improving soonal meana application

Table 28. Identified non-financial barriers for improving disaster response (through the
se of social media) Technology

		for improving disaster management contribute negative to
		the diffusion and transfer of the technology.
		Lack of manpower and resources dedicated to social
		media technology. Lack of resources and personnel's. In
		general, the technology has not been implemented due to
		lack of resources and competence disaster expert to manage
		the social media as mean of strengthening climate change
		disaster response. According to Haataja et al. (2016) lack of
		resources or employee competencies can discourage an
		organization from incorporating social media into its
		climate change disaster response plans. Lack of staffing
		resources is an emerging theme that has been shown to be a
		substantial barrier prohibiting social media use in
		improving disaster response. Hiltz et al. (2014) note that a
		lack of technology is also a barrier and further suggest that
		making software enhancements to improve the filtering of
		social media users by category of user type and providing
		teams with a GIS system map could improve social media
		use during a disaster crisis.
		Unclear roles and responsibilities: Unclear roles and
		responsibilities of stakeholder and unit in charge of
		development and management of social media for improving
		disaster response in the country. This is due to lack of multi-
		agency coordination, cooperation and participation in the
		implementation of social media technology to improve
		disaster response and information dissemination.
4	Market Condition:	Ineffective promotion/ extension and push demand/needs for
		establishment of social media to improved disaster response
		due lack of legal framework on the application of social
		media for improving disaster response.
5	Information and	There is a lack of clarity on which social media platform to
	awareness	be used for climate change disaster management and
		response. In South Sudan, there is no clarity on appropriate
		hashtags and keywords that can be used by climate change
		disaster effected communities to reach the respective
		authority. This is due to lack of standard framework on the
		use of social media for disaster response and management
		using social media. There is an issue with the restriction on
		the word limit of the message. The absence of a statistical

		database and the paucity cross social media platforms have
		been identified as a critical barrier.
6	Language is a	Language is a demographic barrier as most of social media
	demographic	is in English. During the consultation, participants indicated
	barrier as most of	that, "because of lesser-educated society, people are a pro at
	SM is in English	regional languages but English." Another identified barrier
		is a difference in the South Sudan dialect of the language, as
		dialect change makes it difficult to understand the context of
		the message.
7	Social, cultural and	Cultural barriers comprise gender biases in South Sudan
	behavioral	community, with inequality in education juxtaposing males
		and females and differences in rural and urban exposure to
		education. There are cultural reasons for not sharing
		information on social media. During consultation, one of the
		respondents mentions that: "Poor communities have limited
		access to basic phones, so they hardly use smartphones and
		Social media" Rural people are unaware of smartphones,
		which implicitly makes them unaware of social media for
		disaster management and response. This hinders the
		diffusion and deployment of social media as technology for
		improving disaster management
8	Physical barriers	Physical barriers constitute the power supply and
		internet requirements. Improper internet connectivity in
		rural areas in South Sudan is another vital barrier. Network
		coverage and network failure are significant drawbacks in
		the deployment of the technology. Disaster working group
		member's states: During the time of any disaster, the first
		thing that rural remote communities don't have is power
		supply, even network problem because rural don't total have
		access to internet and power connection. So, if community
		do not have any platform, how can their use social media
		during a disaster.

3.4.3 Identified Measures

3.4.3.1 Economic and Financial Measures

Barriers category	Identified economic and financial Measures
Inadequate public budget for strengthening the use of social media technologies to improve disaster response High initial investment cost of building a dense social media network for improving disaster	Allocate sufficient funds in national budget for implementation of EWS framework/policy and the development of social media for improving disaster response and information dissemination and to enable the Ministry of Humanitarian Affairs & Disaster Management (MHADM) hire and trained staff on early warning system including and the of social media for disaster response, logistical facilitation, monitoring and use of ICT in extending climate change disaster risk advice. Public-private partnerships are needed to strengthen the development of social media for improving disaster response and information dissemination on early warning system. Private sector partnerships need to be developed to increase investment in social media strengthening for climate change response. Economic and financial measures should be put in place to reduce interest rates and increase credit facilities leading to adequate credit.
response	Furthermore, if tax rebates and incentives (tax waiver) are provided, the cost of importing social media kits will be reduced. If measures to train more social media technicians for disaster response at subsidized rates are put in place, it will result in more specialized manpower leading to more manufacturers of social media disaster kits and better service delivery. This will contribute to lowering the cost of building a dense social media network.
Limited financial resources for deploying social media technology for disaster response in South Sudan	 The use of social media technology development would require huge capital costs to enhance the domestic research and development capacity. The domestic financial resources need to be supplemented by international sources to meet the targets. Financial support needs to be sought for: Strengthening of research into the use of social media for improving disaster preparation and response and other social media use through research and development. Development of human resources and technical knowledge Knowledge transfer and exchange programmes

Table 29. Identified Economic and financial Measures for improving disaster response (through the use of social media) Technology

3.4.3.2 Non-Financial Measures

The non-financial measures are intended to deal with a wide range of issues in institutional organization capacity and policy, legal and regulatory. These include promotion of social media for the dissemination of disaster risk reduction and lobby government to encourage public-private investment into the use of social media for disaster response and management.

S/No	Broad Category	Identified Non-economic and financial measures	
1	Technical Barriers:	Strengthen technical capacity of national and sub national disaster response teams with strong knowledge and skills to produce and distribute social media content production that contributes to better disaster preparedness, response and recovery and how to employed social media platforms in disaster response and management. For example, on how to post, send and receive messages and material that are proper and, when applicable, related to the particular disaster. Building the capacity of media can significantly increase community resilience. It enables effective early warning information flows that can reach mass audiences before, during and after a disaster, leading to better disaster preparedness, response and recovery.	
		Building media capacity enables better community dialogue, leading to building a more resilient society. In particular, those in management roles can play a significant part in ensuring that social media activities are sustained and the wellbeing of media professionals is protected. Local social media are positioned in communication environments shaped by both emerging global trends and local contexts. In order to best serve the information needs of the community, it is important that media capacity building is positioned within locally specific communication environments, while also embracing emerging ICT techniques that are assessed as being useful to the community.	
2	Policy, Legal and regulatory:	Developing policy, strategy and legislation on the use of social media for disaster response and management. One of the key ways to build the social media capacity and strengthen disaster resilience is to ensure that policy and legislative structures offer strong and enabling social media and	

 Table 30. Identified non-financial Measures for improving disaster response (through the use of social media) Technology

		communication environments that lead to effective information flow across the stages of preparedness, response and recovery. When natural hazards occur, local and international media are among the first responders, joining local authorities and professional emergency service providers to disseminate information to the public. It is vital that every social media institution in the country is equipped with an emergency social media broadcasting communication plan, which is harmonized with other response agencies and actors.	
3	Institutional and organizational capacity and human skills Barrier:	Incorporating and understanding social media policy for improving disaster response in the Country. The government of South Sudan and its development partners need to incorporating social media into the existing government policies of how they respond to climate change crises, as well as integrating social media into continuous training of disaster responders. Liu (2014) recommends that prior to using social media technology for climate change disaster response and management purposes, a country needs to understand the legal policies and regulations related to engaging with social media and managing crowdsourced data, such as considerations with personally identifiable information that may be present on social media	
		Engage in regular training and relationships building with community leaders, who can help provide situational reporting when needed, through mobile apps, texting, or social media. Training and awareness of communities on the significant of use of social media during before, during and after disaster response reduce social and cultural barriers and enhance community participation in the promotion of social media.	
4	Market Condition:	Improve financial markets and capacity to access to finance . To create favorable financial markets and access, the financial and banking sector growth and competition is needed to be	
		and banking sector growth and competition is needed to be enhanced This means, apart from adjusting depositing mechanism, the domestic financial and banking institutes may need to increase cooperation with regional financial to access to lower rate of loan. Hence, the interest rate of loan and procedure for acquiring social media equipment's for disaster management could be reduced and simplified.	

5	Information and awareness	Incorporate mobile texting/apps and social media as the sources of public reporting for data gathering for climate change disaster preparedness, especially for communities with difficult access to social media advanced technologies to ensure diffusion and deployment of the technology. Communicate preparedness information to the community via multiple channels, such as mobile texting, SMS, and social media, and face-to-face can be a faster mean to improved disaster response.
		Rise social media and mobile internet penetration to improve disaster response. Exponential rise of social media platform and mobile internet penetration can enable the use of SM via mobile internet, which implicitly augments the use for disaster response and management. For instance, somebody can share heavy rainfall news on SM for awareness to wide range of communities and different geographical location
		Improving and modernize hydromet services. A well- prepared and well-resourced hydromet services could help South Sudan prepare for, mitigate, and recover from disasters. Such services minimize the disruptions caused by natural hazards by providing warnings to governments and communities in advance of events through the use of social media such as s WhatsApp, messenger, Twitter and Facebook. They provide daily weather information, which can help prevent secondary disasters in environments where vulnerability and risk are high.
		Government of South Sudan should develop reference projects and best practices on early warning systems. Government of South Sudan and international partners should develop a reference projects and best practices to be a showcase the significant of developing and deploying climate change early warning system in dealing with impact of climate change. The deployment may focus on creating and sharing effective and successful climate change emergency including response planning, organizational arrangement, communication and awareness raising and application of tools to effectively and timely response to alerts and disasters. In addition, it is critical to focus on effective approaches and best technologies for climate

change hazards detection and forecast, especially real-time and
accurate forecast.

3.5 Linkages of the Barriers Identified

This section looks at linkages of different barriers that hinder the development and introduction of monitoring and early warning and the improving disaster response (through the use of social media). Barriers that are common for the disaster Risk management include the political instability in the country, lack of budget allocated to disaster risk management activities, and institutional and technical capacities gaps are the most critical key barriers that hindered the deployment and implementation of Disaster risk management technology in South Sudan. Among other challenges to mention include weak institutional coordination mechanisms, poor infrastructure and access to data and analytical capacities. Technology in the disaster risk management sector is presented in table 31 below.

Table 31. Linkages of barrier faced by different prioritized in the Disaster Risk management sector

Barrier Category	Barriers	
Economic and Financial	High initial investment cost for the disaster risk	
	management technologies	
	Inadequate budget for the implementation of Disaster	
	Risk management technologies	
	Insufficient financial resources	
Human skills	Inadequate training of disaster risk management staffs	
	and early warning officers at the national and sub	
	national	
	Low adoptive capacity	
Information and Awareness	Limited knowledge and awareness; - inadequate	
	awareness of the existence of technology	
	Inappropriate communication and extension approach as	
	well as limited communication among technology	
	developer, supplier, and users	
Policy, legal and regulatory	Inadequate policy implementation and enforcement;	
Institutions	Weak institutional coordination mechanisms,	

Overall, the barriers for the two prioritized technologies in disaster Risk management sector were related to the following themes:

The above-mentioned barriers are common and inter-linked in the two technologies within the disaster risk management sector. Therefore, overcoming these barriers would immensely help in

deployment of all two prioritized if disaster risk technologies are integrated into legal framework of South Sudan to ensure effective deployment of the technologies.

3.6 Enabling framework for overcoming the barriers in Disaster Risk Management Sector

Prioritized actions in different government policies, strategies and plans can potentially support the transfer and diffusion of the prioritized technologies for climate adaptation in the disaster risk management sector.

Barriers	Enabling environment	Responsible Institution
Limited funding by the government and insufficient financing for early warning action by international agencies	Establish a dedicated coordinating body for early warning systems. Encourage collaboration between meteorological agencies, disaster management, and other relevant bodies. Higher budgetary allocation to	Ministry of Humanitarian Affairs and Disaster Management (MHADM) Ministry of Finance and Planning (MoFP) - GOSS
	disaster risk management sector can be lobbied under the National Disaster Management Strategic Plan for South Sudan which seeks to increase government and partners' response to climate related disaster such as floods	
	Develop a climate change disaster technologies Investment Plan. The plan will identify and prioritize measures to increase investment for the deployment of technologies under the sector.	
High Initial Investment and	As South Sudan national development funds are limited 'The Ministry of finance and planning in coordination with the MHADM' should made every effort to obtain project specific grants /soft loans from international donor agencies particularly from international climate financing mechanism such	Ministry of Finance and Planning – GOSS Ministry of Humanitarian Affairs and Disaster Management (MHADM)
	as 'Adaptation Fund', 'Green Climate Fund' etc. for the	

Table 32. Enabling framework for overcoming the barriers in disaster risk management sector

	development and introduction of climate change disaster technology and to strengthen the deployment of these technologies Subsidies on equipment and accessories for disaster response such as early warning detection equipment's and social media equipment's for improving disaster information dissemination.	
Maintenance Costs for disaster technologies – Early warning equipment as well as social media equipment's for disaster information dissemination	To ensure the sustainability of two disaster technologies sufficient financial resources need to be make available for enhancing the technical capacity and special training programs be undertaken to train local technicians in operation and maintenance of this technologies. Exploring public – private sector partnerships for system maintenance, and integrate maintenance costs into budget planning.	Ministry of Humanitarian Affairs and Disaster Management (MHADM) Directorate of Meteorological in the Ministry of transport and Road Ministry of Environment and forestry (MoEF)
Legal framework coordination for the development and operation of an effective early warning system (EWS).	Earliest adoption of draft national disaster management policy and the enhanced operationalization of the existing disaster strategic plans such as the National Disaster Management Strategic Plan to strengthen the deployment of technologies	Ministry of Humanitarian Affairs and Disaster Management (MHADM) South Sudan Meteorological Services Ministry of Environment and forestry (MoEF)
Inadequate reference project and best practices on the early warning systems	Government and international under the national Disaster Management Strategic plan can pilot a reference project on early warning and use of social media for improving disaster response	Ministry of Humanitarian Affairs and Disaster Management (MHADM) Ministry of Environment and forestry (MoEF)
Ineffective coordination amongst stakeholders	Inclusive coordination in the deployment of disaster risk management technologies thought the Relief and Rehabilitation	The South Sudan Rehabilitation Commission (RRC)

	Commission (RRC) of the Ministry of Humanitarian Affairs and Disaster Management. The RRC and MHADM can bring together different government sectors and levels, and stakeholders such as development agencies, universities, the private sector, local leaders and civil society, with equitable gender representation.	Ministry of Humanitarian Affairs and Disaster Management - GOSS
Institutional and organizational capacity and human skills Barrier	Develop a skilled workforce to install, operate and maintain disaster risk management technologies such as hydro meteorological devices (hydromet) and warning stations. South Sudan Meteorological Services to set up early warning stations to make communities more resilient to effects of changes in climate, it is necessary to set up early warning systems that can easily be adapted to local needs.	Ministry of Environment and Forestry (MoEF) Universities – University of Juba (UoJ) South Sudan Meteorological Services
Inadequate data and information on early warning system and social media use for disaster improvement	Intensify adequate information, public education and awareness campaigns on early warning and deployment of social for improving disaster through print, electronic and social media; seminars, workshops, conferences, etc.	Ministry of Information, Communication Technology and Postal Services National communication authority (NAC) Mobile telecommunication networks

CHAPTER 4. ENERGY SECTOR

Following independence from Sudan in 2011, the Government of South Sudan's (GoSS) priority to meet the energy deficit as an essential critical element for economic growth, poverty alleviation and in fueling human development in the country. This priority required the government of South Sudan and its development partners to adapt an integrated energy strategy specifying short-term, medium-term and long-term sustainable actions. The reason for adopting the integrated energy strategy is to meet the demand for energy needed for all the sectors in a sustainable manner at competitive prices with a greater reliance on indigenous resources while developing technological base on optimal energy options. Under the energy sector, the Technology Needs Assessment report identified three technologies. Out of these top-ranking technologies, two of the technologies were prioritized for barrier analysis, namely 1) Hydropower (mini/micro hydropower)/small hydropower, 2) Off-grid solar mini-grids up to 100 kW.

4.1 Preliminary targets for technology transfer and diffusion in Energy sector

South Sudan suffers from significant levels of suppressed demand as well as one of the world's lowest energy access rates -6.7% as of 2019. About 70% of the population depends on traditional biomass fuels such as wood-fuel, charcoal, crop residue, and animal dung to provide their cooking and heating energy needs. The Government of South Sudan estimates total demand in the country at around 300MW compared to only around 130MW of supply, of which only around half is both operational and available to the general public (The World Bank (2021). South Sudan's electricity mix is currently 100% thermal, though the country possesses significant renewable potential. Government of South Sudan have identified five high-potential hydropower sites along the Nile that could add up to 2,600MW, while a 20MW mini-grid solar + storage project is currently under construction near Juba (The World Bank (2021). Most of the country's operational power infrastructure is concentrated in and around Juba, where a 33MW thermal IPP supplies around 29,800 connections through the local distributor, JEDCO, at an average tariff of USD 0.40/kWh, among the highest in South Sudan. With few exceptions, most other public generation and distribution infrastructure elsewhere in the country has fallen into disrepair or is no longer operational due to inadequate maintenance and fuel supplies. There is no transmission infrastructure in the South Sudan, though several proposals for transmission lines and interconnectors are at various stages of development both at the national and sub national level.

The following are the specific targets for the energy sector

- Installing 2,729.5 MW of renewable energy power plants by 2030, with a general focus on hydropower and mini-grid solar generation and particular attention on the development of Bedden, Shukoli, Lakki and Fula dam hydropower project, located 33 km downstream of the South Sudan-Uganda border.
- Promotion of private sector participation in hydropower and mini-grid Solar PV production at large and small scales. Engaging Solar companies such as the Sunnova and Seeding Mercy in the development of Mini grids solar system in South Sudan. The solar Mini grids will combat hunger and encourage sustainable farming practices.

