Republic of South Sudan

TECHNOLOGY NEEDS ASSESSMENT REPORT FOR CLIMATE CHANGE ADAPTATION AND MITIGATION

AUGUST 2023

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South Sudan

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Foreword

South Sudan is vulnerable to climate change. The rise in climate extreme events such as floods and dry spells has already had an impact on the country's development plans. Several study findings predicted that the country would experience a more intense impact of extreme events in the future, necessitating concrete climate change action

In response to climate change, as a party to the United Nations Framework Convention on climate change, South Sudan has undertaken several initiatives to ensure that our development pathway is resilient to climate change impacts. South Sudan Nationally Determined Contribution (to the Paris Agreement) (NDC) aimed to create a climate-resilient country by integrating adaptation and mitigation actions and technologies into all vulnerable sectors plans and policies. South Sudan also developed a comprehensive national adaptation programme of action (NAPA) that prioritized urgent and immediate adaptation and mitigation actions in the country. South Sudan has also developed its national adaptation plan (NAP) which has defined the country medium, short, and long-term adaptation needs.

Adaptation and mitigation to climate change impacts is a priority for South Sudan which is well articulated in the various climate change plans documents. Determining a suite of adaptation and mitigation actions, however, poses a challenge given the country's limited knowledge of climate science, vulnerability, and risks. Regardless, identifying and implementing a set of innovative adaptive and mitigation measures will aid in effectively addressing climate risks. In this regard, through a consultative process involving multiple stakeholders, promising adaptation and mitigation technologies for Agriculture, Livestock and Fisheries, Water and Disaster Risk Management, Energy, Waste and Agricultural, Forestry, and Other Land Use (AFOLU) sectors in South Sudan were identified. These adaptation and mitigation technologies have the potential to reduce the negative impact of climate change in the short and long term as well as contribute to climate-resilient development planning.

On behalf of the government of South Sudan and the Ministry of Environment and Forestry (MoEF), I would like to thank all the stakeholders and institutions who got involved in the preparation of this TNA report, their invaluable comments, inputs, and suggestions have enriched the report. I am also grateful to UNEP CCC, the University of Cape Town and the consultant for providing technical assistance and finalization of this report. Similarly, I am thankful to my colleagues at the Ministry of Environment and Forestry (MoEF), Directorate of Climate Change for the strategic guidance in finalizing the TNA report.

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Acknowledgments

South Sudan contributes an insignificant amount of greenhouse gas emission to the global greenhouse gas emission; however, the country has increased its climate change adaptation and mitigation ambition by committing to a net-zero emission and increasing its climate resilience by 2030. The transition to low carbon development and ambition in its adaptation actions are well articulated in the Government of South Sudan NAPA, NAP, and its second nationally determined contribution (NDC) to the Paris Agreement on climate change.

I am confident that the technology needs assessment for climate change adaptation and mitigation, commissioned by the Ministry of Environment and forestry (MoEF) of the Government of South Sudan with support from Global Environment Facility (GEF) and the United Nations Environment Programme (UNEP) will provide an opportunity to integrate, introduce and disseminate prioritized adaptation and mitigation technologies in Agriculture, Livestock and Fisheries, Water, Disaster Risk Reduction, Energy, Waste and Agricultural, Forestry, and Other Land Use (AFOLU) Sectors of the Country.

The Reports prioritized adaptation and mitigation technologies that are the result of a thorough consultative process with relevant stakeholders and experts at the national and sub-national levels. I am optimistic that the adaptation and mitigation technologies recommended in this TNA report will help to accelerate climate action and facilitate low carbon and climate resilience development at all levels of government including counties and states by strengthening sectorial adaptation and reducing emissions from various sectors. At the same time, I believe that implementing these adaptations and mitigation technologies will improve the country's resilience to climate change and reduce emissions to maintain net zero ambition. I encourage national and international development partners to step in and support the promotion of prioritized technologies as part of the South Sudan Government's efforts to ensure a climate-resilient and low-carbon country.

The Ministry of Environment and Forestry (MoEF- GOSS) and the national TNA team express their sincere gratitude to the Global Environmental Facility (GEF) and the UNEP Copenhagen Centre for financial and technical support through the technology needs assessment preparation processes.

In addition, I would like to appreciate the effort of the International TNA Review team comprising Gordon Mackenzie from UNEP Copenhagen Climate Centre, and Debbie Sparks from the University of Cape Town, in guiding the TNA preparation. Further, the MoEF is also grateful to all the TNA Team members, consultants, and sectorial expert working groups who contributed ideas, suggestions, and constructive comments to the completion of this TNA report.

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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
SSDP	South Sudan Development Plan 2011-2016
SSMD	South Sudan Meteorological Directorate
TNA	Technology needs assessment
TAP	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

South Sudan is a least developed country located in the Eastern Africa region. It is the world's youngest country, becoming independent on 9th July 2011 when it seceded from the Republic of Sudan, following a referendum held in January 2011 after 21 years of civil war. In addition to the negative impacts of a prolonged period of conflict, the South Sudan population is also experiencing the negative effects of climate change and variability. Climate Change has been identified as one of the most important threats to the development of South Sudan. The adverse impacts of climate change in South Sudan are already being felt. Over the past 30 years, South Sudan has been among the most rapidly warming locations on the globe, with temperatures increasing as much as 0.4°C per decade (Verisk Maplecroft, 2017). It has been estimated that temperatures in the country have increased by more than 1°C since 1980 (Niang, I., et al. (2014). – warming that is 'two and a half times greater than global warming, (which) is making 'normal' years effectively drier'. The weather pattern changes are inter-alia estimated to lower crop yields by 20% due to increased risks of floods and droughts, exacerbate risks of pests, disease outbreaks and further worsen the alarming levels of food insecurity and famine-like conditions in parts of the country (Relief Web (2019).

South Sudan became a party to the United Nations Framework Convention on Climate Change (UNFCCC) in 2014. It is also a party to the UN Convention on Biological Diversity (UNCBD) and the UN Convention to Combat Desertification (UNCCD). Since becoming a party to the above conventions, South Sudan has prepared several national reports, strategies, and plans such as the National Adaptation Programme of Actions, (NAPA) 2016, Intended Nationally Determined Contributions (NDCs), 5th National Biodiversity Report (5th NR), Initial National Communication (INC) report, and National Capacity Self-assessment (NCSA) report and action plans which provide the blueprint for addressing climate change issues in the country.

In a bid to fully address the challenges to development in the country posed by climate change while also aligning itself to climate finance mechanisms, South Sudan sees the development of a Technology Needs Assessment as an important endeavor, as the lack of a TNA poses a significant capacity gap in South Sudan to adequately address this problem. The South Sudan NDC has presented a rationale that considers key sectors and technologies for exploitation. Therefore, any efforts locally, nationally, regionally, or internationally to support environmental issues in South Sudan must address the above national gap necessary to respond to climate change issues.

For the Technology Needs Assessment (TNA), South Sudan prioritized the agriculture, livestock, and Fisheries sector; Water and disaster risk management sectors for adaptation technologies while Energy; Agricultural, Forestry, and Other Land Use (AFOLU), and waste were selected as prioritized mitigation sectors. These are sectors that were identified as most vulnerable to climate change impacts in the NAPA (2016). These sectors were prioritized in the South Sudan National Adaptation Plan of Action (NAPA) and the nationally determined contributions (NDCs) to the UNFCCC. This report presents the process followed in the identification and selection of technologies for climate change adaptation and mitigation. Sectors considered for climate adaptation and mitigation technologies were those considered as most vulnerable in NAPA (2016), ranked according to the high magnitude of climate-change risks, low capacity to cope for the adaptation sector and mitigation technology based on the contribution of the mitigation technology to sustainable development by minimizing GHG emissions from the sector, maximizing the resilience of the sector to climate change impacts, maximize development

priority benefits in terms of environmental, social, and economic, and to minimize any negative consequences of the technology.

South Sudan has set up the appropriate institutional arrangements for the implementation of the TNA Project. It encompassed the TNA project team operating under the auspices of the Ministry of Environment and Forestry (MoEF- GoSS), the Project Steering Committee, and stakeholder working groups to solicit the inputs of the relevant organizations. The TNA project team comprises a Project Coordinator, an Assistant Project Coordinator, a Lead Consultant, and sectorial technical working groups of experts.

A National Inception Workshop was held to launch the TNA Project in Juba, South Sudan. It was organized by the Ministry of Environment and Forestry (MoEF) on 18th April 2023 at Juba Landmark Hotel and was attended by stakeholders and experts from the Government ministries, International non-governmental Organizations (INGOs), UN agencies, donors, private sectors, universities, and researchers. The workshop was aimed at facilitating enhanced awareness and active engagement of a broader group of stakeholders on the TNA process and addressing relevant issues relating to the TNA process such as the choice of the sectors for the TNA. The forty-five (45) participants who attended the workshop were drawn from the stakeholder organizations including the Ministry of Environment and Forestry (MoEF), Ministry of Agriculture and Food Security (MAFS), Ministry of Irrigation and Water Resources, Ministry of Humanitarian Affairs and Disaster Management, Academia, private sector, INGOs, NNGOs, Ministry of Finance and Economic Planning, United Nations Development Programme (UNDP) and the Food and Agriculture Organization of the United Nations (FAO) During the inception, workshop participants were taken through the Multi-Criteria Analysis (MCA) model, to facilitate the participatory process for prioritizing the technologies presented by the experts based on agreed sets of criteria completed at the workshop.

The Prioritization of Technologies

The Second Stakeholders Workshop was held on 4th, May 2023 to prioritize the technologies for adaptation sectors namely agriculture, livestock and fisheries sector, water, and disaster risk management sectors while the Third Workshop was held on 5th May 2023 at the Ministry of Environment and Forestry (MoEF) Conference Hall to prioritize technologies for the mitigation sectors (Energy, Waste, Agricultural, Forestry, and Other Land Use (AFOLU). The consultants gave presentations on the methodology, highlighting the key objectives, principles, and considerations, which should inform their activities. The main goal of adaptation is generally reducing vulnerability by increasing resilience to climate change impacts while for mitigation the goal is to minimize GHG emissions from the sectors, maximizing the resilience of the sector to climate change impacts, maximize development priority benefits in terms of environmental, social, and economic, and to minimize any negative consequences of the technology.

The discussions at the workshops emphasized that achieving the goal and objectives ultimately requires technologies that are appropriate and feasible for the selected adaptation and mitigation sectors. In each sector, there are a range of technologies, which can be adopted for climate change adaptation and mitigation. Given that resources to support technology adoption and diffusion are limited, there is a need to prioritize the technologies on pre-determined criteria.

Potential climate change adaptation and mitigation technologies in Agriculture, livestock and fisheries, Water, and Disaster Risk Management sectors for adaptation technologies while

Energy, Agricultural, Forestry, and Other Land Use (AFOLU) and Waste Management sectors were identified. Technology identification was based on the following criteria:

- Potential to enable adaptation to projected climate change scenarios
- Priority in the national development documents
- Appropriateness, applicability/acceptability – based on national development priorities
- Experience in using the technology based on what has been tried - status of implementation for example at the pilot or rollout stage, etc.
- Greenhouse Gas Reduction (GHG) Potential in 2030
- Potential scale and replicability – geographical area and number of people impacted
- Co-benefit – Climate-related, economic benefits, environmental benefits, and social benefit
- Cost – Capital, operation and maintenance cost
- Accessibility to material, expertise, and capacity to establish and operate.

Fact sheets on each of the identified technologies were developed and shared with stakeholders. Stakeholders who actively participated in technology identification and selection were from Ministry of Environment and Forestry, Ministry of Agriculture and Food Security, Ministry of Water Resources and Irrigation, Ministry of Energy and Dams, Ministry of Humanitarian Affairs and Disaster Management, Ministry of Finance and Planning, Ministry of Petroleum, Ministry of Livestock and Fisheries, INGOs, UN Agencies, Private sector stakeholders such as Eco Clean Waste Management Company, the academia and civil society. They were engaged in a workshop where the TNA process was introduced and during the breakout sessions, which were done according to the sectors, a more in-depth discussion of potential adaptation and mitigation technologies was conducted, guided by the fact sheets. Stakeholders also recommended additional technologies in the case of both prioritized adaptation and mitigation sectors.

Using the Multi-Criteria Analysis (MCA) provided by the TNA consultant team, both mitigation and adaptation stakeholders then agreed on criteria for ranking the technologies considering potential climate scenarios to reduce vulnerability, Greenhouse Gas emission Reduction (GHGR) or increase resilience, economic, social and environmental costs and benefits. Criteria were given weights according to relative importance. Technologies were allocated scores (from 0 being the least desirable to 100, the most desirable) for each criterion, which were then multiplied by the weight of the criteria. Therefore, for costs, scores tended towards 100 if they were low and towards zero if they were high. For benefits, scores tended towards 0 if they were low and towards 100 if they were high. Total scores for each technology were used to rank the technologies considered to be of the highest priority. The top-ranked climate adaptation and mitigation sectors technologies are presented in Tables 1 & 2 below.

Table 1: Technologies prioritized and rank highest for Climate Change Adaptation

Adaptation sectors	**Total Scores**	**Ranked**
1. Agriculture, livestock, and Fisheries sector technologies		
Micro – Irrigation - Sprinkler and Drip Irrigation	8080	1
Promotion of drought-resistant crop varieties	7620	2
Value addition and processing of agricultural produce	7320	3

2. Water sector		
Solar-powered water supply system	7683	1
Groundwater Abstraction – Water Borehole Drills	7210	2
Rainwater Harvesting (RWH) from Rooftops	6990	3
3. Disaster Risk Management sector		
Development and introduction of monitoring and early warning systems	9000	1
Improving disaster response (through the use of social media)	8655	2
Flood early warning system	8350	3

Table 2: Technologies prioritized and ranked highest for Climate Change Mitigation

Mitigation sectors	**Total Scores**	**Rank technologies**
Energy Sector		
Hydropower (mini/micro hydropower)/small hydropower	7490	1
Off-grid solar mini-grids up to 100 kW – Solar PV Grid-tied	7440	2
Improved Institutional Cookstoves	6680	3
Waste management sector		
Reduce, Reuse, Recycle (3Rs)	9565	1
Transfer waste station	8620	2
Household Waste Segregation/Sorting	8380	3
Agriculture, Forestry, and Other Land Use (AFOLU) sector		
Promoting Forest based enterprises e.g. beekeeping/apiary, butterfly farming, fruit tree production, and ecotourism	8669	1
Substitute management of fossil fuel with wood fuel	8655	2
Sustainable Forest Management (SFM) for reducing emissions from deforestation and forest degradation	8490	3

In conclusion, this report describes the prioritized applicable technologies to address climate change and variability-related impact from both adaptation and mitigation technology opinions. Therefore, two of the four top technologies identified for each of the adaptation and mitigation sectors will be considered in the next step (Step II) Barrier Analysis and Enabling Framework (BA&EF) to identify the barriers and challenges that hinder the implementation of these options in South Sudan and propose an action plan to mainstream the technologies into the national and sub-national sectorial development plans and polices.

Chapter 1: Introduction

According to the Global Climate Risk Index 2021, South Sudan ranked among the top ten highly vulnerable countries to climate change on the African continent (due to its recurrent exposure to extreme weather events such as floods, droughts, extreme heat hazards, and, most recently, a locust infestation and fall armyworm that have taken a heavy toll on both human lives and have indirect and interlinked implications for economic growth, peace and security in South Sudan, (Eckstein David &Vera Künzel, 2019). The country's past climatic trends indicate a rise in temperature by 1-1.5℃ since the 1970s, and high precipitation variability embedded with extreme (wet/dry) precipitation episodes (Quinn, et al., 2019). This climatic variability translates into a heightened level of uncertainty about the frequency and intensity of extreme weather events with the potential to adversely impact the major economic sectors of the country such as agriculture, water, and energy. Within this context, South Sudan needs to develop and strengthen its coping capacity against the climate change risk by adopting a climate-resilient development strategy where technological innovation, transfer, and successful diffusion can become the center of effective country response to a low vulnerability pathway to effectively address the climate change impacts.

South Sudan became a party to the United Nations Framework Convention on Climate Change (UNFCCC) in 2014. It is also a party to the UN Convention on Biological Diversity (UNCBD) and the UN Convention to Combat Desertification (UNCCD). Since becoming a party to the above conventions, South Sudan has submitted several national reports, strategies, and plans such as the National Adaptation Programme of Actions, (NAPA) - 2016, Intended Nationally Determined Contributions (NDCs), 5th National Biodiversity Report (5th NR), Initial National Communication (INC) report, and National Capacity Self-assessment (NCSA) report, The South Sudan National Environmental Policy (2015-2025) endorsed by Parliament in April 2016, the National State of Environment and Outlook Report (SEOR) -2018 and most recently the Second Nationally Determined Contribution - (2021) and National Adaptations plans, (NAP)- 2021. These documents clearly highlight the limitations in mitigation and adaptation and provide the blueprint for addressing climate change risk issues and technologies in the country.

Although the Republic of South Sudan remains a relatively small contributor to global GHG emissions per capita, with 0.1 tons CO_2 equivalent in 2018, compared to 0.8 average in Sub-Saharan Africa, it is also the smallest emitter in Sub-Saharan Africa, with 34,170 $ktCO_2$ equivalents in 2018. The INDC estimates South Sudan's total GHG emissions to be relatively low and dominated by land use, land-use change and forestry (LULUCF), and agriculture sector emissions. GHG emissions from these sectors are mainly driven by reliance on wood fuel by an estimated 96% of the population coupled with the increasing demand for agricultural lands and urban expansion. On the adaptation side, several vulnerabilities, and climate risks have been identified, such as increased droughts and floods, water scarcity, desertification, flood vulnerability and low agricultural yields, among others.

The NAP highlighted the importance of technology transfers for South Sudan to respond to the adverse impacts of global warming and climate change impacts. It also highlights some of the challenges South Sudan is facing in identifying and introducing technologies, such as conflict, inadequate awareness of available adaptation and mitigation technologies, low capacity, poor

understanding of commercial applications, limited research on sustainable climate change resilient technologies and issues in terms of enabling environment, among others.

Within this context, The Ministry of Environment and Forestry- Government of South Sudan has requested the support of UNEP and UNEP-CCC for the development of a Technology Needs Assessment (TNA) and associated Technology Action Plan for climate change mitigation and adaptation. This TNA will be used by the Government of South Sudan for the implementation of its climate change action plans, and for financing requests toward climate finance sources such as the Green Climate Fund (GCF) and the Global Environmental Facility (GEF). The TNA process is expected to support the setting up of coordination mechanisms to govern the TNA project implementation and better coordinate climate change action in the country, while at the same time achieving South Sudan programming goals. It will encompass the identification and prioritization of technologies that can support the achievement of the country's climate goals. The TNA and the action plan developed will provide the guidance required by the South Sudan government entities in developing its climate finance pipeline. It will bridge the gap among the technologies, enabling environment and investments.

1.1: About the Technology Needs Assessment (TNA) Project

The country-driven participatory TNA process suggests a framework to support developing countries that are signatories to the United Nations Framework Convention on Climate Change (UNFCCC) in determining their technology priority needs in order to achieve their goal of climate change resilient development. The purpose of this Technology Needs Assessment (TNA) is to assist participating Developing Country Parties in identifying and analyzing priority adaptation and mitigation technology needs, which can form the basis for a portfolio of environmentally sound technologies (ESTs) interventions and project to facilitate the transfer of, and access to, environmentally sound adaptation and mitigation knowledge, practices and know-how in the implementation of Article 4.5 of the UNFCCC.

The TNA project can help pave the way for environmentally sound technology development and transfer to developing countries such as South Sudan to mitigate its greenhouse gas (GHG) emissions and adapt to the adverse impacts of climate change and variability. Developed during COP13, TNA was a key component of the Poznan Strategic Program on Technology Transfer and supported by the Global Environment Facility (GEF). The UNFCCC identifies the significance of technology development and transfers under Articles of the Convention (Art. 4.1c, Art. 4.5, and Art. 4.7). Article 4.5 states:

"The developed country parties and other developed countries in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of or access to environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention."

South Sudan is amongst 17 countries of the world conducting the TNA process in the fourth phase of this program under the auspice of UNEP CCC—the implementation entity of TNA on behalf of GEF. The Ministry of Environment and Forestry- GOSS is spearheading the TNA process in the country covering both areas of adaptation and mitigation technologies. In South Sudan, the TNA project seeks to support the identification and implementation of potential technologies for climate adaptation and mitigation sectors prioritized in the South Sudan National Adaptation Plan of Action (NAPA, 2016), The initial Nationally Determined Contributions (INDC) and in line with National Development Strategy (NDS) and Development

Plan (SSDP). The TNA is implemented by UNEP through UNEP Copenhagen Climate Centre and coordinated by the National Ministry of Environment and Forestry- GOSS, which is the national focal point for the UNFCCC and the National Designated Entity (NDE) for the Climate Technology Centre and Network (CTCN). The TNA Team in South Sudan is made up of various government institutions, private sector actors, CSOs, INGOs and academia, TNA national consultants, sector working groups, and the TNA steering committee. To make this technological deployment successful and sustainable, TNA adopts a policy-led top-down approach to identify and prioritize technologies for critical climate-vulnerable sectors of a country to achieve its climate action goals in both the short and long run. The entire process is supported by the national TNA institutional structure, vigorous assessment processes involving stakeholder engagement and consultation to ensure the legitimacy of the process while earning their strong political support to ensure full ownership of the process in the long run.

This report presents the process followed in the identification and selection of technologies for climate change adaptation and mitigation. The adaptation and mitigation sectors considered for climate technology identification were those considered as most vulnerable in the Republic of South Sudan's National Adaptation Programme of Actions (NAPA, 2016), ranked according to the high magnitude of climate-change vulnerability and low capacity to cope. 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 and Wastewater Management.

The Republic of South Sudan's Initial National Communication (NC) and the Intended Nationally Determined Contributions (INDCs) to the UNFCCC also served as a baseline for selecting the priority for mitigation and adaptation sectors. The reports, which were submitted on November 12, 2015, and revised on September 30, 2021, respectively to the UNFCCC secretariat, present the South Sudan GHG inventory for the years 2000 and 2010 with trend analysis for the period 1995-2010 and sectorial mitigation measures to reduce the national emission. The reports also present the climate risks to South Sudan, based on modeled climatic projections, identify the most vulnerable sectors, and propose adaptation measures. The preparation of the NCs was based on a participatory approach where relevant stakeholders were involved in data collection and validation of methodology, baseline, and emission scenarios, and proposed measures and action plans (MoEF, 2018).

Potential climate adaptation and mitigation technologies in the agriculture, livestock and Fisheries, water Sector, Disaster risk reduction and Management (DRRM), Energy Sector, agricultural, Forestry and Other Land Use (AFOLU), and Solid waste management sector were identified. Technology identification was based on the following:-

- Potential to enable adaptation to projected climate change scenarios
- Priority in the national development documents
- Appropriateness, applicability/acceptability – based on national development priorities
- Experience in using the technology based on what has been tried - status of implementation for example at the pilot or rollout stage, etc.
- Greenhouse Gas emission Reduction (GHGR) in 2030 potential
- Potential to attract investment in the adaptation and mitigation technologies
- Potential scale and replicability – geographical area and number of people impacted

Co-benefit - Climate-related, economic benefits, environmental benefit, and social benefit

- Cost – Capital, operation, and maintenance costs of adaptation and mitigation technologies
- Availability and accessibility of human, organizational, policy, and financial capacity to establish and operate the technology

At the TNA inception workshop, stakeholders prioritized Agriculture, Livestock and Fisheries, Water resources management, Disaster Risk Management for adaptation, and AFOLU, Energy and Waste for mitigation to Climate Change. Consultants reviewed national development and climate plan-related documents, identified potential technologies, and in consultation with the Ministry of Environment and Forestry and the stakeholders agreed on mitigation and adaptation sectors technologies (six sectors technologies) for which fact sheets were developed. These were shared with stakeholders in a workshop where focus groups used multi-criteria analysis to select the top three in each sector. The identification and selection of technologies through TNA provide a starting point for a range of national activities and projects for accessing support for technology transfer and implementation. The capacity and tools gained from the consultative TNA approach can be applied for strengthening other aspects of national development planning.

1.1.1: Rationale of the South Sudan TNA Project

The national development objective for the Government of South Sudan (GOSS) is to achieve sustainable development through the integration of environmental, social, and economic issues and enhancing linkages and collaboration across various sectors as well as improving partnerships between the government, private sector, civil society and communities on matters of environmental management and climate change adaptation, mitigation and resilience.

This is particularly fundamental because the main productive sectors depend on environment and natural resources and a substantial number of communities derive their livelihoods from environmental and natural resource services and goods. The key economic sectors are also sensitive to climatic shocks. To accomplish these objectives, South Sudan through the Ministry of Environment and Forestry (MoEF) has initiated several steps to mainstreaming climate change priorities into national and sub-national sectorial development policies, plans, and programs; create climate change awareness among stakeholders including government representatives, private sector, local communities, and civil society groups including the establishment of effective communication channels for cooperation and coordination.

In addition, South Sudan has initiated the process of participating in the implementation of climate change adaptation and mitigation projects supported by the Global Environment Facility (GEF) as well as the Green Climate Fund's Readiness and Preparatory Support program for strengthening the NDA and strategic framework for engagement with the key stakeholders and development partner. Thus, the TNA project is crucial for the Government of South Sudan (GOSS) as it implements an economic recovery strategy, and addresses climate change impacts, climate resilience and low carbon growth commitment. Therefore, the TNA project comes to complements all the efforts of the Government of South Sudan (GOSS) to deal with the adverse impact of climate change and aims to provide new information for technology identification and planning to address climate change challenges.

1.2: Existing national policies related to technological innovation, adaptation, mitigation of climate change, and development priorities

In the context of the vulnerability that climate change poses to economic development and social conditions, the Government of the Republic of South Sudan with the support of its international partners such as UNEP, UNDP, GCF, and GEF initiated several programmes to help different sectors adapt and mitigate to the anticipated adverse climatic events. The NAPA, which was adopted in 2016, is perhaps the most visible in outlining the course of action the country needs to take to reduce the impact of climate change on key sectors. It assessed the impact of climate change in South Sudan and proposed a range of adaptation measures to climatic vulnerabilities in the sectors of Agriculture, livestock and Fisheries, water, Disaster risk reduction, energy, waste and Agriculture, Forestry, and Other Land Use (AFOLU).

The NAPA was developed by the Ministry of Environment and Forestry (MoEF) "to support and facilitate a coordinated response to climate change issues in the country". The South Sudan NAPA states the goal, vision, and objectives of a climate change response strategy in South Sudan. It also recommends an institutional framework and to support and facilitate a coordinated response to climate change issues in the country. Climate action projects for example strengthening the capacity of government and communities in South Sudan to adapt to climate change and the watershed approaches for climate resilience in agro-pastoral landscapes are operationalization of the NAPA. Some of the aims are mainstreaming climate change into national and sub-national sectorial development plans, increasing the resilience of key infrastructure, and strengthening GOSS capacity to manage climate change interventions. It is projected to cost US$9,547,268

Besides these two climate change initiatives, there are many other actions on climate change response. Many interventions and policies now take note of climate change. Sector ministries are increasingly integrating climate change-related issues into their sectorial plan. This is mainly because the South Sudan National Adaptation Plan (NAP) attempted to mainstream climate change in the plan and allocated funds to help tackle the expected climatic hazards. There are a number of civil society organizations working on climate change and environment related issues. Producer organizations such as the South Sudan Agricultural Producers Union (SSAPU), and the Ministry of Environment and Forestry in collaboration with UNDP and UNEP are implementing projects to help their producers adapt to and mitigate climate change impact. The private sector is also being courted to become more aware of climate change and take advantage of funding opportunities promoting green economy development. All this is a good indication that the country has awakened to the reality that climate change is a core development problem that needs to be tackled immediately.

There exist several national policies and strategies formulated over time, by the Government of South Sudan (GOSS) relating to technology innovation, economic growth, development priorities, adaptation to climate change, natural resource management, biodiversity, and conservation and enhancement of social welfare. Prominent amongst them are those shown in Table 3.

Table 3: Existing national policies linked to climate change adaptation, mitigation, and development priorities

Existing Policies/ Laws	When enacted	Relevance to climate change adaptation and mitigation

South Sudan Vision 2040: Toward Freedom, Equality, Justice, Peace and Prosperity for All (2011).	2011	The South Sudan Vision 2040 provides a long-term development vision for South Sudan and establishes the political, economic, and social framework for development in the country. It is intended to be implemented through successive 5-year plans. Vision 2020 does not explicitly mention climate change, but climate change could pose a threat to the achievement of some objectives under the strategy's Seven Pillars. The TNA process therefore serves to prioritize adaptation and mitigation technologies that will safeguard Vision 2040 implementation against the threat of climate change.
Revised South Sudan National Development Strategy (R-NDS)	2021-2024	The R-NDS aims to consolidate peace, reduce the humanitarian footprint, stabilize the economy, and promote Sustainable development.
Environmental Protection Bill, 2013, and National Environmental Policy, 2014.	2015-2025	The National Environmental Policy acknowledges the need for the development of climate change adaptation and mitigation innovation solutions and technology for South Sudan. It also recognizes the need for efforts to lessen community vulnerability to climate change across all sectors of development
National Adaptation Programme of Action (NAPA)	2016	The objective of the NAPA is "to communicate to the international community priority activities that will address South Sudan's urgent and immediate needs for adapting to the adverse impacts of climate change" The NAPA identified five "Priority Adaptation Projects" across five thematic areas: 1. Environment: Promotion of reforestation and agroforestry to reduce vulnerability to droughts and floods; 2. Water Resources: Sustainable management and conservation of wetlands in South Sudan; 3. Agriculture: Promotion of climate-smart agricultural techniques to improve livelihoods and food security under changing climate patterns; 4. Disaster Risk Reduction: Establishing improved drought and flood early warning systems in South Sudan through an improved hydro-meteorological monitoring network; 5. Policy and Institutional Framework: Strengthening the institutional capacity of the GoSS to integrate climate change into national

		policies and planning processes
Nationally Determined Contribution (to the Paris Agreement;	NDC, 2015; revised 2021).	The NDC covers the period from 2020-2035 and is built on a "cross-sectorial consultative process involving multiple stakeholders that were conducted in parallel to the NAP preparatory work and associated meetings". The NDC is meant to contribute to the attainment of South Sudan Vision 2040 and the South Sudan Development Plan. The NDC recommends adaptation actions according to several prioritized sectors and estimates that investments of over US$100 billion is required to meet all of the mitigation and adaptation needs across sectors by 2030
Initial National Communication to the UNFCCC (INC, 2018).	INC, 2018).	The INC "represents the commitment of the Government of South Sudan and its people to address climate change, along with the strong belief that all countries must make an effort to greatly reduce greenhouse gas (GHG) emissions in order to avoid the dangerous and potentially catastrophic impacts of climate change" (iii). The INC identifies gaps and constraints relevant to the country's response to climate change, and those that related to adaptation have been incorporated into the initial NAP, as have any recommended actions for overcoming the gaps.
The First South Sudan National Adaptation Plan (NAP)	2021	The Vision of the South Sudan NAP is to mainstream adaptation planning within South Sudan's development planning across different government line ministries and climate-resilient communities and ensure climate-centric development for long-term resilience and interruption of the poverty cycle. The mandate of the NAP is to build leadership and ensure stakeholder participation to fulfill South Sudan's commitment to the UNFCCC, and to operationalize climate change adaptation at all levels.
National Biodiversity Strategy and Action Plan (NBSAP).	2018-2027	The plan identifies the significance of climate change to biodiversity and land use, precisely suggesting the possibility of impacts from changing rainfall regimes, river flow patterns, and the increasing potential for fires, droughts, floods, and other threats.
Disaster Risk Management Policy and Plan (2016)	2016	The Disaster Risk Management policy and plan proposes building dykes to prevent floods but says

		little about building resilience to climatic events such as floods and drought.
National Electricity Policy	2015	The Policy was produced by the Ministry of Electricity and Dams; It outlines the framework for developing and running the electricity supply industry. It focuses on the use of indigenous energy sources, such as crude oil and hydropower, for meeting household energy demand. It emphasizes the need for sustainable technologies such as off-grid solar and hydropower.
National Water Policy Bill (2015) for Sustainable management of water resources	2015	Acknowledges that effective water management can address climate change issues but No direct reference to the adverse impact of climate change on water resources
National Forest Policy	2015	Acknowledges that forest conservation and management are linked to climate change responses. Climate adaptation and mitigation actions are addressed in the policy
Comprehensive Agricultural Master Plan (CAMP)	2015–2040	The CAMP was approved by the Government of South Sudan in March 2017. It is an investment plan that was developed to align with the national policies, plans, and strategies of various ministries, such as the Ministry of Agriculture and Food Security, the Ministry of Livestock and Fisheries, and the Ministry of Water Resources and Irrigation. The CAMP has developed over 110 sub-sector project profiles to ensure food security, improve the livelihoods of communities, and promote sustainable agriculture and livestock-rearing.

