THE FEDERAL REPUBLIC OF SOMALIA
MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE ADAPTATION

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LIST OF ACRONYMS

NDC	NATIONALLY DETERMINED CONTRIBUTION
UNFCC	UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE
GDP	GROSS DOMESTIC PRODUCT
MOECC	MINISTER OF ENVIRONMENT AND CLIMATE CHANGE
TNA	TECHNOLOGY NEEDS ASSESSMENT
MCA	MULTIPLE CRITERIA ANALYSIS
MSP	MULTI-STAKEHOLDER PROCESS
EST	ENVIRONMENTALLY SOUND TECHNOLOGY
FGS	FEDERAL GOVERNMENT OF SOMALIA
ITCZ	INTER-TROPICAL CONVERGENCE ZONE
NAPA	NATIONAL ADAPTATION PLAN OF ACTIONS
IWRMS	INTEGRATED WATER RESOURCES MANAGEMENT STRATEGIC PLAN
NCCC	NATIONAL CLIMATE CHANGE COMMITTEE
NPSC	NATIONAL PROJECT STEERING COMMITTEE (NPSC)
GCF	GREEN CLIMATE FUND
NDA	NATIONAL DESIGNATED AUTHORITY

REPORT I: TNA REPORT

Executive Summary

Somalia's Technology Needs Assessment (TNA)-Adaptation Report is the first of three deliverables aimed at identifying and developing climate technology paths for the Paris Agreement's implementation. The other reports include Barrier Analysis and Enabling Framework (BAEF) and the Technology Action Plan. The report was informed by multi-stakeholder engagement ranging from the government (both Federal and State), civilsociety, and private sector in Somalia. The goal of the TNA project is to identify andprioritise, through country-driven participatory processes, technologies that can contribute to Somalia's adaptation targets, National Development Plans, and sustainable development agenda and enhance the implementation of the Paris Agreement.

Somalia is a Least Developed Country and one of the most vulnerable to climate change-related shocks such as droughts, floods, storms, and desert locust infestation,among others, due to over-dependence on agriculture (including livestock production). Over 80% of the total landmass is Arid and Semi-Arid land and thus considered a water-scarce country. Climate change has further exacerbated water shortage, with Somalia's water potential standing at less than 500 m3/per capita/year, below the 1000 m3 globalwater scarcity threshold.

To address climate change, Somalia has, in the last few years, improved its enablingpolicies and legislative and institutional frameworks at both the Federal and State level. Critical institutions established include the Ministry of Environment and Climate change (DECC), in charge of climate change-related issues in Somalia, Federal and State Level Ministries including Agriculture, Water, Planning, Fisheries, and Marine Environment, Finance, Gender, among others. Also, important policies, including the National Climate change policy, National Adaptation Framework, Initial National Communication 2018, Updated NDC 2021, and NDP 9 2020-2024, among others, have been developed to address climate change in Somalia.

The adaptation sectors selected for Somalia included Agriculture (including livestock production) and water. Agriculture is the mainstay of the economy, but since it is mainly dependent on rainfall, it is sensitive to climate change and variability. Water is an important natural resource and is critical for the sustainable development of practically all social and economic sectors, as it is required for domestic purposes, agricultural and industrial development, energy generation, and livestock.

The report starts by explaining the basis of the TNA in Somalia. It describes the national institutions involved in climate change policymaking and implementation and their roles in the TNA project. The national physical, social and economic circumstances that form the basis for climate change adaptation are also described. The TNA process, criteria,results, and selection of sectors and technologies followed a participatory approach,which included a literature review, technical expertise, and involvement of stakeholders through workshops, one-on-one consultations, and structured questionnaires.

The sectors are considered in the TNA were prioritised based on the country's development priorities andvulnerability to climate change. The processes involved the review of the existing literature, involvement of stakeholders, sector working groups, and technical expertise inconsultation with the national TNA coordination office. The same actors also influenced the criteria and decisions for sector and technology identification and prioritisation.