- The delivery of licenses for small hydropower and mini-grid Solar PV systems projects both at the national and sub national level
- Government of South Sudan also has a target to increase exploitation of a higher number of small hydropower sites such as the Bahr-El-Ghazal, Western/Eastern and Central Equatoria, Juba Barrage ranging from 3 to 11 MW of capacity, such as: Suo and Yei River projects.
- Upgrading of Kinyeti 2MW mini hydro power Project: Feasibility study completed, the GoSS is sourcing for Finance for construction and commissioning
- Promoting the legal and regulatory frameworks of micro-hydropower and mini grids under the monitoring of the Ministry Energy and The South Sudan Electricity Corporation (SSEC) which is mandated by the GOSS to setting up and managing electricity generation and transmission facilities; purchasing electricity from independent power producers (IPPs); selling electricity in bulk to distributors; promoting electricity imports and exports with neighboring countries.
- Development of a national strategy for operation and maintenance of large solar PV system
- Financing and investing through Private Public Partnership (PPP) and Independent Power Producer (IPP) investment negotiation between MoED and local promoters and community-based associations or cooperatives

4.2 Barrier Analysis and Measures for mini/micro hydropower Technology

4.2.1 General Description for mini/micro hydropower Technology

Mini/Micro hydro is a type of hydroelectric power that typically produces from 5 kW to 100 kW of electricity using the natural flow of water. Installations below 5 kW are called Pico hydro (Kumar, A., T., et al., 2011). These installations can provide power to an isolated home or small community, or are sometimes connected to electric power networks, particularly where net metering is offered. Hydropower comes from converting the energy in flowing water – using a water wheel or a turbine - into useful mechanical power. This power is then converted into electricity by an electric generator. Micro-hydropower systems are small hydropower plants that have an installed power generation capacity of less than 100 kilowatts (kW). Many mini/micro hydropower systems operate "run of river," which means that no large dams or water storage reservoirs are built and no land is flooded. The majority of these systems only use a fraction of the available stream flow to generate power, and this has little environmental impact. Microhydropower provides an economical and renewable source of electricity, excellent reliability and proven technology, low maintenance costs and a long life -20 to 30 years'. Micro-hydropower systems are ideal for remote off-grid residential homes, cottages, ranches, lodges, camps, parks and small communities. The basic components of a typical micro-hydro system are: turbines, generators, headwork, intake, gravel trap with spillway, headrace canal and desilting basin, penstock pipe, powerhouse, tailrace, drive systems, controllers and transmission /distribution network The technology is a well-known mitigation option and suitable for both remote areas and wider distribution through national grids (Sikiru et al, (2017).

4.2.2. Identification of barriers of mini/micro hydropower technology

The key barriers for mini/micro hydropower have been identified through literature review and bilateral meetings with the experts by the consultant, and stakeholder consultations during the meeting of Expert Working Group on Mitigation by analyzing causal relation using root-cause analysis (Problem Trees, at Annex 1.1F-) and Market Map (Annex-1.2F) for the technologies. The barriers were grouped under ten different categories (Economic and financial; Market failure/imperfection; Policy, legal and regulatory; Network failures; Institutional and organizational capacity; Human skills; Social, cultural and behavioral; Information and awareness; Technical and other Barriers). Barriers, proposed by participants during the discussion, supplemented the initial list of barriers and the summarized list was screened. The decomposition of barriers within the category, with elements of barriers and dimension of barrier elements was applied.

4.2.2.1 Economic and financial barriers

Economic and financial barriers were identified from stakeholder consultations and were scored and ranked to determine which barriers were most significant. The barriers and scores are given in Table 33 below.

S/No	Identified economic and financial barriers
1	High investment costs of the equipment, and distribution network. High capital cost is one of the main barriers of technology diffusion and deployment in South Sudan. The mini/micro hydropower technology is not net implemented in South Sudan but the government plan to imported into the country.
	There is a need for studying best international practices and applying technologies that are more modern. The cost of equipment for hydropower plants can reach even half or more than half the total cost of construction. According to the Government of South Sudan the investments requirement for installation and construction of 5 kW micro hydro turbine system for residential or commercial sites costs between \$ 60,000 to \$150,000 including equipment, installation, and auxiliary components or more, depending on the complexity of the installation and site conditions.
2	Limited financial capacity of private sector. The number of private investors in energy sector and particularly in power production, supply and distribution is still low due to limited financial capacity
3	Lack of access Finance: In South Sudan, banks and other small-credit institution do not provide loan facility to construct micro hydropower plants. Due to this reason, the potential SHP sites remain unharnessed cross the Country.
4	Lack of funding for power projects is equally a major challenge to investment. Private sector and more donors should be approached with bankable project proposals

Table 33. Identified economic and financial barriers to mini/micro hydropower technology

	for financing. Long term concessional loans will be encouraged based on IMF
	borrowing conditions for South Sudan
5	Economic significant of micro hydropower is not well understood. The economic
	important of Micro hydro power projects is not well understood. This could be
	attributed to a number of reasons, i.e. (i) inadequate information and uncertainty on
	grid extension plans reduces the incentive to develop mini-grid projects, including
	supply of renewable electricity to government of South Sudan (ii) Even though there
	is already identified potential hydropower sites by the GOSS, there is lack of long-
	term hydrological data for these sites.
6	Low participation of private sector. Incentives for private sector investors are
	missing due to lack of frameworks and instruments for delivering the incentives for
	the deployment of the technology
7	Low ability and willingness to pay. Most of the communities in South Sudan
	consist of very poor population with low ability and willingness to pay for the
	connection and operation fees of micro hydropower technology: Their paying
	capacity is limited and they are unable to bear the high initial capital cost of the micro
	hydropower plants. This hinder diffusion and deployment of the technology.

4.2.2.2 Non-financial barriers

The non-financial barriers were identified from stakeholder consultations and scored to determine which non-financial barriers were most significant. The barriers and scores are given in Table 34 below

S/No	Category	Identified economic and financial barriers
1	Technical Barriers:	Inadequate knowledge and skills. Due to 21 years of
		civil war, South Sudan is faced with severely depleted
		human and institutional capacity for designing,
		developing, operating and managing micro hydropower
		plants. Particularly challenging is finding the local
		technical expertise to design, construct and maintain
		hydropower mini-grids. The Ministry of Mining and Dam
		(MoED) and South Sudan Electricity Corporation (SSEC)
		have limited institutional and technical human resource
		capacities
2	Policy, Legal and	In general, no existing legal or regulatory framework
	regulatory	that may serve as rules for required standards
		regarding the transfer and diffusion of the technology.

Table 34. Identified non-financial barriers for mini/micro hydropower Technology in
South Sudan

		At the moment, there is no local commercial company		
		manufacturing or supplying micro hydropower equipment.		
		Also, South Sudan don't have a clear strategies and		
		programs for the promotion of the micro hydropower		
		technology and the legal, regulatory and institutional		
		framework is not yet adequate despite laws and rules been		
		drafted, the endorsement by the parliament is still pending.		
		Insufficient policies for public-private partnerships		
		(PPPs), This has resulted into lack of investment and		
		partnership in the deployment and diffusion of micro		
		hydropower technology.		
3	Institutional and	Limited human and institutional capacity. Technical		
	organizational	experience professionals entering the power sector do not		
	capacity and human	have sufficient skills to carter for this technology.		
	skills Barrier:	Therefore, there is limited expertise in South Sudan to		
		support the diffusion and deployment of technology. The		
		ministry of Energy and dam have limited number of		
		qualified staffs trained on the hydropower establishment		
		and operation		
4	Information and	Insufficient information and data. South Sudan is often		
	awareness	stated to have a potential for hydropower that could be		
		exploited, however, there is insufficient information and		
		data to more precisely estimate the true potential. This		
		lack of long-term hydrological data to provide background		
		information for the development of mini/micro		
		hydropower projects development		
		No effective protocol for dissemination of information		
		and raising awareness among the masses regarding the		
		significant of small hydropower plants. There is no		
		knowledge about machinery, equipment and accessories		
		required for micro hydropower plant, their costs, and		
		relevant agencies from where necessary technical and		
		financial information and support can be sourced.		
5	Political instability	Political instability in South Sudan is one of the most		
		critical key barriers that hindered the implementation,		
		diffusion and deployment of hydropower technology		
6	Ineffective	There is poor coordination among line agencies, which		
	coordination amongst	create hurdles constructing and development the proposed		
	stakeholders	micro hydropower plants in the Country.		

7	No single micro	In South Sudan, no single micro hydropower is	
	hydropower	constructed due to limited research and exchanges, which	
	constructed in South	n resulted from budget, skills, knowledge barriers. A	
	Sudan for reference	reference project and a best practice on how to effectively,	
		efficiently and sustainably develop and manage micro	
		hydropower are not available	

4.3.3 Identified measures

4.3.3.1 Economic and financial measures

Eliminate taxes and duties on imports of hydropower equipment. To reduce the high investment cost for micro hydropower and increase the diffusion of the technology in the Country, the Government of South Sudan will have to eliminate taxes and duties on imports of hydropower equipment's. This will attract private sector investments in the deployment of the technology by ensuring that government provide incentives in the form of reducing taxes on the imports, construction and fabrication of these power plants.

Strengthening the implementation of innovative risk mitigation mechanisms and credit enhancement instruments, to provide ease to lenders. The credit enhancement strategy reduces the credit risk/default risk of the company's debt and thus can make it eligible for a lower interest rate. For example, The Government of South Sudan can provide risk guarantees to facilitate financial institutions on lending for micro hydropower projects/ programmes. These guarantees reduce the real or perceived risks faced by primary lenders and financial intermediaries.

Develop the carbon financing market. Government of South Sudan (GOSS) through the Ministry of Environment and forestry can secure funding to offer subsidies to reduce interest rates and grants to the different players who are interested investing into hydropower renewable energy technologies directly contribute to reduction of Greenhouse Gas (GHG) emissions and would be collectively eligible for green financing. Carbon credits (offsets) can also be earned by the private sector players and this will help in financing their businesses and reducing the need for loans.

4.3.3.2 Non-financial measures

Developing and revising the existing legal, regulatory and institutional framework. South Sudan energy strategy need to be review to include incentives such as accessibility of soft term loans, creation of revolving fund, training of professionals and technicians to support the promotion and deployment of micro hydropower technology cross the country. The policy may also include measures for strengthening the capacity of local level institutions to accelerate the development of micro hydropower plant. Appropriate regulatory measures and context specific guidelines need to be developed to establish efficient implementation and diffusion of the technology. Also, the sub national government should also develop their renewable energy strategy

and target to effectively utilize available resources and options for renewable energy production and assign mandates to concerned state ministries and directorates.

Increasing capacity building training for both public and private institutions in the country. Provide required training for staff of relevant institutions. It's also recommended that capacity building training on hydropower construction should be incorporated into vocational education training institutions. The training should cover all levels of education starting from vocational training to tertiary education. This is particularly vital because of the professional's lack of early exposure to such technologies in their career.

Strengthening the inter-agency coordination for the deployment of micro hydropower in all the state in South Sudan. Approval, investment and implementation of micro hydropower technology required different stakeholder both private and public institutions in acquiring water user right, environmental impact certificate, etc. strong coordination from these various private and public institutions actors will hasten the approval process and consequent implementation of the technology.

Strengthening information & awareness on the significant of micro hydropower technology. In South Sudan, both public and private sector have low level of information and awareness about technical specifications of Hydro motor and turbines, product suitability and performance efficiency in the context of South Sudan. In the absence of such vital information, it is difficult for the consumers to assess suitability and selection of appropriate equipment, appropriate to their specific needs. Therefore, it is very important to create awareness among policymakers, energy experts, potential investors and relevant governmental agencies.

There is need to provide an exchange visit to the relevant officials for exposure to functional mini/Micro hydropower plant technologies in the neighbouring countries of East Africa to lean on the requirement and challenges of developing micro hydropower technologies. This exposure can equip the staffs in the Ministry of Energy and Dam with adequate knowledge on micro hydropower technologies and to enable the MoED and the SSEC have the capacity to explore potential options to implement the technologies.

As a new nation, **the Government needs to embark on a process of technical and institutional capacity building.** The Government will focus on laying the foundation of growth for the future with the following key action items: i) Legal and regulatory framework will be enacted to include measures to promote grid and off-grid programs, including partnership with the private sector; ii) A comprehensive sector-wide capacity building program will be carried out to address the capacity constraints faced by the sector institutions. iii) Generation program will continue on expansion and focus also on long - term planning and project preparation for least-cost transmission program. iv) Distribution program will continue for the planned urban areas and initiate the planning process of new distribution networks in the state capitals without power grids. v) Access enhancement program will continue on planned grid-based connectivity and also launch of off-grid programs, such as, solar lighting and efficient cooking strove.

4.3 Barrier analysis and possible enabling measures for Mini-grid Solar PV technology

4.3.1 General description of technology

Solar photovoltaic (PV) cells convert sunlight directly into electricity. Currently, monocrystalline, polycrystalline and the thin film solar panels technologies dominate the global PV market. In a c-Si PV system slices (wafers) of solar-grade (high purity) silicon are made into cells that are assembled into modules and electrically connected. Mini-grid Solar PV technology consists of thin layers of semiconducting material deposited onto relatively inexpensive, large-size substrates such as glass, polymer or metal. The solar PV systems are modular in structure, and thus, they can be built to meet almost any electric power need, small or large.

The technical requirements for the installation of solar PV vary greatly depending on the size of the system and kind of technology used. Small off-grid systems in remote/rural areas using solar home systems (SHSs) could be bought in off-the-shelve and installed with relatively little local expertise. These are the ones that are common in Malawi including phone charging solar cells, solar lighting lanterns, and solar lighting PV modules. Most of renewable energy enterprises are involved in selling and installation of SHSs. The major applications of SHSs are for lighting.

The other form of solar PV technology that is not common in South Sudan is the solar mini-grids. These are energy systems powered by a number of solar PV modules in a relatively large area. The mini-grid energy system is able to power a community that is not connected to the grid. In other arrangements, the electricity generated could be sold to the main grid. The Government, through Juba Solar PV Mini-Grid ground-mounted solar project which is planned over 25 hectares. The project is expected to generate 29,000MWh electricity and supply enough clean energy to power 58,000 households (Thiak Samuel and Anil Hira, (2024). These demonstration units are currently not functioning and have been decommissioned. Due to size of the mini-grids (being superior to SHSs), they are ideal for rural electrification to support offered based businesses enterprises, thus important ingredient to rural economic transformation.

The majority of IPPs applications in South Sudan are from solar mini-grids. The solar PV systems require relatively minimal maintenance, which involve cleaning of the solar panel to ensure efficiencies are maintained. Installation of SHSs has been increased in the country. Most of the SHSs are undocumented, and are mostly used for lighting and phone charging. The installation of large scale solar PV for electricity generation either as mini-grid or grid based is limited. The latter technology could greatly improve the contribution of renewables in electricity generation mix for the country, thus greater potential for climate change mitigation.

South Sudan has instituted the South Sudan Electricity Regulation Authority that provides regulatory requirements for energy such as solar PV electricity generation. According to South Sudan Electricity Regulation Authority, grid connected systems require an appropriate license or permit to export to the grid along with the necessary metering equipment, connected by a professional, to ensure that the level of export to the grid is measured for any subsequent compensation. Larger installations obviously require appropriate planning permissions that would

accompany any moderate to large infrastructure 32 project. Also, the South Sudan Bureau of Standards has developed standards on solar PV systems, however there are challenges on enforcement of the standards as evidenced by proliferation of poor quality solar products.

4.3.2 Identification of barriers for solar PV mini-grids technology

The identified barriers against wide-scale diffusion of solar PV mini-grids are presented in this section.

4.3.2.1 Economic and financial barriers

Four economic and financial barriers were identified, as presented as follows:

High investment cost for solar mini-grid

Most of the products of solar PV are imported into the country. High initial capital cost of solar product and batteries, fluctuations and inflation affecting the costs of equipment's make the technology unattractive to investors and local developers. In addition, the available solar incentives (like removal of import duties) do not trickle down to the last mile consumer.

Low affordability of consumers to pay for the electricity from solar mini-grid. In general, most rural South Sudan have relatively low levels of incomes and the affordability for electricity without subsidies is much low. In most of the rural areas of the country, there are few households that can connect to a min-grid, which has the investment cost. This makes it difficult to recover the cost of investment and min- grid developers result to grants and for subsidies, in order to bring down the cost of energy (tariff) to a level that is affordable to customers. The grants and subsidies are not even available and often tied to a project.

Limited commercial use of the generated solar PV electricity. The electricity produced should be consumed since it is difficult to store it. If not consumed, then it is wasted. Most of the consumers should be those that use electricity for business purposes. These consumers are very few in most of the communities. The consumers for domestic applications do not warrant installation of sola PV mini-grid. This is the same problem that have hinder the deployment of the mini-hydro mini-grid system in the Country.

Limited financing mechanism. In general, the available financing mechanisms for mini-grids in South Sudan are not existing. Again, most local would be developers are not aware of funding mechanism that might be available from banks and other money lending institutions. There are also other funding opportunities from international organizations, which local private investors may not be aware of. Example of such opportunities is the African Development Bank which approved new financing program for energy providers in sub-Saharan Africa to benefit from off-grid power by 2025 (African Development Bank, 2019). Also, **local expertise in coming up with bankable business proposals for financing solar pv mini-grid projects is lacking**. This explains why the majority of the current IPPs in solar mini-gird are foreign enterprises.

4.3.2.2 Non-financial barriers

The identified non-financial barriers are presented as follows:

Insufficient and ineffective policy support to the diffusion of solar mini-grids. Lack of adequate policy and regulatory framework relating to tariffs, licensing and permitting procedures for the diffusion of solar mini-grid. Solar mini-grid technology is usually not profitable without policy support. In this manner, policy measures are of vital importance for rapid diffusion of environmentally friendly innovations including solar mini-grid PV systems. Stakeholder during consultation argue that, for an effective solar mini-grid diffusion and transfer, the government of South Sudan should reduce the impact of industry interest on regulatory structure because it can impede the diffusion process.

Limitations in technical expertise. There is a general limitation among the local expertise to design, install and maintain the mini-grid-solar PV systems. The country current tertiary education system where training on technical courses like engineering is pitched at Bachelors levels, which have very little practical or hand-on training. The technician training at diplomas levels, which are trained on hands-on is becoming limited. This creates a gap in the industry on skilled manpower to maintain engineering based systems like solar PV mini-grids. The available technical training institutions at technician's level must have curricula that respond to the dynamic needs of renewable energy industry like solar PV mini-grids. This is so critical now because it seems that solar PV electricity production is the most preferred technology.

Lack of demand for electricity is a barrier to the adoption of Off-grid solar mini-grids technology. Without demand, diffusion will be impeded. In some remote areas, lack of demand for electricity is a barrier to the adoption of off-grid solar mini-grids. Here, we distinguish the reasons for the lack of demand is due to the lack of electricity-related activities. Similarly, the market lacks customers who have purchasing power for solar mini grid PV systems and at the same time need electricity.

Limitation of policy funding mechanism. South Sudan has no practical mechanism in place, detailing how to fund the energy policy cost to ensure policy sustainability or guarantee investors security. Further, **the other challenge concerns limitation of the national electricity grid capacity to accommodate major power to the grid.** South Sudan don't have major energy project which can support the increase in the national grid capacity. Also the electricity network infrastructure in South Sudan is still poor with limits amount of solar PV power available in the local market and that can be used to generate national grid.

Limited research and development in solar PV mini-grids. Most of the solar PV components are imported into the country. There is need for the country to invest in research and development of solar PV components and systems so that costs associated with importation of components are minimized as well as the local capacity to develop and maintain the technology is enhanced.