1.2.1: National Circumstances

1.2.1.1 Geography & Topography of South Sudan

South Sudan is a landlocked country located in the tropical zone of Eastern Africa between 3N-12N and 24E-36E. It is bordered by Ethiopia to the east, Kenya to the southeast, Uganda to the south, the Democratic Republic of Congo (DRC) to the southwest, the Central African Republic (CAR) to the West, and Sudan to the North. The country is approximately 650,000 km^2 and is situated almost entirely in the Nile River basin, receiving water from the highlands of CAR, DRC, Ethiopia, and Uganda.

South Sudan is divided into three regions, which correspond to historical provinces dating to the time when South Sudan was still part of Sudan. These regions are Bahr el Ghazal in the northwest, Equatoria in the south, and the Greater Upper Nile in the northeast. The largest settlements are Juba, the capital (526,000), Wau (233,000), and Malakal (147,450).

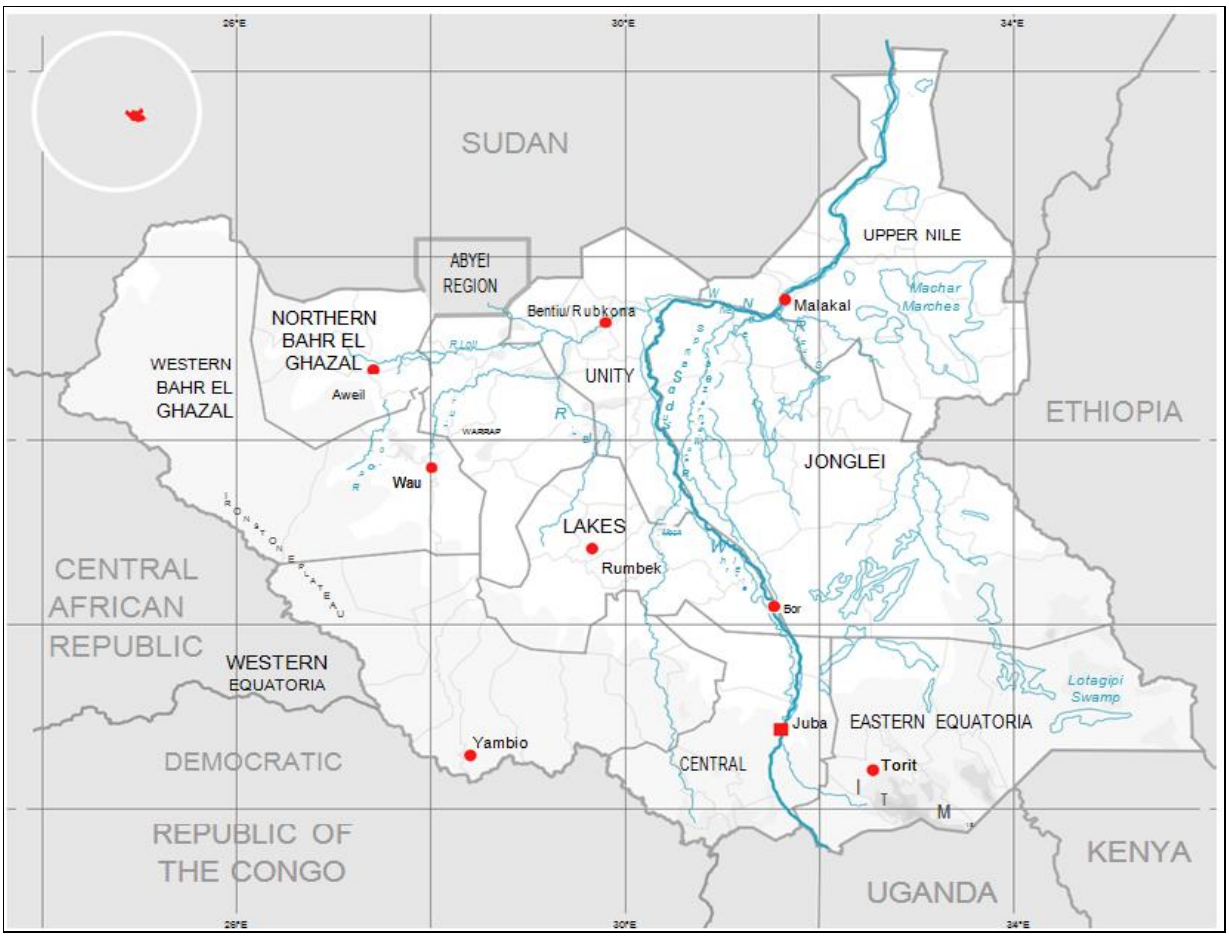

Figure 1: Map of South Sudan (Source: World Atlas, 2020)

Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. The final boundary between the Republic of South Sudan and the Republic of Sudan has not yet been determined. The final status of the Abyei area is not yet determined.

1.2.1.2. Main climate zones of South Sudan

South Sudan is blessed with natural resources and has an abundance of fertile agricultural land with abundant water, as the country is bisected by the White Nile River, and the country's many plains and plateaus are drained by its several tributaries. The Sudd wetland in the central part of the country covers around 100,000 km^2 and comprises lakes, marshes, and extensive floodplains. The Ironstone Plateau rises between the Nile and Congo watersheds and is characterized by numerous inselbergs. In the southern part of the country is found the Imatong Mountains, rising to a height of 3,187 m at Mount Kinyeti, the highest point in South Sudan. The country's climate ranges from warm desert climate (BWh) in the extreme north of the country to warm semi-arid (BSh) as one travels to the south, with tropical savanna (Aw) covering the vast majority of the country.

Arid and Semi-Arid

The arid and semi-arid region of South Sudan occurs in the southeast along the border with Kenya and in the northeast bordering Sudan with a mean annual rainfall of just under 450 mm/year. Rainfall amounts decrease and year-to-year variability increases towards the north. Rainfall occurs in a single rainy season during boreal summer (June – September) with a clearly defined dry season from November to March. Daily mean temperature averages 28° C with a seasonal range of around 7° C. Warmest temperatures generally occur during boreal summer, peaking at the beginning and to a lesser degree at the end of the rainy season, and coolest temperatures during winter.

Tropical Savanna

A wet region of South Sudan with a mean annual rainfall of around 1050 mm/year. Rainfall is highest over the parts of the region within southwest Ethiopia and along the Democratic Republic of Congo border. Rainfall variability from year to year is relatively low. Rainfall occurs during one long rainy season from March to November, exceeding 100 mm/month from May – October. Daily mean temperature averages 27° C with a small seasonal range of around 4° C. Warmest temperatures generally occur during March-May (beginning of the long rains) with a secondary peak in October (tail of the rainy season), with coolest temperatures during July. Strong spatial differences, primarily related to elevation are seen in this region.

Equatorial

A wet region of South Sudan with a mean annual rainfall of just under 1230 mm/year. Rainfall is generally highest around Lake Victoria with relatively low year to year variability. Rainfall in this region falls throughout the year, but peaks at 180 mm/month the long rains from March to May and at 150mm/month in the short rains during November. Daily mean temperature averages 22° C with a small seasonal range of around 2° C. Warmest temperatures generally occur during February – March (beginning of the long rains) with coolest temperatures during December – January and also August. Strong spatial differences, primarily related to elevation are seen in this region.

1.2.1.3 Population

The population of South Sudan is approximately 13,096,000 people and, the population is expected to grow to 19.96 million people by 2050 and 31.74 million by 2100. South Sudan grew 1.19% from 2019 to 2020, an increase of about 131,000 people. While net migration remains negative for the country, its fertility rate is still relatively high at 4.74 births per woman (RoSS and UNEP, 2018). Approximately 70% of the population is under the age of 30, and though the country has one of the lowest population densities in Sub-Saharan Africa (less than 13 people/km^2), the age structure of the population indicates that it will continue to grow rapidly well into the future. The population is not evenly distributed across the country; Jonglei is the most populous area with 16% of the total population, and Western Bahr el Ghazal is the least populous area, with only 4% of the total. The highest population densities are found along the Nile and its tributaries. Currently, food security vulnerability is among the most pressing issues in South Sudan. In the future, the country will have to work hard to ensure that sufficient food is available for the growing population. This challenge is made more difficult by changing climate conditions due to increasing temperatures, increased and more intense flooding and droughts, and seasonal variability will threaten agricultural productivity. Therefore, South Sudan's methodologies to improve food security and agricultural productivity will need to take these

aspects of climate change adaptation and mitigation into consideration. Failure to do so will leave the country at increased risk of humanitarian catastrophe.

1.2.1.4 Economic Context of South Sudan

South Sudan is a Least Developed Country (LDC) and is currently one of the poorest and most underdeveloped countries in the world. There is generally inadequate road infrastructure and less than 1% of the population has access to on-grid electricity (UNEP 2018). The Ministry of Finance and Planning estimated that since the independence of South Sudan, the per capita Gross National Income (GNI) in US dollars has fallen by around 70% (State of Environment Report). These developmental deficits contribute significantly to climate change vulnerability and undermine adaptive capacity.

South Sudan is the most oil-dependent country on earth, with 98% of its GDP and 60% of the government budget coming from petroleum sales. However, it is estimated that the country's oil reserves will be depleted by approximately 2035 (INC). The high dependency on petroleum and its associated price unpredictability means that South Sudan is highly vulnerable to external shocks. The Government of South Sudan has recognized the importance of diversifying the economy away from its over-reliance on the petroleum sector and investing in agriculture, mining, forestry, and manufacturing, and developing more extensive regional linkages. In terms of its technological need assessment (TNA) process, these TNA processes present both an imperative and an opportunity. The imperative is that the identified technologies for all the selected sectors *must* incorporate climate change considerations, including climate change risks, in order to ensure their long-term sustainability and economic and financial viability. At the same time, GoSS has the chance to incorporate these climate change adaptation and mitigation technologies at the earliest stages of sectorial development, which means that with careful planning and execution, climate change adaptation and mitigation technologies can be mainstreamed into sectorial strategies, policies, plans, regulatory and investment frameworks as they are being prioritized, thus leading to climate-resilient development. Thus in the development of the adaptation and mitigation technology, attention should be given to the implementation of more suitable adaptation and mitigation technologies across all sectors.

The most obvious target for diversification is the agriculture sector. Approximately 90% of the land in South Sudan is arable, but only around 5% is currently in use. Agricultural development has been viewed as an alternative driver of growth, which would have the co-benefits of improving food security while reducing household poverty. The country has the potential for significant returns on investment in cattle rearing, dairy products, poultry, meat processing, and fisheries.

However, the private sector in South Sudan is significantly underdeveloped. The private sector faces significant constraints that affect competitiveness with imports and their ability to access export markets, including power shortages, high labor costs, and lack of access to credit and foreign exchange, and poor transport infrastructure. All of these conditions create barriers to enhancing the private sector's role in climate change adaptation.

1.2.1.5 Climate and Weather of South Sudan

South Sudan climate is primarily tropical savannah; however, the far northern and south-eastern parts have a warm semi-arid climate. Rainfall occurs in a single rainy season from March to

November and peaks from June to September. The rainfall regions of South Sudan extend beyond the border of the country into Sudan to the north, Ethiopia to the east, and into Uganda, and beyond in the south. The last two catchments generally have higher annual total rainfall, and the seasonality of rainfall shifts from a single season during boreal winter to all-year rainfall peaking during the long and short rains (March–May and October - November) and over the far south.

Climate variations within the rainfall regions of South Sudan are large. Figure 2: Main characteristics (magnitude and variability) of rainfall in South Sudan as shown by the temperature graphs (below)

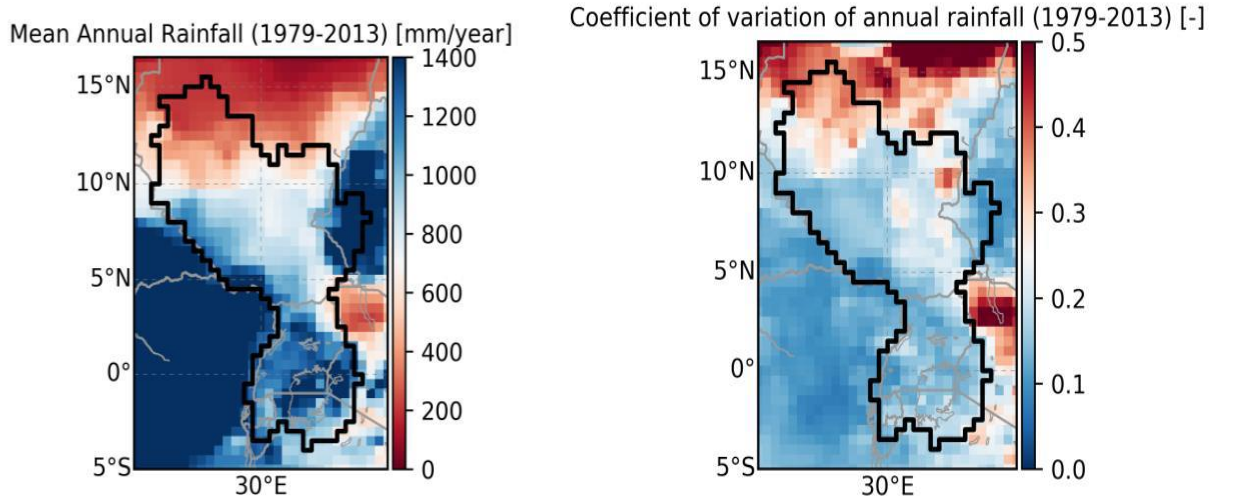

Figure 2: Main characteristics (magnitude and variability) of rainfall in South Sudan and its region (Source: WMO. (2020)

Climate Exposure: Trends and Projections

South Sudan is experiencing the effects of long-term climate change, such as increased temperatures and precipitation change, as well as short-term changes, like more frequent droughts and floods.

Temperature: Mean annual temperatures across South Sudan have varied between 26.8°C and 28.9°C over the past 30 years, with an increase of 0.05°C every decade. There is substantial variation in temperature trends within the country and across the calendar year, with the largest increases between December and March, coinciding with the dry season. Average temperature is projected to increase between 1°C and 1.5°C by 2060, leading to a warmer and drier climate (Sosnowski A. et al. 2016).

Precipitation: In the last 20 years, South Sudan has been experiencing unpredictable rainfall (Quinn et al (2019).) Summer rainfall has decreased by 15–20 percent, particularly in the northeast. Recent floods have affected more than 835,000 people across eight states in South Sudan; livelihoods, food production, and drinking-water supply have all been severely impacted (UNEP, 2011). Consensus is lacking on long-term precipitation trends for the country: recent

data indicate reductions in rainfall, but heavy rains are experienced more often and with greater intensity, increasing the risk of flooding.

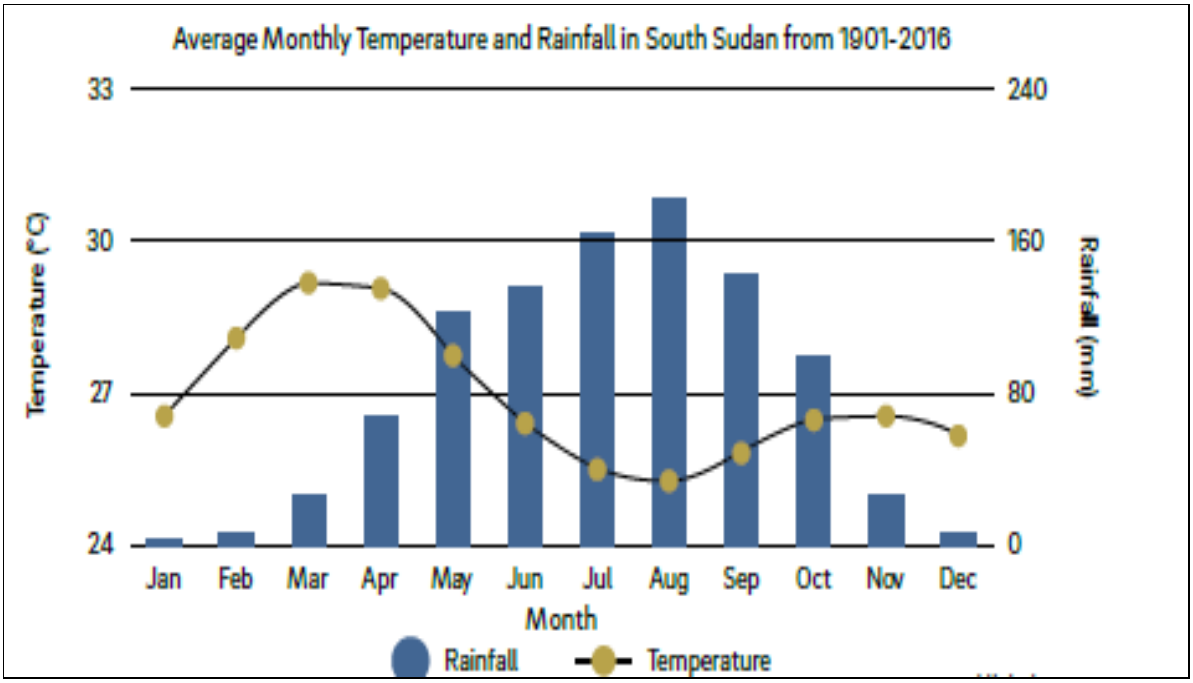

Figure 3 shows the average monthly temperature and rainfall in South Sudan from 1901 to 2016 (Source: Data from CRU.CY.4.04 (Harris et al., 2020).)

1.3: Vulnerability Assessments in the Country

1.3.1: Observed climate variability

Climate data are scarce for South Sudan because of the long period of civil war and the historic focus of many studies and data sets on northern Sudan. However, based on regional trends and meteorological data from the mid-1970s to late 2000s, it has been shown that: i) summer rainfall has decreased by 15–20% across parts of South Sudan; particularly the north-east; and ii) temperature has increased by more than 0.40C per decade over the past 30 years (USAID, 2016).

In addition to this, observed trends and anecdotal evidence indicate that:

1. The duration and timing of rain have become erratic with the rainy season being delayed and shorter;
2. Some areas are receiving less rain and consequently, the water tables are dropping;
3. The region that receives 500 mm or more of rain has contracted, increasingly exposing populations in northern areas to rainfall deficits; and
4. The desert is expanding southwards.

Further to the above trends, the frequency of floods has increased over the last eight decades, with floods having occurred in 1946, 1962-1965, 1978-1979, 1988, 1999, 2006, 2011, 2012, 2013 and 2014, 2019, 2020, 2021 and 2022. Droughts are also becoming more frequent.

Approximately 56% of the rural population surveyed in the National Baseline Household Survey (SSCCSE, 2009) identified droughts and floods as the top source of vulnerability in South Sudan. The other top sources of household vulnerability include the death or loss of cattle, and crop diseases and pests – all of which are attributable to some extent to changing climate conditions.

1.3.2: Expected impacts of climate change in vulnerable Sectors

Because of the limited availability of climate data, no specific climate change scenario models are available for South Sudan. However, if present rainfall trends continue, by 2025 the decreasing rainfall currently experienced mainly in the north-eastern parts of the country will spread south-westward. In addition, rainfall is likely to become increasingly erratic causing an increase in both floods and droughts. Temperatures are also likely to continue increasing, which will exacerbate the effects of droughts.

Future climate change trends will have an adverse effect on the availability of water resources and consequently agricultural productivity. Most of South Sudan is covered by the Bahr el Ghazal, Nile, and Sobat River catchments that join to form the White Nile. In contrast to the Nile, the Sobat River and the Bahr el Ghazal river catchments have a strong seasonal character. Research on these two catchments suggests that an increase of 2°C in temperature might cause the natural flow to fall to 50% of the current average (Jubek *et al.*, .2019). Rising temperatures and uncertain rainfall could also impact the Sudd wetland, which is not only an important source of fish and products but also a wetland of global biodiversity importance.

In addition to reducing water availability, future climate change will also accelerate environmental degradation and desertification. The increased frequency and severity of extreme climate events will have widespread negative socio-economic impacts on people in terms of food security, health, and safety.

With regards to temperature, South Sudan has been among the most rapidly warming countries globally in the last 30 years, with an increase in temperature of as much as 0.4 degrees Celsius (°C) per decade, especially in the central and southern regions (South Sudan Ministry of Environment and Forestry, (2018). General circulation Model projections indicate that temperatures may increase by 0.6–1.7°C by 2030 and by 1.1–3.1°C by 2060 relative to the baseline period of 1961–1990 (ibid.). A simultaneous decrease in precipitation and increase in temperature will amplify the impact of droughts; warming of more than 1°C is equivalent to another 10–20 percent reduction in rainfall through increased evaporation, which would further reduce the availability of water (The Netherlands Ministry of Foreign Affairs, 2018). People are distressed by floods, which have affected approximately 7,900,000 and 1,140,000 people during the period 1996–2016 (AfDB, 2018). If current rainfall trends continue, the drying impacts could extend into Western and Northern Bahr al Ghazal, Warrap, Unity, Lakes, and Central Equatoria by 2025 (Niang et al., 2014; Funk et al., 2011).

Most of the agriculture in South Sudan is rain-fed and therefore depends on seasonal rainfall for optimal crop production, making the sector vulnerable to climate variability. Extended dry seasons (droughts) and increasing precipitation variability negatively impact the economy and the nutrition status of residents who rely on agriculture for their livelihoods and cause loss of grazing lands, loss of soil fertility and biodiversity, water shortage, reduced crop and livestock productivity, and escalation of pests and diseases of crops, livestock, and humans (NAPA 2016). According to FEWSNET (2018), there is likely to be a reduction in sorghum production, one of

the staple grains of most of the population in South Sudan, by 5–25 percent between 2000 and 2050.

The climate calamity is worsening the humanitarian situation in South Sudan. Vulnerability to natural hazards, floods have led to the destruction of shelters and infrastructure, restricted access to basic services, wrecked livelihoods, and facilitated the spread of deadly waterborne diseases and caused fatalities, as well as contributed to communities' displacement. The annual rainy season brings heavy rainfalls and flooding, particularly to Unity State, Jonglei, and Upper Nile State. In 2021, at least 6 states out of 10 states were impacted by adverse weather, affecting over 1 million people. This is expected to increase poverty, and constraint South Sudan potential to achieve its development priorities. The South Sudan NAPA, NDC, NAP, and other climate documents identify Agriculture, livestock and Fisheries, Water, and Disaster risk reduction, Waste and energy as key sectors most vulnerable to climate change. Major vulnerabilities of main sectors to climate change as illustrated in the NAPA (MoEF, (2016) are summarized in Table 4 below:

Table 4: Major vulnerabilities of the main adaptation and mitigation sectors (Source: NAPA, 2016)

Adaptation Sector	Major vulnerabilities of climate change
Agriculture, livestock, and Fisheries	• Desertification and loss of agricultural and grazing land • Crop loss and reduced crop yields owing to increased temperatures and changing rainfall patterns • Increased potential for conflict between farmers and pastoralists • Decreased water and fodder availability for livestock • Increased death and heatstroke in livestock, reduced fish populations and aquatic diversity owing to reduced river flow and drying of wetlands • Reduced aquatic diversity owing to increased water temperatures and decreased access to fishing sites during increased flooding.
Water sector	• Droughts lead to potential drops in the water table, drier seasonal rivers and a reduction of wetland size. Decreased recharge rates would have manifold impacts on the more than 60% of the population that relies on wells and boreholes to access water; • Increased potential for conflict over limited water resources; • Decreased surface water quality, especially during droughts and floods. Reduced rainfall and inflows can lead to water stagnating in ponds due to prolonged dry seasons. Decreasing quality of surface water levels and quality due to climate change would heavily impact the ⅓ of the population that relies on surface water for domestic use; • Rivers dry up or change from perennial to seasonal flows due to higher evaporation from increased temperatures. Decreased water flows can lead to increased sedimentation of

	watercourses and more congested irrigation channels; and • Reduced access to water for drinking and sanitation.
Disaster Risk Reduction	Climate change in South Sudan affects disaster risks in two ways: firstly, through the likely increase in weather and climate hazards and effects of flood; and, secondly, through the increases in vulnerability of communities to natural hazards resulting from ecosystem degradation, reductions in water and food and food availability and changes to livelihoods. In the absence of efficient early warning and disaster management systems South Sudan population remains highly vulnerable to climatic shock disasters. There is an urgent need for setting up or upgrading weather monitoring stations to predict weather patterns so that appropriate preparedness and response Recovery measures can be initiated
Energy	South Sudan faces seasonal weather variations which include amongst others, increased temperatures in the ranges of 360 -400C in some months of the year, and is expected to get warmer with climate change. Increased temperatures trigger increased usage of in-door air condition facilities implying more power demand and increased fuel consumption leading to increased carbon emissions. Increased temperatures cause power distribution lines to sag dry hot weather in South Sudan is also accompanied by high-speed winds which can knock down distribution poles causing a short circuit and power outages affecting the power supply. This is mitigated by the use of concrete poles and insulated conductors. Increased ambient air temperatures impact the operating efficiency of thermal power plants leading to increased carbon emissions, water abstraction for its cooling, effluents, solid wastes and hazardous materials generation all of which have impacts on climate.
Waste	In South Sudan climate change impact on the waste sector in a wide variety of ways. consequences of these impacts fall into a smaller number of overall issues: • Changes to operational business costs in response to environmental factors (for example, the need for additional odour or pest control, or additional fire risk management) • Changes to working environments (indoor and outdoor) and associated health and safety of employees • Implications for the surrounding environment and community as a result of changes in the amounts of leachate, odour, or dust • Changes to the availability or reliability of waste services, from disruption caused directly or indirectly by weather events • Environmental degradation of infrastructure, leading to changes to the expected lifetime of longer-lived structures (such as landfills), through changing frequency and intensity of

	a range of weather events.
Agricultural, Forestry and Other Land Use (AFOLU)	These sectors are grouped together as technologies used in the agriculture sector could enhance the GHG mitigation in land use change and forestry. AFOLU aimed at reducing forest degradation and biodiversity conservation as a sink for carbon to mitigate climate change.

1.4: Sector Selection

The key adaptation and mitigation sectors selected for prioritization were those in the South Sudan Second Nationally Determined Contributions (INDC) (MoEF, 2021). The Republic of South Sudan's National Adaptation Programme of Actions (NAPA) to climate change, The South Sudan First National Adaptation Plan (NAP) to the UNFCCC also served as the baseline for selecting the priority for mitigation and adaptation sectors. The South Sudan NDC reports, which were submitted in 2016, 2018, and, 2015; (revised in 2021) respectively to the UNFCCC secretariat, present the country's GHG inventory with trend analysis for the period 2012-2015 and sectorial mitigation measures to reduce the national emission. The reports also present the climate risks to South Sudan based on modeled climatic projections, identify the most vulnerable sectors, and propose adaptation measures. These prioritized sectors include Agriculture, Livestock and Fisheries Sector, Water and Disaster Risk Reduction sector for adaptation while mitigation sectors Energy, Waste and agricultural, Forestry, and Other Land Use (AFOLU) were prioritized.

1.4.1: Methodology of Prioritization Process

The Multi-Criteria Analysis (MCA) process is the methodology used for identifying and prioritizing climate change mitigation and adaptation sectors and technology options. The adopted procedure to carry out the selection and identification processes for mitigation had to meet several criteria, including reduction of GHG emission potential, dependency on fossil fuel, technology availability, attracting investment, market penetration, and mitigation cost. The same process was followed for adaptation but with different criteria set by the experts and stakeholders, including sector vulnerability to climate change, adaptive capacity, national priority, socio-economic importance, availability of the technology, and adaptation cost. For both mitigation and adaptation prioritization processes, Multi-Criteria Analysis (MCA) was applied, guided, and performed by climate change experts from the relevant stakeholders and policymakers. This process has resulted in the selection of the Energy, Agricultural, Forestry, and Other Land Use (AFOLU) and Waste Management sectors under mitigation and the water and agriculture and DRRM sectors under adaptation as the six (6) most vulnerable sectors. The prioritization and selection of the technology options were performed in three workshops, one for inception and two consultative for adaptation and mitigation.

For all sectors, the process of technology selection was conducted based on the list proposed by the TNA team and participants from the stakeholders. In the consultative workshops, stakeholders from relevant ministries, organizations, academic centers, and private sectors, in addition to the TNA team were actively engaged in identifying, scoring, and prioritizing technologies using Multi-Criteria Analysis (MCA). Moreover, the criteria used to assess and

evaluate the technology options were also proposed and weighted by the stakeholders with TNA team guidance. Fact sheets were also prepared and shared with the participants prior to the workshops to provide a brief description of each technology including the cost of the technology, the application potential in the country, the mitigation of GHG emissions, adaptive capacity enhancement, and other social, economic, and environmental benefits.

1.4.2: Criteria of technology prioritization

Two steps were used to arrive at a shortlist of technology options for all the adaptation and mitigation sectors (Agriculture, Livestock and Fisheries, Water Sector, Disaster risk reduction and Management (DRRM), Energy Sector, agriculture, Forestry and Other Land Use (AFOLU), Waste Management Sectors). The first step consisted of pre-screening most existing implementable adaptation and mitigation technologies from the long list of identified technologies. The second step consisted of developing technology factsheets (TFS) for each of the short-listed technologies and establishing the criteria and indicators for technology prioritization using MCA for both mitigation and adaptation sectors. Fact sheets on each of the identified technologies were developed and shared with stakeholders. Stakeholders who actively participated in technology identification and selection were from the Ministry of Environment and Forestry (MoEF), Ministry of Water Resources and Irrigation (MIWR), the Ministry of Agriculture and Food Security (MAFS), the Ministry of Energy and Dams, the Ministry of Humanitarian Affair and Disaster Management, the academia, INGOs, NNGOs, UN agency such as UNDP and FAO, private sector and civil society). They were engaged in a workshop where the TNA process was introduced and during break-out sessions which were done according to the prioritized adaptation and mitigation sectors, a more in-depth discussion of potential adaptation and mitigation technologies was conducted, guided by the fact sheets. Stakeholders also recommended additional technologies.

The pre-screening was conducted through discussion with a wide group of stakeholders in technical working group meetings, and a short list of the most appropriate technologies were retained based on national priorities and knowledge of the ease of adoption of technologies in the local context.