The TNA has assessed and prioritised technology needs for adaptation for the agricultureand water resources sectors. The technology options for climate change adaptation were arrived at through the multi-stakeholder process (MSP) and a linear additive Multiple Criteria Analysis (MCA) framework. A multi-stakeholder process (MSP) was adopted for the identification and prioritisation of technology options. A maximum oftwo technologies were prioritised for each sector. In Agriculture, Early Warning Systems and drip irrigation were prioritised. In the water sector, rainwater harvesting and Solar powered boreholes were prioritised as preferred technologies

CHAPTER 1: INTRODUCTION

Scientific evidence attests that climate change is increasingly causing serious adverse impacts at global and local levels. Indeed, the formulation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 resulted from this realisation. Climate change-related shocks, including droughts, floods, storms, and forest fires, among others, are experienced more in the global South in comparison to the global north leading to significant losses in GDPs[1]. Somalia is a Least Developed country, with nearly 80% of the landmass categorised as Arid and Semi-Arid Lands (ASAL). Climate change has further exacerbated an already precarious situation resulting in increased frequencies of droughts leading to losses in agriculture and livestock production and resultant poverty. Nearly 69% of the population lives below the poverty line, with women, children, and Internally Displaced Persons making the majority with the least adaptive capacities.

Article 4 of the Convention spells out the key commitments of the Country Parties to respond to climate change. In the context of the climate negotiations, it was recognised that there exist significant gaps in technical, technological, and financial capacities among the majority of developing and least developed countries to meet their climate action agenda.

To address the gap mentioned above, the developed country Parties committed themselves to facilitating the development and transfer of appropriate technologies and technical know-how and financial resources to developing countries in both adaptation and mitigation measures. Thus, it is in this context that the Technology Needs Assessment Project was formulated. TNA involves Identifying priority technologies for adaptation and mitigation, Barrier analysis, and developing a Technology Action Plan (TAP). A TAP is a concise plan for the uptake and diffusion of prioritised technologies for countries, contributing to social, environmental, and economic development and climate change mitigation and adaptation. Somalia's TNA Adaptation focuses on the agriculture and water sectors which are the two most critical in terms of vulnerabilities to climate change and overall contribution to socio-economic development in Somalia.

[1] Parry, M. L., Canziani, O., Palutikof, J., Van der Linden, P., & Hanson, C. (Eds.). (2007). Climate change 2007-impacts, adaptation and vulnerability: Working group II contribution to the fourth assessment report of the IPCC (Vol. 4). Cambridge University Press.

1.1 About the TNA project

The Global Technology Needs Assessment project is funded by the Global Environment Facility (GEF) and executed by the United Nations Environment Programme (UNEP) in collaboration with the UNEP Copenhagen Climate Centre (UNEP-CCC). The Global TNA is a strategic technology transfer program that aims to assist countries in conducting Technology Needs Assessments under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. Its main goal is to reduce national greenhouse gas (GHG) emissions while avoiding the dangers and repercussions of climate change.

The current Global TNA project, deriving from the window (i) of the Poznan Strategic Program on Technology Transfer, is designed to support countries to carry out improved Technology Needs Assessments within the framework of the UNFCCC. The purpose of the TNA project is to assist participant developing country Parties in identifying and analysing priority technology needs, which can form the basis for a portfolio of environmentally sound technology (EST) projects and programmes to facilitate the transfer of, and access to, the ESTs and know-how in the implementation of Article 4.5 of the UNFCCC Convention. Hence TNAs are central to the work of Parties to the Convention on technology transfer and present an opportunity to track an evolving need for new equipment, techniques, practical knowledge and skills, which are necessary to mitigate GHG emissions and/or reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change.

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

Somalia is considered a Least Developed Country that remains susceptible to climate change impacts due to fragile security, a weak economy coupled with climate-related shocks especially extended drought periods and intermittent floods. Adaptation to climate change is critical to enhancing the resilience of local communities and fragile economic systems[2]. Importantly, prioritised adaptation technologies should consider Somalia's national context, including its development plans, policies, and programmes at both Federal and State levels.

[2] Warsame, A. A., Sheik-Ali, I. A., Ali, A. O., & Sarkodie, S. A. (2021). Climate change and crop production nexus in Somalia: an empirical evidence from ARDL technique. Environmental Science and Pollution Research, 28(16), 19838-19850.