Poor quality of solar PV components. South Sudan suffers from influx of cheap and low quality solar PV components that erodes confidence in the technology, all of which are imported into the

country. The main challenge is enforcement of standards, exacerbated by corruption and system abuse. This affects the operation and life-span of solar PV mini-grids in terms of access to genuine spare parts.

Limited networking among key players in the solar PV sector Groups are few and operation of the South Sudan Electricity Corporation (SSEC), Ministry of Energy and Dam and the Renewable Energy Council of South is challenged. Key stakeholders in the solar mini-grid PV such as practitioners, researchers, investors and policymakers could form networking groups to discuss how to advance the sector.

The bureaucracy in processing independent power producers' applications. There is bureaucracy in processing of IPP applications. The time for potential IPPs to acquire concessions, licenses and environmental approvals is substantial. This is true for when it comes to acquiring generation and distribution licenses. The bureaucracy has delayed solar PV project development.

4.3.3 Identified measures

This section presented identified measures to remove barriers against wide-scale diffusion of solar PV mini-grids in South Sudan

4.3.3.1 Measures for Economic and financial barriers

The identified measures to remove economic and financial barriers are presented as follows:

Provision of subsidies to incentivize private mini-grid developers, who can then go on to bid for additional project funding from development banks. Government subsidies for mini-grids solar energy adoption may assist to lower the cost and increase the availability of solar energy for households and enterprises. Governments can provide a variety of incentives, including tax credits, rebates, and performance-based reward.

High investment cost Most of the components of solar PV systems are imported. Just like other renewable energy technologies, the high investment cost can be reduced by government reducing or removing import duties on imports. Also, if some of components are manufactured locally, the investment cost could be reduced further. Furthermore, there should be access to loans and other funding sources provided by the banks and other financing organizations to individual consumers and private investors are able to in solar PV mini-grid electricity supply business. The barrier of high investment cost can be removed through local production of some solar PV system components. In this case, there is need to come up with manufacturing centers for solar PV system components.

Increase affordability of consumers to pay for electricity generated by decentralized power systems like the solar PV mini-grids. Due to Low affordability of consumers to pay for the electricity the government and other stakeholders should create programmes that would increase affordability of consumers to pay for electricity generated by decentralized power systems like the solar PV mini-grids. The programmes would include working on tariff subsidy for electricity

generated from these solar PV systems. The other would to make sure the consumers use the electricity for income generating ventures.

Promoting commercial use of the generated mini-grid Solar PV systems. The Government and other stakeholders should create programmes to train people on how to start an economic venture taking advantage of access to electricity. The other measure on this barrier is to implement the feed-in- tariff.

Strengthening the financing mechanism for solar mini-grids. The government and other stakeholders should enhance and establish more financing mechanism for supporting entrepreneurs to embark on solar mini grid businesses. Further, the access to loans to households for financing their purchasing of renewable energy technologies should be enhanced. Furthermore, financing models that are ideal for different scenarios should be explored. In addition, the Government should make aware and support applications for alternative financing through CDM, for example. The government therefore should create an enabling environment in which financial institutions are able to provide financial resources to developers and consumers of solar PV mini-grids.

4.3.3.2 Measures for Non-financial barriers

The identified measures to remove non-financial based barriers are presented as follows:

As a new nation, the **Government of South Sudan should embark on a process of technical and institutional capacity building** as well as laying the foundation of growth for the future with the following key action items:

Legal and regulatory framework should be enacted to include measures to promote off-grid solar mini-grids programs, including partnership with the private sector. Legal framework to help ensure generation and distribution of off-grid solar power for privately operated mini-grids, flexible tariffs that reflect costs, transparent national utility grid expansion plans and ensure regulations of engagement for if/when the national and sub national off-grid solar arrives in an area served by a mini- solar grid. Also, the legal framework will help the government of South Sudan come up with strategies for engaging private sector to invest in and operate mini-solar grids.

The Government of South Sudan through the Ministry of energy and Dam should integrate Off-grid solar mini-grids into national electrification planning. mini-grids are most successful when they have the support of the national government. Governments can mandate that off-grid solar mini-grids be considered part of formal energy planning processes and help support them with financial resources and incentives. Also, the GOSS access enhancement program should continue on planned grid-based connectivity and also launch of off-grid programs, such as, solar lighting and efficient cooking.

Challenges implementation of Feed-in Tariff policy for increasing uptake of Mini-grid Solar technology

The government should revise the Feed-in-Tariff policy, through a stakeholder consultative process to make sure that it is up-to-date and is accompanied by a robust implementation strategy. The stakeholders include South Sudan Electricity Corporation (SSEC), the Ministry of Energy and Dam, JECO and Aptech Africa company, Consultants, South Sudan Chamber of Energy and Minerals (SSCEM) and the Renewable Energy Council of South Sudan.

Limitations in technical expertise. There is need for the country's higher learning institutions to establish and enhance research and development centers in renewable energy technologies where issues of design, install and maintain the mini-grid-solar PV systems could be addressed. Further, the universities should revise curriculums to make practical element of renewable energy technologies prominent. Furthermore, there should be a platform where university and industry would work together in the training of renewable energy technicians.

A comprehensive sector-wide capacity building program should be carried out to address the capacity constraints faced in the deployment and diffusion of the Mini-grid Solar technology. There is need to capacity-build human resource and research facilities in university and other research-based organizations to that they are engaged in meaningful research and development in renewable energy technologies such as in solar mini-grids. In order to do this, there is need to audit relevant ministries and research institutions in the country to documents capacity gaps.

Poor quality of Mini-grid Solar PV components. Standards enforcement body, the South Sudan Bureau of Standards (SSBS) should ensure enforcement of solar PV standards (both on components and installation). This is necessary to safeguard quality and enhance consumers' confidence concerning installed solar mini-grid systems in South Sudan. Further, the SSBS should develop capacity of their staff that is stationed at South Sudan – Uganda boarder stations on performance testing of renewable energy components that are imported into the country from East Africa so that they can enforce standards accordingly.

Limited networking among key players in the solar PV sector. The South Sudan Electricity Corporation (SSEC) should be revived and active its mandate of promoting renewable energy technologies in a sustainable manner to the satisfaction of renewable energy consumers in South Sudan. The Ministry of Energy and Dam (MoED) should have strong institutional and legal framework to guide its operations.

4.4 Linkages of the Barriers Identified

Even though the nature of the technologies varies from one another, it is evident from a review of the various barriers faced by the three prioritized energy sector technologies that there are some common barriers associated with these technologies. The two technologies of solar mini-grid and micro hydropower are capital goods. This section focuses on the linkages of the common barriers

faced by the two prioritized technologies in the energy sector. Table 35 shows the linkages between the two technologies.

Table 35. Linkages of barrier faced by two prioritized	l technologies in the energy sector
were related to the following themes	

Barrier Category	Barriers	
Economic and Financial	High initial capital or investment cost for the deployment	
	of solar mini-grid and micro hydropower technology	
	within the energy sector in South Sudan	
	Absence of adequate subsidies and financial incentives.	
	Limited access to finance and long-term capital	
Human skills	s Inadequate trained local technical expertise to insta	
	operate and maintain the two renewable energy	
	technology projects	
Information and Awareness	Inadequate and limited information sharing about the	
	technologies	
	among stakeholders at the National and sub national	
	level.	
Policy, legal and regulatory	Absence of strong legal, regulatory and institutional	
	framework have led to limited technical and operational	
	standards and guidelines for the deployment of the	
	technologies.	
Institutions	Weak institutional coordination mechanisms to support	
	the diffusion and deployment of the solar mini-grid and	
	micro hydropower technology.	

4.5 Enabling framework for overcoming the barriers in Energy Sector

Prioritized actions in different government policies, strategies and plans can potentially support the transfer and diffusion of the prioritized technologies for climate change mitigation in the energy sector.

 Table 36. Enabling framework for overcoming the barriers in Energy sector

Barriers	Enabling environment	Responsible Institution
High initial capital or	The government of South Sudan	Ministry of Finance and
investment cost	need to design strategies to low	Planning (MoFP) GOSS
	the investment costs for	
	renewable energy technologies'	The South Sudan national
	project developers and investors	revenue authority (SSNRA)
	using direct subsidies, tax	

	exemptions, feed-in tariff	Ministry of Energy and Dam
	systems, green certificate	(MoED) -GOSS
	schemes.	
	Strengthening public-private	
	partnerships engagement in the	
	deployment and grant-based	
	funding to lower capital risk of	
	the technology	
	The government will need to	
	grant partial waver of taxes and	
	duties on import of hydropower	
	and solar system equipment and	
	machinery.	
	To capture the market venders,	
	they are need to introduced	
	installment payment for the off-	
	grid home based Solar Energy	
	system. Establishment of such	
	facilities will increase income-	
	generating opportunities	
Absence of adequate	The government will need to	Ministry of Trade and
subsidies and financial	grant partial waver of taxes and	Industry (MoTI)
incentives	duties on import of hydropower	5 、 /
	and solar system equipment and	Ministry of Finance and
	machinery.	Planning - GOSS
Limited access to finance	Attracting public and private	Ministry of Finance and
and capital	investment in the energy sector	Planning – GOSS
and cuprim	by providing guarantees for low-	
	cost low-risk financing through	Ministry of Energy and Dam
	country credit lines for	$(M_0ED) = GOSS$
	renewable energy technologies	Commercial banks
	projects linked to climate change	Ministry of Finance and
	mitigation	Planning
	and sustainable development	1 mining
		Ministry of Trade and
		Industry
		indusu y

	Develop strategies to access	Ministry of Energy and Dam
	funds from within the country	
	and outside the country	
	e.g. accessing carbon financing	
	Framework to work with	
	financial institutions providing	
	venture capital for solar PV and	
	Mini Hydropower	
Inadequate and limited	There is a need to increase	Ministry of Energy and Dam
information sharing about	hydropower and solar related	(MoED)
the technologies	information in the curricula. The	(11022)
among stakeholders at the	professional and vocational	Ministry of General
National and sub national	training centers may include	Education & Instruction
level	hasic trainings on solar system	
	its installation operation and	
	maintenance	
	Demonstrations of the	
	technology at grassroots level	
	will increase the awareness of	
	the public regarding different	
	the public regarding different	
	components of the micro	
	nydropower systems and	
	appropriate Mini-grid Solar PV	
	solar system required for their	
	houses.	
Absence of strong legal,	Strengthening energy	Ministry of Energy and Dam
regulatory and institutional	governance system by	with support from
framework have led to	formulating a legal and	International development
limited technical and	regulatory framework that	partners such as UNDP,
operational standards and	mitigates risks associated with	UNEP, AFDB and World
guidelines for the	renewable energy investments.	bank
deployment of the		
technology		
Inadequate reference	Government and international	Ministry of Energy and Dam
project on hydropower and	partners can pilot a reference	International partners such as
solar mini grids	project for hydropower and solar	World Bank and AFDB
	mini grid under the South Sudan	
	energy sector access and	
	institutional strengthening	
	project	
Institutional and	Strengthening and developing	Universities – University of
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organizational capacity and	appropriate Capacity building	Juba
human skills Barrier	training modules targeting the	
	needed human resource expertise	Vocational Training
	engaged in the energy sector.	Institutions
	Piloting a programmes to train	
	people on how to start an	Ministry of General
	economic venture taking	Education and Instruction -
	advantage of access to electricity	GOSS
	and establish further financing	
	mechanism for supporting	
	entrepreneurs to embark on solar	
	mini grid businesses.	Ministry of Energy and Dam
	Revise curricula/ syllabi on Solar	
	PV and hydropower for higher	
	education institutions to enhance	
	the Solar PV mini-grid and	
	hydropower knowledge	
	acquisition as climate change	
	mitigation technologies for the	
	energy sector transition. The	
	availability of education and	
	training institutions to support	
	Promotion, deployment and	
	diffusion of the technologies	
	within the energy sector	
Inadequate data and	Intensify adequate information,	Ministry of Information,
information on solar PV	public education and awareness	Communication Technology
Mini grids and hydropower	campaigns on Solar PV Mini-	and Postal Services
technology	grids and hydropower	
	technology through print,	
	electronic and social media;	
	seminars, workshops,	
	conferences, etc.	

CHAPTER 5. WASTE SECTOR

In 2013, South Sudanese confronted another year of violence, hunger, and stark challenges. The effect of Conflict left the country facing severe environmental challenges, from deforestation to waste management. Among these issues is the inability of the country to treat and dispose of municipal solid waste and sewage across the country. Waste management in South Sudan falls under the Ministry of Environment and forestry (MoEF) which is a Government of South Sudan entity tasked with addressing all environmental and waste management issues in the country however, the government and local authorities at the national and sub-national level have limited available resources and limited capacity for planning, contract management, and operational monitoring.

Waste management system in South Sudan is undeveloped and no sustainable technology such as Reduce, Reuse and Recycle, waste transfer station is implemented. There are no specific National and sub-national Solid Waste Management policies, plan or strategies that have been implemented. South Sudan does not have a single waste processing or recycling industries and have no ability to treat and dispose of municipal solid waste and sewage. Across the country, poor handling of solid waste is made more problematic by a lack of information about the generation, processes and composition of waste and its management. In Juba city and other towns, communities waste is simply burnt right in the open or in pits with little or no recycling, reusing or upcycling. No single solid waste management facility such as waste transfer station is constructed in all the ten states of South Sudan. The separate/reduce, reuse and recycle (3Rs) technology and development of Waste transfer station were ranked very high by the stakeholders in the technology needs assessment prioritization.

5.1 Preliminary targets for technology transfer & diffusion for Reduce, Reuse and Recycle (3Rs) technology

In South Sudan's Second Nationally Determined Contribution (NDC,2021), South Sudan considers waste a priority sector for both climate change mitigation and adaptation. Currently, there are practically no enterprises for the processing of solid household waste in the Republic of South Sudan. Even today, no household waste generated is recycled due to lack of public and private sector involvement in the sector; infrastructures needed to undertake recycling or switch to separate collection are still lacking.

The government aims to cumulatively reduce 19 percent of waste emissions by 2030 compared to the baseline line by developing and implementing a national and subnational level policy and plan for the sustainable waste management through inter-sectoral, interstate and inter-municipal cooperation aimed at the complete elimination of spontaneous landfills, preventing the expansion of new and reduction in the territory of existing landfills. More primary targets will include the sensitization and awareness raising both national and sub national level on reduce, reuse and recycle (3Rs) technology. Under the Solid Waste Management Master Plan in Juba City 2021-2030, government plan to develop waste transfer stations to facilitate the waste management process in areas which have different type of settlements and population density. The waste

transfer stations are expected to prevent the disposal of approximately 104,196.3 kg of waste directly into the rural area round Juba city.

Developing an integrated solid waste management (ISWM) plan for all the ten-state capital cities based on an overview of the existing system and practices, including the gaps in the entire value chain. solid waste reduction, reuse and recycle (3Rs) plants be constructed at all ten (10) and three administrative areas in South Sudan and more particularly in Juba City. This site will therefore have a lot of waste to process each day. A shift from a business-as-usual scenario to a solid waste management approach is recommended. The Preliminary targets, when implemented effectively, will increase the recycling rate and reduce the requirement for landfilling in all the states of South Sudan. Policy reforms to encourage waste reduction and segregation, and the establishment of facilities for waste reduction and recycling.

5.2 Barrier analysis and possible enabling measures for Reduce, Reuse and Recycle (3Rs) technology

5.2.1 General description of Reduce, Reuse and Recycle (3Rs) technology

The 3Rs concept of technologies to be implemented can substantially contribute to the reduction of the amount of waste disposed on land. To carry out the implementation of the 3Rs concept of technologies requires a high degree of coordination and organization of the waste management chain. For the purpose of reduction of the waste problems in the future, reduction in waste generation and reuse of old, products such as electronics can be one of the most important factors. The reduction, for example, possible at the consumption level, includes better buying habits and reducing on the use and purchase of disposable products and packaging. In addition, recycling is viable and the best option for a range of waste products. In some economies, there are already well-organized recycling businesses processes in place for a range of products (e.g. furniture, clothing textile etc.).

With the ultimate goal of reducing the disposal of solid wastes at uncontrolled sites and hence, to reduce GHG emissions, the 3Rs' technology is aimed at achieving the followings:

- 1. Reduce pollution problems and improve the livelihood across the country
- 2. Create job opportunities and improve the socio-economic status of the urban population
- 3. Reduce GHG emissions across the country especially in the urban settlement.

5.2.2 Identification of barrier Analysis for Reduce, Reuse and Recycle (3Rs) technology

The major barriers in the wide diffusion of 3Rs technology are categorized under economic, financial, and non-financial barriers as below:

5.2.2.1 Economic and financial barriers

Economic and financial barriers were identified from stakeholder consultations and were scored and ranked to determine which barriers were most significant. The barriers and scores are given in Table 37 below.

 Table 37. Identified economic and financial barriers to the deployment and diffusion

 Reduce, Reuse and Recycle (3Rs) technology

S/No	Identified economic and financial barriers
1	High investment and operating costs including high cost of landfill sites
	maintenance. Waste Reduce, Reuse and Recycle equipment's suitable for South
	Sudan can be expensive at around 0.5 million to 1 million dollars for systems that can
	recycle from 2.5 to 6 tons per hour employing up to 20 people.
2	Access to capital is a significant barrier to the growth of new and expanding reuse
	and recycling. Most of the Small and Medium Enterprises (SMEs) that are engaged
	in waste reduction, reuse and recycling lack the financial resources to establish and
	manage a waste recycling plant. This has hampering the deployment of the technology.
3	Insufficient Tax Incentives and disincentives to motivate investment in the
	reduce, reuse and recycle technology. Incentives are provided to the private sector
	for various aspects of reuse and recycling technology. Examples include: a) reduced
	concessions on the importation of specialized 3Rs technology equipment (e.g. wood
	chippers, compactors, etc.; b) income tax cut for a specified period during the start-
	up of new waste recycling ventures; c) subsidies or concessions for installing (or
	upgrading to) low waste-producing processes or processes that reuse wastes;
4	Limited budget designated for waste management by the government. The
	budget designated for waste management is very low; this will lower the investment
	in s technology and makes it not attractive to private sector to support in the
	deployment. Diffusion and transfer of reuse and recycling technology in South
	Sudan.
5	Lack of market of solid waste recycling end product or Low demand for some
	recyclable materials. There is a low demand for recyclable waste and that shipping
	to other countries could prove to be prohibitively expensive. it is very important for
	the end products to have a market. In South Sudan the lack of the market for the
	reduce, reuse and recycle technology end products represents a barrier to technology
	adoption and deployment. In addition, there is insufficient funds and insufficient
	demand for recycled products in the local market for the end products of these
	technologies in South Sudan towns making it difficult to sell the end products locally
	and depend on international demand.