A focus group workshop was convened to guide stakeholders through the process of determining criteria categories and weights. The criteria selected were based on the UNEP MCA guidance on adaptation technologies UNEP DTU Partnership, (2015) and sector expert views. The criteria categories selected were financial costs, economic, social, environmental, climatic, institutional, and political. Stakeholders jointly discussed and agreed that weights would range from 0 – 100, with a high-value score assigned to a criterion that most preferred, and a lower-value score assigned to a criterion with a lower preference. Weights were collectively discussed and averaged out to be used for the scoring exercise. While climate parameters were critical when it comes to adaptation and mitigation technology costs, policy alignment (national policy coherence) and social criteria were matters that generated much discussion.

It was agreed that performance scores were to be standardized using a Linkert scale between 0 (lowest score) to 10 (highest score) based on the expected merits of the technology. There were some discussions on public financing needs, especially given the limited data, with respect to establishment and maintenance costs for the technology options. Performance scoring where costs are concerned was therefore to be anchored to a Linkert scale between 0 (most costly) and

10 (least costly). Technology fact sheets (TFS) were produced for each short-listed technology. The TFS contains relevant information on the technical aspects of the technology implementation, including its installation, operation and maintenance, efficiency, cost, and benefits/ opportunities, as well as the barriers for each short-listed adaptation technology.

Chapter 2: Institutional Arrangement for the TNA and the Stakeholder Involvement

2.1: National TNA team,

South Sudan has set up an institutional arrangement for the implementation of the TNA Project. It encompasses the TNA team functioning under the auspices of the National Ministry of Environment and Forestry (MoEF) – Government of South Sudan, the Project Steering Committee, and the relevant stakeholders.

The composition of the Project Steering Committee (PSC) was determined at the inception workshop held on 18 April 2023 in Juba Landmark Hotel, in line with the project guidelines. It was decided that the PSC should have its membership drawn from the institutional representations of all the priority adaptation and mitigation sectors whose membership comprises representatives from organizations such as the Ministry of Water Resource and Irrigation, Minister of Energy and Dams, Ministry of Environment and Forestry, The Ministry of Humanitarian Affairs and Disaster Management, Ministry of Agriculture and Forestry (MoAF), Ministry of Livestock and Fisheries and the private sector**.** In all, the PSC oversees the implementation of the project and works together with the TNA Project Coordinator to ensure political endorsement of the project based on agreed timelines.

Serving on the PSC are the following:

Mr. Payai Manyok John, the UNFCCC Focal Point at the Ministry of Environment and Forestry was appointed as the National TNA Project Coordinator. His responsibilities have been clearly spelled out in the project agreement. Both the TNA coordinator and the Assistant TNA coordinator are the managers of the overall TNA process. This involves providing vision and leadership for the overall effort, facilitating the tasks of communication with the National TNA Committee members, National Consultants, and stakeholder groups, formation of networks, information acquisition, and coordination and communication of all work output**.**

2.1.2: National TNA Committee: This is the principal decision-making body acting as a core driving committee. The group is composed of members from all the line Ministries in the Government of South Sudan who are engaged in climate change adaptation and mitigation activities and planning. The Committee performs specific responsibilities such as:

1) Identify national development priorities and priority sectors for the Technology Need Assessment;
2) Assist in the constitution of sectorial/technical expert working groups;
3) Define stakeholder consultation processes;
4) Review and approve technologies and strategies for mitigation and adaptation as recommended by expert sectorial working groups;
5) Review and approve the TNA report, report on barrier analysis. and technology enabling environment.

The TNA team as recommended at the inception workshop and subsequently constituted comprises:

- National TNA Project Coordinator
- Assistant National TNA Project Coordinator
- National TNA Consultant (Mitigation and adaptation)
- Agriculture, livestock, and Fisheries sector experts
- Water sector experts
- Disaster Risk Reduction (DRR) sector expert
- Waste sector experts
- Energy sector experts
- Agriculture, Forestry, and Other Land Use (AFOLU) working experts
- Overall expert

2.1.3: TNA National Consultant: The consultant Mr, Bul John Ajak was selected by MoEF in coordination with UNEP CCC to carry out the South Sudan TNA assignment based on sufficient experience in climate change adaptation, mitigation and environmental issues in South Sudan. The national consultant for adaptation and mitigation technology is responsible for the research, analysis, and synthesis of the entire TNA process. Under the guidance of the TNA Coordinator and committee, the consultant is required to provide the required technical expertise for adaptation and mitigation, and help identify and prioritize adaptation and mitigation technologies with the help of the adaptation and mitigation sectors expert working group.

2.1.4: TNA Sectorial Expert Working Groups -Adaptation and Mitigation

A Sectorial Working Group (WG) was established for each sector prioritized in the South Sudan TNA. Each group consisted of ten to twenty experts from government institutions, academic institutions, private companies, and nongovernmental organizations. The Sectorial Expert Working Group-Adaptation and Mitigation contributed towards the development and production of the technology factsheet and prioritization of technologies. Each expert working group for all the adaptation and mitigation sectors is composed of different stakeholders with a wide range of backgrounds and expertise mostly in the six priority sectors of agriculture, water resources, DRR, Energy, Waste, and Land Use. The working sectors experts includes relevant officials from national and state ministries and line directorate, local governments & their associated departments, civil society organizations, and international donor organizations.

Within the expert's sector working group’s team, each EWG is responsible for one sector depending on the group experience and specialization working in close collaboration with sectorial core stakeholders. Series of meetings and working sessions have been regularly held at the expert working group level, mitigation and adaptation group level, and at the whole TNA project level.

National TNA Team in South Sudan

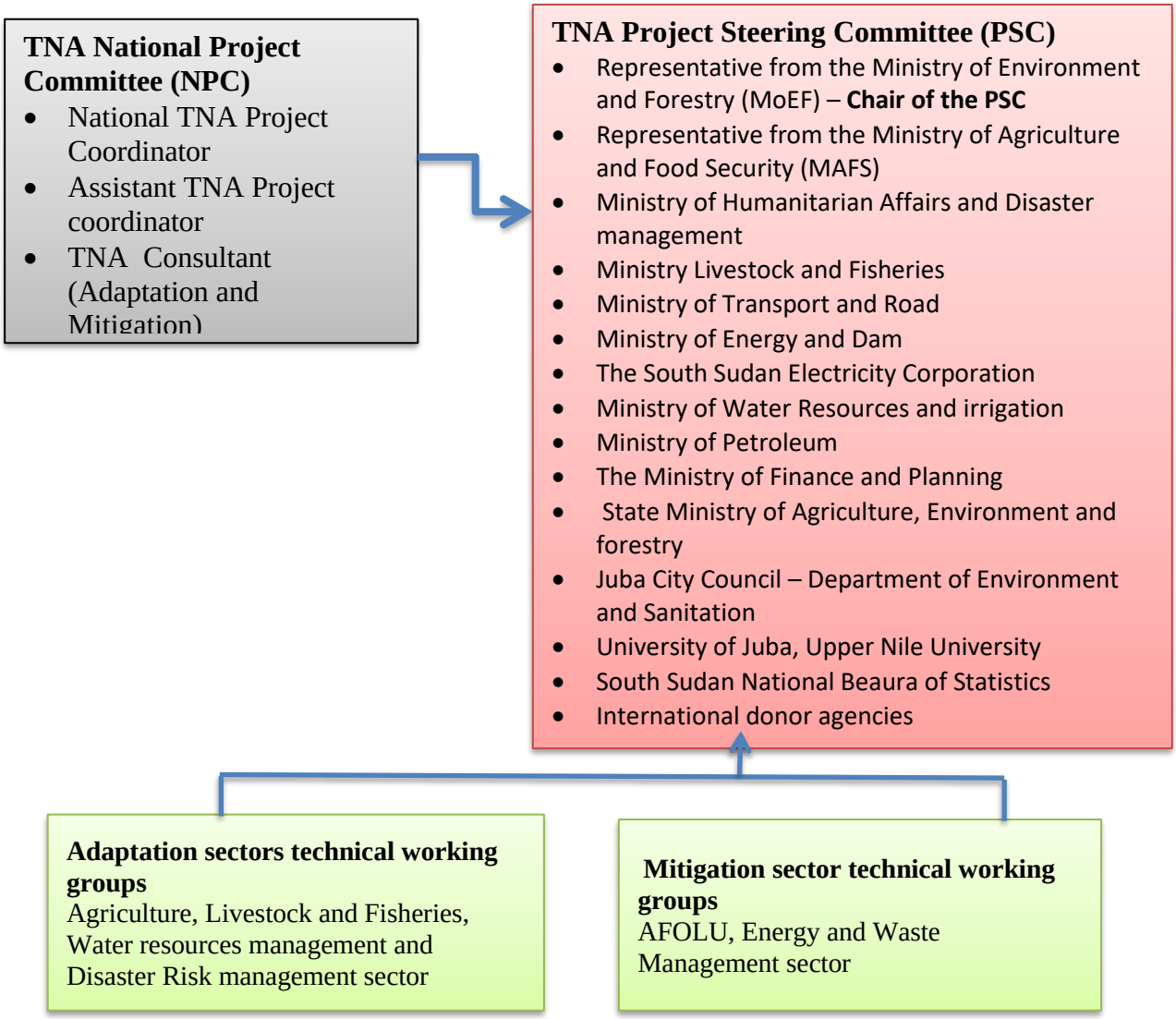

Figure 4: National Team and Stakeholders structure

2.2: Stakeholder engagement process followed in the TNA – Overall assessment

GOSS began the actual implementation of the TNA project with the organization of the Inception Workshop on 18th April, 2023 in Juba Landmark Hotel. The Inception Workshop was aimed at facilitating enhanced awareness and active engagement of a wider group of stakeholders on the TNA process while generating the feedback on the draft work plan. Members of both the Adaptation and Mitigation technical expert working groups and potential stakeholders attended the inception meeting The workshop was attended by forty five (45) participants drawn from Ministry of Environment and Forestry (MoEF), Ministry of Water Resources and Irrigation, Ministry of Agriculture and Food Security, Ministry of Humanitarian Affairs and Disaster Management, Ministry of Energy and Dams, Ministry of Livestock and Fisheries, private sector and the academia (See annex 2.1 for list of participants.) After the

Inception Workshop a number of activities were carried out as part of the implementation of the TNA Project including the constitution of the Project Team, and training on the multi-criteria analysis for the prioritization of technologies. There was the selection of stakeholder institutions and sensitization of the key public institutions on the TNA Project.

Figure 5: Stakeholders who attended the TNA inception workshop (*Photo credit:* Bul John)

At the inception workshop, the TNA coordinator from the Ministry of Environment and Forestry (MoEF) introduced the TNA project, its processes, desired outcomes and timelines. The one-day inception workshop was followed by a meeting of the potential stakeholders to establish technical sector working groups. A presentation was made by Mr. Payai Manyok John, the TNA Coordinator on the TNA process and the expected outcomes, implementation structure, and timelines for implementation of the project.

Figure 5: Mr Payai John presenting the TNA processes and implementation to TNA Stakeholders (*Photo credit: Bul John*)

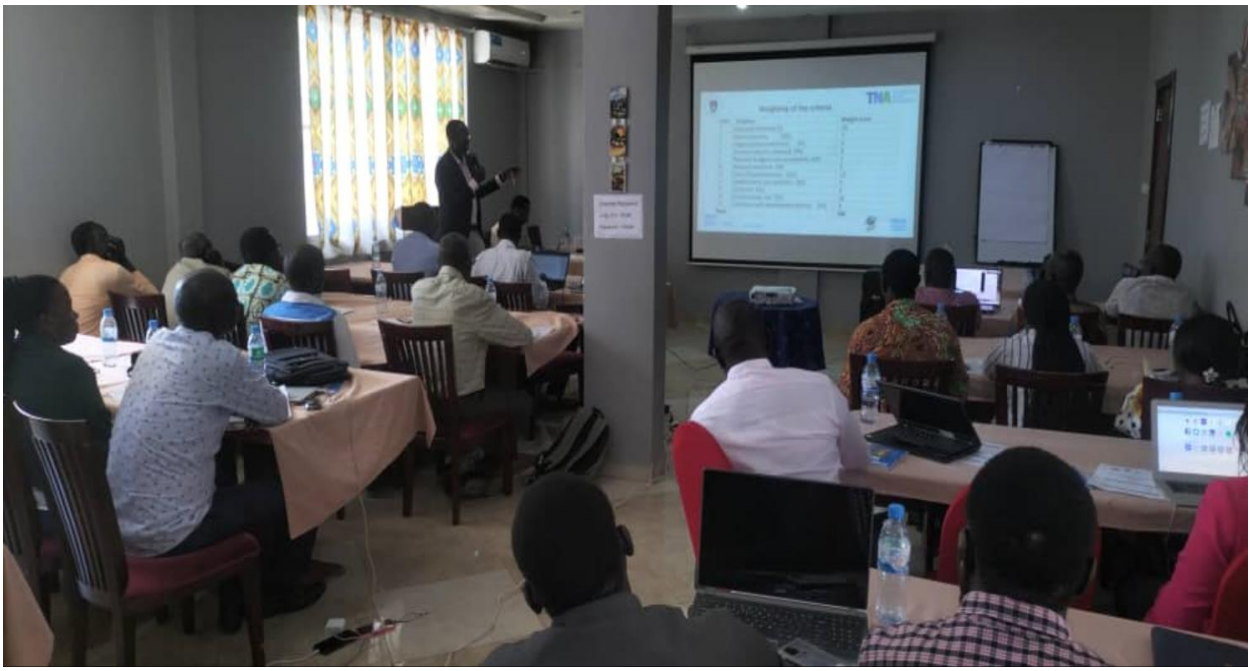

Figure 6: Expert working members undergoing training on MCA at the Technology Prioritization Workshop (*Photo credit: Bul John*)

Prior to engaging with stakeholders in the prioritization exercise, a stakeholder mapping exercise was undertaken by the consultant who identified primary stakeholders (mainly technical staff) from all the relevant institutions working within the priority adaptation and mitigation sectors. All stakeholders were identified based on their ability to implement the project or influence the outcome of the project.

Stakeholders were engaged through a two-day technology prioritization workshop convened and led by the Adaptation and Mitigation consultant and the Assistant Coordinator. The first workshop had the following specified objectives: Validate the list of technologies and criteria for prioritization and prioritize through a participatory process the identified technologies using Multi-Criteria Analysis (MCA) and establish criteria for prioritization; Members of the Expert working group (EWG) on Agriculture, Livestock and Fisheries, Water and Disaster Risk Reduction sector met at the Ministry of Environment and Forestry (MoEF) in Juba on 4th, May, 2023 and second workshop on 5th, May, 2023 was with the Energy, Waste and agriculture, Forestry and Other Land Use (AFOLU) sector technical experts working group. The meeting was spent on training the participants on Multi-Criteria Analysis (MCA) as a tool for the prioritization process and technologies prioritization.

During the workshops, stakeholders were introduced to the TNA process and the Multi-Criteria Analysis Methodology. Workshop participants were then introduced to the technology long lists and the rationale for identification of the technologies for national adaptation. Fact sheets on the alternative adaptation and mitigation technology options for each of the six (6) priority sectors were presented and discussed with stakeholders at the workshop. Sectorial technical experts on the technology options led the discussion and provided information on the status of the technology option in South Sudan.

Figure 7: Expert working group members prioritizing climate technologies using MCA tool (*Photo credit: Bul John*)

In focus groups constituting sector working groups, stakeholders were given printed copies of the technology fact sheets and were guided through them by the consultants. Copies of fact sheets were also shared with stakeholders by email. The workshops were specifically geared to have all sectorial stakeholders develop and provide response on criteria categories and deciding on the various criteria for analyzing technologies for each of the mitigation and adaptation sectors. Similarly, the workshops allowed for sector technical working groups to collectively discuss and agree by consensus on weights to be assigned to each criterion. Costs (Capital, Operation and maintenance cost), ease of implementation and coherence with national goals categories were those which bred much discussion from technical sectorial working expert. Stakeholders then agreed on criteria for technology prioritization broadly grouped into costs, benefits and climate impacts, and allocated weights to them but with difference a cross all the adaptation and mitigation sectors. Using fact sheets as reference, technologies were scored according to the criteria by each specific sector stakeholder.

Subsequent to the sectorial prioritization workshops, participants were emailed asking them to assign scores to the criteria category. Some stakeholders completed the process on their own while others requested guidance from the consultant.

During the prioritization of technologies for each of the adaptation and mitigation sectors, sensitivity analysis was conducted with emphasis on gender and institutions with gender analysis capacity were included. This was done to unpack social and economic related criteria. Individual scoring for each technology was aggregated and the results sent to participants for their review and subsequent comments prior to finalizing the results. The reports on the identified technologies for the six (6) selected sectors of adaptation and mitigation namely, agriculture, livestock and Fisheries, Water sector; DRR, Waste sector experts, Energy sector experts, Agriculture, Forestry and Other Land Use (AFOLU sector was presented by each of the sector technical working group expert.

The engagement of stakeholders goes beyond having representations on committees and participating in meetings and workshops. Generally, participants in the TNA process and other related programmes can be broadly categorized into three. Firstly, there is the public sector category comprising of policy makers, regulators and others in public office. The Ministry of Environment and Forestry, Ministry of Water Resources and Irrigation, Ministry of Humanitarian Affairs and Disaster Management and the Revitalized Transitional Government of National Unity (RTGoNU) parliamentary committee on environment, agriculture and natural resource. The universities and research institutions e.g. University of Juba (UoJ), Upper Nile University were considered as part of the public sector stakeholders. The second group includes private sector stakeholders including those in financial institutions (e.g. Eco waste company, Africa Development Bank (ADB), energy, water and waste company working in South Sudan). The third stakeholder group is made up of the non-governmental and international organizations such as UNDP, FAO, and Water for South Sudan. The respective role and responsibility of the stakeholders in the identifiable groups is to contribute to the TNA process. The academic stakeholders carry out the relevant studies and generate the knowledge base on which to act. The ministries and lead agencies such as the Ministry of Environment and Forestry provide support for the execution of the TNA process.

2.2.1 Methodology of Prioritization process

The South Sudan Nationally determined contributions to the UNFCCC served as the baseline for selecting the priority sectors for mitigation and adaptation. The reports, which were submitted in 2016, 2018 and, 2015; (revised 2021) respectively to the UNFCCC secretariat, present most vulnerable sectors for prioritization. Therefore, the sectors were determined beforehand based on the NDCs. The Multi-Criteria Analysis (MCA) was used for identifying and prioritizing climate change mitigation and adaptation technology options. The adopted procedure to carry out the selection and identification processes for mitigation had to meet several criteria, including reduction of GHG emission potential, technology availability, attracting investment, market penetration, and mitigation cost. The same process was followed for adaptation, but with different criteria set by the experts and stakeholders, including sector vulnerability to climate change, adaptive capacity, national priority, socio-economic importance, availability of the technology, and adaptation cost. For both mitigation and adaptation sector technologies prioritization processes, Multi-Criteria Analysis (MCA) was applied, guided, and performed by climate change experts from the relevant stakeholders and policymakers. This process has resulted in the selection of the Energy, Agricultural, Forestry and Other Land Use (AFOLU) and Waste Management sectors under mitigation and the Water and 8Agriculture and DRRM as the six (6) most vulnerable sectors. The prioritization and selection of the technology options were performed in three workshops, one for inception and two consultative for adaptation and mitigation.

For all sectors, the process of technology selection was conducted based on the list proposed by the TNA team and participants from the stakeholders. In the consultative workshops, stakeholders from relevant ministries, organizations, academic centers, and private sectors, in addition to the TNA team were actively engaged in identifying, scoring, and prioritizing of technologies using Multi-Criteria Analysis (MCA). Moreover, the criteria used to assess and evaluate the technology options were also proposed and weighted by the stakeholders with TNA team guidance. Fact sheets were also prepared and shared with the participants prior to the workshops to provide brief description of each technology including the cost of the technology,

the application potential in the country, the mitigation of GHG emissions, adaptive capacity enhancement, and other social, economic, and environmental benefits. The results of the prioritization process for mitigation and adaptation were as follows: An important feature of Multi-Criteria Analysis (MCA) is its ability to use the expert judgment of the stakeholders e.g., within the experts sectorial working group. This includes creating targets and criteria, valuing relative importance weights and in judging the contribution of each technology to each performance criterion. The stakeholders arrived at a collective decision and prioritized three technologies. The MCA excel based tool provided by UNEP CCC was used for the MCA exercise.

2.2.2 Stakeholder identification

The TNA activities involved stakeholders in all stages of technology prioritization to ensure relevance of evaluated technologies and to engage stakeholders that will be central to implementation of prioritized adaptation and mitigation sectors technologies.

During the valuation of adaptation and mitigation technologies TNA core team had a strong engagement of stakeholders in order to have their commitment in the implementation of prioritized adaptation and mitigation technologies, bring knowledge skills, their experience in the prioritized sectors and technologies ideas. The TNA Team identified stakeholders involved in the mitigation and adaptation sectors. Firstly, the identification of those who are directly impacted by the climate change in the area of interest and work in any of the six (6) prioritized mitigation and adaptation sectors: Ministry of Environment and forestry (MoEF), Ministry of Agriculture and Food Industry (MAFS), Ministry of Finance and Planning, Ministry of Livestock and Fisheries, Ministry of Water Resources and Irrigation, academia, renewable research company, international agency of technology Transfer, other institutions. These initial stakeholders were requested to recommend other stakeholders who have interest in promoting technology transfer and are concerned of future climate change impact cross all the prioritized sectors. An iterative method was applied in identifying other stakeholders, especially those in national institutions who have the power to support the technology transfer process. The audiences that are specifically targeted are planners and decision makers, sectorial planners and key stakeholders at the national levels and sub national level. They are representatives of ministries, individuals with strong political background, private representatives, sectorial experts, academic and research communities' representatives, members of INGOs with climate change activities in the county. The stakeholders group included men and women, youth and senior sectorial experts.

Ministry of Environment and forestry, Ministry of Agriculture and Food Security and Ministry of Water and Irrigation, Ministry of energy and Dam, Ministry of Livestock and Fisheries, Ministry of Humanitarian Affairs and Disaster Management, key national institutions, are identified as potential leading institutions in technological transfer and included in the National Steering Committee of TNA Project. The table 5 below specifies stakeholders' involvement in TNA activities.

Table 5: Stakeholders involvement in the activities of TNA project

Key Stakeholders	**TNA Activities**	
	Workshops	**TNA Activities**
Government institutions/Ministries • **Ministry of Environment and**	Inception workshop,	• Identification of technologies from the long lists of technologies

Forestry (MoEF) • **Ministry of Agriculture and food Security (MAFS)** • **Ministry of Animal Resources and Fisheries** • **Ministry of Water Resources and Irrigation** • **Ministry of Humanitarian Affairs and Disaster Management** • **Ministry of Health** • **Ministry of Lands, Housing and Urban Development** • **State Ministry of Agriculture, Forestry and Environment** • **Ministry of Health** • **Ministry of Energy and Dams** • **Ministry of Lands, Housing and Urban Development** • **State Ministry of Agriculture, Forestry and Environment** • **South Sudan Urban Water Corporation** • **South Sudan Revitalized Transitional Government of National Unity Committee of Agriculture and Food Security (TNLA)** • **Ministry of Wildlife Conservation and Tourism** • **Ministry of Finance and Planning** • **Ministry of Petroleum** • **Minister of Housing, Land and Public Utilities** • **Juba city Council** • **South Sudan Electricity Corporation (SSEC** • **South Sudan Urban Water Corporation** • **CES Directorate or Rural Water and Sanitation**	Sectors prioritization workshop.	• Contributed to the fact sheets by making corrections, providing additional details and recommending relevant documents for the future TNA steps. • Develop criteria for technology prioritization • Providing information and participation in the discussions of current state of technology in particular sector • Technology prioritization applying the multi-criteria analysis (MCA) • Constituting sector s technical working groups members
Academic and research institutions • **University of Juba Department**	Inception workshop,	• Identification of technologies from the long lists of technologies

of Agriculture • **Upper Nile University Department of Agriculture** • **CES Directorate or Rural Water and Sanitation** • **SUDD**	Sector's prioritization workshop	• Contributed to the fact sheets by making corrections, providing additional details and recommending relevant documents for the future TNA steps. • Develop criteria for technology prioritization • Providing information and participation in the discussions of current state of technology in particular sector • Technology prioritization applying the multi-criteria analysis (MCA) Constituting sector s technical working groups members
Agencies and organization **INGOs, NNGOs UNDP, IOM, WFP, FAO, JICA, Nile Hope, Water for South, NPA African Development Bank** **South Sudan Farmers Union** **South Sudan Electricity Corporation (SSEC** **Rural Water Supply and Sanitation Agency**	**Inception workshop Sector's** **Prioritization workshop.**	• Participated in the development of criteria for technology prioritization • Providing information and participation in the discussions of current state of technology in particular sector • Technology prioritization applying the multi-criteria analysis (MCA) • Constituting sectors technical working groups members
Private sector and Renewable Energy Council of South Sudan (RECOSS) **Juba Electric Distribution Company – JEDCO** **Eco Friendly company** **Seed traders association of South Sudan**	**Inception workshop Sector's** **Prioritization workshop**	• Develop criteria for technology prioritization • Providing information and participation in the discussions of current state of technology in particular sector • Technology prioritization applying the multi-criteria analysis (MCA) • Constituting sector s technical working groups members

A number of approaches were applied to have stakeholders' engagement in the TNA Project. These include formal and informal proceedings: appreciative inquiries, informal meetings, workshops, including TNA inception national workshop, focus group meetings, sector group meetings, policy dialogues, participatory events. Interactive participation involving experts and stakeholders in terms of joint analysis and joint action planning to build a strong sense of shared

ownership and long-term implementation activities was used during TNA process. During the inception workshop selected stakeholders have been introduced to the TNA objectives, participated in proposing and agreeing on the work Plan and TNA Project time.

2.3: Consideration of gender aspects in the TNA process

South Sudan developed a National Gender Policy in 2012 to promote gender equity, equality, social justice, and sustainable development and thus, the effective mainstreaming of gender matters into climate change is essential in order to attain a just, transformative change and avoid the adverse impacts of climate change. Moreover, in South Sudan, considering gender parity in the climate change policies, strategies and interventions can be a turning point to support and strengthen the capacity of women in South Sudan in the face of climate change.

The TNA process involved consultation with relevant stakeholders from the public and private sectors. Therefore, it was necessary to ensure that the consultation process was considered gender-sensitive in both processes of the TNA project. During the consultation process, perspectives of both women and men were taken into consideration to ensure that both have an opportunity to voice their opinions. In addition, gender issues were treated as part of both sector and technology selection. However, the representation of men still dominated those of women at every stage of the TNA process, which calls for more work to be done to ensure equal representation in future and a reflection of society beyond the TNA. Both Mitigation and adaptation sectors were generally male dominated and thus, continued mainstreaming of gender inclusiveness policies at Sectorial, Ministry and Directorate levels should be encouraged and supported.

Thus, the proposed criteria considered the gender issues under the social and economic benefits, and the gender issues were involved in the prioritization process of the technology options by using the gender lens. From the inception of the South Sudan TNA project active participation of males and females in all TNA activities such as stakeholder meetings and workshops was taken seriously. For example, women's needs and challenges were taken into account in the final selected technologies, and they will be further analyzed in the next TNA steps, particularly the Barrier Analysis & Enabling framework (BAEF) AND Technology Action Plans (TAPs) and TAP.

Chapter 3: Technology Prioritization for the Agriculture, Livestock and Fisheries Sector

This chapter provides an overview of existing technologies for climate change adaptation in the Agriculture, Livestock and Fisheries Sector and how technologies are selected. It explains the process for identification, selection, and prioritization of applicable technologies for the sector.

3.1: Key Climate Change Vulnerabilities in the Agriculture, Livestock and Fisheries Sector

The Comprehensive Agriculture Development Master Plan (CAMP), and Irrigation Development Master Plan (IDMP) (MAFS, 2015) identified the negative threat of climate variability such as the erratic rainfall in particular on agriculture sector. Climate change impact due to projected rise in temperatures (USAID 2016a, and UNEP 2018) may result in the following vulnerability:

- Increased evapotranspiration, combined with prolonged dry periods, leading to reduced wetlands, and perennial rivers becoming seasonal. This could negatively impact crop yields, pastoralists' access to water resources, and reduce fishing resources by reducing the health and size of fish.
- Increased temperatures leading to increased evapotranspiration in plants, and reduction of soil moisture, increasing the amount of water crops will need.
- Potential increase in pest and pathogen outbreaks in both crops and livestock, leading to decreased crop and livestock production. Crops and livestock in South Sudan already suffer from a myriad of endemic diseases, for example the country currently faces an infestation of Fall Armyworm, which increased temperatures could worsen.
- Increased heat stress in livestock, decreasing food security for pastoralists.
- Crop yields negatively impacted by increased temperatures. For example, temperatures may become too high for sorghum and maize.
- Combined with aridity and land use change, increased temperature could contribute to desertification, particularly in the north and south east of South Sudan, and the Sahel shifting southward, leading to changing habitats.
- Decreased crop yields due to increased temperature increasing food insecurity and negatively impacting nutrition, especially in children, pregnant women, and nursing mothers.

Risks due to increased climate variability, including potential increases in droughts, floods, and changes in the onset and duration of the rainy season (UNEP 2007, USAID 2016a):

- Delay or shortening of rainy season causing crop failure or reducing water resources leading to decreased livestock health.
- Extreme flooding or drought leading to the loss of grazing area or access to water for pastoralists.
- Increased variability of rainfall leading to variable production of grains and cereals, the country's primarily crops, as well as variable access to water for pastoralists, which leads to potential food insecurity and unpredictable dependence on imported food.
- Extreme drought or flooding causing crop failure, contributing to lack of access to nutritious foods, food insecurity, and famine.
- South Sudan generally has poor infrastructure, including lack of roads in rural areas to connect agriculture to markets, flooding, particularly in flood plains and wetlands, could increase the challenge to move agricultural goods and disrupt value chains.
- Increased competition for water resources during droughts between pastoralists and farmers, potentially contributing to increased local conflict.

- Droughts leading to significant drop in water table, drier seasonal rivers, and reduction of wetland size, which decreases both farmers and pastoralists access to water.

3.1.1 GHG emissions and existing technologies in the Agriculture, Livestock and Fisheries Sector

In South Sudan, traditional subsistence agriculture is perhaps the most critical, dominant economic and social development activity with approximately 78% of households reliant upon crop farming and livestock rearing as their main source of livelihood while simultaneously being the most vulnerable to climate change. Given that most communities in South Sudan depend on livestock and crops for survival, a sustainable and resilient agriculture sector is critical for long-term food security and development. Agricultural activities in South Sudan are particularly vulnerable to increasing climate variability induced changes in weather patterns such as floods droughts events, dry spell, increases in evapotranspiration and seasonal rainfall variation.

This will disrupt food production and contribute to food insecurity and malnutrition. Agriculture is also the largest emitter of greenhouse gases (GHG) in South Sudan. The share of emissions from the sector was about 74 percent – 26.8 million tCO2e – of the total emissions in 2015. The majority of these emissions originated from agricultural soils and enteric fermentation, which together made up more than 90 percent of the agriculture sector's total GHG emissions (Figure 19). Most farmers depend upon rain-fed agriculture and use traditional methods of farming. This combination renders them highly vulnerable to climate variability, particularly erratic rainfall. Unfavorable weather conditions – such as persistent droughts and annual flooding – also result in crop and livestock losses. Droughts are also causing encroachment of the desert southwards, while floods have destroyed forests in low-lying areas, particularly in areas close to the Sudd Wetland, Sobat and the White Nile River.