1.2.1 National circumstances

1.2.1.1 Location

Somalia is located in the Horn of Africa with a land area of 637,540 km^2. Kenya borders it in the south, Ethiopia in the west, and Djibouti in the northwest. Somalia has the longest coastline in Africa, over 3,333km on the Gulf of Aden and the Indian Ocean. (FGS, 2021). The country stretches for almost 1,550 km from north to south between latitudes 12°00'N and 1°37'S and 1,095 km from west to east between longitudes 41°00' and 51°21'E[3].

1.2.1.2 Population

Despite the protracted conflict in the last three decades resulting in massive displacement and migration out of Somalia, the recent population census indicates significant population growth estimated at 16 million people. Youth and women make up the majority of the population. Rural households practising nomadic pastoralism account for the majority of the overall population. Also, the census indicated that nearly 2.7 million people are considered internally displaced persons in Somalia (FGS, 2019).

1.2.1.3 Climate

Somalia is among the world's most vulnerable countries to climate change, as characterised by rainfall variability, rising temperatures, and disasters such as floods and drought. Inter-annual analyses of national data for Somalia show that mean air temperatures remain high throughout the year. Precipitation is generally scarce, typical of a desert or semi-desert climate in vast areas, while the wettest areas are occupied by savannah. The driest areas are the northern coast, where annual rainfall drops to around 50 mm per year, and the northeast, which remains under 200 mm. Rainfall in Somalia is generally influenced by the Inter-Tropical Convergence Zone (ITCZ). This north-south movement results in two rainy seasons (Gu and Deyr) and two dry seasons in a year. The main feature of rainfall patterns in Somalia has shifted into an extreme variability within and between years, and spatial variation over very short distances[4]

There has been increased climatic variability during the past three decades leading to frequent droughts and intermittent floods devastating already vulnerable populations. Among the worst climate-related shocks experienced included the 1992 Somalia famine that killed more than 300,00 people, the 2011 drought that killed thousands and displaced millions of people and the 2016 droughts that killed hundreds and displaced thousands, thus increasing the number of internally displaced persons in the country. In 2020/2021, Somalia witnessed erratic floods, droughts, and desert locusts coupled with insecurity and the COVID-19 pandemic, thus affecting Somalia's economy, populations,

[3] UNEP (2005), The State of the Environment Somalia, 2005
[4] Ogallo, L. A., Omondi, P., Ouma, G., & Wayumba, G. (2018). Climate change projections and the associated potential impacts for Somalia.

and livelihoods. Erratic floods are frequently received after heavy rainfall seasons, especially along the rivers Shabelle and Juba, leading to loss of lives, livelihoods, and destruction of infrastructure. The increased climate change-related shocks undermine efforts towards addressing household food security and poverty reduction.