5.2.2.2 Non-financial barriers

The non-financial barriers were identified from stakeholder consultations and scored to determine which non-financial barriers were most significant. The barriers and scores are given in Table 38 below

S/No		Identified economic and financial barriers
1	Technical	Lack of technical standards for the handling, installation and
	Barriers:	maintenance of 3Rs plants. There are inadequate skills to
		operate and maintain sophisticated waste sorting equipment.
		Such equipment separates the waste using a drum screen, a
		ballistic separator, air separators, storage conveyors, non-
		ferrous separators, optic separators, balers, etc., technologies
		not familiar with local maintenance personnel. A well-trained
		manpower is required including expertise to operate the Waste
		reduce, reuse and recycle (3Rs) plants.
		Inadequate knowledge about recycling opportunities Waste
		gets mixed at source due to the fact that recyclable
		materials are not well understood. This can result in the
		contamination of recyclables that can render them non-
		recyclable. Such waste includes glass bottles, paper, cardboard.
		and plastics that are soiled, exposed to oil, food stuffs etc.
2	Dolioy Logal and	Inadaquata regulatory framework to encourage waste
2	rogulatory	inadequate regulatory framework to encourage waste
	regulatory	have policies on wests but does not have a regulatory framework
		to directly drive reduce, reuse and recycle. Lack of strategy
		no unectry unive reduce, reuse and recycle. Lack of shalegy,
		difficult implementation and execution of laws is hindering the
		deployment diffusion and transfer of Deduce Deuce and
		Describe technology
		Recycle technology.
		There are no gracific laws, policies and strategies for waste
		intere are no specific laws, policies and strategies for waste
		strategies for wests conting for rouse, recycling and upcycling. There are no
		strategies for waste softling for feuse, fecycling and upcycling.
		Small communities far from recycling facilities are not provided
		options on now to reuse, recycle and upcycling their waste.
		As related laws, there are the National Environment Bill (2012)
		As related laws, there are the National Environment Bill (2015)
		and the Local Government Act (2009). The National
		Environment Bill has been prepared by the Ministry of
		Environment and Forestry but has not yet come into force. It
		has a comprehensive content that includes waste management.
		Lack of infrastructure is a significant problem Many modern
		buildings, especially those designed abroad for the malls and big

Table 38. Identified non-financial barriers for Reduce, Reuse and Recycle (3Rs) technology

		hotels, have physical space that allows for recycling activities.	
		Most of these companies, however, do not have separate bins or	
		containers for sorting and lack physical infrastructure to carryout	
		sorting in house.	
3	Institutional and	Lack of institutionalization, management programs for the	
	organizational	treatment of solid waste and renewable energy sources. The	
	capacity and	current state institutional system in the field of waste	
	human skills	management is characterized by:	
		• Insufficient institutional capacity needed to plan, organize	
		and implement an integrated waste management system at	
		all levels (national and regional);	
		• Insufficient level of coordination, corporatism and	
		communication between the competent authorities;	
		• Lack of an institution responsible for the regulation and	
		development of the system of secondary resources;	
		• Weak financial support, lack of financial stability;	
		• Inadequate control, which creates the basis for the formation	
		of unauthorized dump	
	Lack of public	Lack of governmental support of initiatives from the private	
	and private	sector and Non-Governmental Organizations (NGOs). There	
	partnership	are many initiatives from the private sector and NGOs that are	
	(PPP)	not supported by the government for example the complex	
	mechanism	procedures required by government to approve any initiative	
		that aims to improve waste segregation and recycling practices	
		as well as awareness among people makes it not possible for the	
		deployment, diffusion and transfer of Reduce, Reuse and	
		Recycle (3Rs) technology	
5	Information and	Lack of knowledge and awareness is problematic. There is	
	awareness	severe lack of awareness about recycling in society and people	
		are generally not aware of the concept of 3Rs. Peoples lack	
		awareness about the importance of 3Rs and its impact on the	
		environment, and therefore generally dump everything together	
		without sorting.	
		Overall, companies in different sectors have extremely low levels	
		or knowledge and awareness of the recycling sector and/or	
		services available. Also, the waste generators lack awareness of	
		the recycling concept and the services available with regard to Reduce Days and Decycle (2De) technology	
		A lash of management shills and server time h	
		A lack of necessary skills and expertise also commonly	
		prevents SMEs from embracing solid waste re-use and recycling	

		opportunities, even when they are generally aware of the	
		potential of waste reduce, reuse and recycle	
5	Social, cultural	Cultural barrier such as customs, traditions and even religious	
	and behavioral	reasons may prevent them from accepting some reusing and	
		recycling practices as essential practices to succeed the	
		deployment and diffusion of the technology adoption in South	
		Sudan. Jesson, J et at, (2014) stated that the public culture plays	
		an important role in the success of any management practice	
6	Physical barriers	Lack of 3Rs infrastructure is a significant problem. Many	
		modern buildings, especially those designed abroad for the malls	
		and big hotels, have physical space that allows for recycling	
		activities. Most of these companies, however, do not have	
		separate bins or containers for sorting and lack physical	
		infrastructure to carryout sorting in house.	
		Physical barriers including limited access to recycling bin	
		containers, unreliable collection service limited the deployment	
		of the technology	
7	Political stability	2013 conflict led to the collapse of South Sudan waste	
		management system and investment project, such as the damaged	
		waste collection vehicles and waste infrastructures and loss of	
		access due to security problems, were directly attributable to the	
		conflict. Private and Public investment into waste reduce, reuse	
		and recycling were adverse effect by the conflict leading to no	
		deployment and diffusion of technology. Many SMEs who	
		express interest for waste recycling suspended and abandoned	
		their investment.	

5.3.3 Identified measures

5.3.3.1 Economic and financial measures

Revision of tariffs for garbage collection, support and development of the 3Rs technology. The main condition for the stable operation of municipal enterprises and the waste management industry is the formation of a sustainable financial flow. To do this, the tariff system should: provide coverage for current and capital costs, encourage producers and consumers to more rational waste management, encourage the introduction of economically and environmentally efficient waste management methods and low-waste technologies.

Setting of appropriate policies (incentives or disincentives). Strengthening laws and regulations, setting of appropriate policies (incentives or disincentives), ensuring climate informed-decision making and planning, promoting research and technology awareness, and implementing pilot demonstration projects.

Develop capacity to source funding from available local, regional and international sources. The total cost of the operation including maintenance will be around 5-10 million US dollars over the life of 20 years of the equipment. Such an amount can be sourced from carbon funding mechanisms under the UNFCCC and the SC. The country can provide the land.

Attraction of investments through Waste management project finance (PF) where Investors or a donor can provide funding on a grant basis and concessional funding for the development of 3R technology in South Sudan, these donors include the Green Climate Fund (GCF) and other climate funds, USAID, GIZ, as well as the World bank group and ADB, which, when providing funds, have a grant component of up to 25% of the loan.

Increased Revenue/Financial Rewards could be better utilized to motivate non-doers. Nondoers expressed a willingness to invest in recycling activities, if the recyclable waste would increase their revenue and cover the cost of the recycling or sorting. As profit-making entities, these commercial waste generators look at the cost-benefit analyses, and most of them consider it costly that lower their net profit, therefore incentives in terms of discounts in electricity cost or gas or tax would help develop their interest in adopting and support the deployment of the technology.

Discounting, marketing and advertising the role of private sector in waste Reduce, reuse, recycle (3Rs) Discounting for adopting discounts for waste recycling is also a significant motivator. Waste generators can be provided with discounts from service providers on the fee they charge for removing waste from the premises. In addition, government such as the local municipality can launch a new initiative, where those companies that do the sorting properly receive a waste compressor free of charge. Consultation with private sector indicate that private recycling companies are interest in adopting more recycling practices if marketed and advertised for adopting recycling technology, which would compensate for the costs and time required to recycle.

5.3.3.2 Non -financial barriers

Promotion of Reduce, Reuse, and Recycle technology. South Sudan solid waste has a large organic content, constituting 65% of household waste and 90% of waste overall. The large proportion of reusable and recyclable materials provides a great opportunity for increasing waste reuse and recycling facilities. As mandated under the National Environment Bill (2013) and the Local Government Act (2009), 3R should be promoted to significantly reduce the amount of waste to be disposed of at final disposal sites, thereby saving costs for final disposal and reducing public health and environmental risks. The key to success would be the segregation of waste at source. This would require better public awareness of the benefits of waste segregation and recycling in reducing greenhouse gas emissions by reducing energy consumption. Using recycled materials to make new products reduces the need for virgin materials. This avoids greenhouse gas emissions that would result from extracting or mining virgin materials.

Develop and implement national plans for waste management that take advantage of, and give priority to waste reuse and recycling. A clear, concise and consistent Waste policy is a necessary requirement for the waste reduction, reuse and recycling industry to establish and set up solid recycling waste management systems and make necessary investments. Thus, a well-established and supported waste policy is of crucial importance in South Sudan

Provide training to relevant personnel to address the issue of relevant skills, the suppliers of the said equipment will have to come to train the personnel on site on how to maintain such equipment. People with the right background and aptitude must be selected for the training on all the aspects of the equipment. Also, there is need to increase the capacity of colleges, universities in the field of sustainable waste reduce, reuse and recycle management, holding seminars and trainings for specialists from both national and sub national bodies in the field of waste management.

Train personnel on reduce, reuse and recycling technologies. Provide these Waste recycling personnel with knowledge on best available techniques (BAT) and best environmental practices (BEP) to address different waste streams cross the country. Information gathered can reveal possibilities to handle such waste and stimulate entrepreneurship in the waste management sector. At the sub national level, there is need to strengthen the capacities of local bodies for segregation, recycling and the reuse of municipal solid waste.

Establish reduce, reuse and recycling Infrastructure: Develop reduce, reuse and recycling infrastructure to enable the effective sorting, processing, and recycling of recyclable materials. Support the establishment of recycling enterprises and incentivize their growth through public-private partnerships. Example: The Waste Management Authority in South Sudan should partner with a recycling company to establish a material recovery facility for sorting and processing recyclable materials. This facility may contribute to increased recycling rates and the creation of employment opportunities for youth and women. Currently most of the local waste is collected for recycling in neighboring East Africa countries, it may be worthwhile to invest in a local recycling plant. Such a waste will not be subjected to high transportation and export costs, and therefore could be viable. If not profitable such a plant can be subsidized by the equivalent amount of landfill space saved and carbon credits generated.

Provide national and sub national education and awareness raising on reduce, reuse and recycle technology at different levels. There will be need for national and subnational campaigns on waste reduce, reuse and recycle. This will be done in all government agencies, industries, municipalities, schools, institutions and communities. Funding for such shall be sourced from funding mechanisms of relevant international conventions. In order to do this, following steps could be undertaken:

• Launch public awareness campaigns to educate residents about the importance of waste reduce, reuse, recycling and waste reduction and responsible waste management practices. Conduct workshops, seminars, and school programs to raise awareness and engage the community.

- Develop campaign material, in form of brochures, pamphlets etc.
- Door-step communication on segregation and storage
- Occasional clean-up campaigns on littering and indiscriminate disposal
- Use of print and electronic media, flyers, movies, etc.

Participation of private entities in development and diffusion 3Rs environmentally sensitive technology is highly acknowledged. Capacity of the local private sector is a defining element in delivery of successful technology to end-users both for private and public waste reduction, reuse and recycling technology. This includes private manufacturing firms for various efficient reduce, reuse and recycling systems. Through public-private partnership (PPP) by Strengthening cooperation between public and private partners in order to develop and implement projects for the creation and / or modernization, operation and maintenance of Waste reduce, reuse and recycle infrastructure facilities and / or infrastructure services.

5.4 Barrier analysis and possible enabling measures for Waste transfer station technology

5.4.1 General description of Waste transfer station technology

Transfer stations are an essential part of minimizing the volume of solid waste from our homes, businesses, schools, etc. that must be buried in landfills. Transfer stations can make it easier to achieve recycling and other zero waste goals. Transfer stations also reduce diesel emissions by minimizing the distance compactor trucks must travel.

Waste transfer station will act as a collection point for waste streams, where collection vehicles and containers are emptied, the waste screened, then loaded into larger transport vehicles for long haul transport. The waste transfer station will act as midway points for waste management in regard to economic value and environmental factors, for example in reducing the length and frequency at which individual collection vehicles have to be drive to get to the end point of disposal or recycling. It is built in between the source of generation and disposal site. In addition to loading and unloading of waste, transfer stations are also used as storage, waste recycling and waste processing sites.

They have facilities for waste separation/ segregation, size and volume reduction (shredding, compaction) and component separation. In some cases, they also have waste treatment facilities such as incineration, pyrolysis and composting. In areas with narrow and congested lanes where use of compacted trucks is limited, the transfer stations are used as a facility to transfer the waste from small vehicles and non-compacted trucks for segregation reloading into large vehicles. Likewise, when waste is not dense, they are brought to transfer station and compacted. The transfer station also serves best when the distance between the collection zone and disposal site is very high. The primary significant that comes with having a transfer station in the community is improved efficiency and carbon footprint reduction. These facilities allow for waste collection and transportation to occur in one centralized location, cutting down on the time it takes waste materials to reach their final destination and the reduction in waste carbon footprint through smart processing and reduction. Other benefit of waste station waste reduction strategies includes more efficient use

of raw materials and packaging as well as reducing the emissions associated with the collection and treatment of waste, which can also lower costs technology operation. The major limitation of transfer station includes additional construction for building transfer stations and labor cost. It also consumes a high amount of energy for waste transfer, segregation and processing. The problems associated with transfer station is that it attracts flies and other insect vectors and creates odours. Traffic and noise due to small and large collection vehicles, collectors, drivers, etc., invite the resentment of the communities living in the vicinity of transfer stations.

5.4.2 Identification of barriers for Waste transfer station technology

5.4.2.1 Economic and financial barriers

Currently, there are no waste transfer station plants in South Sudan. Table 33, the Waste sector working group discussed what currently hinders the construction of Waste transfer station technology or practices cross the country. The main economic and financial barriers to the introduction of this technology are given in table 39:

Barriers category	Identified economic and financial barriers
Economic and	High cost of constructing transfer station sites and labor cost. To
Financial Barriers	establish a waste management facility such as waste transfer station
	is a large-scale undertaking, requiring several years and millions of
	dollars.
	High investment and operating costs of waste transfer station
	maintenance and insufficient municipal budgeting. For Waste
	transfer to ensure an effective ongoing operation, it requires high
	amount of energy for waste transfer, segregation and processing.
	specialist equipment such as pelletizers can be expensive, you may
	also need skips, lorries, grabs, excavators etc. which may cost round
	\$ 250,000.
	Limited budget designated for the waste management by the
	government. The budget designated for the waste management is
	very low, this will lower the investment in Reduce, Reuse and
	Recycle (3Rs) technology and makes it not attractive to private sector
	to support in the deployment. Diffusion and transfer of Reduce, Reuse
	and Recycle (3Rs) technology in South Sudan.
	Lack of Subsidy incentive regulation, Exemption and reduction
	of income tax to stimulate investment in the Solid waste transfer
	station technology. The subsidies support and encourage better
	waste management, waste reduction and investments in improved
	waste management in solid waste transfer, and may take the form of
	direct subsidies or tax exemptions. Subsidies and tax exemptions

Table 39: Identified economic and financial	barriers to the deploy	ment and diffusion
Waste transfer station technology		

are often used to promote investment in improved waste
management infrastructure such as Waste transfer station.
Financial support to the development and deployment of Solid
Waste transfer technology. No funding for solid waste master plan
implementation Limited budget designated for the development of
solid waste transfer station. The budget designated for the
construction of waste transfer station is not included in Ministry of
Environment and forestry (MoEF), this resulted into no investment
and deployment of waste transfer station technology in South Sudan.

5.4.2.2 Non-financial barriers

The non-financial barriers were identified from stakeholder consultations and scored to determine which non-financial barriers were most significant. The barriers and scores are given in Table 40 below

Barriers Category	Identified economic and financial barriers	
Technical Barriers:	The lack of technical skills led to the deployment of solid waste	
	transfer stations, but also to the lack of knowledge to operate	
	waste transfer station machinery and Equipment. This issue is	
	attributed to the low level of education.	
	Lack of Planning and Strategy	
	Planning is normally the first step for designing or developing	
	MSWM. Stakeholders mentioned poor planning when they	
	talked about challenges to waste management in South Sudan.	
Policy, Legal and	Lack of regulatory framework to encourage the construction	
regulatory	and operation of Waste transfer station. Lack of strategy,	
	policies, regulations that encourage public-private sector	
	investment in the construction of Waste transfer station. This	
	hindered the deployment, diffusion and transfer of Reduce,	
	Reuse and Recycle (3Rs) technology.	
	There are no specific laws, policies and strategies that	
	support the development of solid waste transfer station cross	
	South Sudan. As related laws, there are the National	
	Environment Bill (2013) and the Local Government Act (2009).	
	The National Environment Bill has been prepared by the	
	Ministry of Environment and Forestry but has not yet come	

Table 40: Identified non-financial barriers for Waste transfer station technology

	into force. It has a comprehensive content that includes waste	
	management.	
	Lack of infrastructure is a significant problem. Many modern	
	buildings, especially those designed abroad for the malls and big	
	hotels, have physical space that allows for recycling activities.	
	Most of these companies, however, do not have separate bins or	
	containers for sorting and lack physical infrastructure to carryout	
	sorting in house.	
Institutional and	Limited Government Resources and Capacity: The limited	
organizational capacity	financial resources and capacity of the government pose	
and human skills	challenges to development of solid waste transfer station in South	
	Sudan. Insufficient funding for waste collection services, lack of	
	trained personnel, and limited equipment hinder the city's ability	
	to manage waste effectively (World Bank, 2012). The	
	government's resource constraints hamper the implementation of	
	comprehensive waste management practices	
	The current state institutional system in the field of waste	
	management is characterized by:	
	• insufficient institutional capacity needed to plan, organize	
	and implement an integrated waste management system at	
	all levels (national and regional);	
	• insufficient level of coordination, corporatism and	
	communication between the competent authorities:	
	• lack of an institution responsible for the regulation and	
	development of the system of secondary resources;	
	• weak financial support, lack of financial stability;	
	• Inadequate control, which creates the basis for the formation	
	of unauthorized dump	
Lack of public and private	Lack of governmental support to initiatives from the private	
partnership (PPP)	sector and Non-Governmental Organizations (NGOs). There	
mechanism	are many initiatives from the private sector and NGOs that are	
	not supported by the government for example the complex	
	procedures required by government to approve any initiative	
	that aims to improve waste segregation and recycling practices	
	as well as awareness among people makes it not possible for the	
	deployment, diffusion and transfer of Reduce, Reuse and	
	Recycle (3Rs) technology	

I	Look of multic anyoneness and information. Eailung to show	
Information and	Lack of public awareness and information. Failure to share	
awareness	information and knowledge on the significant of waste transfer	
	station in Solid waste management in a participatory	
	communication approach will hinder diffusion of segregation	
	and baling technologies.	
Social, cultural and	Cultural barrier such as customs, traditions and even religious	
behavioral	reasons may prevent them from accepting some reusing and	
	recycling practices as essential practices to succeed the	
	deployment and diffusion of the technology adoption in South	
	Sudan.	
Political stability	During the consultation, political stability was mentioned as one	
	of the barriers that have an adverse impact in the waste	
	management; therefore, it represented a barrier against	
	technology adoption. Stakeholder mentioned that political	
	stability affects the investment into the waste recycling since	
	South Sudan has been undergoing political instability since	
	independence in 2011. This has affected waste investment in the	
	country, including investing in WM projects.	