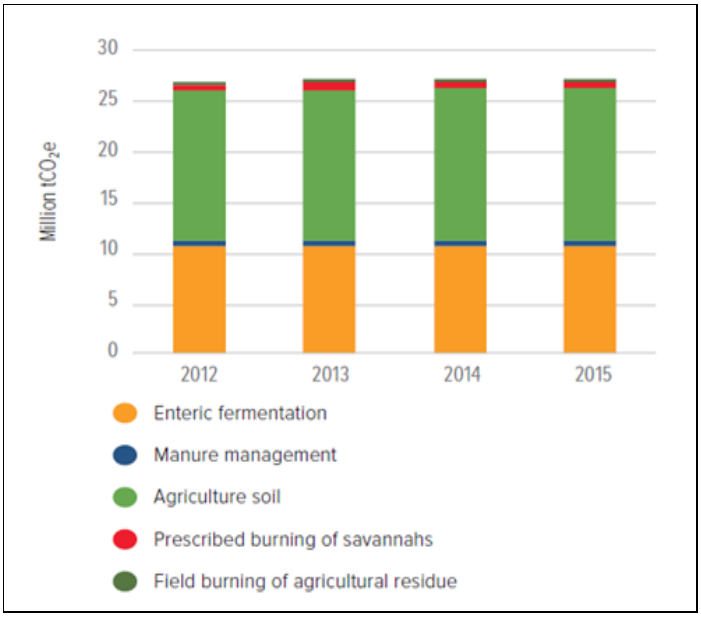

Figure 8: GHG emission from domestic production in the agriculture sector, 2012-2015
Source: South Sudan Ministry of Environment and forestry, 2018

Prolonged and heavy rainfall, for example, damage seedlings and encourage environment that promote diseases and pests. Droughts, on the other hand, cause added thermal stress on plants and livestock. Communities in upper Nile, Jonglei state and Unity state in particular reported

impacts from increase in floods, increased temperatures and dry spell resulting into declining crop yields and lowered livestock productivity. Changes in the frequency and intensity of extreme events (e.g., droughts, floods and heavy rains) have been identified as the greatest challenge that would face the agricultural sector as a result of climate change. Extreme pattern, difficult to both predict and prepare for, can devastate agricultural production, as has been demonstrated several times in the past. Drought and extreme heat have also been shown to affect livestock production and productivity in the country.

3.2: Decision context for the Agriculture, Livestock and Fisheries Sector

South Sudan government has taken key steps in the agriculture sector to attain growth and development in the face of climate change and other natural challenges. Some of the current initiatives in the agriculture sector gear towards adapting to climate change vulnerabilities include the comprehensive Agricultural Master Plan, 2015–2040, South Sudan national Development Strategy 2018-2021, Irrigation Development Master Plan 2015-2040 (IDMP) and the National Agriculture and Livestock Extension Policy (NALEP) which provide a clear direction to all stakeholder working in the agriculture sector towards agricultural intensification and transformation in the face of climate variability. The prioritized agriculture, livestock and fisheries sector is aligned with the following key priorities of the Agriculture sector under the ministry of Agriculture and food Security (MAFS).

The Comprehensive Agricultural Development Master Plan (CAMP), 2015 and Irrigation Development Master Plan (IDMP) consider climate change as the major bottleneck in the agricultural intensification process and it has prioritized climate smart Agriculture as a key program for the 5-10 year period of its implementation. The decision also stemmed from the National Adaptation Programme of Action (NAPA 2016) which identifies agriculture, livestock and fisheries sector as mostly vulnerable to climate change and prioritized climate-smart agricultural techniques and Value addition and processing of agricultural produce to improve livelihoods and food security under changing climate pattern. The prioritized agriculture adaptation technologies presented in this report will contribute towards the South Sudan government's efforts to reduce the vulnerability of the agriculture, livestock and fisheries sectors to climate change impacts and build resilient agriculture, livestock and fisheries production systems as outlined in the National Agriculture and Livestock Extension Policy (NALEP), 2011. Technologies to be considered were mainly prioritized according to those which were already used in South Sudan and based on national priorities and knowledge on ease of adoption of technologies in the local context. Pre-screening was undertaken through discussion with the relevant stakeholders in technical expert sector working group meetings, and a short-list of twenty five (25) most suitable technologies were chosen from an initial list of thirty (30) technologies.

3.3 Overview of existing technologies in Agriculture, livestock and fisheries sector

Existing technologies in the Agriculture, Livestock and fisheries Sector are many. They are broadly categorized here, but the list is by no means exhaustive. This assessment was done to determine which technologies are currently in use or have the potential to be utilized and adopted in South Sudan

Table 6 below provides an overview of the status of existing technologies in South Sudan

Category	Adaptation technologies	Status of technology in country

Sustainable water use and management	Small and large-scale irrigation schemes	Low level of implementation.
	Sprinkler and Drip Irrigation	Its uptake by small subsistence farmers is low because of the high initial investment.
	Rainwater Harvesting	Water harvesting implementation in some state but needs to be reinforced.
	Soil and water conservation technologies: terracing, contouring, conservation tillage	The technology is implementation in few location and there is needs for sufficient support and enforcement
Soil Management	Mulching and soil cover	Currently implemented by farmers cross the country. Needs more reinforcement
	Soil fertility improvement	Currently implemented. Needs reinforcing
	Crop Rotation	Currently implemented. Needs reinforcing
	Integrated Nutrient Management	Low implementation level
Sustainable Crop and livestock Management	Crop Diversification and growing of new varieties of crop	This technology is general implemented by farmers in all the ten State in South Sudan with support from the state Ministry of Agriculture and forestry and the national Ministry of Agriculture and Food Security. There is need for continue up scaling up.
	Drought tolerant crop varieties	Low level of implementation
	Changing sowing, planting and harvesting dates	Currently implemented majority of farmers cross the country.
	Seed storage	Low level of implementation, only traditional seed storage practices is practices by farmers in most of the country
Sustainable Farming Systems	Mixed Farming/Integrated Farming	Highly implemented by farmers cross the ten states in South Sudan
	Agroforestry	Currently implemented but requires encouraging by the Ministry of Agriculture and Food Security and partners
	Beekeeping and honey production	Currently implemented in most of the state in South Sudan. Need

		reinforcement from government and partners
Solar dry- Post harvest handling	Solar drying - Preserving food and reducing wastage	Implementation in few locations, needs reinforcement
Livestock Disease Management	Livestock management	This technology is still limited and require more reinforcement from government and partners
	Livestock disease prevention and control	Currently implemented. Needs reinforcing to improved livestock health and productivity
	Breeding of cattle, goats, poultry & fish	The technology is not implemented in South Sudan by the Ministry of Livestock and Fisheries and the development partners
Capacity Building and Stakeholder organization	Community-based Agricultural Extension Agents	Implemented by the Ministry of Agriculture and Food Security and Non-governmental organizations, however it requires strengthening
	Farmer Field Schools	Low implementation
	Farmers resource center (FRC)	Low implementation
	Extension programmes	Currently implemented by the national and state Ministry of Agriculture and Food Security
	Information and Knowledge Management	Very limited and require robust reinforcement

3.4: Adaptation technology options for agriculture, Livestock and Fisheries sector and their main adaptation benefits

Technologies selection was guided by general recommendations from a number of key documents and current climatic challenges faced by the agriculture, livestock and fisheries sector. A pre-selection list of 28 possible adaptation technologies was identified. These technologies were selected mainly to improve climate change resilience of agriculture, livestock and fisheries production system.

Twenty-Five technology options for agriculture, livestock and fisheries sector adaptation were identified and agreed upon by the TNA team members and working groups. Factsheets for the top three ranked technologies were prepared and circulated to stakeholders for review and feedback.
The fact sheets provided a description of the technology, its potential to contribute to adaptation to climate change and the status of the technology in South Sudan. Estimated costs and benefits of the technology options were provided where available. Refer to Annex I for the fact sheets.

Brief summaries of the Adaptation technology options for agriculture, Livestock and Fisheries are provided below (Table 7).

Table 7: Adaptation technology options for agriculture, Livestock and Fisheries sector

#	Category	Adaptation technologies
1	Soil Management	Conservation tillage /Zero-Tillage (ZT)
		Soil and water conservation – Terraces, contour Farming
		Crop Rotation
		Integrated Nutrient Management and use of organic matter
		• Mulching and soil cover • Rainwater harvesting and storage technique
2	Sustainable Farming Systems	• Mixed Farming/Integrated Farming
		• Agro-forestry
		• Integrated soil nutrient management
4	Sustainable water use and management	• Micro – Irrigation - Sprinkler and Drip Irrigation
		• Pressurized irrigation technologies
		• Rainwater harvesting and storage technique
5	Sustainable Crop Management	• Crop Diversification and New Varieties
		• Drought tolerant crop varieties
		• Ecological Pest Management
		• Community-based Agricultural Farmer Field Schools
		• Pastoralist farmers field School (PFS)
6	Capacity Building and Stakeholder Organization	• Farmers resource center (FRC)
7	Post-harvest handling and value addition	• Solar drying - Preserving food and reducing wastage helps in adaptation and solar drying is a technology to dry food at a faster rate without contamination of dust
		• Value addition and processing of produce
8	Fodder conservation	• Fodder conservation is conservation and storage of succulent roughage, crop residues or hay.
		• Improved livestock feed
9	Livestock Disease Management	• Livestock disease prevention and control
		• Breeding of cattle, goats, poultry & fish
		• Culture Based Fisheries and Aquaculture

3.5: Criteria and Process of Technology Prioritization for the Agriculture, livestock and fisheries sector

In the agriculture Sector Group, MCA was used for ranking and prioritization of the listed technologies. Following the methodology of the TNA, the Agriculture Sector expert prepared the list of criteria and presented it to the stakeholders for discussion and revision. Criteria for

prioritization of agriculture technologies for climate change adaptation were assessed by allocating scores of 0 (not favorable) to 100 (very favorable) to costs and benefits.

Table**8**: Criteria for Prioritization of Adaptation Technologies in the Agriculture, livestock and fisheries Sector

Criteria Category	Criterion/Explanation
Contribution to economic development priorities	Macro economy: The technology should envisage agriculture growth creating opportunities for farms and other enterprises while safeguarding the environment and achieving food security
	Trigger private investment
	Poverty reduction potential (PR): Technology should contribute towards reducing the impacts on the society and thus promote job opportunities, urban and rural development, healthy living condition, and reduce risks associated with disasters
Contribution to social development priorities	Reduced drudgery and acceptability (DR): Potential of the technology to enable society or the economy to avoid, overcome or withstand climate change e.g. projected increase in temperatures
	Improved food security (and Livelihood. Potential to enhance food security
	Improved institutional capacity, networking, cross learning (IC): Availability of human, organizational, policy and financial capacity to establish and operate the technology. Congruence of the technology with existing social systems
Contribution to environmental development priorities	Contribution of the technology to protection of soil and water (S&W) : Ability of the technology to prevent soil loss, improve soil fertility and prevent water loss contamination.
	Protection of biodiversity: Ability to maintain ecosystems in the locality
	Reduction of pests and diseases (P&D): Ability to prevent occurrence and mitigate spread of pests and diseases. The technology should be able to offer environmental opportunities in reducing the ill-effects of climate change for South Sudan
Climate related:	Reduced emissions (ER): Ability to reduce pollutants such as carbon dioxide, nitrogen oxide, and other hydrocarbon
	Reduced vulnerability and improved resilience to climate change (R/VR): Potential of the technology to enable society or the economy to avoid, overcome or withstand climate change e.g. projected increase in temperatures
Cost	**Establishment and operation**: Equipment, human expertise, energy sources, land and organizational resources needed to set up technology, and operate the technology and equipment, human expertise, energy

	sources, land and organizational resources needed to set up technology, and operate the technology
	Social cost: Threat to cultural norms and local cohesiveness, inclusiveness of needs of different sections of society, threat to food, livelihood and employment security.
	Cost of building human capacity to generate and operate the technology: Existence of trained professionals, ease of passing on skills to other people to run the technology
	Environmental cost: Threat to biodiversity, risk of increasing adverse climatic effects
Institutional/Implementation	Ease of implementation; Ease of handling, accessible, repairable, market potential, and higher benefits in comparison to costs of the technology.
	Replicability and ability to impact at large scale: Potential feasibility to spread technology where it is needed. Number of beneficiaries
Political support	**Coherence with development policies:** Contribution of the technology to current development priorities

Source: Based on stakeholder analysis

3.5.1: Weighting of the Criteria for the Agriculture, Livestock and Fisheries sector

Stakeholders allocated weight to each criterion (adding to 100) according to urgency, importance in contributing to the applicability and suitability of the technology for adapting to climate change. Technologies were allocated scores for each criterion as in Table 9).

Table 9: Weighting of criteria for the agriculture, livestock and fisheries sector

Criterion	Weight
Establishment and operation (EO)	5
Social cost (SC)	3
Cost of building human capacity to generate and operate the technology (HC)	4
Macro economy (ME)	4
Trigger private investment (PI)	5
Poverty reduction potential (PR)	5
Reduced drudgery and acceptability (DR)	4
Improved food security and Livelihood (FSL)	7
Contribution of technology to protection of soil and water (S&W)	6
Environment and biodiversity protection (PB)	7
Reduction of pests and diseases (P&D)	4
Reduced vulnerability and improved resilience to climate change (R/VR)	22
Reduced emissions (ER)	3
Ease of implementation (EoL)	7

Replicability and ability to impact at large scale (R/S)	9
Coherence with development policies (DP)	5
Total	100

3.6: Results of Technology Prioritization for the Agriculture, Livestock and Fisheries sector

Adhering to the methodology for the prioritization, the agriculture, livestock and fisheries sector working group was facilitated by the consultant with a sector expert providing technical insight into each technology during the discussions. The criteria were also categorized as cost related to the establishment and operation of the technology) table 8). For each criterion, a scale of 1 to 5 was employed for scoring each technology. Each technology was deliberated by the sector working group taking account of the national context. Each individual member of the group then provided a score for the technology. The average of the individual scores was then adopted as the group score. The criteria scores were then converted into standard scores of between 0 and 1. The average scores of the technologies were employed to do a final ranking of the technologies. A second ranking of the technologies was completed by inclusion of a weighting scale to prioritize the technologies. The outcomes of the prioritization are also shown in Table 10. The main bottleneck in the prioritization of technology options was limited data to ascertain costs and benefits.

Table 10: Criteria scores for technologies in the Agriculture, Livestock and fisheries Sector

Technology / Criteria	Costs			Benefits										Others		
				Economic			Social		Environmental			Climate related		Institutional and Implementation		Political
Criteria	**EO**	**SC**	**(HC)**	**ME**	**PI**	**PR**	**DR**	**FSL**	**S&W**	**PB**	**P&D**	**R/VR**	**ER**	**EoL**	**R/S**	**DP**
Conservation agriculture/Conservation tillage /Zero-Tillage (ZT)	80	40	45	40	40	60	50	70	65	70	50	75	60	65	80	60
Soil and water conservation – Terraces, contour Farming	70	50	60	50	40	50	50	80	70	75	60	80	65	50	60	70
Crop Rotation	85	40	40	60	20	60	40	65	85	85	70	50	60	80	85	80
Integrated Nutrient Management and use of organic matter	60	50	60	65	50	60	50	70	70	60	75	60	50	60	50	70
Mulching and soil cover	50	40	70	60	45	65	40	65	75	65	70	70	70	75	80	85
Rainwater harvesting and storage technique	80	40	50	50	40	50	40	50	80	60	50	75	60	70	80	80
Mixed Farming/Integrated Farming	50	50	60	40	20	40	50	50	60	70	40	70	50	80	90	50
Organic farming	75	50	70	50	40	50	50	60	70	75	50	65	60	70	75	90
Agro-forestry	70	40	75	50	65	40	40	50	75	80	40	70	60	50	60	60
Integrated soil nutrient management	60	50	70	40	40	50	40	70	70	75	45	60	50	40	50	50
Micro – Irrigation - Sprinkler and Drip Irrigation	80	90	100	100	80	60	50	75	80	60	50	100	60	70	70	80
Pressurized irrigation technologies	50	40	70	50	60	40	40	60	75	50	60	80	60	50	65	70
Crop Diversification and New Varieties	70	55	75	50	50	40	30	70	70	60	70	75	65	60	70	75

Promotion of drought-resistant varieties	80	60	80	60	70	50	40	75	75	80	60	100	60	60	80	85
Ecological Pest Management	80	50	70	50	40	30	40	70	80	85	80	60	50	70	85	80
Community-based Agricultural Farmer Field Schools	60	40	50	60	30	50	50	60	85	60	70	65	60	80	85	80
Pastoralist farmers field School (PFS)	70	45	60	70	40	60	50	70	70	50	75	70	50	85	70	75
Farmers resource center (FRC)	80	50	70	50	40	50	40	60	65	60	60	65	50	80	85	80
Solar drying - Preserving food and reducing wastage helps in adaptation	80	40	60	60	50	60	50	70	60	65	70	75	50	85	90	90
Value addition and processing of produce	85	50	70	70	70	65	80	80	50	80	75	80	40	80	70	80
Fodder conservation is conservation and storage of succulent roughage, crop residues or hay/ Fodder conservation improves availability of feed for livestock	80	40	75	50	60	50	40	60	50	60	70	75	40	60	65	70
Improved livestock feed	70	40	60	50	70	60	50	70	60	50	40	70	50	65	60	65
Livestock disease prevention and control	80	50	70	60	75	60	40	60	80	60	70	75	40	50	70	80
Breeding of cattle, goats, poultry & fish	70	50	60	65	60	50	50	70	80	70	65	70	50	60	75	70
Culture Based Fisheries and Aquaculture	60	40	70	50	40	60	40	60	50	65	70	75	40	70	50	50

 # See Table 9 for explanation of abbreviations

Table 11: Weighted scores for technologies in the Agriculture, Livestock and fisheries Sector

Technology	Cost			Benefits										Others			Total Score	Technology Rank
				Economic			Social		Environmental			Climate related		Institutional and Implementation		Political		
Weight	5	3	4	4	5	5	4	7	6	7	4	11	14	7	9	5		
Criteria	EO	SC	(HC)	ME	PI	PR	DR	FSL	S&W	PB	P&D	R/VR	ER	EoL	R/S	DP		
Conservation agriculture/Conservation tillage /Zero-Tillage (ZT)	400	120	172	160	200	300	200	490	390	490	200	1650	180	455	720	300	6427	14
Soil and water conservation – Terraces, contour Farming	350	150	160	160	200	300	200	560	420	525	240	1760	195	350	540	350	6460	13
Crop Rotation	425	120	160	240	200	300	160	490	510	595	280	1100	180	560	765	400	6485	6
Integrated Nutrient Management and use of organic matter	310	150	240	260	250	300	200	490	420	420	300	1320	150	420	450	350	6030	20
Mulching and soil cover	250	120	280	240	225	325	160	455	450	455	280	1540	210	525	720	425	6660	5
Rainwater harvesting and storage technique	400	120	200	160	200	250	160	350	480	420	200	1650	180	490	720	400	6380	17
Mixed Farming/Integrated Farming	250	150	240	160	100	200	200	350	360	490	160	1540	150	560	810	250	5970	23
Organic farming	405	150	280	240	350	250	200	350	420	525	200	1430	180	490	675	250	6395	10
Agro-forestry	350	120	300	200	325	200	160	350	450	560	160	1540	180	350	540	300	6085	19
Integrated soil nutrient management	300	150	280	160	200	250	160	490	420	525	180	1320	150	280	450	250	5565	25
Micro – Irrigation - Sprinkler and Drip Irrigation	400	270	400	400	400	300	200	525	480	420	200	2200	180	490	765	450	8080	1
Pressurized irrigation technologies	260	120	280	200	300	200	160	420	450	350	240	1760	180	350	585	350	6205	18
Crop Diversification and	350	156	300	200	250	200	120	490	420	420	280	1650	195	420	630	375	6456	9

New Varieties																		
Promotion of drought-resistant varieties	400	180	320	240	350	250	160	525	450	560	240	2200	180	420	720	425	7620	2
Ecological Pest Management	400	150	280	200	200	150	160	490	480	595	320	1320	150	490	765	400	6550	7
Community-based Agricultural Farmer Field Schools	300	120	200	240	150	250	200	420	510	420	280	1430	180	560	765	400	6425	8
Pastoralist farmers field School (PFS)	350	138	240	280	200	300	200	490	420	350	300	1540	150	595	630	375	6558	11
Farmers resource center (FRC)	400	150	280	200	200	250	160	420	390	420	240	1430	150	560	765	400	6415	15
Solar drying - Preserving food and reducing wastage helps in adaptation	400	120	240	240	250	300	200	490	360	455	280	1650	150	595	810	450	6990	4
Value addition and processing of agricultural produce	425	150	280	280	350	325	320	560	300	560	300	1760	120	560	630	400	7320	3
Fodder conservation - Fodder conservation improves availability of feed for livestock	400	120	300	200	300	250	160	420	300	420	280	1650	120	420	585	350	6275	22
Improved livestock feed	350	120	240	200	350	300	200	490	360	350	160	1540	150	455	540	325	6130	21
Livestock disease prevention and control	400	150	280	240	375	300	160	420	480	420	280	1650		420	585	350	6510	16
Breeding of cattle, goats, poultry & fish	350	150	240	260	250	250	200	490	480	490	260	1540	700	420	675	350	7105	12
Culture Based Fisheries and Aquaculture	300	120	280	200	200	300	160	420	300	455	280	1650	560	490	450	250	6415	24

 # See Table 9 for explanation of abbreviations

Table 12: Summary of results top five priority adaptation technologies for the agriculture, livestock and fisheries sector

Adaptation technologies for the agriculture sector	Total score	Ranking priority
Micro – Irrigation - Sprinkler and Drip Irrigation	8080	1
Promotion of drought-resistant crop varieties	7620	2
Value addition and processing of agricultural produce	7320	3

In all, the top three (3) prioritized adaptation technologies are:

The top three ranked technologies for agriculture sector namely 1) Micro irrigation –Sprinkler and drip irrigation, and 2) Promotion of drought-resistant crop varieties, 3) Value addition and processing of agricultural produce were selected, prioritized, and ranked through a consultation process with sector experts and relevant stakeholders are considered to be the most appropriate technologies for the sector.

Micro – Irrigation - Sprinkler and Drip Irrigation: Small scale micro irrigation for lifting, conveying and applying irrigation efficiently include gravity fed drip and pressurized sprinkler irrigation used to improve water use efficiency and food production. They may be gravity fed or pressurized system. Water source can be from borehole, reservoirs, field pond or portable source. Sprinkler and drip irrigation provide a best alternative for sustainable water use and management and strengthening the adaptive capacities of farmers living in economies that are greatly dependent on rain feed agriculture, as the case in South Sudan.

Promotion of drought-resistant crop varieties: South Sudan NAPA indicated, increased occurrence of pests and diseases in various parts of the country has been observed and climate change is suspected to be a major factor in this regard. Further, FAO, (2015) studies have shown that majority 75% of the crops planted in South Sudan are traditional varieties of crops and that there are low adoptions rates of improved varieties. In this regard, it becomes important that South Sudan government especially the Ministry of Agriculture and food Security (MAFS) moves towards developing drought and pest resistant varieties of important cereals and horticulture crops to ensure food security at the face of climate change and variability in the country**.**

Value addition and processing of agricultural produce

The South Sudan comprehensive Agriculture Master Plan (CAMP) recommended the need of creating value addition to agricultural produce at different stages, by different actors throughout the value chain by add value of agricultural production. Value added should consider quality, costs, delivery times, delivery flexibility, and innovativeness of agricultural products, among other standards**.**

Chapter 4: Technology Prioritization for the Water Sector

4.1: Key Climate Change Vulnerabilities in the Water Sector in South Sudan

South Sudan is generally considered to be rich in water resources, which are stored in the form of lakes, streams, rivers, reservoirs, and aquifers (Doran D. 2009). The surface water covers 39% of the country's territorial area of about 2,000 km-long stretch of the Nile and tributaries. The underground water is widespread, and its occurrences are associated with the Sudd swampy. The Sudd is an inland delta of the White Nile and is made up of lakes, swamps, marshes, and extensive flood plains. It is also one of the largest wetlands in the world, averages in size at about 30.000 square kilometers and covers about 5% of the area of South Sudan.

Historically, South Sudan water resources have exhibited a high sensitivity to changes in climate system. These water resources are considered vulnerable to climate change due to extensive reliance on precipitation as the principal source of their availability and the exposure of the surface water to increased temperatures that enhance evapotranspiration (Jubek Dora et al, (2019). Along with the rise in temperature, climate change has affected the hydrological cycle altering precipitation variability, soil moisture, surface runoff and water yield (Mohamed, Y. et al, 2014). Between 1981 and 2010/11, South Sudan experienced major droughts and many incidences of flooding, which heavily impacted many people in the country (Petersen G et al, (2010). The January 2015 floods, for example, were the most devastating and affected over 1.1 million, displaced 900,000 people 230,000 and killed 68 people (ACAPS, 2022). The floods also affected infrastructure (including roads, rail, bridges and homes), crops, and increased incidences of water borne diseases (diarrhea, cholera and malaria).

Since the 1970s, precipitation has declined by an average of 10 to 20 percent while variability in the onset, duration, and timing of precipitation has increased. Total annual precipitation is 900 mm with rainfall ranging between 700 mm in the north, northeast, and far southeast to 2,200 mm/year in the south of the Country. Most of the states in South Sudan experience one rainy season from May to October, however, the southern zones of Western and Central Equatoria have two rainy seasons beginning April-June and August-November, FAO (2020b). Interannual inconsistency in precipitation variability is also high and can range from 50% lower to 50% higher from the baseline average (USAID, 2019). The rainy season has started later and finished earlier while the frequency of heavy rainfall events and floods has increased measurably in the last eight decades and is expected to continue to rise (USAID, 2019).

Land use, moderate rain, temperature increases, and more recurrent droughts have decreased vegetation coverage, thereby accelerating desertification (Funk C, et al, (2011).) This has resulted in many perennial rivers having dried up or become seasonal during the past two decades. Increased evapotranspiration and dry spell are also anticipated to shrink South Sudan's wetlands. In the last two decades, several perennial rivers have dried up or become seasonal.38 Increased evapotranspiration and dry periods are also expected to shrink South Sudan's wetlands (MOFA-NL, (2018). Study finding on Equatorial Lakes and Bahr el Ghazal sub basins indicated that a 2°C increase would reduce their average flow by 50%. Land degradation may also continue to impact the northern and southeastern areas as the Sahel shifts southward and climate shifts is projected to leave a large number of South Sudanese vulnerable to increased food shortage due to losses in both crop and livestock yields (WFP/VAM Nairobi Regional Bureau 2014).

The potential climate change adaptation technologies in the water sector were identified from desk review of the following key development documents taking into consideration development priorities and predicted climate change and its impacts. South Sudan Vision 2040: National Adaptation Programme of Action (NAPA 2016), the NAP (2021), the Nationally Determined Contribution (to the Paris Agreement; NDC, 2015; revised 2020), the government of South Sudan Water Policy, 2017, the Disaster Management Plan (2016), peer reviewed reports and publications.

Criteria for identifying potential technologies in the water sector were:

- Capital costs – Cost of setting up the technology – often incurred during the start–up phase.
- Operating costs historical
- Maintenance cost
- Economic benefits – the ability of the technology to improve local economy; catalyze private investment; economically empower women and girls; and create jobs
- Social benefits – ability of the technology to reduce poverty; improve health, especially of women and girls; contribute to gender equality and reduce inequality; and preserve cultural heritage.
- Environmental benefits – ability of the technology to protect the environment and/or biodiversity.
- Climate-related benefits – ability of the technology to reduce vulnerability and build climate resilience.
- Technology-related benefits – ease of diffusion and in-country accessibility of the technology; and efficiency and effectiveness of the technology in achieving the desired results
- Institutional-related benefits – ease of implementation (enablers), and coherence with national goals

4.2: Decision Context for the Technology Prioritization in the Water Sector

In South Sudan, water is accessed in several ways, either via individual supply systems; rural community managed systems, public entity system or by a collective private sector run reticulated system. Urban water supplies are provided by South Sudan Urban Water cooperation which reaches over 5% of the population and via a reticulation system servicing about 90% of the entire population with generally reliable and clean water, generally sourced from aquifers. Other water supplies are operated and managed by the local population and are either sourced from groundwater via open wells and bores, from surface water sources, or rainwater collection with storage in polyethylene tanks. Demand for irrigated water is extremely low and limited to a few small horticultural locations suited along the river Nile.

In all the states and major town of South Sudan there is a range of different problems with the delivery of safe drinking water including intermittent supply caused by drought or damaged infrastructure, contaminated water and competing uses for drinking water causing conflict in communities. Water in the context of catchment management and flooding is also an issue. Several catchments are prone to flooding causing damage and disconnecting major populations to the main centers. This means those populations are denied access to general services and local communities are not able to trade or sell their produce in the local markets. Moreover, climate change may lead to unintended displacement and encourage the patterns and rates of relocation.

Most displacement related to extreme weather events has, to date, been temporary. However, if climate change renders certain areas uninhabitable (for example, if they become too dry or too frequently flooded) such migration may increase in scale and lead to permanent resettlement within South Sudan and beyond the country borders. Avoidance of these impacts in South Sudan calls for decisive responses and firm adaptation decisions for the water sector to adapt climate variability technologies options. The decision for the section of water sector stemmed from literature review of existing climate change and development framework documents which included the NAPA and South Sudan water policy (2017) which was developed by the ministry of Irrigation and water resources.

South Sudan National Water Policy (2017) in particular seeks to achieve and align its' strategic objectives for sustainable development via safe and sufficient, accessible and affordable, reliable and sustainable source of water for all. South Sudan NAPA proposed water management policies or programmes such as integrated water resource management, including rainwater harvesting as specific adaptation technologies. Consultation with stakeholders and water sector working groups considered the various climate issues and development issues at hand, especially their significance for water. Water technologies were mainly prioritized on their ability to improve the resilience of domestic water supply, availability of water for households' livelihoods. Technologies to be considered were especially prioritized according to those which were already used in South Sudan, were based on national priorities and knowledge on ease of adoption of technologies in the local context.

Pre-screening was conducted through discussion with the relevant stakeholders in technical working group meetings, and a short-list of eight (8) most appropriate technologies were retained from an initial list of thirteen (16) technologies. Technology factsheets were produced namely by gathering information existing climate change plan and policies. More specifically, information with respect to costs and benefits was also limited or unavailable locally. Given the paucity of locally appropriate information on the technologies, utilization of expert judgment was therefore the preferred option to facilitate the prioritization exercise. The technology factsheets were circulated prior to the stakeholder workshop and were further discussed at the workshop or bilaterally via meetings. Stakeholders also provided information on the status of each technology in South Sudan and where available historical information about technologies, which have been used in the country. Technology criteria and weights were discussed collectively and agreed upon by way of consensus among stakeholders. Scores and results for technologies were undertaken and distributed to participants.