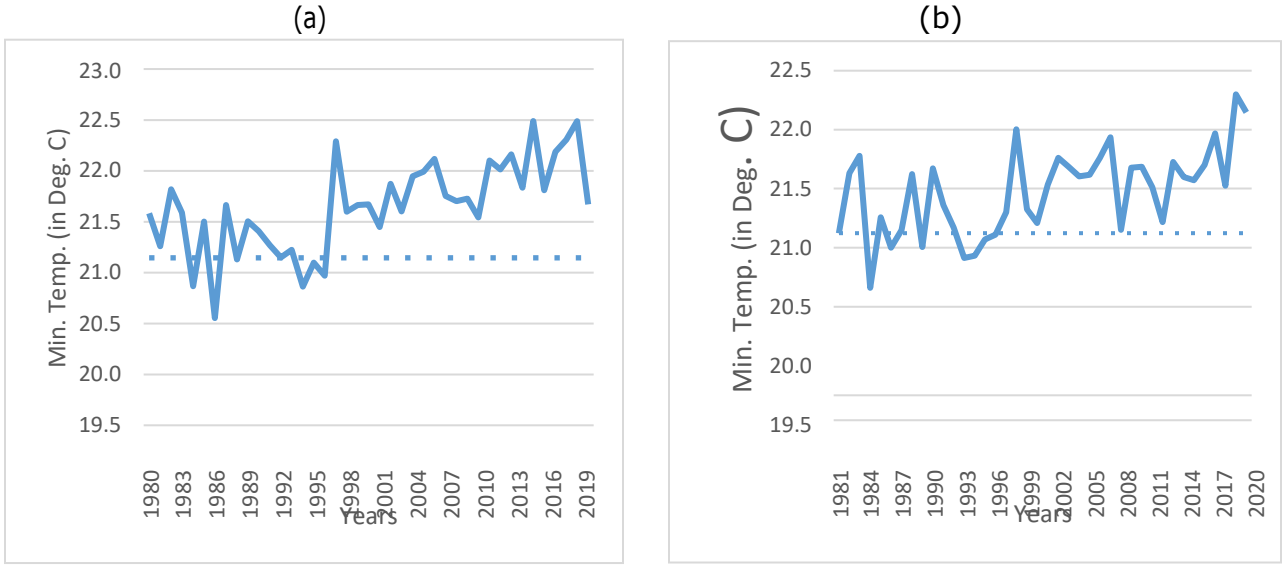

Figure 1. 1: Monthly minimum temperature for (a) the months of Sep- Nov.(1980-2020) and (b) annual average minimum temperature (in ^{O}C)

Temperatures over Somalia are expected to increase at a rate of 0.3- 0.5° C per decade until 2050. And by the end of the century, the mean temperature is projected to increase between 3°C and 4°C. These changes will have dire consequences for the agricultural and pastoral sectors that are the main livelihood base for the majority of the population,with further implications for associated sectors such as water, sanitation, energy, andhealth services and compromise the region's development trajectory. The projected temperature variations in the middle and later stage of the century is likely to present dire consequences for the fragile agriculture, livestock, and water sectors leading to disruptions and shortage of food. There is a need for climate change adaptation initiatives such as water harvesting, climate-smart agriculture, and livelihood diversifications to cushion local communities against projected climate-related shocks especially extended drought periods. (Ajuang Ogallo et al., 2018).