5.4.3 Identified Measures

5.4.3.1 Economic and Financial Measures

Povide funding incentive, technical assistance and various facilities to private investors involved in solving solid waste management. Incentives to potential contractors in order to encourage them to join PPPs for the construction of waste transfer station cross the country more particularly in Juba and in all the ten (10) state capacity city. This public-private partnerships (PPPs) can be facilitated thought the following measures:

- 1) Innovative models for attracting external funding by implementing waste transfer station project finance (PF) and public-private partnerships (PPPs) for waste transfer station.
- 2) Establish partnership with the public, private and civil society organizations for the purpo se of initiating different solid waste transfer station.
- 3) Increase in budget financing for the establishment of waste transfer station cross the country; Attracting investments based on public private partnership (PPP) projects for the waste transfer station development.
- 4) Government needs to establish waste transfer station tariff system which coverage for current and capital costs, encourage producers and consumers to more rational waste transfer station management, encourage the introduction of economically and

environmentally efficient waste transfer station management methods as low-waste technologies.

Study on the feasibility of developing a waste transfer station. Feasibility and market analysis study implementation will indicate the appropriate actions required locally to achieve the construction of waste transfer station and financial sustainability in all contracted PPPs. Given that South Sudan do not have a single solid waste transfer station, a feasibility study is recommended to look at the following key elements before investing into the solid waste transfer station technology deployment:

- 1) Evaluate current economics of solid waste flow in-county (cost per ton managed) as compared to other counties with landfills and/or transfer stations.
- 2) Evaluate costs of operating a waste transfer station and the overall costs per ton managed.
- 3) Determine the feasibility of a private owned and operated, county owned and operated, and county owned and privately operated waste transfer station based on economic analysis.

5.4.3.2 Economic and Financial Measures

Development or updating existing laws and regulations, facilitation of licensing procedures, and activation of the Investment Promotion Law for the waste transfer station. The Government of South Sudan represented by the Ministry of Environment and forestry (MoEF) need to provide legal support to local authorities. Local laws and rules that the Solid waste transfer stations are required to comply should be available to determine public -private sector investment. Procedures for acquiring permits to construct and operate a solid waste transfer station must be easy and flexible to attract investment, deployment of the technology.

In addition, develop a waste transfer station strategy that is integrated into an SWM policy. A strategy should aim to encourage solid waste deposit at the waste transfer station activities at the source like the government offices, hotels, supermarkets, etc. to reduce exposure to workers of airborne microorganisms and toxic products at dumpsites.

Strengthen the institutional capacity of municipality to manage solid waste transfer station – Ministry of Environment and forestry and Municipal Solid Waste Management department should organize trainings and workshops to enhance the capacity of municipal staff and solid waste transfer station personnel on proper waste management practices.

Promote public waste education program, correct attitude and social values reinforcement in keeping public cleanliness and proper waste disposal management for all children and citizens in the society. Providing basic information and ideas on a waste reduction, reuse, recycling, composting and buying recycled products and packaging programs for your school and other institutions in the country.

5.5 Linkages of barriers identified

Stakeholder noted that the two technologies of the Reduce, Reuse and Recycle (3Rs) technology and the solid waste transfer station are closely related. Linkages of barriers have been assessed,

First, there are barriers that are common to the two technologies, and hence common measures which can benefit all technologies.

 Table 41. Linkages of barrier faced by two prioritized technologies in the Waste sector

 were related to the following themes

Barrier Category	Barriers	
Economic and Financial	High cost of 3R and waste station maintenance and	
	insufficient municipal budgeting	
	Low access to finance	
	Low demand for recyclable materials,	
Human skills	The lack of technical skills	
Information and Awareness	Lack of public awareness and information	
Policy, legal and regulatory	Lack of Lack of strategy, policies, regulations that	
	encourage public-private sector investment in the	
	construction of Waste transfer station and in waste	
	reduce, reuse and recycle (3Rs) technology.	
Institutions	Insufficient institutional capacity needed to plan,	
	organize and implement an integrated waste management	
	system at all levels	

Barriers related to high cost and low access to finance, low demand for recyclable materials, barriers related to lack of knowledge and awareness and barrier related to policies, strategies and regulatory framework. Therefore, implementing measures to overcome the common barriers can lead to more effective scaling up of mitigation actions, and hence increases the ambition of GHG emission reductions. Second, there are linkages between barriers for each technology. These linkages imply that a holistic or integrated approach has to be adopted when developing the technology action plans (TAPs) in order to avoid partial implementation of measures proposed for the mitigation technologies. Common barriers allow for focusing on policy measures that would contribute to the mitigation of most important obstacles and trigger further deployment and diffusion of the two technologies.

5.6 Enabling framework for overcoming the barriers in Waste Sector

First, an appropriate policy and strategic framework needs to be developed by the government of South Sudan, together with technical guidelines on key issues such as reduce, reuse and recycle (3Rs), organic composting and landfill operations, to properly guide local government, partners and private sector in the waste sector in effective SWM.

Reduce, reuse, and recycle (3R) should be promoted. Consultation with stakeholder identified great potential for resource recovery in South Sudan, which could be realized with better public awareness and initiatives by government, international partners and communities.

Waste expert working group recommended that South Sudan should plan an Integrated Waste Management System to start any further waste management technology in the country. This is a reflection of the urgent need for a clear strategy, plan, or system that can formulate and coordinate waste management sector in the country

It's also recommended that government should focus on reducing, reusing and recycling initiatives. South Sudan requires a waste management sustainable development agenda regarding minimization of generated waste, reuse and recycling as a main priority." Poor planning and lack of waste management legislation are barriers in addition to the absence of strategic waste management plans. Introducing a series of economic instruments aimed at reducing the waste problem. Reduced tax on waste management equipment to encourage more activity in Reduce, Reuse and Recycle (3Rs) technology. Government should also exempt paper bags from tax and increase the tax on plastic carry bags to discourage their use as well as ban on thin plastic bags.

Introducing a deposit/refund system on aluminum cans, plastic bottles, and car batteries. For example, a small deposit can be paid on purchase and 80% of this is re-paid when the materials are returned to privately operated depots. A single recycling operator operates the system, and issues a refund for example 500 SSP for each can/bottle collected. Meanwhile, the operator can also make a claim from the fund for the deposits on each can collected (For example 600 for each can). The remaining 100 SSP comprises the handling fee. The recycling operator pays all costs associated with the processing and handling and shipping, but recovers the value of the materials sold. The government provides the operator with the money to pay the refund, and the balance is used for any subsidies needed to pay for exporting the items for overseas recycling. This allows less waste going into its expensive landfill, less litter, a source of income for unemployed Youth and women, a significant small business, and less dumping of toxic waste from car batteries: all this at zero cost to the government.

During the consultation, stakeholder also agreed and **mentioned the role of education in raising public awareness**; the stakeholder appealed that: "increasing public awareness is a priority to start with in order to have a good waste management strategy because the power to make a change in the society starts with the education, people must be aware enough. "public awareness is an important enabler in order to prepare the society for the diffusion of the waste management technologies.

Boosting Public-Private Partnership for sustainable Waste Management. Public–private partnership offers opportunities for operational efficiency and cost effectiveness for Reduce, Reuse and Recycle technology and waste station establishment and management. The role of the private sector can be more important for complex tasks such as the operation of landfill sites, as municipalities are less experienced in these areas.

The enabling framework for addressing barriers common to the two technologies in the waste sector is summarized in the Table 42.

Barriers	Enabling environment	Responsible Institution
High investment and	The willingness of the	National ministry of
operating costs including	government, NGO and	Environments, State ministry
high cost of landfill sites	companies to contribute to	of Environment and Juba city
maintenance.	waste reduction cost	Council and Juba county
Lack of Subsidy incentive	Wiliness of the government of	Ministry of Environment,
regulation, Exemption and	South Sudan to exempt taxes on	Juba city Council.
reduction of income tax to	waste	
stimulate investment in the		
Solid waste transfer station		
technology		
Limited budget designated	The lunching of Solid Waste	MoEF, Juba City Council
for the waste management	Management Master Plan in	Private companies
by the government	Juba City 2021-2030 will	
	support in raising budget for the	
	management of Waste	
The lack of technical skills	Strengthen training for waste	University of Juba (UoJ) in
and knowledge led to the	Collectors and recyclers to	collaboration with the
deployment of the two	enable them to receive training	Ministry of Environment and
technologies	on technologies	Forestry, JICA and Juba city
	and appropriate waste	council
	management practices, share	
	ideas, and learn from each other	
	through observation and	
	experimentation.	
Limited Government	The Lunch of the Solid Waste	Ministry of legal and
Resources and Capacity	Management Master Plan in	constitutional affairs and Juba
	Juba City 2021-2030 that will	city council, ministry of trade
	finance the waste sector	and industry
Lack of regulatory	The wiliness of policy makers to	Ministry of Environment,
framework to encourage the	work out relevant waste policies	Ministry of legal and
construction and operation	and regulation	constitutional affairs and Juba
of two technology		city council, ministry of trade
		and industry

 Table 42. Enabling framework for addressing barriers common to the two technologies in

 the waste sector

No specific policy provision	The wiliness of Law makers to	Ministry of legal and
to provide subsidy and	work out relevant waste	constitutional affairs and Juba
concession	regulations related to the	city council, ministry of trade
	provision of subsidy	and industry
Inadequate renewable	Increasing demand of energy by	Ministry of electricity and
energy policy, strategy and	South Sudanese population	market.
action plan		
Limited human resource,	Government and private sectors	Ministry of Environment and
and machinery	engaged in the waste	Forestry GOSS
	management should strengthen	
	its technical capacity through	Ministry of Labour and Public
	capacity building programmes	Service
	and intervention	
Lack of public and private	Government should expedite	National, state and local
partnership mechanism	action on the passage of the	government
	public private Partnership Bill	
	into law to help boost PPP	
	arrangements in South Sudan	
Lack of awareness to the	Provision of subsidy by the	Ministry of Environment,
citizens about health	government, to carry out	Ministry of legal and
impacts of a control solid	awareness programmed	constitutional affairs and Juba
waste		city council, ministry of trade
		and industry
	Tax exemption to enable the	Ministry of Environment,
Poor technology and quality	machine to be imported	Ministry of legal and
for proper waste		constitutional affairs and Juba
management		city council, ministry of trade
		and industry
Lack of sanitary landfill	Provision of land lease	ministry of housing and land,
sites, proper incineration		and land lord
equipment.		

CHAPTER 6. AGRICULTURAL, FORESTRY, AND OTHER LAND USE (AFOLU) SECTOR

For ages forests have played an important role in the sustainable development of nations round the globe, by providing clean air and water, food, shelter, raw materials, improving watershed, conserving biodiversity including the critical species of food chain, and ecosystem, and reducing greenhouse gases (Lawry, S., *et al.* (2015).

Over the years, there has been an increasing pressure on the forest resources that have threatened the livelihood of millions of people in South Sudan who depend on the forests for their livelihoods. For this population to keep surviving and meeting their needs, there is a need for sustainable forest management. The forests in South Sudan are still not managed sustainably due to lack of appropriate policy and regulations, infrastructure framework to promote sustainable forest management or inadequate funding and lack of technical capacity (USAID, 2007). In order to maintain and improve on the forests of South Sudan, the following AFOLU sector technologies have been selected and they include;

- 1. Promoting Forest based enterprises e.g. bee keeping/apiary; butterfly farming; fruit trees production; ecotourism.
- 2. Sustainable Forest Management (SFM) for reducing emissions from deforestation and forest degradation.

6.1 Preliminary targets for technology deployment and diffusion

Forest resources in South Sudan, along with other sectors, contribute around 14.5%t to the national Gross Domestic Product (GDP) (USAID, 2017). Forest based enterprises have great potential for contributing to the national economy when its well streamlined and strategized since it contributes to the local livelihoods and national economy through different means such as carbon trading, environmental services, timber production, herbal and aromatic plants, and food. Establishing forest-based enterprises is one of the sectors with the most potential in South Sudan's forest resources because it will create job opportunities and increase trade markets. However, establishment and operation of forest-based enterprises are far from the success and achievements of full potential. Despite these facts, some successful examples exist in different parts of the country. However, documentation and analysis of these examples is still lacking yet such processes have a direct implication in the effective communication, advocacy and lobbying for deliberate policy making processes. All the forests in South Sudan are diverse and unique in terms of ecological features and geographical landscapes thus the possibility of initiating diverse forms of economic activities, particularly establishing, and operating different types of forest-based enterprises. The preliminary targets for deployment and diffusion of the prioritised forestry sector technologies are as follows.

• Government target to improve forest productivity in 21, 950.6 km² and 2,194.4 km² SOC stocks in lands of South Sudan by 2030 as compared to 2015.

- Rehabilitate 27,019.6 km² of degraded and abandoned land of South Sudan by 2030 to improve the Livelihoods of Poor community adjusted to forest:
- Halt the conversion of forests and wetlands to other land cover classes by 2030
- Increase forest cover by 20% by 2030 as compared to 2015
- Reduce the rate of soil sealing (conversion to artificial land cover) by 100% by 2030 as compared to 2015.
- The Government of South Sudan (GOSS) has targeted rural poverty and agricultural revitalization as its priority areas for intervention. Forests and forestry have key roles to play in these interventions through provision of both wood and non-wood forest products and a vital source of income to the rural poor. Forest based enterprises offer unique opportunities for transforming rural livelihoods. In addition to direct benefits in the form of income, the forests provide many vital indirect benefits in forms of environmental protection (as shade, wind belts), improved agricultural production (increased soil fertility through mulching and nitrogen fixation), food (Shea butter, fruits, etc.), fodder for wildlife and wildlife, etc.
- Also, the Government of South Sudan through the Ministry of Environment and Forestry GOSS target is to plant 100 million trees across the country by 2030 as an effort that will help mitigate effects of climate change, restore degraded land-based ecosystem. The campaign aimed to protect and restore the biodiversity of the South Sudan forests, promote a move towards sustainable forest management practices, and enhance bee keeping/apiary enterprise; butterfly farming; fruit trees production; ecotourism enterprises to increase household incomes.
- Under the South Sudan Pilot Community Forestry Project, the government and its development partners target to promoted the forest-based enterprises targeting communities living adjacent to the national forest in various parts of the country. South Sudan's leading sustainable forestry/Tree Companies, Private tree growers/members of the Equatorial Teak Company (ETC) and Central Equatorial Teak Company (CETC) have promoted forest-based enterprises within the forest plantation and also targeting participation of the surrounding communities
- Increase area of community forests and woodlots to 200,000 ha by 2030. This is to strengthen forest and landscape restoration technologies
- Forest encroachment, deforestation and degradation are minimised to the extend it deserves or at least no worse than current situation by 2030;
- 60% of the village forest areas including resources, ecological functions, services and values are well-maintained and/or enhanced by 2025 and 60% of community forests including its services and values are effectively and sustainably managed and preserved by 2030 and become forests with carbon stock close to (about 70% of carbon stock) of origin forest by 2030.

• Deforestation and forest degradation are minimal for the rest of the forest areas by 2030 and efficient use of forest products is increase to meet the demand. In general, the option of efficient use of forest products includes the following: reduction in the waste of wood residues; improvements in tree felling operations; low impact wood extraction systems; and changing processing technology and product development. The target set includes wood based enterprises, forest plantations and community managed forest. Other targets are NGOs, forest users at community levels, and traditional authorities.

6.2 Barrier analysis and possible enabling measures for promoting forest-based enterprises technology

Globally, many people living in rural areas near forests depend on forests as direct sources of food, fuel, building materials, fodder, and medicines. The products derived from the forests can also provide cash income. Some of the major constraints to promoting forest-based enterprise in South Sudan include inadequate capacity development and poor financing, access to markets, policy and regulation. Financing the forestry sector is a long-term commitment that requires significant investment in producing skilled, knowledgeable, and trained human resources; obtaining specialized equipment, building infrastructure, providing access/logistical equipment; enacting and implementing policies, legal frameworks and regulations that will enable the system to run.

6.2.1 General description of forest-based enterprise

Forests and woodlands of various types cover a large proportion of South Sudan's vast territory. The diverse natural forests and woodlands are estimated to cover a total area of 191,667 Km2. Its natural forests have high levels of biodiversity and wildlife habitat and generate important ecosystem goods and services. These include provisioning of goods (shelter, timber, fuel, food, medicines etc.) and services, carbon sequestration, hydrological cycling, soil stabilisation and cultural services (RSS., 2015).

More than 95 per cent of the South Sudan population directly depends on forests for fuelwood and charcoal production, timber for construction, and non-timber forest products for food and nutrition security; however, this resource is fast disappearing (FAO., 2016). About 30% of the total land area has been seriously degraded since the war began. It has also been estimated that some 45% of the forest cover and a large proportion of biodiversity has been lost since 1983.

According to International Council for Research in Argo- forestry (ICRAF) and Global forest watch (WFW,2023) on deforestation rate, South Sudan loses about 2% of its forests every year. Forests conservation plays a crucial role in watershed stability, livelihood support, sustainable agricultural production and mitigation of climate change. However, there is still low level of knowledge and skills in forestry, management, conservation and utilization compromise forestry development initiatives by Government, communities and other national and international partners.