4.3: Overview of existing technologies in the Water Sector

Following are the current adaptation technologies in water sector in South Sudan. All the below technologies are practiced in some parts of the South Sudan but adoption and diffusion in many parts of the country face several barriers and therefore, call for reinforcement in the implementation of all the below technologies by government and development partners in the country,

- Harvesting rainwater from ground surfaces for irrigation and drinking purposes
- Roof top Rainwater harvesting,
- Household water treatment and safe storage (HWTS) (water purification systems);

- Soil and water conservation structures including: i) contour bunds, check dams and gabions; ii) re-seeding of rangelands; iii) afforestation and agroforestry; iv) protection from grazing.
- Water storage structures that serve dual purposes of storing water and recharging groundwater, such as delay action dams, check dams;
- Boreholes and tube wells;
- Flood early warning system with flood protection structures such as levies.
- Constructing small dykes, hafirs, diversion canals and water storage ponds and spreading structures
- Awareness raising campaigns to encourage efficient water use and conservation of water resources.
- Catchment protection including afforestation and soil conservation techniques for example building terraces and planting cover crops.
- Solar Powered water supply systems
- Water abstraction from surface water sources. Water is usually pumped using diesel or electric powered pumps from the source (rivers, lakes or dams) to either directly to the consumers or to the treatment works where it is chemical treated for distribution to consumers.

4.4 Adaptation technology options for Water Sector and their main adaptation benefits

Water sector experts, practitioners, and stakeholder's members of Sectorial Expert Working Group agreed on the following eight (8) adaptation technologies options for water sector (Table 13).

Table 13: Below provides a summary of adaptation technologies in the Water Sector

#	Technology option	Features/ Adaptation Benefit
1	Roof top Rainwater Harvesting (RWH)	This technology provides a diversified source of household water supply and a convenient and reliable freshwater supply during seasonal dry periods and droughts.
2	Integrated Flood Management (IFM)	With the projected increase in frequency and severity of floods in many flood-prone areas of South Sudan, IFM will make these areas become resilient to negative impacts of flood disasters in many of their forms (e.g. loss of life and damage to property) and maximize use of alluvial-rich floodplains for agriculture.
3	Catchment-based watershed conservation/Communities in micro-watersheds - Integrated River Basin Management	Micro-catchment water harvesting systems

4	Constructing small dykes, heifers, diversion canals and water storage ponds and spreading structures	Example techniques include earth and stone bonds, terraces and pots. Observed storage media include soil, tanks, underground cisterns, small check dams and one large dam
5	Flood early warning system – Flood hazard warning and mapping	Minimize risk level to property and life 2. Early evacuation of the vulnerable population. Allow for installation of flood resilience measures such as sand bags and help in pre-flood maintenance operations to ensure safety of flood control structure
6	Surface rainwater harvesting	Reduce pressure on the surface and groundwater resources by decreasing household water demand and mitigate or reducing the instances of flooding by capturing rooftop runoff during intense rainstorms
7	Groundwater Abstraction – Water Borehole Drills	address the problem of water shortage during droughts and access to clean quality groundwater
8	Solar powered water supply systems	Solar water heating systems use panels or tubes, called solar collectors, to gather solar energy that pump water for irrigation and domestic used.

4.5: Criteria and Process of Technology Prioritization for the Water Sector

Multi-criteria analysis was employed in determining which technologies to prioritize to allow objectivity consensus among technical working group's stakeholders with different views. According to the MCA guidance on Adaptation the steps listed in the sections below were followed.

4.5.1: Identification of the criteria for technology prioritization in the water sector

The following standards for technology prioritization were developed through deliberations with stakeholders in the water sector technical working group from government, INGOs, civil society and private sectors institutions. Stakeholders were guided by the technology fact sheet that was shared by the consultant to decide the appropriate criteria for water sector technology prioritization. Criteria for technology prioritization were based on their potential to reduce vulnerability or enhance resilience to climate change, and their potential social, economic and environmental benefits as well as cost implications (Table 14).

Table 14: Criteria for technology prioritization for the water sector

Criteria Category	Criterion/Explanation
Costs	1. Capital costs – Cost of setting up the technology – often incurred during start-up phase.

	2. Operating costs -Availability and ability to purchase equipment parts, availability of energy sources to ensure functionality.
	3. Maintenance cost
Benefits	4. Economic benefits – the ability of the technology to improve local economy; catalyze private investment; economically empower women and girls; and create jobs
	5. Social benefits – ability of the technology to reduce poverty; improve health, especially of women and girls; contribute to gender equality and reduce inequality; and preserve cultural heritage.
	6. Environmental benefits – ability of the technology to protect the environment and/or biodiversity.
	7. Climate-related benefits – ability of the technology to reduce vulnerability and build climate resilience; and reduce greenhouse gas (GHG) emissions - as a co-benefit
	8. Technology-related benefits – ease of diffusion and in-country accessibility of the technology; and efficiency and effectiveness of the technology in achieving the desired results
	9. Institutional-related benefits – ease of implementation (enablers), and coherence with national goals - Availability of human, organizational, policy and financial capacity to establish and operate the technology.

4.5.2 Scoring of criteria for technology prioritization in the water sector

Criteria were assessed by allocating scores of 0 (not favorable) to 100 (very favorable) to costs and benefits (Table 15) following the logic recommended in the MCA guide handbook.

Table 15: Scoring of criteria for technology prioritization in the water sector

Category	Cost	Benefit
Very low	70-100	0-25
Low	50-69	30-49
Medium	30 -49	50-69
High	0-29	70-100

4.5.2 Weighting of the criteria for technology prioritization in the water sector

Stakeholders allocated weight to each criterion (adding to 100) according to urgency, importance in contributing to development priorities, applicability and suitability of the technology for adapting to climate change (Table 16).

Table 16: Weighting of criteria for the Water Sector

#	Weighting of the criteria	Weight Score
1	Capital costs – Cost of setting up the technology – often incurred during start-up phase.	13
2	Operating costs	6
3	Maintenance cost	8

4	Economic benefits – the ability of the technology to improve local economy; catalyze private investment; economically empower women and girls; and create jobs	12
5	Social benefits – ability of the technology to reduce poverty; improve health, especially of women and girls; contribute to gender equality and reduce inequality; and preserve cultural heritage.	10
6	Environmental benefits – ability of the technology to protect the environment and/or biodiversity.	12
7	Climate-related benefits – ability of the technology to reduce vulnerability and build climate resilience; and reduce greenhouse gas (GHG) emissions - as a co-benefit	30
8	Technology-related benefits – ease of diffusion and in-country accessibility of the technology; and efficiency and effectiveness of the technology in achieving the desired results	6
9	Institutional-related benefits – ease of implementation (enablers), and coherence with national goals	13
Total		**100**

4.6: Results of Technology Prioritization for the Water Sector

Inadequate data to establish costs and benefits posed a major challenge in the prioritization of water technology options. Technical working group experts provided perspectives to the advantages of individual technologies relative to their relevance to increasing resilience of domestic water supply to climatic hazards (such as prolonged dry periods, drought and flood).

Importance was also given to technologies with the potential to contribute to development objectives such as economic, environmental, social benefit such as health improvement and gender mainstreaming. Cost implications of a technology and whether implementing a technology will contribute to broad development or sector development objectives promoted much discussion.

The performance of each technology was rated individually by stakeholders and with scores aggregated in order to determine ranking. The weight assigned to each criterion was multiplied by the score value (0-10) that each technology was assigned. The scores for each technology options were aggregated and the technology receiving the highest score was consigned high priority.

Using sector working group expert view, scores were assigned to the technologies against each criterion (Table 16). The scores were multiplied by the weight assigned to each criterion (Table 17). The total weighted score for each technology was then summed up. The technologies were then ranked according to their total weighted score (Table 18). Three technologies were prioritized and these were:

A. Solar-powered water supply system
B. Groundwater Abstraction – Water Borehole Drills
C. Rainwater Harvesting (RWH) from Rooftops.

Table 17: Criteria scores for technologies in the Water Sector

Weight criteria	Costs			Benefits					
Technology	Capital	Operation cost	Maintenance cost	Economic	Social	Environmental	Climate related benefit	Technology-related benefits	Institutional and Implementation
Rainwater Harvesting (RWH) from Rooftops	80	50	65	60	75	70	75	60	70
Integrated Flood Management (IFM)	65	55	60	65	60	60	55	60	70
Catchment-based watershed conservation/Communities in micro-watersheds - Integrated River Basin Management	65	60	50	70	60	55	50	50	70
Constructing small dykes, heifers, diversion canals and water storage ponds and spreading structures	85	50	60	75	60	65	60	60	65
Flood early warning system – Flood hazard warning and mapping	60	50	55	80	65	70	80	50	80
Surface rainwater harvesting	70	50	60	65	60	65	55	50	65
Groundwater Abstraction – Water Borehole Drills	90	70	65	70	75	70	70	65	60
Solar powered water supply system	95	80	75	75	85	75	70	75	60

Table 18: Weighted scores for technologies in the Water Sector

Criteria	Costs			Benefits						Total scores	Ranking
Criterion weight	13	6	8	12	10	12	30	6	13		
Technology	Capital Cost	Operation cost	Maintenance cost	Economic	Social	Environmental	Climate related benefit	Technology-related benefits	Institutional and Implementation		
Rainwater Harvesting (RWH) from Rooftops	1040	300	520	720	750	840	2250	360	210	6990	3
Integrated Flood Management (IFM)	845	330	480	780	600	720	1650	360	210	5975	7
Catchment-based watershed conservation/Communities in micro-watersheds - Integrated River Basin Management	845	360	400	840	600	660	1500	300	210	5715	8
Constructing small dykes, heifers, diversion canals and water storage ponds and spreading structures	1105	300	480	900	600	780	1800	360	195	6520	5
Flood early warning system – Flood hazard warning and mapping	780	300	448	960	650	840	2400	300	240	6918	4
Surface rainwater harvesting	910	300	480	780	600	780	1650	300	195	5995	6
Groundwater Abstraction – Water Borehole Drills	1170	420	520	840	750	840	2100	390	180	7210	2
Solar powered water supply system	1235	480	600	900	850	900	2100	450	180	7695	1

Table 19: Ranking of technologies in the Water Sector

Technology	Total Score	Ranking
Solar powered water supply system	7683	1
Groundwater Abstraction – Water Borehole Drills	7210	2
Rainwater Harvesting (RWH) from Rooftops	6990	3

Here is the brief account of priority adaptation technologies in the Water Sector

Solar powered water supply system

A solar water powered supply system is essentially an electrical pump system in which the electricity is provided by one or several photovoltaic (PV) panels. A typical solar powered pumping system consists of a solar panel array that powers an electric motor, which in turn powers a bore or surface pump. The water is often pumped from the ground or stream into a storage tank that provides a gravity feed, so energy storage is not needed for these systems**.**

Groundwater Abstraction – Water Borehole Drills

Abstraction of ground water increases water availability for domestic and agricultural purposes. Ground water is relatively less likely to be affected by increased temperatures (evaporation) and drought compared to surface water sources and will therefore be a good water source option especially in area of water scarcity of South Sudan. Deep well water extraction involves digging and drawing water from underground using containers. Most commonly, it involves a vertical bore hole with a diameter of 80 to 400mm, within which an extraction pipe is placed that has a perforated section (filter) and sand trap, surrounded by filter gravel. Borehole coverage is still not sufficient yet well-known, The ones with too many users per point are not well maintained and dry up during drought events (MEDIWR, 2015), As an adaptation technology, it will increase access to water in dry periods, reduce negative impacts on community health, preventing epidemic diseases e.g. diarrhea, relieve pressures on surface water sources.

Rainwater Harvesting (RWH) from Rooftops

Generally, rainwater is still the cheapest and most economical source of drinking and domestic water available in most rural areas in South Sudan. With normal rainfall of 400-900 mm a year, rooftop water harvesting could provide clean water for a wide number of families, but this resource is poorly exploited and harvested with local containers. Rainwater harvesting (RWH) through roof catchments is being promoted by international development partners such as FAO, international trade Centre (ITC), the ministry of agriculture and food security and ministry of irrigation and water resources in South Sudan because it is affordable and manageable by communities especially in water stressed areas both at household and institutional levels. Rainwater harvesting systems can be applied from small to large scales. They comprise a roof, a storage tank and a means such as guttering to connect one to the other. As an adaptation measure, it will eliminate the need for the energy and chemicals used to produce pure drinking water, improve agricultural production when water is used for livestock and irrigation of gardens leading to food security and resilience to climatic shocks such as dry spell and drought.

Chapter 5: Technology Prioritization for the Disaster Risk Reduction and Management (DRRM) Technologies

5.1: Key Climate Change Vulnerabilities in the Disaster Sector in South Sudan

Climate change can increase disaster risk in South Sudan by altering the rate of recurrence and intensity of climatic hazard events, increasing population vulnerability to hazards, and changing exposure patterns. South Sudan faces a high risk of natural and human-induced hazards, such as, floods and dry spells (more than 1 in 100 people are at risk), human and livestock disease, crop pests and diseases infestations (WFP, 2014). About 78 percent of households (predominantly rural communities) are reliant on crop farming (mostly rain-fed) and livestock rearing as their main sources of livelihood (International Crisis Group, 2022). Droughts, floods and heavy short rainfall impact the livelihoods of these communities, as they lead to significant losses of crops and livestock. Furthermore, floods have destroyed forests, especially in the low-lying areas of South Sudan, and this has had negative impacts on biodiversity and the livelihoods of population dependent on forestry food sources such as leaves, fruits, roots, gums, fungi, and wild animals.

According to the UN Office for the Coordination of Humanitarian Affairs (OCHA) reports, (OCHA, 2022), about 900,000 people (approximately 6 percent of the total population) across 9 states in South Sudan were affected by floods that inundated homes and left them without food, water and shelter.

In addition, there are a number of cross-cutting factors that influence vulnerability to disaster. These factors, all linked to development, are often the root causes of individual and societal vulnerability and may increase the risk of disasters and emergencies. They include poverty, scarcity of natural resources to support livelihoods, lack of relevant and sustainable policies and infrastructure, urbanization, and inadequate health services among others.

5.2 Decision context for the Disaster Risk Management Sector

South Sudan is already vulnerable to a wide range of disasters and natural hazards. In South Sudan, an absolute decline in rainfall of ~10-20% has been observed, as well as changes to the profile (amount and timing) of rainfall from year to year since the mid-1970s. Additionally, the proportion of the country receiving adequate rain for livestock and farming has been declining over this same period. Climate change in South Sudan is expected to result in erratic duration and timing of rain, a delayed and shorter rainy season, and certain areas receiving less rain, leading to falling water tables and the southward expansion of the Sahara Desert. While there is a projected decrease in the total annual precipitation, there is likely to be an increase in the hourly maximum rainfall rate with projected changes in 2060 showing an increase in intensity of approximately 10% and 17%, for RCP4.5 and RCP8.5 respectively.

These expected changes to rainfall and temperature are likely to cause more frequent disasters such as droughts and floods, which are already becoming increasingly severe. Land and water resources, which are already fragile and mismanaged, are particularly at risk from these impacts. These disasters will affect all sectors — including farming, livestock and fisheries — and natural

resources, the main livelihood sources for more than 80% of the population. Unless communities' adopt appropriate technologies to these impacts, climate change disaster will reduce agriculture production, increase food insecurity and generally hinder socio-economic development of South Sudan

South Sudan declared its intention to implement the Sendai Framework for disaster risk reduction in the East African region along with Burundi, Kenya, Rwanda, Uganda, and Tanzania on 31 May 2017. The country then began developing a disaster risk management policy to prevent and prepare for natural hazards. In the short term, it will be important for the country to ensure coordination between climate change adaptation efforts and those aimed at reducing and managing disaster risks. In addition, the disaster risk management sector is a priority in South Sudan's Vision 2040 and the NAPA. The NAPA stresses improving collection, analysis and dissemination of weather information and strengthening drought and flood early warning systems.

5.3: Overview of existing adaptation technology options in Disaster Risk Management Sector

This section gives an overview of existing technologies in the Disaster Risk Management sector. The following are some of the likely adaptation options assessed from the vulnerability studies done. The South Sudan NAPA, (2016) which resulted from assessment that was carried throughout the country, recommended the following as prioritized options for Disaster Risk Management sector.

- Reforestation and tree planting to combat desertification
- Establish improved drought and flood early warning systems in South Sudan through improved hydro-meteorological monitoring network.
- Increasing knowledge on climate change and environmental issues through a national awareness-raising campaign and inclusion into school curricula
- Reduction in water-borne diseases due to flooding and river overflow resulting from extreme climate events.
- Improved environmental management in the oil industry to reduce the impact of floods and droughts
- The Development of the South Sudan's Ministry of Humanitarian Affairs and Disaster Management Strategic Plan 2018–2020 Sectorial strategies focuses on a holistic approach that includes implementing preventive and/or development measures to reduce vulnerability in addition to emergency responses for saving lives and livelihoods
- Early warning systems. The Government of South Sudan and development partners are now planning to rehabilitate five national disaster risk management centers in Juba, Wau, Malakal, Renk and Raja to support in early warning monitoring and update.

5.4 Adaptation technology options for Disaster Risk Management Sector and their main adaptation benefits

Literature review on possible adaptation options for disaster risk management adaptation technologies was firstly undertaken by the consultant to come up with a pre-selection list from which the prioritization process will stem from. This assessment was done to determine which technologies are currently in use or have the potential to tackle the Disaster risk related impact on South Sudan population.

Table 20: below provides an overview of the adaptation technology options for Disaster Risk Management Sector and their main adaptation benefits

S/NO	Technologies	Features and benefit of the technologies
1	Flood early warning system	Early identification of type and extent of climatic hazards and population at-risk Effective prevention or mitigation of risk with quick recovery of hazard-hit population in disaster prone areas. Enhanced effectiveness of vulnerability monitoring, allowing individuals (farmers) and community systems to prepare for hazards
2	Development and introduction of monitoring and early warning systems	Early-warning systems warn of weather-related extreme events such as, flooding, dry spell, fires that present immediate risk to life and property.. Technologies are needed to forecast extreme events, generate warnings, and communicate risks to the public. Various levels of technological input, from phone trees to automatic monitoring stations, can be involved. Early-warning systems, when used effectively, can significantly reduce the number of deaths in disasters.
3	Disaster risk maps for flooding, drought, and crop pests	Utilize climate data and projections to develop disaster risk maps for flooding, drought, earthquakes, and crop pests
4	Awareness raising campaign and inclusion in school Curricula	Making disaster risk education part of national primary and secondary school curricula fosters awareness and better understanding of the immediate environment in which children and their families live and work
5	Strengthening Disaster Risk Governance to Manage Disaster Risk	Increased dialogue, networking, and sharing best practices of science-based solutions and user-friendly technologies.
6	Disaster response (through the	The use of social media in disaster response.

	use of social media)	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
7	Disaster Risk reduction structural Measures such as Embankments, Dams and Reservoirs, natural detention basin, channel improvement, drainage improvement and diversion of flood waters, watershed Management / Catchment area treatment and anti-erosion works	Drainage and embankment to control flood and water runoff in flood sensitive cropping pattern
8	Improved evacuation techniques	Social protection systems are a fundamental in preparing, responding and mitigating the impact of disasters.

5.5: Criteria and Process of Technology Prioritization

Two steps were employed to arrive at a shortlist of technology options for adaptation in the disaster risk management sector. The first phase consisted of pre-screening the most likely implementable adaptation technologies from the long-list of identified technologies. The pre-screening was done considering 1). South Sudan's current disaster-related risks as a result of climate change and variability in the DRM sector, 2). The proposed technologies aligned with the National Disaster Management Strategic Plan 2018-2020, and 3) Based on the view and opinion of participants in the workshop; the second phase consisted of developing technology factsheet (TFS) for each of the short-listed technologies, and establishing the criteria for technology prioritization using MCA. In the second technical working group workshop (May 4, 2023) expert working group discussions of the stakeholders selected 8 technologies according to the technology contribution to economic development priorities, social development priorities, environmental development priorities, ease of implementation; potential to maximize resilience or reduce vulnerability to the effect of climate change.

5.6: Results of Technology Prioritization for the Disaster Risk Management Sector

The TFS were circulated to all members of the technical working group for familiarization with the technology options prior to the MCA prioritization exercise, which involved scoring, weighting. The MCA was employed for technology prioritization in disaster risk management.

A performance score card in which each row describes a technology option and each column describes the performance score of the options against each criterion was developed and filled following thoroughly discussion with disaster risk management technical working team during the prioritization workshop. The scoring matrix for each criterion's scores was from 0 to 100. The working group agreed that 0 was the least score and 100 were the highest score. Expert judgments were sought from members of the disaster risk management technical working group to assign a numerical weight (between 0 and 10) to each criterion to reflect their relative importance in the decision-making process. The cumulative sum of weights across all criteria

was equal to 100. In order to minimize bias, weights were assigned to criteria prior to scoring the technologies.

Table 21: Weighting of criteria for the Disaster Risk Reduction Sector

S/NO	Criteria	weight score
1	Establishment and operation (EO)	8
2	Social cost (SC)	9
3	Cost of building human capacity to generate and operate the technology (HC)	8
4	Contribution to economic development priorities	14
5	Contribution to social development priorities	10
6	Contribution to environmental development priorities	10
7	Ease of implementation	13
8	Potential to maximize climate change resilience or reduce vulnerability	28
	Total	100

The linear additive model was employed to derive the total weighted score of each technology option. This was done for a technology by multiplying its score for each criterion by the corresponding weight of that criterion, and then adding the weighted scores to give the total weighted score for this technology. The 8 disaster risk management adaptation technologies were then ranked according to overall contribution to economic development priorities, social development priorities, environmental development priorities, ease of implementation; potential to maximize resilience or reduce vulnerability to the effect of climate change. The option scoring the highest total weighted score was ranked as the most implementable adaptation options, whereas the one with the lowest score was ranked as the least suitable option. Please see below table 23 showing the ranking of adaptation technologies in the agriculture sector. There was no sensitivity analysis carried out during the prioritization of adaptation technologies for the disaster risk management sector.

Table 22: Criteria scores for technologies in the Disaster Risk management Sector

Technology	Cost			Benefit				Climate related
Weight criterion	**Establishment and operation**	**Social cost**	**Cost of building human capacity to generate and operate the technology**	**Contribution to economic development priorities**	**Contribution to social development priorities**	**Contribution to environmental development priorities**	**Ease of implementation**	**Potential to maximize climate change resilience or reduce vulnerability**
Flood early warning system	80	50	80	70	70	80	80	100
Development and introduction of climate monitoring and forecasting early warning systems	85	90	80	100	80	80	90	100
Disaster risk maps for flooding, drought, earthquakes, and crop pests	70	40	80	30	40	70	60	100
Awareness raising campaign and inclusion in school criteria	50	40	70	60	60	50	70	100
Strengthening Disaster Risk Governance to Manage Disaster Risk	70	60	40	70	40	35	25	20
Improved evacuation techniques	80	80	78	75	95	30	65	40
improving disaster response (through the use of social media)	70	80	70	70	80	70	95	100
Disaster Risk reduction structural Measures such as Embankments, Dams and Reservoirs, natural detention basin, channel improvement, drainage improvement and diversion of flood waters, watershed Management / Catchment area treatment and anti-erosion works.	70	40	80	80	70	60	40	70

Table 23: Weighted scores for technologies in the disaster risk Management Sector

Technology	Cost			Benefit				Climate related		
Criterion weight	8	9	8	14	10	14	13	28	100	
Technology criterion	**Establishment and operation (EO)**	**Social cost (SC)**	**Cost of building human capacity to generate and operate the technology (HC)**	**Contribution to economic development priorities**	**Contribution to social development priorities**	**Contribution to environmental development priorities**	**Ease of implementation**	**Potential to maximize climate change resilience or reduce vulnerability**	**Total**	**Rank**
Flood early warning system	**640**	**450**	**640**	**280**	**700**	**800**	**1040**	**3800**	**8350**	**3**
Development and introduction of climate monitoring and forecasting early warning systems	680	810	640	400	700	800	1170	3800	**9000**	**1**
Disaster risk maps for flooding, drought, earthquakes, and crop pests	560	360	640	120	400	700	1040	3800	**7620**	**4**
Awareness raising campaign and inclusion in school criteria	400	360	560	240	600	500	910	3800	**7370**	**5**
Strengthening Disaster Risk Governance to Manage Disaster Risk	560	540	320	280	400	350	325	760	**3535**	**8**
Improved evacuation techniques	640	720	624	300	950	300	845	1520	**5899**	**7**
Improving disaster response (through the use of social media)	560	720	560	280	800	700	1235	3800	**8655**	**2**
Disaster Risk reduction structural Measures such as Embankments, Dams and Reservoirs, natural detention basin, channel improvement, drainage improvement and diversion of flood waters, watershed Management / Catchment area treatment and anti-erosion works.	560	360	640	320	700	600	520	2660	**6360**	**6**

Table 24: Ranking of technologies in the disaster risk management Sector

Technology	**Total score**	**Ranking**
Development and introduction of monitoring and early warning systems	9000	1
Improving disaster response (through the use of social media)	8655	2
Flood early warning system	8350	3

Overall, the top three (3) technologies are:

Development and introduction of monitoring and early warning systems at the national and sub national level

Due to the complexity of global climate and weather systems, regular measurement of specific variables provided by climate monitoring and early warning systems are indispensable that would facilitate disaster preparedness and adaptation planning in the country. With effective early warning communication channels for all disaster related in place, this technology increases the effectiveness of vulnerability monitoring, allowing individuals (farmers) and communities to prepare for hazards. It also enables early identification.

Improving disaster response (through the use of social media)

Increasing knowledge on disaster risk management and response both at the national and state level through awareness raising campaign and inclusion into school curricula. Social network tools and applications like cellphones, Facebook and email can be employed by household to communicate with friends, family, first responders, and response team from the county and state level. If this technology is implemented well, it can contribute toward building and strengthening community resilience in the face of climate and weather related disasters.

Flood early warning system

Flood warnings is a system purposely established to detect and forecast threatening flood events so that the public can be alerted in advance and can undertake appropriate responses to minimize the impact of the event. The technology is a highly important adaptive measure where protection through large-scale, hard defenses, is not desirable or possible. The technology provides benefits for risk informed development planning, emergency management/response and raising awareness for flood hazard risks as well allow for installation of flood resilience measures such as sandbags.

Chapter 6: Technology Prioritization for the Energy Sector

The technology identification and prioritization step was intended to establish and rank the most appropriate technologies for low carbon emissions and reduced vulnerability. It involved the identification and classification of technologies for mitigation, starting by generating a comprehensive listing of technologies available, including new or unfamiliar technologies. This extensive analysis was performed using the Multi-Criteria Decision Analysis, by quantifying the selection process and determining to what extent each potential technology contributes to sustainable development goals, reduces GHG emissions, while being cost effective. The results of this analysis produced a weighted score that was used to prioritize the technologies in the energy sectors.

6.1: GHG emissions and existing technologies of the energy sector

South Sudan is the country in Africa with the lowest per capita electricity consumption, with only 1% of the South Sudan's 12.5 million people connected to the electricity grid (World Bank, 2013). According to a Ministry of Electricity and Dams survey 2013), many people use rooftop solar arrays or noisy, polluting diesel-powered generators to provide electricity; still many more are left without electricity supply. Those who can access the grid usually pay electricity rates. Energy emissions are mainly from electric power generation followed by transportation. Waste and industrial processes contribute minimally to total GHG emissions.

6.2: Decision context

As it has been indicated in the South Sudan second Nationally Determined Contribution (NDC), only about 1 percent of the country population has access to grid electricity. Electricity demand in the country is increasing swiftly largely due to faster growing productive investments, increasing population and access. Demand for electric power is growing and typically exceeds supply. The South Sudan National Electricity Sector Policy (May, 2007)/ Draft South Sudan Electricity Master Plan anticipates that South Sudan will increase electrification status from 1 percent to at least 75 percent by 2030 while demand from connected customers will increase significantly as South Sudan becomes a middle income country as stipulated in South Sudan Vision 2040 and the 2021–2024 revised national development strategy (R-NDS). In the short to medium term electricity generation expansion plan (up to 2030), the majority (60 percent) of the planned electricity generation capacity additions are expected to be based on hydropower and solar**.**

6.3 An overview of existing mitigation technology options in Energy Sector

The existing technologies in the energy sector in South Sudan include the following

- Solar rooftop PV systems. Solar photovoltaic (PV) cells convert sunlight directly into electricity. The installation of large-scale solar PV for electricity generation either as mini-grid or grid based is limited in the Country.
- Solar water heaters are majorly used in hotels, solar energy hair clippers are used in saloons, solar cookers, fridges and dryers are also common.
- Traditional Cook Stove (Mud)/ Clay firewood cooking stove
- Metallic stove with and without space heating

6.4: Mitigation technology options for Energy and their main adaptation benefits

There are a number of technologies that can help the energy sector to mitigate climate change. These are listed in table below and further details are provided in factsheets (for the priority technologies)

Table 25: Energy technology options for South Sudan and how they help in mitigating climate change

#	Technology option	Features/Mitigation benefit
1	Off-grid solar mini-grids up to 100 kW	• It is a renewable energy. • It is a mature technology. South Sudan is rich in solar energy. • It produces no GHGs.
2	Solar roof top systems/Roof top Solar Photovoltaic (PV) with Energy Storage System including Battery	• It is a mature and renewable energy. • South Sudan is rich in solar energy. • It has no GHG emissions
3	Biomass briquette - Production of non-carbonized briquettes	• The organic materials that go into briquettes are already part of the carbon cycle, and they have lower net GHG emissions compared to fossil fuels • Briquettes prevent negative impacts of decomposing waste, prevent forest degradation which leads to more carbon storage, and release less GHG and reduction of environmental destruction by use of charcoal and firewood for cooking.
4	Improved Institutional Cook stoves/Efficient firewood cook stoves	• Increasing thermal efficiency, reducing specific emissions increasing ventilation. • Reduces the use of firewood, lowers carbon emissions, and expels the toxic fumes outside the users' homes.
5	Hydropower (mini/micro hydropower)/small hydropower	• It is a renewable energy. It does not contribute to GHG emission. • The Nile River has large project sites identified. Locations include Fula, Shukoli, Lakki and Bedden are major sites to develop, as the potential to deliver a total of 2,927MW as well as 11,852GWh of average energy.
6	Cooking energy biogas	• Offers a low carbon pathway for effective sanitation and energy production with significant environmental, social, and economic benefits.

7	Energy conservation and efficiency for industry and buildings	• It is a mature technology. • High energy saving potential. • High lifetime and low environmental concerns • It also reduces GHG emission when powered by fossil fuel
8	Liquefied Petroleum Gas for cooking	• LPG could also be used for as a vehicular fuel, and in heating, refrigeration and air conditioning systems. The gas has low carbon content compared to coal and its use is thus connected to climate change mitigation.
9	Wind Power	• Generating electricity from wind energy

As indicated in Table 25, these pre-selected technologies have climate change mitigation benefits and were suggested by stakeholders as they felt these technologies were mature for the experts as well as political endorsement would be received faster for the given technologies, since they contribute to increase acceleration of energy access particularly in the country. Also the South Sudan Electricity Corporation (SSEC) and the South Sudan Electricity Regulation Authority are committed to promote sustainable energy technologies as they provide opportunity for the country's development and access to electricity, mostly those not accessing the national electricity grid. These technologies have multiple benefits (social, economic and environmental). For example, energy accessibility is key to improved socioeconomic development, reduction of poverty and expansion of industrials. These were developed into factsheets and further prioritized during the technology prioritization workshop.

6.5: Criteria and Process of Technology Prioritization for the Energy Sector

Technology prioritization was done at a workshop held between 4-5th,May 2023 in Juba at the MoEF conference hall where criteria for prioritizing technologies was developed by stakeholders and multi-criteria analysis was used to prioritize technologies. The steps for undertaking the MCA were explained to the stakeholders especially on how to identify the options, identify the criteria, and assign weights for each of the criteria to reflect their relative importance to the decision. Weights and scores for each of the technology options were combining to derive and overall weighted score and ranking technologies to select the highest priority technologies.