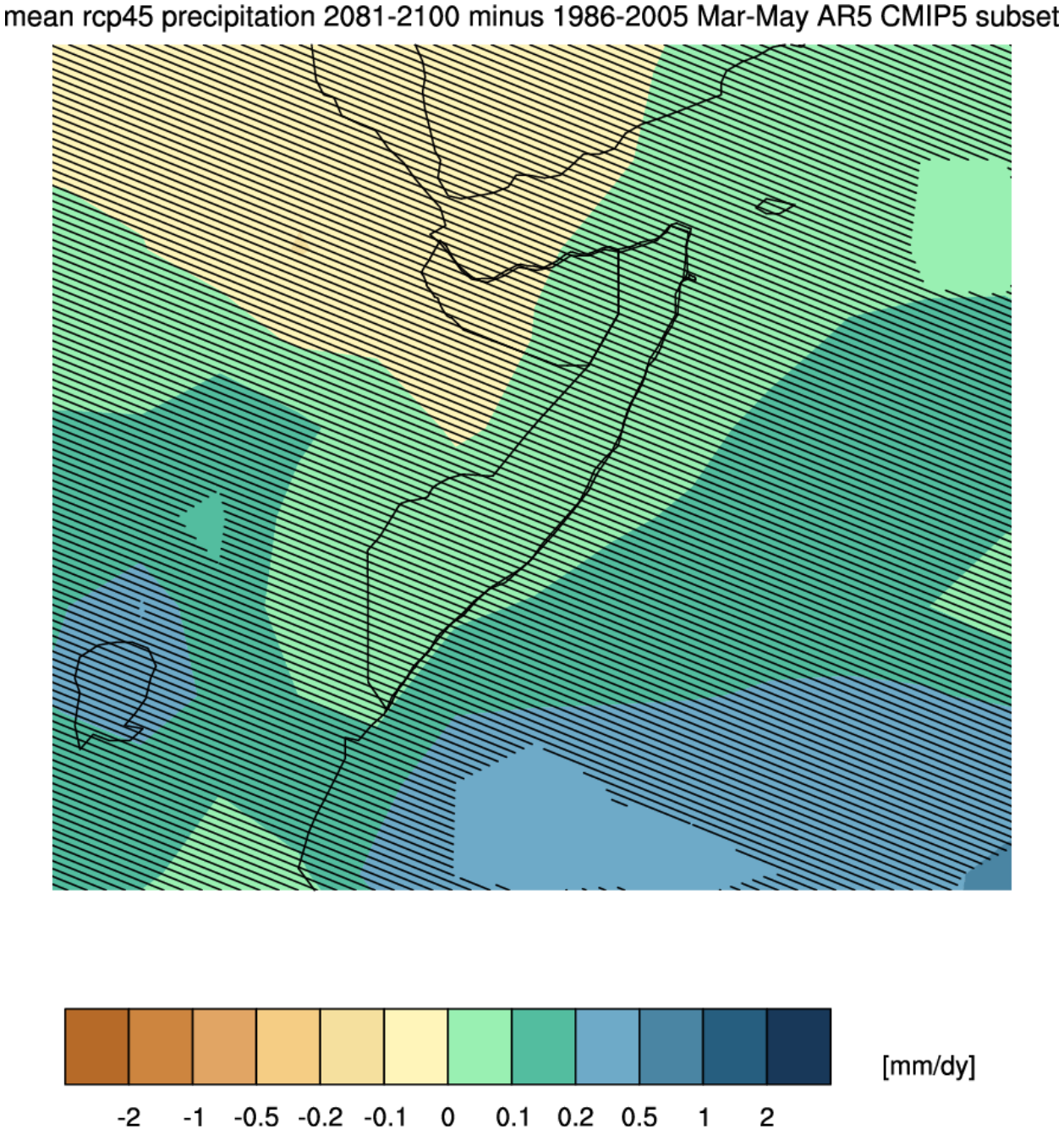

Figure 1. 2: Projected precipitation change (1986-2100)

In addition, projections indicate increased precipitation variability in terms of intensity, frequency and distribution across Somalia. The mean annual rainfall will rise by 1% by 2100 and 4% by the end of the century. Southern Somalia and Central regions are expected to experience higher precipitation by the end of the century, with implications for livestock and agricultural production, the mainstay of most populations. (Figure 1.2).

1.2.1.4 Economy

Somalia's economy remains weak due to the protracted conflict in the last three decades, coupled with the impact of climate change on the critical sectors of the economy. The country remains heavily dependent on agriculture, with a share of around 80% of GDP[5]. Livestock accounts for 60% of GDP and 85% of exports from 2013-2019. Overdependence on agriculture has made the economy highly vulnerable to natural and external shocks, including droughts and fluctuations in demand for livestock exports. Thus, agricultural transformation is key for resilience building and higher growth, which requires large investments in irrigation infrastructure and improved livestock production methods. The industrial sector's contribution to GDP has fallen since the start of the conflict in 1991, currently ranging between 3% and 7% from about 10% in 1990. This trend is attributed to insecurity, poor business climate, and lack of investment. Besides the existing challenges, Somalia's economy continued to show signs of growth in the last decade due to increased stability and favourable investment environment. However, the confluence of the fragile political system, poverty, instability, and climate change coupled with the impact of the COVID-19 pandemic, continues to undermine the slow progress made in the last decade.

1.2.1.5 Ecosystems (Agro–Ecological Zones)

Somalia comprises 12 agroecological zones as influenced by soils, land suitability, and climate. These have given rise to a variety of ecological systems (Figure 3). These are characterized by various climatic regimes namely; desert, arid, dry semi-arid, moist semi-arid, and in other areas varying regimes[6].These ecological zones have given rise to a variety of habitats and ecological systems making. Biological diversity is the basis of development including the regulation of climate and hence there is a mutual beneficial relationship between economic well-being, conservation of biodiversity, and adaptation to climate change

[5] Africa Development Bank, Africa Economic Outlook 2021
[6] Food Agriculture Organization SWALIM, 2009