6.2.2 Identification of barriers for the promotion of Forest based enterprises e.g. bee keeping/apiary; butterfly farming; fruit trees production; ecotourism

6.2.2.1 Economic and financial barriers

Table 43: Identified economic and financial barriers for the promotion of Forest based
enterprises e.g. bee keeping/apiary; butterfly farming; fruit trees production

Barriers category	Identified economic and financial barriers
Economic and	Limited capital and access to financial resources. Limited capital
Financial Barriers	and access to financial resources not only key barrier for the promotion of Forest based enterprises e.g. bee keeping/apiary; butterfly farming; fruit trees production; and ecotourism, but also other businesses. Almost all of the organic farmers and entrepreneurs are small-scale and limited capital for production and business expansion. High investment costs for the promotion of Forest based enterprises e.g. bee keeping/apiary; butterfly farming; fruit trees production; acetourism programme involves high up front costs amongting from
	the procurement of inputs.
	Limited access to credit services: Forest finance encompasses all the actions required to secure adequate financial resources for the ongoing management of a forest-based enterprise and to ensure its financial viability and profitability. Initial investments to set up a forest enterprise or to make operations sustainable involves costs that are usually funded by loans, which in turn implies the creation of long-term liabilities that ultimately must be serviced with revenue generated by the enterprise (Adam, 2013). Lack of or limited access to loans and financial services is a major hindrance to the development and diffusion of such enterprise among the communities depending on the forest for their survival. This is because financial institutions are mainly located in urban areas where they find a larger number of clients than in rural areas (Solangi, 2021). Many forest operations are seasonal, for example, forest fruits, honey harvesting, which means that revenue may not be collected evenly throughout the year. Small and medium-sized forest enterprises may particularly struggle to obtain adequate credit for their operations due to lack of stability in the harvests since forest-based enterprises are seasonal thus it may take several years for an investment to start generating returns.

6.2.2.2 Non-financial barriers

Table 44: Identified non-financial	barriers for the promotion of Forest based enterprises
e.g. bee keeping/apiary; butterfly f	farming; fruit trees production

Barriers Category	Identified Non-economic and financial barriers
Market Variability	Lack of markets for the forest produce is one of the challenges
	facing the communities relying on the forest for their livelihood.
	This is because the markets are a far distance away which
	requires transportation which is not affordable and not walkable.
	Also, the demand for forest-based produce is low which comes
	with low prices throughout the production area. Most of the
	beekeepers, and fruit and vegetable gatherers have no choice but
	to sell their products within the communities they live due to their
	small production quantities and difficulty of accessing large
	markets. Therefore, prices are controlled by the existing local
	retailers who always offer the lowest they can give.
Policy, Legal and	Inadequate policies on Forest based enterprises e.g. bee
regulatory	keeping/apiary; butterfly farming; fruit trees production;
	ecotourism including resources uses.
Institutional and	Ineffective and inadequate professional training and learning
organizational capacity	course on the promotion of Forest based enterprises e.g. bee
and human skills	keeping/apiary; butterfly farming; fruit trees production and
	ecotourism
	Quality and standards of products. The South Sudan National
	Bureau of Standards (SSNBS) is mandated to develop standards
	for all products, assess the conformity with international and
	local standards, and determine the metrology of products.
	However, in South Sudan these mandates are not adequately
	fulfilled due to inadequate technical capacity and equipment. For
	example, small-scale collectors still depend on traditional hives
	and knowledge in collecting, processing, and packaging of
	honey. The honey is usually processed in pots, with the
	honeycomb mixed in, which compromises the quality of the
	honey and eliminates the opportunity to process and sell the wax
	(FAO., 2022). As a result, local producers don't have the required
	standards for the products and cannot compete with other
	imported products on the market. Due to limited technical
	guidance these producers have not established Good
1	
	Manufacturing Practices (GMP) with a sound code of practice,

	safe production of goods that meet international standards
Poor road network	(UNDP, 2023).
1 001 10au network	Road infrastructure plays a crucial role in the sustainable
	development of any nation since it connects communities,
	The poor road conditions in South Sudan hinder economic
	growth, access to essential services, and social cohesion, and the
	roads are in dire need of repair and upkeep. According to the
	world bank report of 2022 on sustainable development of South
	Sudan, lack of well-maintained roads makes it difficult for forest
	produce and other goods to reach markets on time, resulting in
	increased transportation costs and reduced profitability.
	Poor road network also discourages local and foreign direct
	investment into forest-based enterprises, as such businesses
	require reliable transportation infrastructure to operate efficiently
	(World Bank Group, 2022). Lack of investment into forest based enterprises stifles economic growth and perpetuates the cycle of
	poverty among the communities living around the forests.
T.C	
Information and	inadequate accurate and updated information on forest resources
awareness	enterprise resources
Technical	Lack of technical skills and knowledge. There is a lack of
	technical expertise from either government or other
	organizations to facilitate optimal use of modern equipment for
	better product extraction, storage, and packing, as well as to
	enhance ability of the local communities to add value to the
	produce. For example, beekeepers lack the skills on how to
	handle the honey and keep the quality and standards requires for
	equipment to keep the fruits and vegetables fresh until it is sold
Political stability	Political instability and lack of government support in South
	Sudan is a barrier as without a secure and stable government,
	it can be difficult to establish and implement policies and
	regulations that support the development of the forest-based
	enterprise. Political instability can make it difficult for businesses
	and investors to plan for the long term and make investments in
	the sector due to uncertainty. Also, insecurity can cause the
	(Bothak 2022)
	(Faulak, 2022).

6.2.3 Identified measures

6.2.3.1 Economic and financial measures

The development of forest-based enterprises is one of the meaningful pathways for the alleviation of poverty among communities that depend on forest products for their livelihoods in South Sudan. Forest resources have the potential to create economic opportunities at the local level and strengthen resource conservation. Many regulations have been made in the last few years regarding the management of forest resources, but still, there is lots of reform to be made for the betterment of the people involved in the different enterprises in the community forests. To enable the development of these enterprises, the following measures can be implemented:

Barriers category	Identified economic and financial measures	
Economic and	Incentive for the establishment of forest-based enterprises in	
Financial Barriers	communities living within the forests.	
	Incentive and/or soft loans to the communities involved in forest- based enterprises are required mainly to expand the enterprise and increase production and community participation to uplift their socio-economic status. Since forest-based enterprise is mainly done by socially and economically poor communities that have no clear source of income or access to financial services.	
	The government of South Sudan and its development partners can provide some startup capital for the establishment of the enterprise so that they can make their living from the enterprises. During the establishment phase some enterprises may not require large sum of investment but for a community with no access to credit services it may be a lot. Developing mechanisms such as microfinance, venture capital, and credit guarantee schemes to support their financial needs. This will help them acquire modern equipment and technology in the harvesting, processing, and packaging of the products for a better market.	
	Increased transparency would reduce transaction costs and increase market competition to minimize the gap between forest gate and market prices, ensuring that producers reap the benefits of South Sudanese, lucrative markets for forest based products.	

Table 45: Identified economic and financial measures barriers for the promotion of Forest based enterprises e.g. bee keeping/apiary; butterfly farming; fruit trees production

6.2.3.2 Non-financial measures

 Table 46: Identified non-financial measures barriers for the promotion of Forest based enterprises e.g. bee keeping/apiary; butterfly farming; fruit trees production

Barriers Category	Identified Non-economic and financial measures
Market Variability	Establishing and strengthening a forest based enterprise
	product value chain would help promote fair, transparent and
	competitive processes, and increase private sector investment in
	forest-related business.
	Facilitate market for local products. Availability of a stable
	market for forest-based products should be ensured by any
	means. This will encourage locals who depend on these forests
	to ensure continues production of these products all year round
	and stop depending on the seasons, for example honey gathers
	will be forced to adopt technologies that will ensure there is
	constant supply of this product to the market and stop depending
	on wild honey alone. If the local communities have access to the
	markets, they will produce more, cut of the middlemen who offer
	low prices and start dealing directly with traders who will offer
	them premium for their produce which will increase on their
	income and livelihood
Policy, Legal and	Reform the forest sector; establish Forest based enterprise
regulatory	practices, and build capacity for government services, law
	enforcement personnel, and civil society
	South Sudan needs to develop an enabling policy, institutional
	and legislative environment to increase private sector
	involvement and investment in forest based business.
	Reduce or modify regulations, including tax mechanisms, that
	impede the development of forest based product or make them
	more competitive. Provide secure tenure and access to forest
	resources, including authority to make key decisions
Institutional and	Providing secure environment for businesses. Government of
organizational capacity	South Sudan should ensure there is security for the communities
and human skills	staying near and surviving on the forests, investors, NGOs,
	suppliers of equipment to ensure they are not vandalised because
	of conflicts and theft. For any business to thrive it requires an
	enabling environment since the cost of investment is very high,
	there should be guaranteed security that there will be no
	distraction of property and lives.

	Strengthening Capacities and Market Linkages to forest based MSME. Most forest based MSMEs need to strengthen their capacity to establish lasting partnerships with other businesses along the supply chain, including specialized processors and buyers. On the one hand, partnerships may offer increased benefit capturing through the formulation of benefit/risk sharing mechanisms, clear labour division and related value adding, and access to specific information and embedded technical, business and financial services for forest based products.
	On the other hand, there is need to build the capacity of forest based MSMEs to communicate and coordinate effectively, and deliver quality products on time and in sufficient volumes.
	Strengthen Business Support Institutions . It's important to invest in the capacities of business support organizations is crucial. These institutions can help forest-based enterprises access financial services, obtain certifications, and upgrade their operations.
Poor road network	National strategy for forest road network development and
	maintenance. The forest road infrastructure development as a
	measure to increase efficiency and have the potential to reduce transport costs and make it easier for forest based businesses to
	reach internal and external markets.
Information and	Increased invested in targeted awareness raising information
awareness	dissemination research, training and development in forest based enterprise to contribute to livelihoods, landscape restoration
	Promoting participation of communities in the management
	of forests and other natural resources, as part of a broader
	process of local government reform . Stronger participation of
	it will safeguard the forest assets and strengthen community
	rights over their traditional land and forest resources.
	Promote forest based enterprises with short term benefits with
	due consideration of preferences of men, women and youth for
	diversification with farmer managed natural regeneration.
	Forest based enterprise knowledge enhancement through
	Orientation Meetings.
Technical and Training	Skills and knowledge enhancement. Training and educating the
	communities on product nandling and processing methods will

	go a long way in ensuring their products are of quality and
	acceptable in any national and international markets.
	Communities living around the forest may not be educated due
	to numerous challenges raging from lack of schools within to
	access and affordability which makes them do everything the
	traditional way. Training programs on entrepreneurship,
	management, marketing, and financial literacy with relevant
	skills to boost competitiveness. This will enable them to change
	on how they perceive and handle these enterprises for the
	betterment of their households and communities.
	The national and state local governments should work on
	training, education and empowerment of rural dwellers
	(most especially those living around the forest) on alternative
	green entrepreneurs such as establishment of wood lot, bee
	keeping, snail farming, mushroom production, rabbit farming
	and so on. This will enhance sustainable livelihood and reduce
	pressure on the forest.
Political	Providing secure environment for businesses. Government of
instability/Insecurity	South Sudan should ensure there is security for the communities
	staying near and surviving on the forests, investors, NGOs,
	suppliers of equipment to ensure they are not vandalised because
	of conflicts and theft. For any business to thrive it requires an
	enabling environment since the cost of investment is very high,
	there should be guaranteed security that there will be no
	distraction of property and lives.

6.3 Barrier analysis and possible enabling measures for Sustainable Forest Management (SFM) for reducing emissions from deforestation and forest degradation.

Much of the population of South Sudan, both urban and rural, depend on the forests in one way or the other. There is a high degree of dependence on firewood and charcoal as the main sources of energy. Forests also provide timber for construction and furniture. For many years' forest ecosystems have provided a range of benefits, from non-wood products such as honey, gum Arabic, and traditional medicines to serving as areas for grazing, hunting, and fulfilling key ecological functions in the Nile Basin (El Tahir, 2015). Many rural livelihoods depend on forests, which provide a vital source of income for the rural poor. Furthermore, the commercial lumber industry is a small but growing source of employment and revenue for the government of Southern

Sudan. Despite all the numerous benefits, its estimated that in the next fifty years South Sudan may have no more forests left if they are not managed sustainably (AWEPA., 2007).

6.3.1 General description of Sustainable Forest Management (SFM) for reducing emissions from deforestation and forest degradation.

Sustainable forest management involves planning and implementing practices for maintaining and use of forests to meet specific environmental, economic, social, and cultural objectives. It deals with the administrative, economic, legal, social, technical, and scientific aspects of managing natural and planted forests. It may involve varying degrees of deliberate human interventions, ranging from actions aimed at safeguarding and maintaining forest ecosystems and their functions, to those favouring specific socially or economically valuable species for the improved production of forest goods and services (Lawry, S., McLain, R., & Kassa, H. (2015).

Given the importance of forests to the population of South Sudan, sustainable management is essential to ensure society's demands don't compromise the resource. Sustainable forest management offers a holistic approach to ensure forest activities deliver social, environmental, and economic benefits, balance competing needs and maintain and enhance forest functions now and in the future. Sustainable forest management creates outcomes that are socially just, ecologically sound, and economically viable (PEFC., 2023)

6.3.2 Barrier analysis and possible enabling measures for Sustainable Forest Management (SFM) technology for reducing emissions from deforestation and forest degradation.

6.3.2.1 Economic and financial barriers

In South Sudan, sustainable forest management faces several financial challenges.

Barriers category	Identified economic and financial barriers
Economic and Financial Barriers	Limited Financial Resources. South Sudan, despite its rich forest resources, grapples with limited financial capacity to invest in sustainable forest management. Insufficient funds hinder the implementation of effective conservation and restoration measures. Sustainable fforest financing involves all the actions required to secure adequate financial resources for the ongoing management of a forest and ensure its financial viability and profitability. Initial investments to set up a forest management team and or make operations sustainable involves costs that are usually funded by loans, which in turn implies the creation of long-term liabilities that ultimately must be serviced with revenue generated by the enterprise (Adam, 2013)

able 47: Identified economic and financial barriers for Sustainable Forest Managemen	t
SFM) technology	

Lack of or limited access to loans and financial services is a major
hindrance to the development and diffusion of such activities among
the communities depending on the forest for their survival. This is
because financial institutions are mainly located in urban areas where
they find large number of clients than in rural areas.

6.3.2.2 Non-financial barriers

Table 48: Identified non-financial barriers for Sustainable Forest Management (SFM)	
technology	

Barriers Category	Identified Non-financial barriers		
Illegal Logging and Trade	Combatting illegal logging and timber trade requires financial resources for surveillance, law enforcement, and capacity- building. Climate change is already impacting lives and livelihoods, especially in the equatorial regions. According to environmental experts, this relatively unmanaged and unsustainable practice could have serious environmental and climate impacts.		
	Involving local communities in forest management is crucial for sustainability since they are the ones who depend on it for their survival and so need to protect it from illegal logging, bush burning and encroachment. However, community engagement initiatives (such as training, awareness campaigns, and participatory planning) require funding.		
Technical	Lack of technical skills and knowledge.		
	There is lack of technical expertise from either government or		
	other organizations to facilitate optimal use of modern equipment		
	for better monitoring, documentation and enhancing the ability		
	of the local communities to manage and utilize the forest		
	resources sustainably. For example, beekeepers lack the skills on		
	how to harvest the honey and they end up burning the forest all		
	in the name of harvesting honey.		
Policy, Legal and	South Sudan has experienced multiple challenges in managing		
regulatory	its forest sustainably and related environmental resources for		
	quite a long time. These challenges are associated with poor legal		
	and institutional framework, which resulted in considerable loss		
	of the country's forest cover, topsoil, bio-diversity resources, and		
	emission of GHG due to inadequacy of the forestry legal		
	framework and weak law enforcement, and unclear tenure and		
	forest user rights.		

Institutional and	Poor education system and capacity building. Formal forestry
organizational capacity	education in South Sudan, is going through hard times because
and human skills	the national government invested too little in it, and donors have
	stayed away from financing academic training in forestry. The
	overall current Forestry sector staffing level of around 200 staff
	may not be sufficient to develop an administration that could
	efficiently oversee South Sudan's forest resources. The poor
	manpower situation in South Sudan is partially attributed to the
	war and budget problems that have led to either the closure of
	many forestry training institutions or the high turnover
	experienced in the sector. Students who manage to complete their
	graduate or certificate courses are poorly equipped with forestry
	knowledge, information, and skills, badly remunerated and
	unmotivated, such that they look for greener pastures elsewhere.
Poor road network	Poor road Infrastructure. The poor road conditions in South
	Sudan hinder sustainable management of the forest resource
	since access to essential services that would prevent illegal
	activities and continuous monitoring of the forests is not done
	because the areas are not accessible (Kaiser, 2022).
	According to the world bank report of 2022 on sustainable
	development of South Sudan, lack of well-maintained roads
	makes it difficult for forest managers and other emergency
	services such as fire trucks, mobile patrol to reach on time
	resulting in increased deforestation and destruction of natural
	resources. Poor road network also discourages local and foreign
	direct investment into forest sector such as agroforestry since
	these businesses require reliable transportation infrastructure to
	operate efficiently.
Insecurity	Political instability and lack of government support in South
	Sudan is a barrier as without a secure and stable government it
	can be difficult to establish and implement policies and
	regulations that support the development of a sustainable forest
	resource. Political instability in South Sudan makes it difficult
	for husinesses and investors to plan for the long term and make
	investments in the sector due to uncertainty. Also insecurity
	within the forests of South Sudan has made many people to lose
	their lives in the forests while looking for food for their
	households (EACH Initiative 2018)

1.3.3 Identified measures for Sustainable Forest Management (SFM) technology

6.3.3.1 Economic and financial measures

Table 49: Identified economic and financial measures barriers for Sustainable Fore	st
Management (SFM) technology	

Barriers category	Identified economic and financial measures		
Economic and	Introducing Predictable and Sustainable Long-term Financing		
Financial Barriers	Mechanisms. A major constraint to putting in place an effective		
	forest administration in South Sudan has been low budget allocations		
	to the forest sector. Forest revenues are directed to the central		
	Ministry of Finance and are not reallocated to the forest		
	administrations at the national or regional levels. Development and		
	operations budgets from national to the state level have dwindled year		
	after year, and so has the ability of the Forest Service to sustainably		
	manage forest resources (World Bank, 2010).		
	Strengthening policies and advocacy for Private Financing for		
	Sustainable Forest Management and Forest Products both at the		
	national and sub national cross the country.		
	Government and corporate decision-makers should modify forest		
	policy to include instruments and incentives that promote		
	financially viable smallholder/sustainable forest management in		
	a targeted manner. Providing long-term tenure and user rights through		
	policy and legislation, and assisting in effective land-use planning		
	(surveying, demarcation, titling, etc.) will encourage communities to		
	invest in forestry.		