Stakeholders went through a process of technology prioritization where they selected technologies for climate change mitigation. For the energy sector the criteria for ranking technologies were energy efficiency, capital cost, job creation, maturity, sustainability (environmental), social acceptability and gender equity, GHG emission reduction potential, access potential. The weighting was as follows

Table 26: Criteria for analyzing technologies and weighting of criteria for the energy sector

Consideration	Criterion	Weight
Cost	Capital Cost	6
	Operation cost :	5
	Maintenance Cost	8
	GHG emission reductions in 2030	23

Climate related	Energy Efficiency - reducing energy losses, Reduction of greenhouse gases emission, mainly CO_2 and methane and will not release more emissions to the environment	11
Economic Benefits	Employment and new skills	9
Environmental Benefit	Reduced air pollution	5
Social benefit	Job creation: Creating new job opportunities & income generating activities and Inclusion of men women and youth in the process	8
Security of energy supply	Security of energy supply - Meeting the energy demand of the nation	5
Institutional and Implementation	Ease of implementation (EoL)	8
	Replicability and ability to impact at large scale (R/S)	5
Political	Coherence with development policies	7
Total		**100**

6.6: Results of Technology Prioritization in the Energy Sector

Scoring was determined for each technology by stakeholders, facilitated by the national consultant, and depicted in an Excel based worksheet designed using the Multi-Criteria Analysis (MCA). The MCA was applied to score and rank the technologies. Table 26 shows scores of the technologies that were used in the prioritization exercise and the results of evaluation, the scoring was done individually by each expert, and the averages were adopted after some discussions. The Table 27 provides final weighted scores and technologies prioritized mini and micro hydropower got the highest score followed by off-grid solar mini-grids up to 100 kW – Solar home PV System Table 28.

As seen in Tables 28 and 29, the top three ranked technologies are Hydropower (mini/micro hydropower)/small hydropower, Off-grid solar mini-grids– Solar home PV System, roof top Solar Photovoltaic (PV) with Energy Storage System including Battery. All the three technologies represent the South Sudan needs in the energy sector. These three energy technologies can efficiently mitigate GHG emissions by reducing the consumption of fossil fuels used to run generators. As mentioned above, South Sudan has a great potential for renewable energy resources, especially solar and hydropower. Hence, it is reasonable to have the Off-grid and On-grid PV systems within the most prioritized three options, as these technologies are future promising and can effectively contribute to providing an alternative sustainable solution to the problem of electrical power access in South Sudan as well as reduce the GHG emissions in the future.

In South Sudan the use of LPG is yet to be adopted and will be constrained by the distribution system and collection of LPG cylinders. The natural gas will face similar situation since the infrastructure for natural gas distribution are not yet available. Geothermal energy is still not yet developed as such not easy to attract investors. The three top prioritized technologies would be developed into technology action plans with further stakeholder engagement at a later stage in the TNA project.

Table 27: Criteria scores for technologies in the energy sector

Technology	Costs			Climate related		Benefits			Other			
						Economic	Environmental	Social	Security of energy supply	Institutional/Implementation		Political
Weight criteria	Capital cost	Operation cost	Maintenance cost	GHG emission reductions in 2030	Energy Efficiency	Employment and new skills (C8)	Reduced air pollution	Creating new job opportunities & income generating activities	Security of energy supply C6 Meeting the energy demand of the nation	Ease of implementation	Replicability and ability to impact at large scale	Coherence with development policies
Off-grid solar mini-grids up to 100 kW	75	70	50	100	100	60	95	80	90	85	70	60
Solar roof top systems	60	45	30	75	80	40	85	20	90	90	85	10
Roof top Solar Photovoltaic (PV) with Energy Storage System including Battery	80	90	25	80	85	30	80	20	90	90	80	10
Improved Institutional Cook stoves	85	50	70	100	80	70	85	30	70	85	65	30
Efficient firewood cook stoves	60	30	55	90	70	35	70	20	85	85	90	20
Hydropower (mini/micro hydropower)/small hydropower	90	80	70	100	100	90	95	90	85	80	80	60
Cooking energy biogas	20	50	50	60	30	60	85	50	70	30	10	30
Energy conservation and efficiency for industry and buildings	85	65	50	80	85	20	70	40	80	70	90	10
Wind Power - Generating electricity from wind energy	80	75	40	85	80	60	90	30	60	70	20	20

Table 28: Weighted scores and ranking for technologies in the energy Sector

	Costs			Climate related		Benefits				Other			Total scores	Ranking
Weight criteria	6	5	8	23	11	9	5	8	5	8	5	7		
Technology						Economic	Environmental	Social	Security of energy supply	Institutional/Implementation		Political		
Weight criteria	Capital cost	Operation cost	Maintenance cost	GHG emission reductions in 2030	Energy Efficiency - reducing energy losses	Employment and new skills	Reduced air pollution	Creating new job opportunities & income generating activities	Meeting the energy demand of the nation	Ease of implementation	Replicability and ability to impact at large scale	Coherence with development policies		
Off-grid solar mini-grids up to 100 kW	450	350	400	2300	1100	540	475	640	450	680	350	420	8155	2
Solar roof top systems	360	225	240	1725	880	360	425	160	450	720	425	70	6040	6
Roof top Solar Photovoltaic (PV) with Energy Storage System including Battery	480	450	200	1840	935	270	400	160	450	720	400	70	6375	4
Improved Institutional Cook stoves	510	250	560	2300	880	630	425	240	350	680	325	210	7360	3
Efficient firewood cook stoves	360	150	440	2070	770	315	350	160	425	680	450	140	6310	7
Hydropower (mini/micro hydropower)/small hydropower	540	400	560	2300	1100	810	475	720	425	640	400	420	8790	1
Cooking energy biogas	120	250	400	1380	330	540	425	400	350	240	50	210	4695	9
Energy conservation and efficiency for industry and buildings	510	325	320	1840	935	180	350	320	400	560	450	70	6260	5
Wind Power - Generating electricity from wind energy	480	375	320	1955	880	540	450	240	300	560	100	140	6340	8

Table 29: Ranking of technologies in the energy Sector

Technology	Total Score	Ranking
Hydropower (mini/micro hydropower)/small hydropower	7490	1
Off-grid solar mini-grids up to 100 kW	7440	2
Improved Institutional Cook stoves	6680	3

Below is a brief description about the 3 top mitigation technologies for the energy sector.

Hydropower (mini/micro hydropower)/small hydropower

This energy technology option involves development of hydroelectricity projects which have been elaborated in South Sudan electricity sector strategy supply plan. Small hydro power uses the flow of water to turn turbines connected to a generator for the production of electricity. Small hydro is divided into further categories depending on its size, such as mini- (less than 1000kW), micro-hydro (less than 100kW) and Pico-hydro (less than 5kW). Useful source for electrification of remote geographical locations mainly in rural areas where national grid cannot be reached cost effectively.

Off-grid solar mini-grids up to 100 kW

Off-grid solar mini-grid is the electric power generated from sunlight using devices called solar cell modules. Solar technologies facilitate the extraction of a renewable energy source by harnessing power from the sun. The technology involves installation of 1000 kW grid tied PV system. Electric devices transform solar energy into electricity for lighting, pumping water, powering radios, etc. The solar energy generates very low GHG compared with fossil based power generation Off-grid renewable energy solutions signify a sustainable electrification solution that can be quickly expandable, easily scalable, and environmentally sustainable, can be tailored to local environments and, crucially, has the potential to empower rural communities, particularly the youth and women. Off grid solar can also boost local demand for energy services and improve the sustainability of business activities from a technical, economic, social and environmental standpoint.

Improved Institutional Cook stoves

Institutional stoves are used where larger amounts of food than can be accommodated on a standard kitchen stove can be cooked. Typical examples are schools, hospitals, prisons and other institutions. Normally, these institutions will use institutional stoves with a cooking capacity of 50 liters to 150 liters. Other users are entrepreneurs who own cafés or restaurants, selling street foods, or selling staple foods such as bread or chapattis. In such cases, the stove is likely to be used for several hours each day. The benefits of institutional cooking stoves include: reduced deforestation given that institutions use less firewood for more cooking, reduced GHG emissions since they are more efficient, minimized health risks due to reduced indoor air pollution, health effects of carrying wood for long distances by children and other institutional staff are also avoided, gender considerations: both men and women can be engaged in the construction of the institutional stoves. Most importantly, the stove can be produced locally. The materials and skills to create these institutional cook stoves are abundant in South Sudan and, when harnessed correctly, will create a sustainable solution to the economic and health crisis the traditional stove has been causing.

Chapter 7: Technology Prioritization for the Waste Management Sector

This chapter explains the technology prioritization for the Waste Management sector based on the MCA of technologies. Technology prioritization in the waste management sector was based on the concept which leads to low carbon emission development pathway as in the South Sudan NDC.

7.1: GHG emissions for waste management sector

South Sudan submitted its Initial National Communications report to the United Nations Framework Convention on Climate Change (UNFCC) in December 2018 (MoEF, 2018a). As a non-Annex I country and a developing country, South Sudan has chosen year 2030 as the base year for estimating GHG inventory as part of its Second National Communication. Methane is the most prominent gas emitted from the waste sector. Unmanaged solid waste (SW) and waste water sites lead to methane emissions. The methane emissions are estimated using the quantity of waste generated in the management of the waste, the proportion of carbon that may be transformed into methane etc. Waste collection services using garbage trucks are currently being provided by the private sector across the country. The frequency of waste collection differs for each town across the ten states in South Sudan. In Juba, the capital of South Sudan, waste is collected three times a week, whereas waste collection for towns in most other states is done once a week. There are no recycling or wastewater treatment plants or sewer systems in the country. Municipal wastewater, sewage and industrial effluents run directly into natural water bodies due to the lack of sanitation and wastewater management infrastructure. According to the NATCOM, the waste sector contributed 11 percent (4.1 million tCO_2e) to the country's total GHG emissions in 2015 (South Sudan Ministry of Environment, 2018). The major GHG emissions from the waste sector are landfilling generated methane and wastewater-generated methane and nitrous oxide.

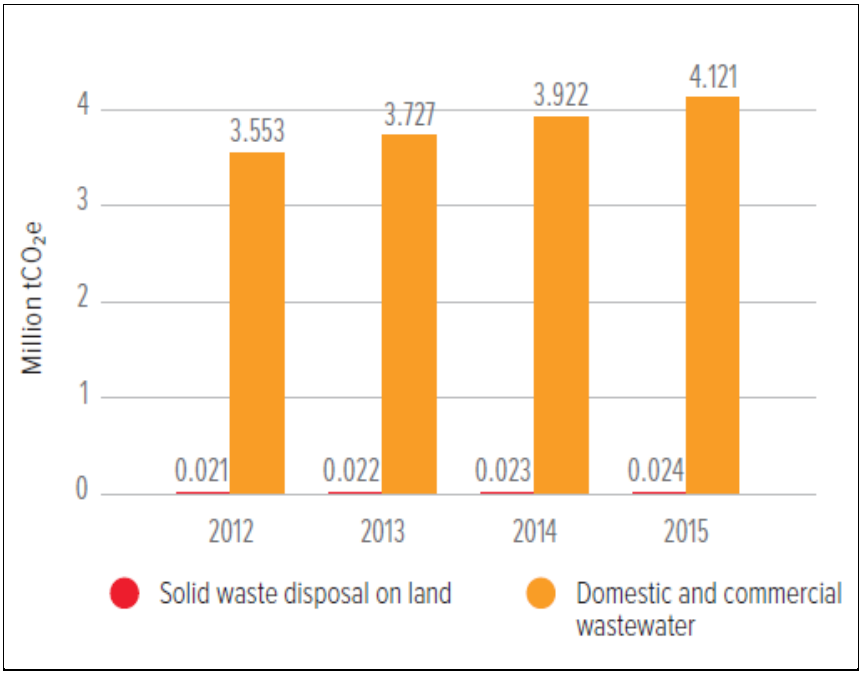

Figure 9: GHG emissions from the waste sector, 2012–2015
Source: South Sudan Ministry of Environment, 2018

The solid waste comprises hard plastic (shredded and solid), plastic bottles (defective bottles are exported), worn out cloth (textile), Metals, Organic (mostly food waste) etc. The main sources of solid wastes are households, commercial establishments and markets. The organic component of the solid waste of Juba city is 1,337 tonnes of solid waste per day, which breaks down to a daily per-capita waste of 0.68 kilograms made up mostly of plastics and food waste (Andrew Lako Kasmiro Gasim (2019). With the growing urbanization, management of solid waste has been one of the biggest environmental challenges faced by many municipalities in South Sudan. Wastes produced are disposed and openly burnt. Waste segregation and sorting is not a common practice at household level and at the same time South Sudan does not have large waste processing or recycling industries. Municipal wastewater runs directly into natural water bodies due to the lack of sanitation and wastewater management infrastructure. This contaminates surface drinking water and groundwater resulting in serious health risks to local population. Poorly managed and untreated waste not only impacts human and ecosystem health, but also results in high and increasing GHG emissions. The greenhouse gases emitted are methane, nitrous oxide, carbon dioxide, and nitrogen oxide. Emissions from anaerobic decay in waste dumping sites are not estimated as the waste is pre-burned and due to mixing with salty high-water table.

7.2: Decision Context

The main decision context for solid waste management sectors is founded on South Sudan NAPA where the vision for the waste sector is to effectively manage waste and pollution that minimizes negative impacts on public health and environment. Key Performance Indicators include proportion of waste effectively and sustainably managed and integration of waste into sector policies, plans and programs. Also, the decision context of prioritizing technologies in the solid waste sector is determined by its ability to trigger private investment, improve economic performance, protect health reduced drudgery, gender aspects and acceptability, GHG emission reduction potential and technological influences. In terms of sustainable development, solid waste management is important for addressing challenges related to population health, environment protection and economic development, as set out in the South Sudan NDC and Solid Waste Management plan (MoEF *et al*, (2022). The main goal of the TNA in the solid waste sector is to support technology transfer that supports the goal of zero-waste and GHG removal, with effective waste management practices.

7.3: Existing technologies for solid waste management sector in South Sudan

Solid waste disposal in South Sudan is generally open dump method at un-managed dumpsite. The dumpsite covers a fairly large area and is a pollution threat to the environment, community and underground water resources. South Sudan does not have a national policy framework for Waste Management or for technologies such as Semi-aerobic landfill, Aerobic/anaerobic decomposition of wastewater, baling at commercial level and with limited waste sector data collection including waste audits. Below are the existing technologies:-

- Temporary dump sites where solid wastes are kept for a short period of time during an emergency period such as after flood and heavy rain. The waste is finally disposed of in the landfill

- Landfill without methane recovery
- Temporary Transfer Station
- Environmental education through awareness and campaign including promotion of 3R however this has low implementation and requires reinforcement.

7.4: Mitigation technology options for solid waste management sector and their main mitigation benefits

Possible technology options to reduce GHG in the waste sector are presented in table 30 below.

Table 30: Mitigation technology options for solid waste management sector in South Sudan

#	Technology option	Features/Mitigation benefit
1	Temporary dump sites	These are sites where solid wastes are kept for a short period of time during an emergency period such as after flood. The waste is finally disposed of in the landfill
2	Biogas Production from Organic Waste	Biogas production from the organic waste has been proposed in South Sudan urban town as a waste management solution. The organic waste undergoes anaerobic composting and produce gas which is suitable for cooking or electricity production.
3	Transfer station	Solid waste is compacted at various sites and transferred to the landfill
4	Sanitary landfill without methane recovery	A contained and engineered bioreactor designed to enhance anaerobic digestion and consolidation of compacted refuse materials within confined layers of compacted soil with leachate recovery but not methane.
5	Reduce, reuse and Recycling	Reduce, reuse and recycling resulting mainly from medium and large sources and enterprises. Recycling and waste prevention diverts materials away from landfills, which produce large amounts of methane through the decomposition process. The transformation of waste collected during manufacturing or after use into useful products
6	Leaching field	A soil purification system for the partially treated wastewater.
7	Household Waste Segregation	Waste segregation refers to the separation of wet waste and dry waste where the purpose is to recycle dry waste easily and to use wet waste as compost
8	**Integrated waste management system**	Developing a national-level policy and plan for solid waste management with a focus on a circular economy. The policy and the plan is expected to draw attention to the climate change threats to human and environmental health due to hazardous substances. Risks from toxic substances contained in, or

		produced by the degradation of waste not disposed of appropriately. policy solutions include ban on single use plastics, which includes replacing plastic bags in supermarkets

7.5: Criteria and Process for Technology Prioritization for Waste Management Sector

The criteria were elaborated and presented to the waste management sector working group members by the national consultant during the inception workshop initial meeting held on 5th May 2023 at the Ministry of Environment and Forestry - GOSS. The proposed criteria were finalized in consultation with the waste sector technical working group members. The assigning of weight for each of the criteria was done during the MCA exercise. Table 31 below describes the criteria and assigned weights used for the MCA for the Waste Management sector.

Table 31: Criteria used by the working group during the MCA exercise

Consideration	Criterion	Explanation	Weight score
Economic benefit	Creates jobs	Employment, competitive markets, price stability, trade and export earning	5
	Improve economic performance and	Economic benefit to South Sudan e.g. the technology improves production of goods/services, revenue opportunities Employment, competitive markets, price stability, trade and export earning	5
	Trigger private investment/ sustainability	Potential for companies, financial organizations, or other investors, to finance investment and generate a business revenue stream	8
Social benefit	Protect health	Removing health hazards – e.g. removal of gases etc. linked to waste	10
	Reduced drudgery, gender aspects and acceptability	Ability to reduce labor demand from for women and men. Alignment with cultural norms, inclusiveness of needs of different sections of society, enhancement of food, livelihood and employment security.	8
Environmental protection and Climate benefit	Addresses plastics and hazardous waste streams	Addresses plastics and hazardous waste streams	3
	Minimal harm on environment and protect biodiversity	Causes no harm/degradation	3

	and natural resources		
	GHG emission reduction potential	Potential to reduce emissions, or emits less GHG compared to alternative	24
Institutional or implementation advantage	Ease of technology implementation	Availability of human, organizational, policy and financial capacity to establish and operate the technology. Congruence of the technology with existing social systems	10
	Replicability and ability to impact at large scale	Potential feasibility to spread technology where it is needed. Number of beneficiaries.	12
Cost of technology	Capital cost	Cost of equipment, human expertise, energy sources, land and organizational resources needed to set up technology, and establishing the technology	5
	Operation and Maintenance cost	Cost of building human capacity to generate and operate the technology (HC)	7
Total			100

7.6: Results of Technology Prioritization in Waste Management Sector

Technology prioritization for the waste management sector was conducted by the consultant in collaboration with all relevant stakeholders at the national and subnational level. The tool used for technology prioritization is Multi-Criteria Analysis (MCA). For the waste management sector, the following climate mitigation technologies were subjected to MCA. Temporary dump sites, biogas production from organic waste, transfer waste station, sanitary landfill without methane recovery, reduce, reuse and recycling, waste segregation, development of national policy framework for waste management and pollution prevention and improvement of waste sector data collection including waste audits.

Table 32: The performance matrix/ Criteria scores for technologies for the waste management sector MCA

Technology	Costs of technology		Benefits								Other	
			Economic			Social		Environmental protection and Climate benefit			Institutional/Implementation	
Technologies	**Establishment and operation (EO)**	**Cost of building human capacity to generate and operate the technology (HC)**	**Create Job**	**Improve economic performance**	**Trigger private investment / Investment sustainability**	**Protect health/Remove health hazards**	**Reduced drudgery, gender aspects and acceptability**	**GHG emission reduction potential**	**Addresses plastics and hazardous waste streams**	**Minimal harm on environment and protect biodiversity and natural resources**	**Ease of implementation (EoL)**	**Replicability and ability to impact at large scale (R/S)**
Temporary dump sites	60	80	68	40	50	80	60	100	40	50	90	90
Biogas Production from Organic Waste	25	25	55	40	75	90	30	100	60	90	10	60
Transfer waste station	60	80	100	100	100	80	70	100	100	80	60	60
Sanitary landfill without methane recovery	60	80	40	60	20	50	80	100	90	30	40	50
Reduce, Reuse, Recycle (3Rs)	90	80	20	55	90	100	85	100	100	100	100	100
Household Waste Segregation	80	75	50	60	80	80	70	100	90	80	100	90
Integrated waste management system	80	70	50	80	80	70	80	80	65	70	80	80
Improvement of waste sector data collection including waste audits	60	50	70	20	10	90	10	100	30	60	95	95

Table 33: Weight Scoring and Normalization Matrix

The information provided by the stakeholders on the performance matrix was normalized and scoring was done by the national consultant.

Criterion	Costs of technology		Benefits								Others		Total Scores	Technology ranking
Weight	7	5	5	5	8	10	8	24	3	3	10	12		
Technology	Establishment and operation (EO)	O&M Cost	Create Job	Improve economic performance	Trigger private investment/ Investment sustainability	Protect health/Remove health hazards	Reduced drudgery, gender aspects and acceptability	GHGs emission reduction potential	Addresses plastics and hazardous waste streams	Minimal harm on environment and protect biodiversity and natural resources	Ease of implementation (EoL)	Replicability and ability to impact at large scale (R/S)		
Temporary dump sites	420	400	340	280	250	800	480	2400	120	150	900	1080	7620	4
Biogas Production from Organic Waste	175	125	275	280	375	900	240	2400	180	270	100	720	6040	8
Transfer waste station	900	400	500	700	500	800	560	2400	300	240	600	720	8620	2
Sanitary landfill without methane recovery	420	400	200	420	100	500	640	2400	270	90	400	600	6440	7
Reduce, Reuse, Recycle (3Rs)	1350	400	100	385	450	1000	680	2400	300	300	1000	1200	9565	1
Household Waste Segregation/sorting	560	400	250	420	400	800	560	2400	270	240	1000	1080	8380	3
Integrated waste management system	560	350	250	560	400	700	640	1920	195	210	800	960	7545	5
Improvement of waste sector data collection including waste audits	420	250	350	140	50	900	80	2400	90	180	950	1140	6950	6

Table 34: Ranking of technologies in the waste management Sector

Technology	Total Score	Ranking
Reduce, Reuse, Recycle (3Rs)	9565	1
Transfer waste station	8620	2
Household Waste Segregation/Sorting	8380	3

Reduce, reuse and recycling: Reduce, reuse, recycle to minimize waste and use waste as a resource by promoting waste prevention from different sectors by utilization of urban waste for making briquettes; plastic waste to generate refuse-derived fuel, which could be used in industry; methane capture during flaring for biogas electricity-generating plants; and reuse and recycle construction material, such as wood, bricks, iron, etc. Government and private sector to increase participation by procuring compactors, excavators, dumper trucks and shredders to manage waste disposal; train staff to manage waste facilities. The foremost imperative advantage with reusing is that it decreases the generation of greenhouse gasses since there's redirection of the waste from the landfills. Reusing too decreases the utilization of modern resources and contributes to economic development. Materials like paper, glass, steel, plastic, and aluminum can be reused such that rather than arranging them of, they can be recaptured and subsequently reused.

Transfer waste station: 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.

Household Waste Segregation/Sorting: Waste segregation refers to the separation of wet waste and dry waste where the purpose is to recycle dry waste easily and to use wet waste as compost. When waste is segregated, there is reduction of waste that gets landfilled and occupies space, air and water pollution rates are considerably lowered. Segregation at the source reduces the amount of recyclable wastes ending up at the landfill where it usually becomes impractical to sort. Segregation at the household level can be achieved with the support of the Government of South Sudan particularly the Ministry of Environment and forestry and the private sector investment and the provision of proper color coded bins for specific types of recyclable wastes. Central Equatoria state government is currently promoting Waste sorting and segregation best practices at household level, commercial places and institutions by providing them with the proper bins with pictures of recyclable wastes pasted on the side. This segregation and waste sorting awareness and campaign are aimed to encourage household level to practices waste segregation.

Chapter 8: Technology Prioritization for the Agriculture, Forestry, and Other Land Use (AFOLU) Sector

The prioritization of mitigation technologies for agriculture, forestry, and other land use (AFOLU) sector was carried out in a similar process followed for the selection of Waste technologies

8.1: GHG emissions and existing technologies of Agriculture including land use and forestry sector

AFOLU activities generate CO_2 emissions by sources (e.g., deforestation) as well as removals by sinks (afforestation, management for soil carbon sequestration) and non-CO_2 emissions primarily from agriculture CH_4 from livestock, N_2O from manure storage and agricultural soils, and biomass burning. In South Sudan around 81 percent of the population is dependent on fuel wood and 14 percent on charcoal for cooking. South Sudan also witnessed extensive conversion of forests and woodlands into grasslands, pastures, and agricultural lands. The current deforestation rate is estimated to be 2 percent per year (UNEP, 2018a). As a result of continual deforestation and rapid conversion of forestlands, land use, land-use change, and forestry was a net positive emitter of GHG emissions between 2005 and 2015, with net emissions equal to 2.76 million tCO_2e in 2015 (Figure 10)

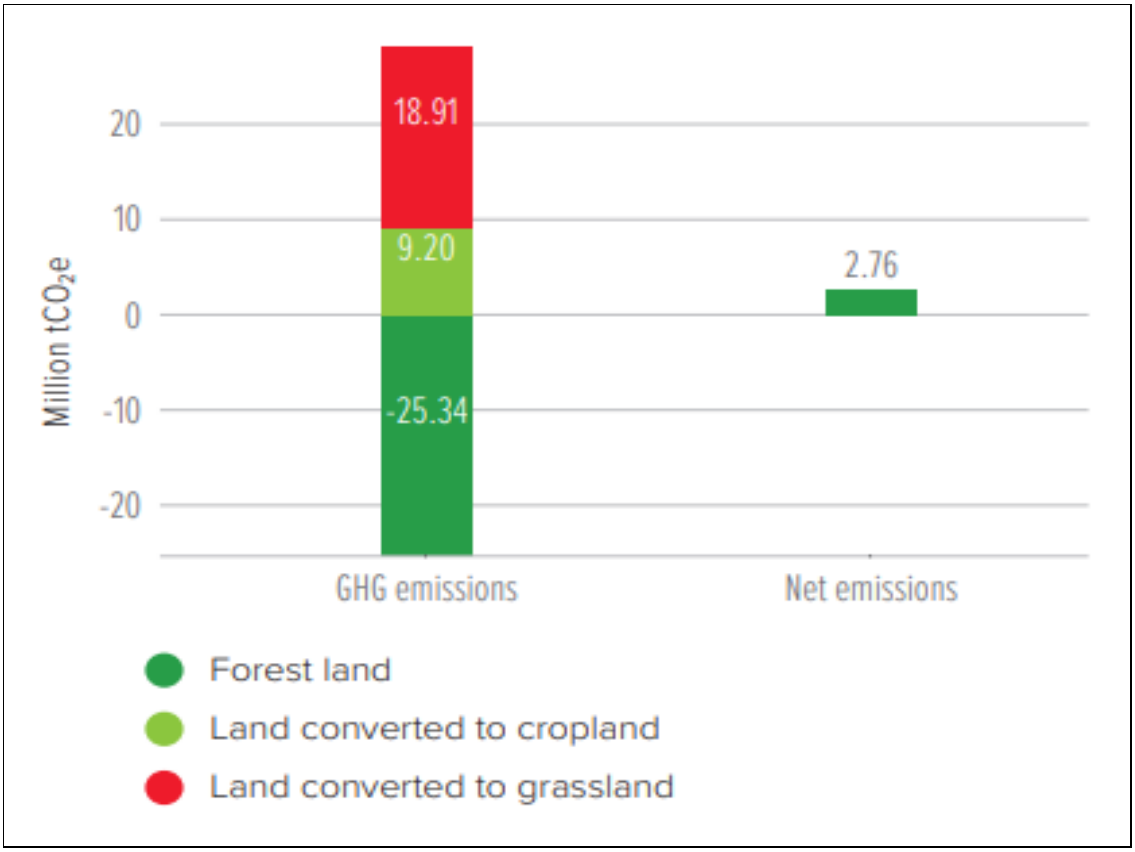

Figure 10: GHG emissions and sinks in land use, land-use change, and forestry, 2015
Source: South Sudan Ministry of Environment and Forestry, 2018

8.1.1: Key Climate Change Vulnerabilities in Agriculture, Forestry and Other Land Use (AFOLU) Sector

Agriculture, forestry, and other land uses (AFOLU) generate the largest share of greenhouse gas emissions in South Sudan, but it can also be part of the solution to emission reduction. AFOLU contributes towards climate change through greenhouse gas emissions and by the conversion of non-agricultural land such as forests into farming land. Adopting sustainable forest and land management practices can help ecosystems retain and store substantial amounts of carbon. While emissions from deforestation and forest degradation, which make up about 12% of total global emissions today, are on a declining trend, agricultural emissions, currently at 12% of the global total, are projected to grow through 2030, driven by population growth and changes in dietary preferences in developing economies.

The Intergovernmental Panel on Climate Change (IPCC, 2022) 6th assessment report finds that the "Agriculture, Forestry, and Other Land Use (AFOLU)" sector on average, accounted for 13-21% of global total anthropogenic GHG emissions in the period 2010-2019. Through more sustainable use of lands and forests, along with the adoption of climate-smart agriculture techniques, it may be possible to balance the needs of people with the environment.

Land: Keeping carbon in the land (sequestration) can mitigate climate change through "avoided" emissions. Techniques include converting non-forest land to forests; planting trees or allowing forests to regenerate naturally; restoring compost lands; and converting cropland to permanent pasture.

Forests: Mixing trees with crops (agroforestry) or with forage and livestock (silvopasture) can also be effective ways to sequester carbon. What's more, these tactics are compatible with sustainable forest management (SFM) as well as climate-smart agriculture (use of perennials, low-till or no-till practices, good fertilizer and feed management, and soil fertility techniques).

In South Sudan, the burning of savanna woodlands and grasslands is the largest contributor to GHG emissions from agricultural practices, followed by emissions from the livestock production subsector in the form of enteric fermentation and manures from pastures as in table 35 below

Table 35: Annual greenhouse gas emissions from agricultural practices, forestry, and other land use in South Sudan (estimated for 2014-2017)

VARIABLE	ANNUAL EMISSIONS (MT CO_2e)
Burning - crop residues	0.02
Burning - savanna	21.5
Crop residues	0.1
Cultivation of organic soils	0.1
Enteric fermentation	11.9
Manure management	0.5
Manure applied to soils	0.2
Manure left on pasture	8.7
Total emissions	**43.1**

Statistics derived from the Global Forest Watch (GFW) database statistics on South Sudan total area of wooded vegetation in various categories of canopy cover density indicated 10-30%

canopy cover as savanna, 30-50% cover as woodland and 50-100% cover as dense forest), as well as the historical rates of change in each vegetation category. South Sudan has widespread woody vegetation cover, where it is estimated that ~66% of the total land area is under tree cover. The vegetation cover includes over ~4 million hectares of dense (50% canopy cover) forest, 7 million hectares of moderately dense woodland, and forests (~30-50% canopy cover), and over 31 million hectares of woodland in Sudanian Acacia savanna. GFW reports the total aboveground carbon stock of South Sudan's forest biomass as ~ 495 million tonnes.