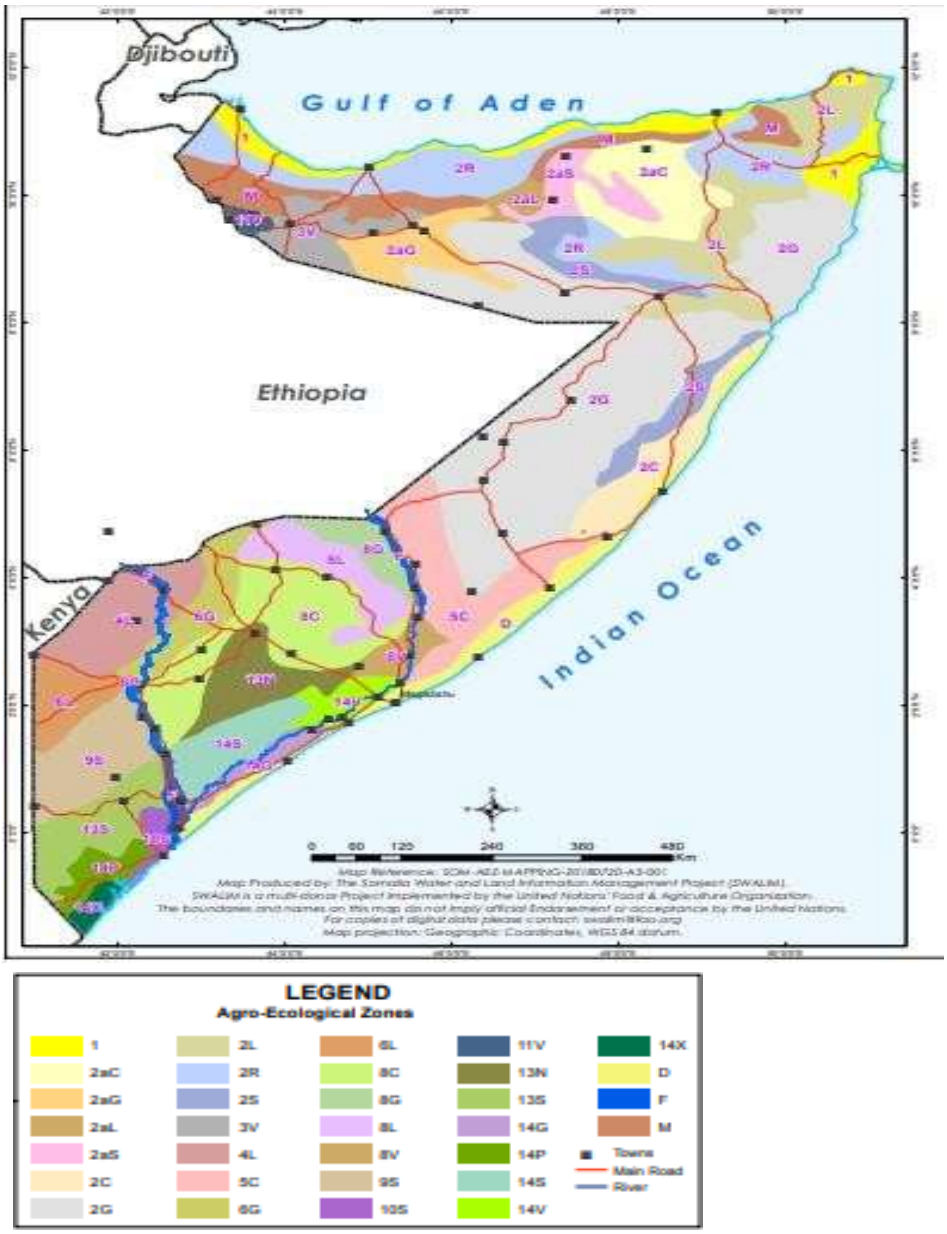

Figure 1.3: Source: FAO, 2020 -The Somalia Water and Land Information Management Project (SWALIM).

Somalia's environment has been degraded in the last three decades due to the absence of governance systems and increased poverty levels pushing more people to depend on the natural environment for survival. The Somalia National Environment Policy 2019 recognises the extreme environmental degradation caused by human activities coupled with climate change impacts leading to massive losses in biodiversity, water resources, land, minerals, and marine resources, among others.

1.3 Existing Policies about Climate Change Adaptation and Development Priorities

Somalia has made significant progress in developing climate change, agriculture, waterand environment (including marine and biodiversity resources) related policies and legislative frameworks aimed at sustainable management and governance of Somalia's natural and environmental resources. Key relevant policies, actions, strategies and plansare discussed in detail below.