6.3.3.2 Non-financial measures

Table 50: Identified non-financial barriers for Sustainable Forest Management (SFM) technology

Barriers Category	Identified Non-financial barriers	
Policy, Legal and	Create a new mind set for all stakeholders so sustainable forest	
regulatory	management (SFM) technology becomes a core focus of all	
	decisions related to legislation, policy, and implementation.	
	Build institutional capacity for law enforcement and use available	
	resources in the most efficient way, along with examples of	
	partnerships that improve compliance	

Institutional and	Improving knowledge of the forest resource and improved		
organizational capacity	means to monitor changes over time. Strengthening		
and human skills	 institutions will support good forest governance, particularly the establishment of forest owners' associations and cooperatives. They can greatly advance smallholders' understanding of forest ownership, sustainable forest management, forest-based income generation, environmental issues, improvement of local institutional capacity and bargaining power. Use of modern technology in forest management. Remote sensing technologies such as satellite imagery and aerial photography that increase the speed at which forest mapping and monitoring can be done, while also analysing and synthesizing vast amounts of existing data is not yet widely used in South Sudan. 		
	Geographic information systems (GIS) and global navigation satellite systems and new technologies (airborne light detection and ranging from the use of lasers or space-borne radar and radio detection and ranging, etc.) would provide South Sudanese foresters and managers with increasingly precise information on the nature and condition of forest resources (e.g. variable height, structure, density, and composition of forests; estimates of tree cover and height, shape of individual trees, estimates of stand volume and biomass) which can be processed and transmitted rapidly. This will ensure the availability of forest information as a key pillar of a comprehensive forest management planning system in the longer term (World Bank, 2010).		
Illegal Logging and Trade	Promoting participatory community forest management Interests of communities and their traditional authorities in forest resource management needs to go beyond user interest to include custodial and guardianship interest, which derives from history, locality, and socio-environmental interest, rather than product use only. Given that about 90 percent of forests in South Sudan lie outside gazetted forests, involving traditional authorities and their communities in the management (including custodianship and guardianship) of these forests is the most promising option for ensuring that forest resources are not further degraded and deforested. Also, making public participation and consultation a cornerstone of the governance reforms by ensuring that the public is actively		

	and fully engaged in framing, implementing, and monitoring forest policies and laws, governance regimes, and management plans and decisions to prevent illegal logging and trade.
Technical	Using technical approaches to Conservation and Sustainable Management of Forest Resources. Technical approaches to management of agroforestry-based farming systems are being supported through joint technical programs with the World Centre for Agroforestry (ICRAF) based in Nairobi, which has supported training of agroforestry extension staff. Technical approaches for improving agroforestry farming systems include, among others, the planting of nitrogen-fixing leguminous tree species, the establishment of shelter belts, planting of improved fruit tree species, and species that provide a source of medicinal products
Insecurity	Providing secure environment for businesses . Government of South Sudan should ensure there is security for the communities managing the forests, investors, NGOs, suppliers of equipment to ensure they are not vandalized because of conflicts and theft. For sustainable forest management strategy to thrive it requires an enabling environment since the cost of investment is very high, there should be guaranteed security that there will be no distraction of property and lives in the process of executing the duties.

6.4 Linkages of the barriers identified in Agricultural, Forestry, and other Land Use (AFOLU) Sector.

Barriers that are common in promoting forest-based enterprises and Sustainable Forest Management (SFM) technology for reducing emissions from deforestation and forest degradation in South Sudan technologies are indicated in the table 51 below.

Table 51. Link	ages of barrier fa	ced by two prioritiz	ed technologies i	n the Agricultural,
Forestry, and	Other Land Use (AFOLU) sectors we	re related to the	following themes

Barrier Category	Barriers
Economic and Financial	Low budgetary allocation and lack of financial services in the
	communities where the forests are located is another limiting
	factor to the deployment of these technologies. For sustainability
	of the forests there is need for work force, capacity building,
	investment in automotive, research which all require financing.
	For the promotion of forest-based enterprises, there is need for

	equipment, skilling the producers on production, packaging, and
	quality aspects. The poor communities cannot finance all this but
	it's the government of South Sudan and development partners to
	allocate resources that will enable smooth implementation of all
	these technologies.
Human skills	The lack of trained personnel and educational facilities is in
	South Sudan still one of the principal impediments to the
	deployment and diffusion of forest-based enterprises and
	Sustainable Forest Management (SFM) practices
Information and	Limited knowledge and awareness; Raising public awareness is
Awareness	the crucial first step for many on the path to understanding the
	issues and a better appreciation of the benefits well managed
	forests provide. The need to strengthen the links between the
	forest sector and society by increasing public awareness of the
	direct and indirect benefits from forests is critical. Recently, the
	concept of raising awareness of forests and forestry is now
	recognized as an integral part of sustainable forest management.
Policy, legal and	Inadequate policy implementation and enforcement; The
regulatory	government of South Sudan will need to review and, where
	necessary, update all existing forest legislation (including laws,
	regulations, administrative rules and procedures) so that they
	support the promotion of forest-based enterprises and
	Sustainable Forest Management (SFM) for reducing emissions
	from deforestation and forest degradation and strengthen forest
	law enforcement, through training and adequate funding of forest
	law enforcement activities and stricter penalties for illegal
	activities.
Institutions	Weak institutional capacity building and coordination
	mechanisms to support the diffusion and deployment of the
	forest-based enterprises and Sustainable Forest Management
	(SFM) practices
Others	Poor road network and infrastructure, inadequate technical
	capacity, limited financing of forestry sector and inadequate data
	and information on available resources. Given that most
	beneficiaries of these technologies are rural poor communities
	who depend on forests for their survival, the road infrastructure
	is extremely important to enable them access markets, transports
	goods, and do routine monitoring and regulation of the forests to
	ensure they are not encroached or destroyed
Insecurity within the forest is one of the factors hindering	
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diffusion of these technologies, this has caused the communities	
to lose their lives, people being robbed of their income from sale	
of forest products and vandalism of the installed equipment like	
beehives. Insecurity also hinders monitoring of the illegal	
activities in the forest such as illegal logging, illegal fires,	
deforestation as all these prevent sustainable management of the	
forest resources	

6.5 Enabling framework for overcoming the Barriers in the Agricultural, Forestry, and Other Land Use (AFOLU)

Addressing the key barriers for each of the prioritized technologies requires a responsive enabling framework in place. The Ministry of Environment and Forestry (MoEF-GOSS) and the local governments, working in collaboration with other key stakeholders (iluding: forest adjacent communities, civil society, the private sector, cultural institutions, and religious institutions), have a key role to play based on their mandates and responsibilities as stipulated in the existing National Forest Policy (2012) and the Environment Protection Bill, 2010 Cap 7 (Draft).

The current South Sudan forestry policy and legislation presents a great opportunity for addressing some of the barriers by integrating appropriate strategies to strengthen the diffusion of forest-based enterprises and sustainable forest management (SFM) for reducing emissions from deforestation and forest degradation. This will require structured engagements with policymakers and decision-makers to appreciate the barriers and the associated strategies for addressing barriers that hinder the transfer and diffusion of the two climate change mitigation technologies. Government of South Sudan initiatives in support of implementation of the strategy, action, and response for addressing the barriers for the prioritized Agricultural, Forestry, and Other Land Use (AFOLU) technologies.

Subsequently, the stakeholder Consultation considered the following as the most important strategies/actions:

Barriers	Enabling environment	Responsible Institution
Low budgetary allocation	IEstablish workable financingMinistry of	
and lack of financial	options for SFM and forestry based Environment a	
services	enterprise activities	Forestry both at
		national and State level
	Improving access to inputs and	
	services for example providing	Private sectors engaged
	incentives to support forest based	in the forestry sector

Table 52. Enabling framework for addressing barriers common to the two technologies in the waste sector

	enterprise and sustainable forest management (SFM) for reducing emissions from deforestation and forest degradation for instance, small grants and or technical support for development of sustainable forest management plans	
Limited knowledge and awareness	Strengthening awareness creation round sustainable Forest based enterprise and sustainable forest management (SFM) for reducing emissions from deforestation and forest degradation. Also, creating awareness about existing policies and laws, which provide for and protect the forest.	Ministry of Environment and Forestry both at national and State level Private sectors engaged in the forestry sector
Inadequate policy implementation and enforcement	Strengthen enforcement of forestry and land policies, laws and guidelines through proactive stakeholder engagement and standards for quality at different scales. Policy for promotion investment,	Ministry of Environment and Forestry (MoEF) and Forest protection unit or Police within the areas
business and development private sector including capital market and access to finance		
Limitation in information and knowledge	Identify knowledge gaps in implementation of Forest based enterprise as well as SFM activities. Provide support for testing and demonstration on SFM and forestry based enterprise activities in South Sudan and training programmes in SFM and forest based enterprises	Ministry of Environment and Forestry Central Forest Reserves and Plantations authority
Technical skills limitation	Enhanced capacity of government of South Sudan (GOSS) institutions and rural communities to	Ministry of Environment and Forestry

	sustainably manage and benefit			
	from CF and buffer zone natural	State Forest Plantations		
	resources. Strengthen institutional	Private forest authority		
	and technical capacities for the	Community Forest		
	integrated management of forest	authorities		
	through responsive institutional			
	capacity building training programs			
	and public awareness-raising			
	activities.			
	Creation of well-developed rural			
	forest-based enterprises, which			
	provide sustainable economic			
	opportunities for farmers and forest-			
	dependent communities while			
	combatting deforestation and forest			
	degradation,			
Market and business	Strengthening Capacities and Ministry of			
limitations	Market Linkages in Community	Environment and		
	Forestry MSME. Equipping	Forestry		
	MSMEs with the business			
	management skills needed to	State Forest Plantations		
	increase market access and the	Private forest authority		
	knowledge and competencies	Community Forest		
	necessary to comply with forest	authorities		
	sector regulations.			
	Create new and improve existing			
	market access to market of the forest			
	products and developing niche			
	market for high quality forest based			
	enterprise products			

CHAPTER 7. CONCLUSION AND NEXT STEPS

The Barrier Analysis and Enabling Framework for climate change adaptation and mitigation technologies report echoes the contributions of the numerous and diverse stakeholders and expert working groups consulted cross the six (6) adaptation and mitigation sectors and for the twelve technologies prioritized for BA&EF. In each technology, barriers to diffusion and measures to overcome them were identified in participatory and consultative workshops involving stakeholders. These barriers and measures, both financial and non-financial, are discussed in this report as well as background material relevant to overall development needs of South Sudan.

The findings identified several interrelated barriers among the twelve (12) adaptation and mitigation technologies, and it is significant that for all potential interventions, access to finance for capital and operating expenses was a common barrier for the diffusion of both adaptation and mitigation technologies. Market categorization of the technologies was useful for relating potential cost and source of funding, and the categories were as follows: Consumer goods - 5; Capital goods-3; and Publicly Provided Goods 4. The need for strengthening laws and regulations, setting of appropriate policies (incentives or disincentives), ensuring climate informed decision-making and planning, promoting research and technology awareness, and implementing pilot demonstration projects were some of the recurring measures.

Other barriers and associated enabling measures included: the limited budget designated for the diffusion of the technologies, lack of technical skills and knowledge; lack of clear government policy framework; integrated approaches to the dissemination of technologies; knowledge gaps, research and knowledge transfer mechanisms; regulatory and institutional environments; insecurity and political decision-making.

Barriers were not considered insurmountable even though the challenges of accessing /identifying funding and creating behavioral change would require targeted, funding and innovative approaches. It is important to underscore that the technologies prioritized for each sector are linked to South Sudan National Development Plan - Vision 2030 - which stipulates the need for sustainable environment protection and resilience to climate change. The associated outcomes of this goal are Sustainable management and use of environmental and natural resources, Disaster risk reduction and climate change adaptation, and sustainable development. Other target speaks about energy security and efficiency and resilient agriculture. Of further note is the medium-term revised South Sudan National Development Strategy (R-NDS) which reinforces the implementation of long-term Vision 2030, and which identifies medium term priorities, strategies, and actions to achieve Agenda 2030. The R-NDS (2021) has identified environmental sustainability and climate change response as one of the strategic priorities to be addressed. The

Environmental Protection Bill, 2013, and National Environmental Policy, 2014 further align with the Sustainable Development Goals and the relevant targets for SDG 13 primarily - Climate action - and Goals 6 and 7 which address water and energy, respectively.

The ability to quantify costs and benefits of transferring the technologies was stymied by readily available data. While many of the prioritized technologies are already used in South Sudan, there is a lack of research, auditing, and development on the true economic, environmental, and social benefit of these technologies. It is recommended that consideration be given to conducting audits and economic analysis, particularly to any potential funded projects which utilized these prioritized technologies. This study will allow for a better understanding of the economic, social and environmental benefits of the proposed climate change adaptation and mitigation technologies.

LIST OF REFERENCES

Adam, Y.O., Pettenella, D. 2013. "The Contribution of Small-Scale Forestry-Based Enterprises to the Rural Economy in the Developing World: The Case of the Informal Carpentry Sector, Sudan." https://link.springer.com/article/10.1007/s11842-012-9223-1

Adenle, A. A. 2020. "Assessment of solar energy technologies in Africa-opportunities and challenges in meeting the 2030 agenda and sustainable development goals. ." https://doi.org/10.1016/j.enpol.2019.111180

Adesina, A. A., Langyintuo, A., Bugo, N., Makinde, K., Bigirwa, G., & Wakiumu, J. 2012. "Improving farmers' access to agricultural inputs and finance: Approaches and lessons from sub-Saharan Africa. In Hazell et al. (Ed.), New directions for smallholder ." https://doi.org/10.1093/acprof:oso/9780199689347.003.0009

Adkins, Bryan. 2015. "Forestry and Prospects for Stability, Livelihoods and Peace building in theEquatorial States of South Sudan." DOI:10.13140/RG.2.1.3812.1200

Alkire, S., Kanagaratnam, U. and Suppa, N. 2020. "The global Multidimensional Poverty Index (MPI)." https://ophi.org.uk/publication/MN-49-2020

Alliance for a Green Revolution in Africa, (AGRA,2022). Seed Sector Development for South Sudan (SSD4SS). Report February 2022.

Amogpai, Ater. 2011. "Energy and Politics in South Sudan."

Anyang, Robert. 2017. "Fostering Youth-Led Farmer Services Enterprises in Uganda."

Arbab, Neelam, Farooq, Usman, Ashraf, Adnan, Ullah, Sami, Israr, Muhammad, Khattak, Sanam,Ghafoor, Irshad, 2021. "The Role Of Formal Education In farm Productivity And Farmer's Socio- Economic Development In District SWAT."

AWEPA. 2007. "AWEPA Annual report."

https://www.bibalex.org/Search4Dev/files/369358/207446.pdf

Britannica, Encyclopedia. 2023. "Britannica, The Editors of Encyclopaedia. "poverty". Encyclopedia Britannica, 19 Nov. 2023, https://www.britannica.com/topic/poverty. Accessed 22 November 2023."

Bryan Adkins (2015) Forestry and Prospects for Stability, Livelihoods and Peace-building in the Equatorial States of South Sudan.

Choudhary, Jean-Luc Stalon and Biplove. 2017. "Confronting Climate Change in South Sudan: Risks and OpportunitiesSudan Tribune."

Dijkxhoorn, Y., van Galen, M., Barungi, J., Okiira, J., Gema, J., & Janssen, V. 2019. "Dijkxhoorn, Y., van Galen, M., BaruThe vegetables and fruit sector in Uganda: Competitiveness, investment and trade options."

Doss, Cheryl R , Morris, Michael L. 2000. "How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana." *Agricultural economics* 27-39.

Duah, Hans Kwaku and Segbefia, Alexander Yao and Adjaloo, Michael Kodwo and Forkuor, D. 2017. "Income sustainability and poverty reduction among beekeeping value chain actors in the Berekum Municipality, Ghana." *International Journal of Development and Sustainability* 667--684.

Edoardo Borgomeo, Claire Chase, Nicolas Salazar Godoy, and Victor Osei Kwadwo (2023). Rising from the Depths: Water Security and Fragility in South Sudan (2023), doi: 10.1596/978-1-4648-1943-8. A PDF of the final book, once published, will be available at https://openknowledge.worldbank.org/handle/10986/29311 and <u>http://documents.worldbank.org/</u>

El Tahir, B.A. 2015. "Climate change adaptation through sustainable forest management in Sudan: Needs to qualify agroforestry application. ." *Sudan Academy Science Journal*.

Elzaki, E., Tian, G. 2020. "Economic evaluation of the honey yield from four forest tree species and the future prospect of the forest beekeeping in Sudan." *Agroforest Syst 94, 1037–1045*.

FAO. (2020). Early Warning Early Action Report on Food Security and Agriculture (January–March 2020). Rome. <u>https://www.fao.org/3/ca7557en/ca7557en.pdf</u>

FAO. 1996. "Rome Declaration on World Food Security and World Food Summit Plan of Action : World Food Summit, 13-17 November 1996, Rome, Italy."

FAO. 2016. "South Sudan strengthening natural resources; emergencies: http://www.fao.org/emergencies/fao-in-action/stories/stories-detail/en/c/418029/."

FAO. 2020. "sustainable forest management."

FAO. 2022. "Scaling up efforts to support the development of South Sudan's honey sector."

FAO. 2022. "State of world's forests."

Ferreira, Thomas. 2018. "Does education enhance productivity in smallholder agriculture? Causal evidence from Malawi." *Stellenbosch Econ Work Pap WP05*.

Foster, S., Tuinhof, A., & Van Steenbergen, F. 2012. "Managed groundwater development for water-supply security in Sub-Saharan Africa: investment priorities. ."

Garang Kuch S, Bavumiragira JP. 2019. "Impacts of crude oil exploration and production on environment and its implications on human health."

Garvey, Nihal Fernando and Walter. 2013. "The Rapid Water Sector Needs Assessment and a Way Forward."

Gebre, Girma Gezimu. 2019. "Gebre, Girma Gezimu, et al. "Gender differences in the adoption of agricultural technology: The case of improved maize varieties in southern Ethiopia."

Gille, V. 2013. "Education spillovers in farm productivity."

Gogoi, A., Ahirwal, J. and Sahoo, U.K. 2022. "Contribution of ecosystem carbon storage in major forest types of Eastern Himalaya: implications for carbon management." *Journal of Environmental Management*.

Haataja, M., Laajalahti, A., & Hyvärinen, J. (2016). Expert views on current and future use of social media among crisis and emergency management organizations: Incentives and barriers. Human Technology, 12(2), 135–164. <u>https://doi.org/10.17011/ht/urn.201611174653</u>

Hayat, M. B., Ali, D., Monyake, K. C., Alagha, L., and Ahmed, N. 2019. "Solar energy—A look into power generation, challenges, and a solar-powered future." International Journal of Energy Research, 43(3), 1049-1067.