Table 36: Vegetation cover and land use change in South Sudan (estimated for 2015)

VARIABLE		TOTAL (HECTARES)	TOTAL (% OF LAND AREA)
Total tree cover	10-30% canopy cover % of total land area Total	31,244,612	48.49
	30-50% canopy cover	7,211,244	11.2
	50-100% canopy cover	4,043,168	6.3
	Total	**42,499,024**	**66.0**
Land use change and agricultural expansion	The historical annual rate of deforestation	10-30% canopy cover	0.0
		30-50% canopy cover	0.0
		50-100% canopy cover	0.1

8.2: Decision context

In spite of the South Sudan Forestry Policy (2015) recognition of AFOLU as providers of critical environmental services, water catchment, and in mitigating climate change, the policy implementation is very weak. Many **factors** are responsible for this. Firstly, nearly all forests are located in areas that have previously **experienced and** continue to experience civil conflicts which lead to weak enforcement of laws and regulations. Secondly, the subsistent fuel-wood producers lack appropriate skills in charcoal and wood production which the increases rate of deforestation caused by excessive exploitation of forest resources for energy, using very **in**efficient traditional conversion technologies and practices. In addition, South Sudan's land use is changing rapidly due to high population growth and urban expansion. The combination of these activities has the potential for increasing greenhouse gas emissions in the sector. These call for urgent technolog**y** development in the AFOLU that will aim at reducing CO_2 emissions now and in the future.

8.3: An Overview of Existing and Possible Mitigation Technology Options in AFOLU Sector

There are a number of mitigation measures and technologies practiced for reducing GHG emissions in the agriculture, forestry, and other land use (AFOLU) sector. The main current technology involves afforestation and proper land management. Prior to identifying the technologies in the AFOLU sector, the priorities of the government of South Sudan and the mitigation benefits of the AFOLU technologies were noted down. Main existing and potential technologies include the following.

Table 37: An Overview of Possible and Existing Mitigation Technology Options in the AFOLU Sector

Agriculture technologies	• Appropriate application of fertilizers & soil carbon management • Farming practices having enhanced carbon sequestration • Increasing use of crop varieties having enhanced carbon sequestration • Rice cultivation by alternate wetting & drying/aerobic • Off-field crop residue management • Energy efficiency improvement of tube-well • Nutrient management: mycorrhiza • Conservation tillage
Livestock technologies	• Appropriate diet for reducing enteric fermentation in ruminant animals • Biogas – Compressed bio-methane including Waste and Bagasse • Manure management • Genetic modification to produce new breeds that have better digestive efficiency and so better GHG mitigation potential
Land-use, Land-use Change, and Forestry (LULUCF)	• Afforestation and forestation aim at increasing the sequestration rate. (afforestation on previous cropland or pasture and reforestation – establishing forest on clear felled areas) • Social forestry as Carbon sink • Sustainable Forest Management (SFM) plans for reducing emissions from deforestation and forest degradation • Sustainable forest management • Land use Planning at local and provincial levels & legal support to implement the plans • Land use management to enhance carbon sequestration • Forest utilization such as establishing fire lines to control haphazard forest fires or utilization of improved stoves to reduce forest cutting.

8.4 Mitigation Technology Options for the Agriculture, Forestry, and Other Land Use (AFOLU) Sector and their Main Adaptation Benefits

The Government of South Sudan through the Ministry of Environment and Forestry is leading in the implementation of mitigation technologies. Most of these technologies have the co-benefits and trade-offs between Mitigation and adaptation. GHG emissions can be reduced with increased uptake of Sustainable Land and forest utilization and the use of modern practices in the agriculture, forestry, and other land use (AFOLU) sector. The technology options are;

- Increasing afforestation and reforestation on previous cropland or pasture and reforestation – establishing forest on clear felled areas
- Forest conservation under SFM- (Extending harvesting age, reducing or avoiding deforestation, and forest preservation)
- Cultivation of perennial shrubs, short rotation woody crops, or traditional crops for bio-fuel production) -Reduction of CO_2 emission from fossil fuel use through the use of biomass fuel
- Conservation tillage
- Substitute management of fossil fuel with wood fuel
- Promoting **f**orest-based enterprises e.g. beekeeping/apiary, butterfly farming, fruit trees production, eco-tourism;
- Sustainable Forest Management (SFM) and plan for reducing emissions from deforestation and forest degradation
- Land use management to enhance carbon sequestration
- Agroforestry

8.5: Criteria and Process of Technology Prioritization in agriculture, forestry, and other land use (AFOLU) sector

The Criteria for technologies prioritization in the AFOLU sector start by consulting the relevant documents, followed by identifying development priorities with a focus on potential benefits of the AFOLU. This step followed discussions within the AFOLU expert working group team and consequently agreeing on the relevant criteria for the AFOLU sector technologies prioritization. The overall objective of this step is to identify areas where intervention would make a strong contribution in meeting the identified development priorities besides the technology's ability to reduce GHG emissions/increase sink. Hence, the criteria include the reduction of GHG emissions and developmental criteria namely social, economic, environmental and institutional. Under these criteria, the following criteria have been selected.

Table 38: Criteria for the technology Prioritization in agriculture, forestry and other land use (AFOLU)

Criteria	Specification
Cost	Capital Cost
	Operation cost
	Maintenance Cost
Climate change mitigation	(Greenhouse Gas Emission Reduction (GHGR)) in 2030 GHG emission reduction/carbon sequestration: Reduction of

	greenhouse gases emission, mainly CO_2 and methane and will not release more emissions to the environment
Technology related impact	Time efficiency (Quick implementation & result)
Health benefits	Safety and reliability
Social impact	Social benefit - level of acceptance and gender equity
Sustainability/Potential of applications	Potential of applications of the technology ensuring the availability of spare parts, possibility of maintenance and ability to withstand under all circumstances
Institutional/ political	Capacity building
	Coherence with development policies

8.5.1: Weighting of the criteria for the technology Prioritization in agriculture, forestry and other land use (AFOLU)

Stakeholders allocated weight to each criterion (adding to 100) according to greenhouse Gas emission Reduction (GHGR, importance in contributing to development priorities, contribution to the local economy in terms of improving local economy and jobs creation, applicability and suitability of the technology for adapting to climate change **(Table 39)**.

Table 39: Weighting of criteria for the agriculture, forestry and other land use (AFOLU)

S/No	Criterion	Weight score
1	Capital Cost	8
2	Operation cost	8
3	Maintenance Cost	9
4	Employment generation & market potential	11
5	Greenhouse Gas emission Reduction (GHGR) potential	30
6	Safety and reliability	7
7	Social benefit - Level of acceptance and gender equity	7
8	Sustainability/Potential of applications	5
9	Capacity building	9
10	Coherence with Development policies	6
Total		**100**

Table **40**: Criteria scores for technologies in the Agriculture, forestry, and other land uses (AFOLU)

Weight criteria	Cost			Benefit				Others		
				Economic	Environmental	Health	Social	Potential of applications	Institutional/Political	
Technology	Capital	Operation cost	Maintenance cost	Employment generation & market potential	Greenhouse Gas emission Reduction (GHGR)	Safety and reliability	Level of acceptance and gender equity	Sustainability/ Potential of applications	Capacity building	Coherence with development policies
Reforestation on previous cropland or pasture and reforestation – establishing forest on clear felled areas	80	70	60	85	90	65	80	60	70	80
Forest conservation under SFM - (Extending harvesting age, reducing or avoiding deforestation, and forest preservation)	85	65	60	80	85	70	70	70	65	80
Cultivation of perennial shrubs, short rotation woody crops, or traditional crops for bio-fuels production) -Reduction of CO2 emission from fossil fuel use through the use of biomass fuel	85	80	75	70	80	80	85	75	70	85
Conservation tillage	85	70	75	75	80	80	80	80	75	80
Substitute management of fossil fuel with wood fuel	90	90	90	75	100	100	90	90	85	90
Sustainable Forest Management (SFM) and plan for reducing emissions from deforestation and forest degradation	90	80	85	85	90	85	90	85	85	90
Land use management to enhance carbon sequestration	70	85	85	70	85	70	80	80	75	80
Agroforestry	80	80	90	75	80	85	80	80	85	65
Promoting Forest based enterprises e.g. bee keeping/apiary, butterfly farming, fruit trees production, ecotourism;	90	90	95	80	100	100	100	100	90	85

Table 41: Weighted scores for technologies in the Agriculture, forestry, and other land uses (AFOLU)

	Cost			Economic	Environmental	Health	Social	Potential of applications	Institutional/Political		Total scores	Ranking
Weight criteria	8	8	9	11	30	7	7	5	9	6		
Technology	**Capital**	**Operation cost**	**Maintenance cost**	**Employment generation & market potential**	**Greenhouse Gas emission Reduction (GHGR)**	**Safety and reliability**	**Level of acceptance and gender equity**	**Sustainability and Potential of applications**	**Capacity building**	**Coherence with development policies**		
Reforestation on previous cropland or pasture and reforestation – establishing forest on clear felled areas	640	560	540	935	2700	455	560	300	630	480	7800	**8**
Forest conservation under SFM - (Extending harvesting age, reducing or avoiding deforestation, and forest preservation)	680	520	540	880	2550	490	490	350	585	480	7565	**9**
Cultivation of perennial shrubs, short rotation woody crops, or traditional crops for bio-fuel production) -	688	640	675	770	2400	560	595	375	630	510	7843	**6**
Conservation tillage	680	560	675	825	2400	560	560	400	675	480	7815	**7**
Substitute management of fossil fuel with wood fuel	720	720	810	825	3000	700	630	450	765	540	9160	**2**
Sustainable Forest Management (SFM) and plan	720	640	765	935	2700	595	630	425	765	540	8715	**3**
Land use management to enhance carbon sequestration	560	680	765	770	2550	490	560	400	675	480	7930	**5**
Agroforestry	640	640	810	825	2400	595	560	400	765	390	8025	**4**
Promoting Forest based enterprises e.g. bee keeping/apiary, butterfly farming, fruit trees production, ecotourism;	720	720	855	880	3000	700	700	500	810	510	9395	**1**

8.6 Results of Technology Prioritization in the AFOLU sector

Based on the AFOLU sector expert working options, the scores were assigned to the technologies against each criterion indicated in Table 40 above. The scores were multiplied by the weight assigned to each criterion detailed in Table 41 above. The total weighted score for each technology was then summed up. Based on this, the 3 most ranked technologies are:

Table 42: Ranking of technologies in the agriculture, forestry, and other land uses (AFOLU)

Technology	**Total score**	Rank technologies
Promoting Forest based enterprises e.g. beekeeping/apiary, butterfly farming, fruit trees production and ecotourism	9395	1
Substitute management of fossil fuel with wood fuel	9160	2
Sustainable Forest Management (SFM) for reducing emissions from deforestation and forest degradation	8715	3

1. Promoting Forest based enterprises e.g. beekeeping/apiary, edible insect farming, fruit trees production, ecotourism. The technology is community-based and is aimed at minimizing the negative impacts of tree cutting on the forest. The Forest-based enterprise is intended to promote forest restoration and conservation and at the same time improve the livelihoods of the forest adjacent communities through income generation and food security. The technology is largely managed by the forest-adjacent communities after they are equipped with the requisite knowledge and skills to manage the enterprises efficiently and effectively.
2. Substitute management of fossil fuel with wood fuel. Reduction of CO_2 emission from fossil fuel use through the use of biomass fuel-cultivation of perennial grasses or traditional crops for bio-fuels production. This technology will help the minimize use of fossil fuels and the release of carbon dioxide to the atmosphere. At the same time, it's a cheaper option for climate change mitigation
3. Sustainable Forest Management (SFM) and plans for reducing emissions from deforestation and forest degradation. This technology is related to silvicultural technology such as reforestation, forest fire control, insect and pest control, Invasive species prevention, forest degradation and deforestation prevention. Emissions of GHGs from forest land are reduced by slowing down the rates of deforestation and forest degradation. Reduction of GHGs from the atmosphere can be achieved through numerous forest management practices, such as afforestation on non-forested lands, replanting degraded or deforested areas or enrichment planting in riparian buffers/zones like river banks, streams and wetlands, and protection. The most efficient technique for reducing emissions from deforestation and forest degradation is by preparation of forest management plans.

Chapter 9: Summary and Conclusions

This section presents the conclusions and summary of the South Sudan TNA activities undertaken during the prioritization of climate change adaptation and mitigation technologies phase. The TNA project is fundamental for South Sudan due to inadequate sectorial-based studies to assess climate change technology needs for the sectors contributing to GHG emissions and those most vulnerable to the impacts of climate change. There is an urgent need for establishing environment-friendly technologies to backstop South Sudan capacities in identifying and deploying the appropriate mitigation and adaptation technologies. As a result, the TNA Project of South Sudan, funded by GEF and implemented by UNEP CCC, and executed by the Ministry of Environment and Forestry (MoEF), comes at the right time to fill the gap of technology needs identification and complement the integration approach that South Sudan is undertaking to address the impacts of climate change and variability. This is mostly because the Government of South Sudan (GOSS) is currently endeavoring to overcome the consequences of the civil war and conflict to achieve economic recovery that meets the country's development priority needs.

Relevant national stakeholders from different institutions both at national and sub-national levels were involved in the TNA consultation process to select, identify, and prioritize technology options for mitigation and adaptation sectors. In the inception workshop held on 18th April 2023, at Juba Landmark Hotel in Juba, all participants for all relevant sectors were gathered in one place to learn the process of technology and criteria identification and prioritization using MCA. Whereas the consultative workshops held from 4th to 5th, May 2023, focused on identifying criterion and conducting prioritization of the most appropriate technologies for adaptation and mitigation sectors.

Through this process, sector selection was based on two main criteria, namely the level of GHG emission under mitigation, and the vulnerability assessment for adaptation. The sector selection was based on the NDC which clearly indicated that the three top mitigation priority sectors are Energy, Waste and Agriculture, Forestry and Other Land Use (AFOLU), and the top three sectors for adaptation are Agriculture, livestock and Fisheries, water and Disaster risk management.

The technologies were selected based on screening of initial lists prepared by consultants and reviewed and improved by the stakeholders. Moreover, under the guidance of the TNA team, participants selected criteria and provided scale and weight for each. It is also important to note that participants discussed the advantages and disadvantages of each technology option before and after prioritization using sheets developed by the TNA consultant.

In order to cover the different climatic zones in the country to the extent possible, the TNA team tried to select up to three technology options for each sector. The final list of the top three ranked technologies for South Sudan adaptation and Mitigation sectors are presented below.

Adaptation Technologies:

Existing technologies for the Agriculture, Livestock, and Fisheries, Water sector are generally conventional and have been practiced by communities in the country. Similarly, as for the disaster risk management sector, during the TNA project inception and consultative workshops, a long list of existing technologies for the Agriculture, Livestock and Fisheries, Water and Disaster risk sectors was identified. To ensure that selected technologies are in line with national and

sectorial policies and strategies, all national reports of policy documents were consulted to take stock of the already identified vulnerabilities, adaptation measures, priorities, and efforts related to the focus areas. Such documents include climate change National Communications (NCs), and the National Adaptation Programme of Action (NAPA).

Based on the selected criteria, the technologies have been arranged, and scale limits in percentage for each criterion were decided and elaborated to obtain weights in score points in order to rank the technologies and prioritize them accordingly. Then, per the TNA guidance, participants went through a prioritization and ranking process for technology options and came up with a top list of four ranked technologies in each sector under adaptation.

1. **For the agriculture, livestock and Fisheries sector, the selected technologies are** (1) Micro–irrigation - Sprinkler and Drip Irrigation, (2) Promotion of drought-resistant crop varieties, and (3) Value addition and processing of agricultural produce.
2. **For the Water sector,** the final prioritized options are (1) Solar powered water supply system, (2) Groundwater Abstraction – Water Borehole Drills, (3) Rainwater Harvesting (RWH) from Rooftops Rainwater Harvesting (RWH) from Rooftops.
3. For **Disaster risk management, the selected technologies include** (1) The Development and introduction of monitoring and early warning systems, (2) Improving disaster response (through the use of social media), (3) Flood early warning system. The prioritization of this adaptation technology responds to the South Sudan resilience building goal, aimed at putting vulnerable communities on a more sustainable path by strengthening their resilience to seasonal predictable shocks, and extreme shocks such as drought and floods, which are expected to increase owing to climate change. This is also echoed in the South Sudan National Disaster Risk Management Policy (2015)

Mitigation technologies:

1. **In the energy sector**, twelve options divided between energy efficiency and cleaner and renewable energy were proposed by the TNA team and stakeholders. These options were evaluated and prioritized using 12 different criteria. The top four potential options for mitigation in the energy sector are; (1) Hydropower (mini/micro hydropower)/small hydropower, (2) Off-grid solar mini-grids up to 100 kW, (3) Improved Institutional Cook stoves. All selected options are reasonable and represent the country's needs for GHG emission reduction potential and sustainable development. All these energy-efficiency options can reduce the consumption of energy by at least 80% compared to conventional energy. On another side, Off-grid, On-grid PV system is the most potential renewable energy resource that the government of South Sudan have suggested in its second Nationally Determined Contribution (NDC). Both technologies are promised technologies to solve the energy crisis in the country.
2. **In the Waste Management sector**, sixteen mitigation technology options were initially suggested by the consultants and stakeholders. After intense discussions and consultations with the TNA experts working groups and the TNA team, only eight technology options were considered to be more suitable for South Sudan. The stakeholders, guided by the TNA team, proposed 12 criteria and assigned the initial weight for each criterion for the prioritization process of the technology options. The

scores and ranking of the final prioritization process of the technology options for the Waste sector were tabulated. The first four mitigation technology options for the waste sector were as follows: (1) Reduce, Reuse, Recycle (3Rs), (2) Transfer waste station, (3) Household Waste Segregation/Sorting. These three options represent the country's needs in the Waste sector for GHG mitigation purposes, and are aligned with current national policies and strategies in the waste sector and recommended for further analysis in the next TNA process – Barrier Analysis and Enabling Framework.

3. **Similarly, In the Agriculture, Forestry and Other Land Use (AFOLU) sector**, sixteen mitigation technology options were initially suggested by the consultants and stakeholders. After participatory discussions and consultations with the TNA experts working groups and the TNA team, only nine technology options were considered to be more suitable for South Sudan. The stakeholders, guided by the TNA team, proposed 10 criteria options and assigned the initial weight for each criterion for the prioritization process of the technology options. The scores and ranking of the final prioritization process of the technology options for the AFOLU sector were tabulated. The first three mitigation technology options for the AFOLU sector were as follows: (1) Promoting Forest based enterprises e.g. beekeeping/apiary, butterfly farming, fruit trees production, and ecotourism, (2) Substitute management of fossil fuel with wood fuel, (3) sustainable forest management (SFM) for reducing emissions from deforestation and forest degradation. These Three options represent the country's needs in AFOLU sector for climate change mitigation on the low-carbon development path to achieving sustainable development.

Finally, this report assessed the most prioritized applicable technologies to address climate change issues from both the adaptation and mitigation points of view. It is therefore two of the four top technologies identified for each adaptation and mitigation sector to the next step (Step II) Barrier Analysis and Enabling Framework (BA&EF) to identify the barriers and challenges that hinder the implantation of these options in the country and propose an action plan to mainstream them into the national sectorial development plan and polices.

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Annex I: Technology factsheets for selected technologies

These factsheets and long list of adaptation and mitigation technologies were used to inform the stakeholders during the MCA process

Annex 1.1: Technology Fact Sheets for Selected Technologies for climate change adaptation sectors

Sector	**Agriculture, livestock and Fisheries sector**
Technology	**Micro – Irrigation - Sprinkler and Drip Irrigation**
Introduction	Irrigation can help farmers in South Sudan to adapt to changing climate and substantially improve food production. The objective of micro irrigation is to supply each plant with just the right amount of water it needs, thereby reducing wastage of water. Micro irrigation systems include drip irrigation which target roots of field crops, and sprinklers, which are pressurized irrigation systems that use moving platforms or devices to stimulate natural rainfall. Water efficiency for sprinklers is 50-70%, while for drip irrigation it is up to 90% and can also be used in greenhouses, nurseries and plants in containers. Both systems can be gravity fed or pressurized. Adaptation of this technology promotes sustainable management of energy, water, land, and labor. Under conditions of raise water stress resulting from climate change, the benefits of the technology increase very significantly.
Technology characteristics	Micro irrigation conserves water as they use pipes or underground tubes. It delivers water directly to the soil surface close to the plant roots- avoid wastage of water through evaporation. Micro irrigation systems ensure uniform distribution of water by delivering water only wherever necessary.
Country Specific Applicability and Potential	Micro Irrigation has the potential of providing a means for farmers to adapt to changing climate and is easily adapted by farmers in all the ten state of South Sudan
Status of Technology in Country	In South Sudan, irrigation is used by farmers in many places from individual farmers to associations or producer cooperative and is also supported by NGOs such as FAO, CORAID, and ITC where several farmers benefit.
Availability of technology	The technology is suitable for various users from small scale to large scale and can be low-cost gravity-fed or automatic and pressurized. Suppliers are available locally or equipment can be imported from within East Africa
Climate change mitigation	Micro irrigation best meets the environmental, energy-efficient and resource-saving requirements under climate change. Drip

	and sprinkler systems are a means for climate change adaptation as they aid in sustainable water use and management, thereby increasing productivity and strengthening the adaptive capacities of communities that are heavily dependent on agriculture. When faced with water scarcity, sprinklers and drip irrigation systems allows for efficient use of water and represent an adaptation strategy against scarcity of water.
Benefits to economic / social and environmental development	The water efficiency increases, thereby aiding in sustainable use of water resources. Maintenance of irrigation equipment needs skilled labour and use of this technology creates jobs for the skilled labour. Contributes to food security priority by increasing productivity. Leads to increase in income of rural population. Reduces migration to urban areas from rural communities.
Capital, operating costs	Depending on the type of system, drip irrigation systems range from 1000 USD to 3500 USD per hectare. Financing for equipment may be available from financial institutions via leasing operations or direct credit. Operational cost for technology will be around 50-100 USD per hectare per year.

Technology	**Promotion of drought-resistant crop varieties**
Sector	**Agriculture, Livestock and Fisherries**
Introduction	Drought can reduce crop yields and crop hectare because less water and soil moisture are not available for crop growth. This specifically impacting the lives of poor. During a drought, farmers may consider reducing the cropping hectare and only drought-tolerant crops. Drought tolerance is an important management strategy for efficient water use and better crop yield in the areas with limited or unpredicted water supply.
Technology characteristics	The technology involved breeding and genetic engineering techniques and tools to create stress-tolerant crop varieties. The plant breeding offers a more active role to farmer by offering them observer plant performance in the field while attempting to select the plant traits for better drought tolerance. Genetic engineering involves the use of molecular markers to better understand the genetic basis of drought tolerance and to select more efficiently for this trait. Both techniques though take considerable time in development of a new crop variety and its field-testing procedures
Country Specific Applicability and Potential	The technology provides resourceful use of available crop water especially in drought prone areas or those with seasonal rainfall; reduces high demand of water by minimized evaporation losses from the crop surfaces; exhibit generally multi-stressor tolerance such as resistance against pests and salinity
Status of Technology in	South Sudan has not yet developed the technology and farmers

Country	are not yet aware of technology and no drought tolerant varieties have been developed so far in the country.
Availability of technology	The technology is not yet implemented in South Sudan and population only access drought tolerant crop
Climate change mitigation	The technology provides resourceful use of available crop water especially in drought prone areas or those with seasonal rainfall; reduces high demand of water by minimized evaporation losses from the crop surfaces; exhibit generally multi-stressor tolerance such as resistance against pests and diseases.
Benefits to economic / social and environmental development	Support in improving livelihood and strengthening the resilience of rural farmers to climate change
Capital, operating costs	It is difficult to calculation exact expense due to many reasons including: investment is needed to build well equipped laboratories of molecular biology and reliable mutagens resources, maintenance of laboratories and permanent operations require stable and permanent funding and a pool of technology experts and trainers

Technology	**Value addition and processing of agricultural produce**
Sector	**Agriculture, Livestock and Fisheries**
Introduction	Adding value to a product is important for maximizing profit. Adding value to products gives recipients many choices in selecting products as per their need (UNDP, 2022).
Technology characteristics	Value addition refers to changing raw agricultural products into something new. It's achieved either through processing, cooling, pasteurization, drying or packaging.
Country Specific Applicability and Potential	It has a higher market potential as there is a greater need to save time and money and very applicable for South Sudan farmers
Status of Technology in Country	This technology is somewhat new to South Sudan, therefore implementing this technology will require the National Ministry of Agriculture and Food security to work hand-in-hand with the States Ministry of Agriculture to implement this technology
Availability of technology	Technology not widely adapted in South Sudan
Climate change adaptation	Improves farmers' incomes and savings; Guarantees the availability of food crops and help farmers save more money.
Benefits to economic / social and environmental development	Improve farmers' income level and bring about economic stability. Reduce wastage of agricultural products thereby preventing pollution. It can be easily used by male or female farmers and producer of agricultural products.
Capital, operating costs	It will cost an initial investment of US$15 million to establish 10 major facilities for value addition of agricultural products. Operation and maintenance cost (per facility) USD $40,000

Technology	**Conservation agriculture/Conservation tillage /Zero-Tillage**
Sector	**Agriculture, livestock and Fisheries**
Introduction	Conservation agriculture/Conservation tillage /Zero-Tillage is a method of plowing or tilling a field in which the soil is not so much disturbed – the plant seed is sown directly into the seed bed which has not been till since harvest of the previous crop. In South Sudan there are three major farming systems: the irrigated agricultural system, semi-mechanized system and traditional rain fed production system. Zero tillage aims at making better utilization of agricultural resources through the integrated management of soil, water and biological inputs. It contributes to environmental conservation and to sustainable agricultural production by increasing rural producer's crop' productivity.
Technology characteristics	Conservation agriculture/Conservation tillage improves the soil, increases production and reduces the cost of production. Conservation tillage require less used of fossil fuel powered machinery like tractor, better water holding capacity of the soil, less soil erosion and improved soil health because no-till farming does not require a tractor to pull a plow, it saves fuel, cutting emissions.
Country Specific Applicability and Potential	Conservation agriculture/Conservation tillage production system requires knowledge and skills and requires producers to be into cooperative organization or groups. In South Sudan there are numerous available producers' cooperatives and organized groups that can easily take up the application of the technology. Therefore the applicability of the technology is feasible.
Status of Technology in Country	Conservation tillage has been introduced by Non-governmental organization in few state of South Sudan particularly in Western Equatoria and Northern Bahr el Ghazal. Training and skills Counties Directorate of agriculture and forestry the adoption of technologies of zero tillage (planting, spraying, fertilizer application. Moreover producers are knowledgeable about the zero tillage system in the country.
Availability of technology	Producers in South Sudan are knowledgeable about the zero tillage system and many practices the technology
Climate change adaptation	Conservation tillage can improve the productivity in rain-fed and irrigated farming areas. Zero tillage can build climate resilience by enhancing soil health. Healthy soil has a higher water-holding capacity, meaning it can better absorb and hold on to water during periods of heavy precipitation and drought, making farms more resilient to extreme climatic shocks. it also reduces the use of fossil fuel-powered machinery and helps soil

	hold on to carbon, preventing the release of greenhouse gas emissions during tillage. Because no-till farming does not require a tractor to pull a plow, it saves fuel, cutting emissions
Benefits to economic / social and environmental development	The economic benefits of the technology include the creation of new job opportunities, increase of producer's incomes, increased food production. The social benefits of zero tillage are improvement of living standards, upgrading the livelihood skills of farmers and enhancing their resilience to climatic and external economic shocks.
Capital, operating costs	Cost of establishing one unit with Zero conservation Tillage equipment: = 28,500 USD. Cost of cultivation of one Feddan by Zero Tillage = 60 USD The production of one Fadden using traditional system = 6 sacks (1 sack of crop = 100kg).

Sector	**Water sector**
Technology	**Solar powered water supply system/ Water Yard**
Introduction	A solar water powered supply system is essentially an electrical pump system in which the electricity is provided by one or several Photovoltaic (PV) panels.
Technology characteristics	A typical solar powered pumping system consists of a solar panel array that powers an electric motor, which in turn powers a bore or surface pump. The water is often pumped from the ground or stream into a storage tank that provides a gravity feed, so energy storage is not needed for these systems.
Country Specific Applicability and Potential	Scale of application: widely applicable from national and state level and for both urban and rural settings. Many parts of South Sudan constantly experience dry spell as a result of climate variability and changes. This persistently threatens crop growth and productivity, resulting in many households becoming food insecure and exacerbated poverty. Solar powered water supply has the potential to transform crop production in the face of climate change by efficiently providing water to plants and for domestic use from external water sources.
Status of Technology in Country	In South Sudan, utilization of the technology is in its' early stages. Solar powered water supply system technology is being promoted in many part of South Sudan through government, NGOs and private initiatives. There is high potential to scale up this technology so that many smallholder farmers are able to benefit from it.
Benefits to economic / social and environmental development	The use of solar Powered water supply pumps therefore provides a reliable, safe and adequate water supply, which improves the community's health, an important aspect for vulnerable groups such as women, children and people with special needs.

	Other benefits to social development are the improvement of social cohesion within the community, reduced migration out of the community, and increased community interaction in social events due to increased time availability. Solar powered water supply opens up new land for crop production in areas with permanent or seasonal water scarcity. Additionally, as the technology is adaptable to terrains where other systems cannot work well due to climatic or soil conditions, these are also opened up for production.
Climate change mitigation benefits	Extensive use of solar water pumps would therefore lead to substantial greenhouse gas emission reductions. Solar powered water supply technology supports households and to adapt to climate change by providing efficient use of water supply. In seasons with dry spell, solar water supply reduces demand for water and reduces water evaporation losses by providing the necessary water resources direct to household for domestic and irrigation used when required
Financial requirements and costs	Several aspects of a PV pump system are key in determining the system costs such as size of the system, insolation levels, pumping head. However, some estimated the costs for the procurement and installation of the Solar powered water supply can be in the range of US$15,000 – US$20,000. The costs vary with the design system of the technology and the size and other characteristics of the target area earmarked for water supply.

Technology	**Groundwater Abstraction – Water Borehole Drills**
Sector	**Water**
Introduction	Groundwater abstraction is the process of getting water from the ground source for domestic use and agricultural irrigation. Groundwater abstraction can be either manual, where water table is high or automated typically by employing a rotary drilling rig which is able to reach deep aquifers of several meters.
Technology characteristics	A water borehole is a specially engineered hole in the ground, making provision for water to flow into this hole and allowing for a pump to be installed inside the hole to allow abstraction of water. Air percussion technique utilizes compressed air to operate a down-hole air hammer on the end of the drill string that helps to break up the rock formation. The compressed air that is used to operate the down-hole air hammer also blows the crushed rock fragments out of the hole to the surface along with any water that flows into the hole during drilling
Country Specific	Groundwater is more immune to the effects of climate

Applicability and Potential	fluctuation compared to other sources of water, especially surface water (Quinn C, *et al*, 2019). Therefore, groundwater abstraction will be a vital water source option in the face of climate change. The government is encouraging individuals, groups and communities, through development of appropriate policies and provision of financial assistance to utilize groundwater, especially in the areas where surface water is in short supply or unavailable.
Status of Technology in Country	Groundwater abstraction – Borehole is common in all part of South Sudan. In most areas, the boreholes needed to abstract Groundwater would require a depth of as much as 40 - 75 m and the cost of sinking such a borehole is high. Drilling of boreholes has continued to increase as an option by the government and humanitarian partners to address increased water demand and water shortage due to droughts.
Benefits to economic / social and environmental development	Borehole ground water increases availability of quality water for domestic and agricultural purposes. In many cases, water boreholes are drilled closer to homesteads, thereby providing readily available water to women, girls, boy and reducing time spent by women looking for water to family and other socio-economic activities. The abstracted water is usually safe and there is a reduced incidence of water-borne diseases.
Climate change adaptation benefits	Ground water is relatively less likely to be affected by climate change compared to surface water sources and will therefore be a good water source option especially in areas with water scarcity in South Sudan
Financial requirements and costs	The average cost of drilling and equipping a borehole in South Sudan is estimated at (**US$15,000 - 20,000)** depending on factors such as aquifer depths, design and the difficulty to construct a borehole in a specific geological location. This kind of borehole can serve up to 300 households.