Table 1.1. Somalia's existing policies and legislative Frameworks

Policy/Instrument
(a) The Somalia Constitution 2012 Article 25 (FSG, 2012) *stipulates that.* • Every person has the right to an environment that is not harmful to their health and well-being, and to be protected from pollution and harmful materials. • Every person has the right to have a share of the natural resources of the country, whilst being protected from excessive and damaging exploitation of these natural resources. *The Federal Government of Somalia has shown slow progress in the implementation of its constitution in relation to environmental protection and rights to natural resources. Illegal fishing in Somalia's waters and illegal export of charcoal remains a challenge.
(b) *The National Adaptation Programme of Actions-NAPA (2013)* Identified urgent and immediate climate change adaptation needs of the most vulnerable groups through Somalia. It provided the premier and pivotal climate change adaptation point for mainstreaming into development plans. It recommends: • 1) Build community awareness on climate change • (2) Increase monitoring and risk forecasting capacities and • (3) Support the adoption of government policies and strategies to improve resilience to climate risks among vulnerable population groups (including women and children) and economic sectors. *NAPA was the first climate change related action plan for Somalia setting the stage for the Initial National Communication, Climate change policy, Updated NDC and NAP Framework. Implementation of NAPA priorities remains a challenge due to limited funding, capacity gaps and fragile governance systems in Somalia. Importantly, the Government considered adaptation to climate change as critical to national development at both Federal and State level.
(c) The National Environment Policy (2019) articulates the government blueprint to adopt mitigation and adaptation approaches to deal with climate change, among other issues. • It Recommends climate change and disaster management as emerging environmental issues. • Specific climate change interventions are articulated a regards biodiversity, waste management, clean technology, and GHGs emission reductions. *The Federal Government of Somalia is implementing the policy albeit challenges of vertical and horizontal coordination between Federal and State governments.

(d) The Ninth National Development Plan (2020-2024) recognises the threats posed by climate change in meetings its development objectives (FGS, 2019). It:

- Recognizes Climate Change resilience building as a key theme of the NDP-9 and the plan
- Prioritises most strategic interventions with multiple benefits including economic benefits alongside environmental sustainability, conflict reduction, strengthened governance and reduced exclusion.

* NDP 9 remains the main national development blueprint that guides Somalia's development agenda. Slight progress have been made in different sectors including climate change, agriculture, water, security, among others with the establishment of institutions, policies and capacity development.

(e) National Climate Change Policy, 2020 provides a strategic direction, as regards climate change adaptation and mitigation. Further, it

- Facilitates coordination of climate change work at national and sub-national levels of government as well as with development partners, international and regional institutions.
- Stipulates the country's vision and strategies that recognize the importance of climate change, international agreements, and national commitments on climate change.

* The Government recognized the importance of mainstreaming climate change into development plans and budgeting. The Ministry of Planning coordinates hand in hand with the Directorate of Environment and Climate change (DECC) to ensure effective mainstreaming into all development plans.

(f) *The Initial National Communication to UNFCCC 2018* was submitted to UNFCCC in 2018. The report

- Highlights the country's situational context with respect to climate change and steps towards the implementation of the UNFCCC, proposed mitigation and adaptation strategies.
- Promotes comprehensive nationwide response to climate change actions including; adaptation, mitigation and creating resilient communities.
- Indicates overall gaps and constraints including capacity, financial and technological challenges faced by the country in its efforts to respond to climate change.

* The Government showed commitment to addressing climate change and meeting its global obligations in line with UNFCCC by submitting the INC for Somalia. The Federal Government solicited for financial, technological and capacity support informed by the Initial National Communication report recommendations.

(g) *Updated NDC 2021*. The report

- . Considers climate change adaptation as critical for Somalia
- The specific priority actions identified included Agriculture and Food security, Disaster Preparedness and Management, Water resources management and public health, Coastal, marine environment and fisheries, Forestry and Environment, energy, Infrastructure including roads, bridges and Infrastructure including roads, bridges.
- Somalia's NDC estimates the cost of implementing the adaptation components of the NDC target at USD 55.5 Billion for the 10 years.

*The Federal Government of Somalia development agenda between 2021-2030 is guided by the Updated NDC 2021 which identified priority adaptation and mitigation actions. The government is committed to ensure all funding/investments in mitigation and adaptation are informed by the prioritised sectors so that it is in harmony with national development agenda.