Heckl, Renaud and Smith, Pete and Macdiarmid, Jennie I and Campbell, Ewan and Abbott, Pamela. 2018. "Beekeeping adoption: A case study of three smallholder farming communities in Baringo County, Kenya."

Hiltz, S. R., Kushma, J., & Plotnick, L. (2014). Use of social media by U.S. public sector emergency managers: Barriers and wish lists, 10. Proceedings of the 11th International strategies and barriers for social media in crisis 54 ISCRAM conference, University Park, Pennsylvania, USA.

http://ww.w.iscram.org/legacy/ISCRAM2014/papers/p11.pdf

https://documents1.worldbank.org/curated/en/609951468330279598/pdf/693580ESW0P1230ast er0Risk0Reduction.pdf

https://rise.esmap.org/data/files/library/south-

sudan/Electricity%20Access/South%20Sudan_Electricity%20Sector%20Diagnostic_2021.pdf https://www.fao.org/3/I8656EN/i8656en.pdf

https://www.government.nl/binaries/government/documenten/reports/2022/02/04/seed-sectordevelopment-for-south-sudan-end-of-project-

evaluation/SSD4SS+End+Of+Project+Evaluation.pdf

https://www.preventionweb.net/publication/south-sudan-mhadm-strategic-plan-2018-2020 https://www.researchgate.net/publication/305767433_Forestry_and_Prospects_for_Stability_Liv_elihoods_and_Peace-building_in_the_Equatorial_States_of_South_Sudan

https://www.unccd.int/sites/default/files/ldn_targets/202003/South%20Sudan%20LDN%20Coun try%20Commitments.pdf

https://www.usaid.gov/sites/default/files/2024-02/2024-02-

01_USG_South_Sudan_Complex_Emergency_Fact_Sheet_2.pdf

ICPALD. 2016. "The Contribution of Livestock to the South Sudan Economy: Policy Breif."

International, Trade, Centre. 2022. "Promoting SME Competitiveness in South Sudan: Targeted solutions for a resilient future. ITC, Geneva."

Irfan, M., Zhao, Z. Y., Ahmad, M., and Mukeshimana, M. C., 2019. "Solar energy development in Pakistan: Barriers and policy recommendations."

Irmak Suat et ta., (2011)"Irrigation Efficiency and Uniformity, and Crop Water Use Efficiency" (2011). Biological Systems Engineering: Papers and Publications. 451. https://digitalcommons.unl.edu/biosysengfacpub/451 Jeil, Emmanuel Bintaayi and Segbefia, Alexander Yao and Abass, Kabila and Adjaloo, Michael. 2020. "Livelihood security along beekeeping value chain: lessons from Ghana's beekeeping experience." *GeoJournal* 565--577.

Jesson, J., Pocock, R. and Stone, I. (2014) Barriers to Recycling: A Review of Evidence since 2008. The Waste & Resources Action Programme: Banbury.

JOUR, Mohamed, Issam, Akongdit, Addis. 2012. "Political Stability and Economic Development in the New Nation of South Sudan." *Electronic Journal*.

Kaiser, Noah, and Christina K. Barstow. 2022. "Kaiser, NoahRural Transportation Infrastructure in Low- and Middle-Income Countries: A Review of Impacts, Implications, and Interventions"."

Kumar, A., T. Schei, A. Ahenkorah, R. Caceres Rodriguez, J.-M. Devernay, M. Freitas, D. Hall, Å. Killingtveit, Z. Liu, (2011) Hydropower. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/site/assets/uploads/2018/03/Chapter-5-Hydropower-1.pdf

Kumar, A., T., et al., (2011) Hydropower. In IPCC Special Report on Renewable Energy Sources and Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. <u>https://www.ipcc.ch/site/assets/uploads/2018/03/Chapter-5-Hydropower-1.pdf</u>

Kwai Malak Kwai Kut, Ankur Sarswat, Jochen Bundschuh, Dinesh Mohan (2019). Water as key to the sustainable development goals of South Sudan – A water quality assessment of Eastern Equatoria State, Groundwater for Sustainable Development, Volume 8 Pages 255-270, ISSN 2352-801X, <u>https://doi.org/10.1016/j.gsd.2018.07.005</u>.

Latif, Mohd Nazip Suratman and Zulkiflee Abd. 2020. "Managing World's Forests for Sustainable Development." *IntechOpen*.

Lawry, S., McLain, R., & Kassa, H. (2015). Strengthening the resiliency of dryland forest-based livelihoods in Ethiopia and South Sudan: A review of literature on the interaction between dryland forests, livelihoods and forest governance. Center for International Forestry Research. http://www.jstor.org/stable/resrep02389

Lawry, Steven, Rebecca McLain, and Habtemariam Kassa. 2015. "Dryland Forests, Livelihoods and Governance in South Sudan." Strengthening the Resiliency of Dryland Forest-Based Livelihoods in Ethiopia and South Sudan: A Review of Literature on the Interaction bet."

Lin, X., Spence, P. R., Sellnow, T. L., & Lachlan, K. A. (2016). Crisis communication, learning and responding: Best practices in social media. Computers in Human Behavior, 65, 601–605. https://doi.org/10.1016/j.chb.2016.05.080

Liu, Jianxu, Li, Xiaoqing, Liu, Shutong, Rahman, Sanzidur, Sriboonchitta, Songsak. 2022. "Addressing rural–urban income gap in China through farmers' education and agricultural productivity growth via mediation and interaction effects." *Agriculture*. MacAlister C, Pavelic P, Tindimugaya C, Ayenew T, Ibrahim ME, Meguid MA (2013). Overview of groundwater in the nile river basin. doi:10.4324/9780203128497

Majid, M. A. 2020. "Renewable energy for sustainable development in India: current status, future prospects, challenges, employment, and investment opportunities. Energy, Sustainability and Society." 1-36.

Manuela Lasagna, Sabrina Maria Rita Bonetto, Laura Debernardi, Domenico Antonio De Luca, Carlo Semit Chiara Caselle. 2020. "Groundwater Resources Assessment for Sustainable Development in South Sudan."

Mburu, Peter Denis Muiruri and Affognon, Hippolyte and Irungu, Patrick and Mburu, John and Raina, Suresh. 2017. "Gender roles and constraints in beekeeping: A case from Kitui County, Kenya." *Bee World* 54--59.

Ministry of Agriculture and Food Security, Goss (2019) Governmental high-level note of measures to achieve the national LDN targets"

Ministry of Agriculture and Food Security, Ministry of Livestock and Fisheries, Ministry of Environment and Forestry, (2016) Comprehensive Agricultural Development Master Plan Final Report.<u>http://mafsconcept.mafs.gov.ss/wp-content/uploads/2022/07/GoRSS-0-CAMP-Final-</u>Report.pdf

Ministry of Agriculture, Forestry, Cooperatives and Rural Development, (2022). Agriculture Sector Policy Framework (ASPF): 2012-2017. <u>https://faolex.fao.org/docs/pdf/ssd149325.pdf</u>

Ministry of Environment and Forestry, (2021), Juba South Sudan's Second Nationally Determined Contribution.<u>https://www.undp.org/sites/g/files/zskgke326/files/migration/ss/South-Sudans-</u> <u>Second-Nationally-Determined-Contribution.pdf</u>

Moorthy, K., Patwa, N., and Gupta, Y. 2019. "Breaking barriers in deployment of renewable energy." <u>https://www.sciencedirect.com/science/article/pii/S2405844018354240</u>

Mozersky, David. 2018. "South Sudan's Renewable Energy Potential: A Building Block for Peace." https://www.usip.org/sites/default/files/2018-01/sr418-south-sudans-renewable-energy-potential-a-building-block-for-peace.pdf

MWRI, and Ministry of water Resources and Irrigation. 2021. "Preliminary Water Information Assessment Study." JUBA.

Nayak, S. and Sahoo, U.K. 2020. "Contribution of mahua to household economy in Odisha. ." *Odisha. Environment and Ecology*, *38*(2), *204-207* (Odisha. Environment and Ecology, *38*(2), 204-207).

Nsubuga, F. N., Namutebi, E. N., & Nsubuga-Ssenfuma, M. 2009. "Water resources of Uganda: an assessment and review." *Journal of Water Resource and Protection*, 6(14).

Opoku, A. (2019), "Sustainable development, adaptation and maintenance of infrastructure", International Journal of Building Pathology and Adaptation, Vol. 37 No. 1, pp. 2-5. https://doi.org/10.1108/IJBPA-02-2019-074

orgomeo, Edoardo, Claire Chase, Nicolas Salazar Godoy, and Victor Osei Kwadwo. 2023. "Rising from the Depths: Water Security and Fragility in South Sudan."

Oseni, Gbemisola and Goldstein, Markus and Utah, Amarachi. 2013. *Gender dimensions in Nigerian agriculture*. World Bank, Washington, DC.

Pathak, S. K., Sharma, V., Chougule, S. S., and Goel, V. 2022. "Prioritization of barriers to the development of renewable energy technologies in India using integrated Modified Delphi and AHP method. Sustainable Energy Technologies and Assessments."

PEFC. 2023. "Sustainable forest Management."

https://www.pefccanada.org/docs/2023_sept_12_pefc_sustainable_forest_management_standard _pefc_can_st_1001_20xx.pdf

Peter Alstone, Dimitry Gershenson, and Daniel Kammen. 2015. "Decentralized Energy Systems for Clean Electricity Access; Nature Climate Change." 305-314.

Pragst F, Stieglitz K, Runge H, et al. 2017. "PragsHigh concentrations of lead and barium in hair of the rural population caused by water pollution in the TharJath oilfields in South Sudan. ." *Forensic Sci Int.*

Ragasa, Catherine, Sengupta, Debdatta, Osorio, Martha, OurabahHaddad, Nora, Mathieson, Kirsten. 2015. "Gender-specific approaches, rural institutions and technological innovations."

REACH Initiative (2018) South Sudan - Now the Forest is Blocked": Shocks and Access to Food. https://reliefweb.int/report/south-sudan/now-forest-blocked-shocks-and-access-food

Relief and Rehabilitation Commission (RRC, 2023), Flood Assessment Report in South Sudan <u>https://www.fao.org/3/I8656EN/i8656en.pdf</u>

Rogers David and Vladimir Tsirkunov (2010). Costs and benefits of early Warning systems.

RSS. 2015. "Fifth National Report to the Convention on Biological Diversity. Juba: Ministry of Environment (MOE), Republic of South Sudan (RSS)."

Ruiz, A., and J. Guevara. 2020. "Sustainable Decision-Making in Road Development: Analysis of Road Preservation Policies."

Ruzzante, Sacha, Ricardo Labarta, and Amy Bilton. 2021. "Adoption of agricultural technology in the developing world: a meta-analysis of the empirical literature." (World Development).

Sikiru, Anaza & Abdulazeez, & Yisah, Yakubu & Yusuf, Y & Salawu, B & Momoh, S. (2017). Micro Hydro-Electric Energy Generation-An Overview. American Journal of Engineering Research. 6. 5-12. <u>https://www.researchgate.net/publication/356028778_Micro_Hydro-Electric_Energy_Generation-An_Overview/citation/download</u> Sloots, R. 2010. "Assessment of groundwater investigations and borehole drilling capacity in Uganda. Government of Uganda (MWE) and UNICEF."

Solangi, Y. A., Longsheng, C., and Shah, S. A. A. 2021. "Solangi, Y. Assessing and overcoming the renewable energy barriers for sustainable development in Pakistan: An integrated AHP and fuzzy TOPSIS approach." 209-222.

South Sudan Relief and Rehabilitation Commission (RRC, 2022) Flood Assessment in South Sudan. <u>https://www.undp.org/south-sudan/publications/flood-assessment-report-south-sudan</u>

SPR MWE. 2019. "Water and Environment Sector Performance Report."

Subedi, A., Van Uffelen, G.J., Ngalamu, T. (2022). Contextual Analysis of South Sudan's Seed Sector and Pathways for Building to Seed Sector Resilience. A Feed the Future Global Supporting Seed Systems for Development activity (S34D) and Food and Nutrition Security Resilience Program (FNSREPRO) report. <u>https://www.crs.org/sites/default/files/cont-analysis-ssudan-seeds.pdf</u>

Subedi, A., Van Uffelen, G.J., Ngalamu, T. 2022. Contextual Analysis of South Sudan's Seed Sector and Pathways for Building to Seed Sector Resilience. A Feed the Future Global Supporting Seed Systems for Development activity (S34D) and Food and Nutrition Security Resilience Program (FNSREPRO) report. <u>https://www.crs.org/sites/default/files/cont-analysis-ssudan-seeds.pdf</u>

Sudan, AfDB. South. 2013. " An Infrastructure Action Plan - A Program for Sustained Strong Economic Growth. Tunis, Tunisia."

Taylor, R. G., Koussis, A. D., & Tindimugaya, C. 2009. *Groundwater and climate in Africa—a review*. . Hydrological Sciences Journal, 54(4), 655-664.

The Food and Agriculture Organization of the United Nations & World Food Programme (2018) Special Report. Crop and food security assessment mission to South Sudan. https://www.fao.org/3/i8702EN/i8702en.pdf

The Food and Agriculture Organization of the United Nations (FAO, 2017) The impact of disasters and crises on agriculture and food security in South Sudan.

The Ministry of Humanitarian Affairs and Disaster Management – GOSS (2018). The South Sudan Disaster Management Strategic Plan 2018 – 2020.

The United States Agency for International Development (USAID, 2014). South Sudan – Complex Emergency.

The World Bank (2021). South Sudan Electricity Sector Diagnostic

Thiak Samuel and Anil Hira, (2024). Strategic options for building a new electricity grid in South Sudan: The challenges of a new post-conflict nation, Energy Research & Social Science, Volume 109, 103417. ISSN 2214-6296, <u>https://doi.org/10.1016/j.erss.2024.103417</u>.

Twaha, S., M.A. Ramli, P.M. Murphy, M.U. Mukhtiar, and H.K. Nsamba. 2016. "Renewable based distributed generation in Uganda: Resource potential and status of exploitation. Renew. Sustain."

Udimal TB, Jincai Z, Mensah OS, Caesar AE. 2017. "Udimal, Thomas Bilaliib, et al. "Factors influencing the agricultural technology adoption: The case of improved rice varieties (Nerica) in the Northern Region, Ghana." *Journal of Economics and Sustainable Development* 137-148.

UNDP. 2023. "Strengthening Agricultural Value Chains & AfCFTA Linkages in South Sudan: Opportunities and Challenges."

United Nations Entity for Gender Equality and the Empowerment of Women (UN Women), (2022) South Sudan/Floods, Local Conflict and Drought Humanitarian Gender Alert. <u>https://africa.unwomen.org/sites/default/files/2023-</u>

06/SOUTH%20SUDAN%20HUMANITARIAN%20GENDER%20ALERT%5B73%5D.pdf

United States Agency for International Development (USAID, 2017) Southern Sudan Environmental Threats and Opportunities Assessment Biodiversity and Tropical Forest Assessment.

https://documents1.worldbank.org/curated/en/784491468119336169/pdf/611190ESW0P1071SS Forest0Policy0Note.pdf

USAID (2007) Southern Sudan Environmental Threats and Opportunities Assessment Biodiversity and Tropical Forest Assessment. <u>https://pdf.usaid.gov/pdf_docs/PNADL108.pdf</u>

USAID. 2021. "Sustainable water partnership." https://winrock.org/projects/swp/

WHO/UNICEF. 2020. "Joint Monitoring Program." https://washdata.org/

Wilkins, G. 2010. "Technology Transfer for Renewable Energy; Taylor & Francis: Abingdon, UK."

World Bank Group, WBG. 2022. "South Sudan receives \$120 million to continue strengthening service delivery, Community Institutions, and Resilience to Floods."

World Bank. 2010. "A Legal and Institutional Policy Framework for Sustainable Management of Forest Resources in Southern Sudan; a Policy Note."

WPDx. 2020. "Water Information Management System (WIMS) developed by Ministry of Water Resources and Irrigation. Waterpointdata.org. ."

Wyllie, Jamalia O.Y. & Essah, Emmanuel A. & Ofetotse, Eng L., 2018. "Barriers of solar energy uptake and the potential for mitigation solutions in Barbados." *Elsevier* 935-949.Borgomeo, Edoardo, Claire Chase, Nicolas Salazar Godoy, and Victor Osei Kwadwo (2013), Rising from the Depths: Water Security and Fragility in South Sudan. International Development in Focus, 2023. https://www.worldbank.org/en/country/southsudan/publication/rising-from-the-depths-water-security-and-fragility-in-afe-south-sudan

ANNEX 1: MARKET MAPS AND PROBLEM TREES

Annex 1.1 A: Market Mapping for Micro Sprinkler and Drip Irrigation technology

ANNEX 1: MARKET MAPS AND PROBLEM TREES

Annex 1.1A: Market Map for Micro Sprinkler and Drip Irrigation technology



Annex 1.2A: Problem Tree – Micro Sprinkler and Drip Irrigation technology

Annex 1.2A: Problem Tree - Micro Sprinkler and Drip Irrigation technology



Annex 1.1B: Market Mapping for the Promotion of Drought Tolerant Crop Varieties



Annex 1.1B: Market Map for the Promotion of Drought Tolerant crop varieties

Annex 1.2B: Problem Tree – Promoting Drought tolerant crop varieties

Annex 1.2B: Problem Tree - Promoting Drought tolerant crop varieties



Annex 1.1C: Market Map for micro–Hydro power technology



Annex 1.2 C: Problem Tree – Micro Hydropower technology



Annex 1.1 D: Market Mapping for Off-grid solar mini-grids technology of up to 100 Kw



Annex 1.2 D: Problem Tree – Off-grid solar mini-grids technology of up to 100 kW.







Annex 1.2 E: Problem tree– Waste Reduce, Reuse and Recycle (3Rs) technology



Annex 1.1 F: Market Mapping for Solid Waste transfer station technology



Annex 1.2 F: Problem Tree – Waste transfer station technology



Annex 1.1 G: Market Map for Promoting Forest based enterprises e.g. bee keeping/apiary



Annex 1.2 G: Problem Tree – Promoting Forest based enterprises e.g. bee keeping/apiary



Annex 1.1 H: Market Mapping for Sustainable Forest Management (SFM) technology



Annex 1.2 H: Problem Tree – Sustainable Forest Management (SFM) technology



Annex 2: List of Stakeholders involved and their Contacts

2.1 Attendance Register for the South Sudan Barrier Analysis and Enabling Framework Workshop

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