Technology	**Rainwater Harvesting (RWH) from Rooftops**
Sector	**Water**
Introduction	Rainwater harvesting is a technology through which rainwater is captured from manmade surface catchments such as rooftops, and road drainage and culverts, and stored in reservoirs or storage tanks for use during dry periods or drought. The technology is mainly used in places which receive little rainfall but intense and often seasonal. If properly designed, manmade catchment surfaces can collect large quantities of rainwater and used for different purposes, including washing and drinking,

	irrigating backyard vegetable gardens, grass, lawns or field crops.
Technology characteristics	The technology includes the Rooftop rainwater harvesting as a system which collects water from rooftop surfaces using gutters and drain the water into the collection vessels through down-pipes and Ground surface rainwater harvesting (Kwai Malak K et al, (2029). The system collects ground surface runoff into water storage reservoirs or tanks for future use. The reservoirs can vary in size depending on the amount of rainwater from runoff to be stored.
Country Specific Applicability and Potential	South Sudan experience seasonal variation in rainfall for example during the dry season (Dec – March), water shortage is experienced, while during the rainy season (April – November) the country receives a monthly average rainfall of 955 mm. Rainwater harvesting has therefore potential to collect and store water in reservoirs for future use and ease water shortages problem in the country
Status of Technology in Country	Rainwater harvesting is a known technology in South Sudan. Households collect rainwater from rooftops when it rains using water buckets for their immediate household use. The technology has been mainstreamed in national policies (e.g. South Sudan National Water Policy (2017) and Comprehensive agriculture master plan (CAMP). Recently, International organizations like UN- FAO have embarked on a campaign to create a mass awareness and knowledge sharing on rainwater harvesting to adopt the practice at a wider scale to increase water sources.
Benefits to economic / social and environmental development	Rainwater harvesting will supplement domestic water requirement during seasonal dry periods and droughts, and provides self-sufficiency to freshwater supply. The technology will have environmental benefits through reduction in runoff which chokes storm drains, avoid flooding of roads, reduce soil erosion and reduce ground water pollution. It provides quality water, soft and low in minerals, thereby enhancing social acceptability.
Climate change adaptation benefits	This technology can contribute significantly to reducing climate vulnerability at the household level primarily by diversifying household water supply, and providing reliable freshwater supply during season of water scarcity.
Financial requirements and costs	The cost of a standard 1,000 liters household rainwater jar/tank is approximately US$ 250 if built according to Government of South Sudan - Ministry of water resources and irrigation guideline. The cost of construction of a retainer dam depends on the size of the project and location but estimates for a small dam serving 200 households in about US$95,000.

Sector	Disaster Risk Management sector
Technology	**Development and introduction of monitoring and early warning systems**
Introduction	The accurate and reliable predictions of future impacts of climate change are largely handicapped by high level of uncertainty associated with availability of accurate and reliable data. Due to the complexity of global climate and weather systems, regular measurement of specific variables provided by climate monitoring systems are indispensable that would facilitate disaster preparedness and adaptation planning in the country.
Technology characteristics	This technology integrates satellite observation, ground based data and forecast models to monitor and forecast changes in climate and weather. The Directorate of Metrology at the Ministry of Transport and Road serve as the main operating GOSS institutions at the national level to monitor various weather variables and timely communicate with population both at the national and sub national level about potential changes in the climate system such as drought, flood and increase temperature or heat waves on monthly or seasonal basis.
Country Specific Applicability and Potential	The Early Warning Systems are not yet developed and operational especially by the Directorate of Meteorology in the Ministry of Transport and Road. Weather forecasts and disaster preparedness plan are being drafted by the Ministry of Humanitarian Affair and Disaster Management but implemented is not yet initiated. The country still requires technical experts in the field of multi hazard warning systems including flood, and epidemic outbreak and South Sudan still required the need to set-up a specialized medium range weather forecasting centre. Indigenous Knowledge by communities is also very important
Status of Technology in Country	In South Sudan, weather system monitoring and information dissemination is the responsibility of Directorate of Meteorology hosted at the Ministry of Transport and Road, the Ministry of Environment and Forestry, Ministry of Humanitarian Affair and Disaster Management (PMD). South Sudan hydro-meteorological warning systems are not satisfactory due to few installations and need for a powerful weather surveillance radars both at the national level and states level.
Availability of technology	Currently, South Sudan don't have an effective climate variability monitoring and early warning systems
Climate change mitigation	This technology increases the effectiveness of vulnerability

	monitoring, allowing individuals (farmers) and community systems to prepare for hazards if effective communication channel are employed. The technology also helps in the identification of at-risk population in disaster prone areas and provides decision makers with the information for effective adaptation planning and its mainstreaming in national development priority.
Benefits to economic / social and environmental development	The technology has the potential in avoiding disaster and saving livelihood by ensuring early preparedness. Climate variability monitoring and early warning help to reduce the number of displaced and distressed peoples
Financial requirements and costs	The cost includes up gradating of the existing climate monitoring stations, and dissemination of early warning information both at the national and state level. Approximately US $6,500,000.00 While the cost for rural weather station is estimated at US $ 1800 for a rural weather station. The cost relates to equipment and construction of a station.

Technology	**Improving disaster response (through the use of social media)**
Sector	**Disaster Risk Management sector**
Introduction	Social media are Internet-based applications that promote high social interaction and user-content generation often at a one-to-many or a many-to-many scale. Most social media services are supported across multiple devices including smartphones, computers, and tablets. Examples of popular social networking applications include Facebook and massager
Technology characteristics	Social media has emerged as a vital technology to support disaster risk reduction, including preparedness, response, and recovery activities. The remarkable growth in the diversity and richness of time-critical information that is generated on social media sites during disasters provides a great opportunity to harness large-scale spatio-temporal data of enormous value to disaster managers. In times of crises and disasters, social media platforms such as Facebook, massager, Twitter, Facebook and telephone call are often used by communities to stay connected, share experiences, and access vital information and resources as needed to support disaster response and recovery.
Country Specific Applicability and Potential	In South Sudan social media Natural hazards are becoming increasingly expensive as climate change and development are exposing communities to greater risks. Preparation and recovery are critical for climate change resilience, and social media are

	being used more and more to communicate before, during, and after disasters.
Status of Technology in Country	Technology not widely used in South Sudan although the Ministry of Humanitarian Affair and Disaster Management is now rolling it out by implementing the County Disaster Management Plan.
Availability of technology	Technology implementation is still low and requires up scaling. The technology is acceptable to local stakeholders.
Climate change mitigation	The technology will aid in successful adaptation by improving disaster management approaches and risk reduction.
Benefits to economic / social and environmental development	• Creation of jobs for people in a wide range of disciplines – climate scientists, meteorologists, agriculture scientists, socioeconomics, support operation and maintenance of water systems and to provide training to users/households and communities. • Potential saving in disaster avoidance and livelihood saving • Help reduce the number of displaced and distressed people. • Good and reliable climate and weather information would assist in environmentally sustainable development.
Financial requirements and costs	Costs are high and could exceed US $4,500,000.00.

Technology	**Flood early warning system**
Sector	**Disaster Risk Management sector**
Introduction	Early warning system is a crucial part of disaster reduction and comprises of coordinated procedures through which information on foreseeable hazards is collected and analyzed for predicting a possible future hazard. This would benefit communities and government by preventing or reducing loss of life and assets. South Sudan has been adversely affected by recurrent flood and dry spell in the past decades. A series of recurrent floods hitting the country in 2010, 2011 and 2012, have affected 4.8 Million peoples (International crisis group, (2022) each time including a larger proportion of victim population's lives and livelihood sources that were affected repeatedly without providing a window for full recovery. Preliminary FAO analysis indicates that about 74 157 Ha of cultivated land has been damaged due to floods with an estimated loss of 72 611 tons of cereals and up to 3 million livestock are likely to be affected by the floods.
Technology characteristics	Flood early warning system require the monitoring, detection and forecasting of hydro-meteorological hazards providing

	lead-times for action; combined with, risk analysis; dissemination of timely and authoritative warnings; and the activation of emergency plans to prepare to respond. These elements must be supported by appropriate policies, legislations and legal frameworks, with coordination across many agencies at national to sub national levels.
Country Specific Applicability and Potential	The technology is applicable in South Sudan and have the potential of reducing the neglect impact of climate related disaster such as flood and improved communities' preparedness
Status of Technology in Country	South Sudan Meteorological Department at the Ministry of Transport and Road is the national institution responsible for early warning systems for floods, drought, dry spell, and diseases of which flood warning system is the most mature and sophisticated one. So far, no single flood alert and management information system (PIFMIS) has been installed so that it serves for flood alert, flood control and management, knowledge base for policy and decision making
Availability of technology	Limited coverage of flood early warning system both at the national and sub national level
Climate change mitigation	Improving the resilience of communities by disaster risk reduction
Benefits to economic / social and environmental development	Application of flood warning systems further aid to avoid or reduce loss of lives, property and livelihood activities particularly where vulnerable groups (i.e. women, children, elderly and people with disabilities) are concerned. The technology will help in reducing the magnitude of disasters by lessening the number of human casualties and loss of properties and livestock resulting from climate change related disasters such as flood and dry spell
Financial requirements and costs	The costs of implementing flood warning systems are expected to differ widely, depending on the level of sophistication of monitoring and forecasting technologies. In developing countries, meteorological observations are frequently made using basic methods, which may include ground-based methods and weather balloon observations, coupled with limited computing. In these cases, annual running costs are expected to be around USD 6 million.

Annex 1.2: Technology Fact Sheets for Selected Technologies for climate change Mitigation sectors

Sector	**Energy**
Technology	**Hydropower (mini/micro hydropower)/small hydropower**
Introduction	About 95 percent of South Sudanese live in both urban and rural do not have access to electricity. Lack of access is exacerbated by lack of national grid. To improve economy and quality of life of rural people, the Government of South Sudan will have to commit to a robust urban and rural electrification program. Providing electricity to the rural population is challenging compared to electrification of urban areas. It affects many more people, and because of the low population density and dispersed nature of settlements, will come at a high cost, even though these people are the ones least able to afford to pay.
Technology characteristics	Mini- hydropower is mostly of the run-of-river power plants which use the flowing water to generate electricity without the need to change the river flow. After use, the water used in mini-hydropower generation is returned to the natural course. Fulla in Nimule has the potential for hydropower generation. The amount of power that can be produced by a mini-hydropower plant is determined by the head (the height of power drop) and the flow rate. The higher the head, the smaller the flow rate needed to produce the same amount of electricity. Mini- hydro power plants are best suited for isolated locations where there is no electricity grid. Off-grid power plants need local load controlling to stabilize frequency and voltage supply.
Country Specific Applicability and Potential	About 95 % of South Sudanese's living in both urban and rural areas of South Sudan do not have access to electric power due to lack of national grid. Development of mini- hydropower power plants will therefore contribute to both Urban and rural electricity supplies. South Sudan is endowed with a rich mini-hydropower potential of about 11,852 megawatts and only 0 megawatts have been developed. Mini- hydropower is especially suited to micro-enterprises especially agro- processing industries as well as to health and indoor lights The Nile River has large project sites identified. Locations include Fula, Shukoli, Lakki and Bedden are major sites to develop, as the potential to deliver a total of 2,927MW as well as 11,852GWh of average energy, and 7,634GWh of firm energy.
Status of Technology in Country	No Mini- hydropower plants in South Sudan due to the country lack adequate capacity for installation.
Benefits to economic / social	The development of mini- hydropower generation could result

and environmental development	in great socio- economic and environmental benefits for South Sudan. Mini- hydropower generation technology is by and large pollution free and ecological friendly. The technology will have relatively low environmental impacts compared disease electricity generation currently employed in the country
Climate change mitigation benefits	Mini- hydropower plants are practically carbon free. Mini-hydro's can replace fossil fuel generation capacity. In this regard, the mitigation potential is in the order of 13 ktCo2/year by 2030
Financial requirements and costs	The capital requirements for mini- hydropower plants depend on the effective head, flow rate, geological and geographical features, In general, sites with low heads and high flows need greater capital outlay.

Technology	**Off-grid solar mini-grids up to 100 kW – Solar home PV System**
Sector	**Energy**
Introduction	South Sudan lies along the Equator. Solar energy resources are available in many areas of the country in quantities that are commercially viable. Solar Home Systems provide households lights, and electrical power for televisions, cassette players and small appliances. In addition, small scale systems for households and institutions such as schools, hospitals in especially in isolated rural areas not connected to the grid can be developed for local community utilization. Off-grid solar mini-grids– Solar home PV System Solar electricity if adopted fully in South Sudan could be widely used in all the state and rural areas to power domestic activities and industries and rural-urban connectivity.
Technology characteristics	Solar electricity is the electric power generated from sunlight using devices called solar cell modules. Electric devices transform solar energy into electricity for lighting, pumping water, powering radios, etc.
Country Specific Applicability and Potential	Solar Home Systems has very high potential given the fact that the South Sudan is located near to the Equator.
Status of Technology in Country	Solar Home Systems is yet to get wide adoption and application in the country. Up to now both urban and rural area are not yet connected to the grid due to conflict and insecurity as well as high initial costs of investment. The Government of South Sudan will have to initial clean decentralized photovoltaic technology development in order to ensure rural electrification
Benefits to economic / social	• Employment creation for rural population

and environmental development	• Social and health benefits such as better health as the technology does not emit any pollution as opposed to the use of paraffin lamps, improved health. Traditionally families in rural areas use paraffin candles and lamps as source of light. These candles and lamps produce fumes which are harmful to human health
Climate change mitigation benefits	Application of this technology replaces kerosene lamps and candles that are majorly used for lighting in rural off-grid communities and fossils fuels used in generators to power electric appliances such as milling machines, refrigerators, hair cutting machines, televisions, radios and telephone charging points.
Financial requirements and costs	$700,000 including one-off development costs required in the early stages. Operational and maintenance costs of $400,000 over its lifetime (5% of the capital cost per kW per annum)

Technology	**Roof top Solar Photovoltaic (PV) with Energy Storage System including Battery**
Sector	**Energy**
Introduction	Solar rooftop systems are developed based on photovoltaic (PV) technologies and integrated with DC-electricity-based appliances. It is the most suitable technology used in remote and rural areas, which are not served by the electricity grid. A typical system consists of a 10 to 50Watt Peak PV module, charging controller, storage battery, and various end-use equipment that operate with DC electricity (e.g. fluorescent lamps, radio, television, fan, etc.). Solar technologies perform better in regions and seasons with the highest sun intensity and long sunlight hours.
Technology characteristics	Solar will consist of the following elements: • PV solar panels/modules (arranged in arrays) • PV module mountings • DC-AC current inverters • Electricity distribution boxes • Cabling • Earthing systems • Electrical substation
Country Specific Applicability and Potential	Currently, South Sudan has few solar projects as such the technology is known and can be scale up.
Status of Technology in Country	Government of South Sudan is yet to making significant efforts in the implementation of the Solar Photovoltaic (PV) and to extend the grid to various parts of the country.

Benefits to economic / social and environmental development	• Job creation for distributors and retailers of solar rooftop systems and those in the business value chain. The implementation of solar charging stations provides opportunities for new businesses that are environmentally friendly. Solar lighting extends the work day and allows merchants longer time periods to sell their goods. • Attracting investments into the country
Climate change mitigation benefits	Generating electricity from solar panels produces no harmful emissions, and the more homes and businesses that rely on solar power means less toxic emissions from fossil fuels into our air. The technology has the potential of reducing GHG emissions, reduced pollution, and conservation of eco systems.
Financial requirements and costs	$ 1800 per Solar system of 100 watts; 4 Lights for 4-6 hours per day – replaces 4 kerosene lamps; radio more than 6 hours – this replaces use of disposable dry-cell batteries; TV for 3-6 hours – displaces diesel. Note installation cost is not included. Rooftop solar PV systems have very minimal cost to operate and maintain. Panels are self-cleaned whenever it rains.

Technology	**Improved Institutional Cookstoves**
Sector	**Energy**
Introduction	In South Sudan most of households in the rural and urban areas use the traditional three stones open fire stoves to prepare their food. Some public institutions, especially, School, prisons and army camps also use the same three stones stoves to prepare meals. It is acknowledged that the efficiency of the traditional stoves used are exceptionally low; therefore a lot of fuel wood is burnt unnecessarily leading to loss of forest cover which is an important sink for GHGs. Over-reliance of biomass-based fuels and inefficient technologies such as traditional stoves has placed great pressure on local forests. Institutional stoves are also used in refugee camps, particularly in the early stages when large influxes of people require food urgently. Typically, these groups will use institutional stoves with a cooking capacity of 50 liters to 200 liters. Another very different group of users are entrepreneurs who own cafés or restaurants, selling street foods, or selling staple foods such as bread. In such cases, the stove is likely to be used for several hours each day
Technology characteristics	Improved institution Stoves can be designed and built in various ways, depending on the local conditions. At their simplest, Improved institution stoves provide an enclosure for the fire to

	reduce the loss of radiant heat and protect it against the wind. In addition, attention can be given to methods controlling the upward flow of the combustion gases, so as to increase the transfer of heat to the cooking pot. Many of these stoves are made of mud or sand since both are almost free and readily available.
Country Specific Applicability and Potential	Institutional stoves have the potential for providing important services at a low cost to large numbers of people. These include: health The stove provides energy which is cleaner and requires less effort to use, environment – stoves with improved combustion require much less wood, thus benefiting the environment.
Status of Technology in Country	Improved institutional cook stoves both for household and institutional uses are available in South Sudan and produced locally by a number of trained artisans. As per the South Sudan development strategy, lowering the deforestation is the main issue in all developmental plans.
Benefits to economic / social and environmental development	• Minimize the pressure on forests to provide wood fuel for cooking • Improve economic situation through Job creation; improving house energy budget • Improve the health conditions delivered from cooking with relatively a clean smokeless stove • Saving time for women and children in collecting firewood, and reduce the burden of carrying wood long distances are also avoided
Climate change mitigation benefits	If South Sudan implemented the technology, it may result in annual reduction of 95 ktCO2e/a from 1,000 institutional cooking stoves by 2030 (refer to NDC).
Financial requirements and costs	$3,500,000 if the stoves are well maintained and serve for 5 years. If some of the stoves are decommissioned, the cost will be USD 4,512,564

Technology	**Promotion of Energy Efficiency and conservation in industries and Institutional buildings**
Sector	**Energy**
Introduction	Energy efficiency is the use of less energy to perform the same task or produce the same result. Energy-efficient homes and buildings use less energy to heat, cool, and run appliances and electronics, and energy-efficient manufacturing facilities use less energy to produce goods
Technology characteristics	The measure involves Efficient Electrical Transmission, Distribution, through Smart grid applications to stop the flow of lost energy, and technologies that anticipate and monitor actual

	energy demand
Country Specific Applicability and Potential	There are large opportunities that can be tapped in introduction of energy efficiency measures such as insulation, improving lighting, and energy conservation measures. Some initiatives have started with government buildings e.g. in Nile Petroleum Head Quarter in Juba
Status of Technology in Country	The technology is known and can be scale up in the Country. The South Sudan government leadership appears committed to increasing energy efficiency and conservation, and much groundwork has already been completed, the potential is high for even greater improvements in energy efficiency and conservation.
Benefits to economic / social and environmental development	Saves money and minimize power generators overcapacity and can accommodate integration of renewable energy technologies some which are intermittent and corresponding lower capacity factors Reduction of energy cost for production of unit service and product. This would make contribute energy savings for households and reduction in unit market price of the service and product resulting into competitive advantage and growth of a industry (ii). Energy efficiency and conservation minimizes power interruptions during peak hours, contributing to smooth operations of economic activities at all times.
Climate change mitigation benefits	Energy efficiency and conservation delivers a number of environmental benefits. It notably reduces GHG emissions, both direct emissions from fossil fuel combustion or consumption, and indirect emissions reductions from electricity generation.
Financial requirements and costs	Energy conservation costs depend on the equipment purchased and the plans implemented. There are costs associated with tracking energy usage, equipment efficiency, and with gaining knowledge about the distribution of energy usage.

Sector	**Agricultural, Forestry and Other Land Use (AFOLU)**
Technology	**Promoting Forest based enterprises e.g. bee keeping/apiary, butterfly farming, fruit trees production and ecotourism**
Introduction	Forest based enterprises are described as enterprises that have a direct linkage and base on the forest, thus their success directly depends on the trees and the forests. The technology has been applied in many tropics and is reported as effective in building resilience of communities against climate change as it provides alternative livelihoods and reduces over dependence on the of forest adjacent communities. In South Sudan the technology has been piloted and promoted

	by Equatoria Teak Company (ETC) and the Ministry of Agriculture and food security through collaboration with Non-Governmental Organizations and the Local Governments among others.
Technology characteristics	In South Sudan, the technology promoting forest restoration and conservation and at the same time improving the livelihoods of the forest adjacent communities through income generation and food security. The technology is mainly managed by the forest adjacent communities once equipped with the requisite knowledge and skills to management the enterprises efficiently and effective**.**
Country Specific Applicability and Potential	The technology has a national wide potential, thus its applicable in buffer zones along protected forests found in all forest landscapes especially in Western and central Equatoria state
Status of Technology in Country	The technology has been largely tested and promoted by Equatoria Teak company in Western Equatoria state, South Sudan and by Non-Government Organization in collaboration with the MoEF and MAFS. The South Sudan Wildlife Services as well has promoted the technology with communities living adjacent to Boma and Badingilo National Parks.
Benefits to economic / social and environmental development	Creation of jobs The stakeholders involved in the application of the community-based forest enterprise benefit from the knowledge and skills associated with their management. The products (e.g. honey, fruits, mushrooms,) from some of the selected enterprises have positive impact on the nutrition and health in the community when consumed as part of the diet.
Climate change mitigation benefits	Promoting Forest based enterprises technology promote sustainable use and conservation of forests and, therefore, a reduction in forest-related carbon emissions.
Financial requirements and costs	The average estimated cost to put in place 1 ha of integrated Forest based enterprises such as bee keeping/apiary is 1000-2500 USD.

Technology	**Substitute management of fossil fuel with wood fuel**
Sector	**Agricultural, Forestry and Other Land Use (AFOLU)**
Introduction	In South Sudan, wood fuel is the major source of energy for most urban and rural household. Commercial institutions also use wood fuel as their core source of energy. This situation has contributed for the deforestation of natural forests and land degradation in the Country
Technology characteristics	Forests remove carbon dioxide from the atmosphere via photosynthesis, and store carbon in biomass and soil. When forests are harvested, part of the carbon is released and part is stored in wood based products. In addition to carbon storage in

	forest ecosystems and harvested wood products (HWP), using wood to substitute greenhouse gas intensive- materials and fossil fuels can have climate change mitigation benefits.
Country Specific Applicability and Potential	Substitute management of fossil fuel with wood fuel technology has very high potential given the fact that the country has wood-based products that can quickly replace fossil-based ones
Status of Technology in Country	The technology is not yet adopted in South Sudan however the use of forest products as wool fuel is common with some communities. The market for forest wood products is therefore big as fuel.
Benefits to economic / social and environmental development	Promotion of efficient use of forest wood products as fuel increases the productivity level since wastes are put into economic use. Also, there are indirect economic benefits from saved forests as a result of promotion of efficiency in the use of wood forest products as fuel
Climate change mitigation benefits	The technology promotes sustainable biomass use by substitute use of fossil fuel and reduces the amount of CO2 emission to the atmosphere.
Financial requirements and costs	The average estimated cost to put in place 1 ha of Forest based system is between 1500-3500 USD.

Technology	**Sustainable Forest Management (SFM) for reducing emissions from deforestation and forest degradation**
Sector	**Agricultural, Forestry and Other Land Use (AFOLU)**
Introduction	This technology is related to silvicultural technology such as reforestation, forest fire control, insect and pest control, invasive species prevention, forest degradation and deforestation prevention. The technology is very important in reducing GHG emissions if implemented well.
Technology characteristics	SFM is applicable in all types of forests in all geographic regions and embraces management for different purposes such as production, protection, conservation, or a combination of multiple objectives (multipurpose forest management).
Country Specific Applicability and Potential	The technology is not widely adopted in the country and have the potential for uptake by communities
Status of Technology in Country	The practice of sustainable forest management is not new in South Sudan, only that it has not been implemented by the intended stakeholders. As the technology is recommended as one of the strategies to control deforestation and forest degradation, the potential for its application is high in South Sudan**.**

Benefits to economic / social and environmental development	• Prevention of land degradation and desertification by stabilizing soil, reducing water and wind erosion, and maintaining water and nutrient cycling in the soil • Increased income through sustainability-verified timber trading • The technology can create more jobs and increased income. If implemented well can result in sustainable forest use and management. • Forests provide household income and revenues for the government through the sale of timber and reduce dependence on expensive and imported energy sources.
Climate change mitigation benefits	Sustainable management of forests is the most important technology in reducing GHG emissions. SFM supports community adaptation through ecosystem-based adaptation strategies practices such as landscape management, conservation and restoration and agroforestry
Financial requirements and costs	Operational and maintenance basically consist of forest monitoring, restoration, sustainable harvesting. In addition, capacity building of forest staff and forest conservation groups is crucial for sustainable management of forest resources. Full project implementation: USD 5 million Project design: USD 80,000

Sector	**Waste management Sector**
Technology	**Reduce, reuse and recycle (3Rs)**
Introduction	Reducing the generation of waste, re -using and recycling products can substantially reduce the amount of waste to be disposed on land. These activities require a high degree of coordination and organization of the waste management value chain in the country
Technology characteristics	To reduce waste problems in future, reduction in waste generation and re-use of old products such as electronics can be one of the most important factors. Examples of possible reduction at the consumption level include better buying habits and cutting down on the use of disposable products and packaging
Country Specific Applicability and Potential	Although, the concept of 3Rs has been known to South Sudan, the actual implementation of the 3Rs concept has been difficult due to lack of proper guidance, budget, human resource and public awareness. Currently, South Sudan particularly the private sector actors are struggling in putting more step forward in managing organic waste, pet bottles and paper wastes

	through the application of 3R technologies.
Status of Technology in Country	Currently, South Sudan doesn't have waste Prevention and Management Act and guideline and principles that can support the implementation of waste Reduce, Reuse and Recycle. Public Private Partnership models for waste management is also lacking and not yet initiated
Availability of technology	The technology is still at maturing stage and government will need to support private waste company to invest in waste reduce, reuse and recycling to avoid environmental and air pollution as well as emissions greenhouse gas.
Climate change mitigation	Reuse of containers will result in lower energy use and hence reduced emissions of the gases. Reduction of greenhouse gas emissions from burning of plastic wastes. In addition, the GHG impact of the production of other waste categories, such as old washing machines, computers, mobile phones, etc. can be significantly reduced by reusing them or formulating them with a view to promote durable, re-usable and recyclable products.
Benefits to economic / social and environmental development	Economic benefits i) Creation of jobs and poverty reduction ii) Minimizes Environmental benefits i) Energy conservation and preservation of biodiversity ii) Prevents the unnecessary waste of natural resources and raw materials
Capital, operating costs	In term of reuse, the initial investment cost is about US$ 2800 to start a biogas plant. Recycling requires high initial investment costs of about 50,000- 100,000 USD

Technology	**Transfer waste station**
Sector	**Energy**
Introduction	A waste transfer station technology is a light industrial-type facility where trash collection trucks discharge their loads so trash can be compacted and then reloaded into larger vehicles (e.g., trucks and barges) for delivery to a final waste disposal site, typically a landfill. Transfer station operators usually move waste off the site in a matter of minutes or hours. Transfer stations serve both rural and urban communities.
Technology characteristics	A waste transfer station is more cost-effective when they are located near a collection area. A waste transfer station also lowers collection costs, as crews spend less time traveling to and from distant disposal sites and more time collecting waste. This reduces costs for labor, fuel and collection vehicle maintenance.

Country Specific Applicability and Potential	In South Sudan, communities use transfer stations to move their waste efficiently from the point of collection to landfills. By consolidating solid waste collection and disposal points, Waste transfer stations have the potential of helping communities reduce the cost of hauling waste to these remote disposal sites.
Status of Technology in Country	Solid waste transfer stations in South Sudan particularly Juba accept the following types of waste: Garbage, rubbish, Food wastes, non-hazardous liquid waste, and biohazardous medical waste from households and refuse generated by households, commercial entities, or municipalities. Waste collection services using garbage a truck is currently being provided by the private sector. The frequency of waste collection differs for each state. In Juba, CES, waste is collected on the Juba town street three times a week, whereas waste collection for most other town is done once a week (Kajokare *et al*, (2013).
Availability of technology	The technology is only limited to major towns like Juba city. Most of the state capital lacks the waste transfer station while the existing solid waste transfer stations are poorly sited, designed, or operated.
Climate change mitigation	Waste transfer stations reduce air emission and fuel consumption, hence low GHGs emission
Benefits to economic / social and environmental development	Waste transfer stations make solid waste collection more efficient and reduce overall transportation costs, air emissions, energy use, truck traffic, and road wear and tear. This saves community money and lowers the cost of your solid waste management services.
Capital, operating costs	The cost of a 30-foot-long scale is approximately $23,000 and a 60-foot scale is approximately $33,000; a computerized data management system at the waste transfer station costs an estimated $15,000.

Technology	**Household Waste Sorting (Segregation)**
Sector	**Waste management Sector**
Introduction	Waste poses a danger to public health and the environment if it is not stored, collected, and disposed of properly. Waste sorting or separation at the source, also called source separation, is the process of separating different fractions of waste at the place where it is generated, i.e., at home.
Technology characteristics	Onsite handling, storage, and processing are the activities at the point of waste generation which facilitate easier collection. For example, waste bins are provided at the home sites which generate sufficient waste.
Country Specific Applicability and Potential	Almost all of the South Sudan households in major town of South Sudan have waste generated at the household, so this

	technology can be implemented.
Status of Technology in Country	It is very limited, the public in South Sudan hardly practices waste segregation and no clear or adequate policies on SWM and recycling, lack of clear regulations on SWM, National, state and local authorities unable to enforce policies and regulations and the inefficient SWM system. More reinforcement is required in awareness-raising on waste and recycling.
Availability of technology	They technology is available; however there is no available infrastructure or laws that help the use of this technology in South Sudan.
Climate change mitigation	Reduction in uncontrolled solid waste disposal at the dumpsite thus reducing GHG emissions
Benefits to economic / social and environmental development	Proper waste management at the source of generation is a public benefit in term of employment opportunities. Controlling what goes into the landfills in terms of household solid waste segregation can significantly reduce the emission of GHG
Capital, operating costs	The price of 240 L wheelie bins range between USD 50 to USD70 each. Capital cost will be dependent on the number and types of bins required per household multiplied (x) by number of households (x) by the cost of each bin. Cost of freight is not included.

Annex II: List of stakeholders involved and their contacts

The Participants of the TNA Inception Workshop

Attendance Register for Inception Workshop for South Sudan Technology Needs Assessment for Climate Change 18TH – 04 – 2023

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Annex 2.2: Sector working groups, consultants and other contributors to technology selection

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