(h) *National Adaptation Plan (NAP) Framework.* Prioritizes

- Reducing vulnerability to climate change, and to mainstream climate change adaptation in all levels of planning.
- Defining medium and long-term climate adaptation action and initiatives for implementation by state and non-state actors
- Enhance coordination and promote climate finance mobilization

*The Government considers adaptation to climate change as a major priority in comparison with mitigation. This is due to the vulnerability of major critical sectors such as agriculture, water, energy, health among others to climate change. Significant funding including donor funds are allocated to adaptation related sectors to enhance resilience.

(i) *Integrated Water Resources Management Strategic Plan (IWRM) (2019-2023*) supports co-ordinate integrated water management including in response to climate change, guide the creation of appropriate rates and standardize best practices. It sets strategic issues regarding:

- Establishing water governance framework
- Operationalizing IWRM
- Improving the provision of priority water services

*Efforts are being made to ensure sustainable management of water resources for example, enhanced protection and conservation of river Juba and Shabelle, capacity building for water sector personnel and enhancing water harvesting during rainy seasons so that it is utilized in periods of water shortages

CHAPTER 2: INSTITUTIONAL ARRANGEMENT FOR THE TNA AND THE STAKEHOLDER INVOLVEMENT

Other than the policies mentioned above, actions, strategies and plans relevant to climate change adaptation in Somalia, there exist critical institutions responsible for the different sectors, including climate change, water, agriculture, marine and biodiversity, among others. The Ministry of Environment and Climate Change (MOECC) is the main Federal level institution responsible for climate change and environmental issues in Somalia. The DECC, under the Office of the Prime Minister, Federal Government of Somalia, also serves as UNFCCC's National Focal point and the National Designated Authority (NDA) for Green Climate Fund. The Federal Ministry of Agriculture and Irrigation is responsible for the overall management of agriculture development and resources for sustainable food security, poverty reduction and improved livelihood in Somalia. The Federal Ministry of Livestock and forestry is mandated with the overall responsibility of livestock sector development in Somalia. At the same time, the Federal Ministry of Fisheries and Marine Resources is responsible for the overall sustainable management of Somalia's marine and fish resources.
The Federal Ministry of Planning, Investment and Economic Development, the Federal Ministry of Finance, the private sector, civil society organisations, academic institutions and development partners also play a critical role in Somalia's climate change and natural resources management.

2.1 National TNA team

The Technology Needs Assessment process for the Federal Government of Somalia is a national process involving various Federal ministries, civil society organisations, academia and the private sector.

2.1.2 National Project Steering Committee (NPSC)

The National Project Steering Committee (NPSC) comprises members responsible for policy-making from all the relevant Federal ministries, as well as key stakeholders from the private sector. The National Climate Change Committee (NCCC) was utilised to implement the TNA process- The NCCC is a multi-stakeholder, high-level policy coordination committee. It is responsible for the overall coordination and supervision of climate change activities in Somalia. It comprises the Prime Minister (or his designate), Director General of the Directorate of Environment & Climate Change, Sectoral Ministries, Directors of Governmental Agencies, Member States' Ministers for Environment, civil society organisations, and the private sector.

2.1.3 The National TNA Coordinator

The TNA Coordinator is the focal point for overall TNA process management in Somalia and directly engages the Country Coordinators at UDP and Enda Energie, the regional centre. He coordinates with the Ministry of Environment and Climate Change (MOECC), under the office of the Prime Minister, which is the officially mandated institution responsible for the formulation of federal-level climate policies and also served as UNFCCC National Focal point and the National Designated Authority (NDA) for Green

Climate Fund. Importantly, the TNA Coordinator provides overall supervision and support for the TNA adaptation and mitigation consultants throughout the project.

2.1.4 The TNA (Adaptation) Consultant

The TNA Adaptation consultant was hired through a national process involving the UNEP DTU team, the TNA Coordinator and the Ministry of Environment and Climate Change. The Consultants underwent training sessions with other participants from participating countries on the TNA process.

2.1.5 Key Stakeholders

The Adaptation consultant, in consultation with the Ministry of Environment and Climate Change, undertook the identification of stakeholders relevant to the TNA process. Stakeholders from agriculture, livestock, water, marine, biodiversity, and environment from government, civil society, and the private sector were involved in the process. For this study, stakeholders are institutions that are in one way or another involved or have an interest in climate change technology development, promotion, transfer, or application, as well as individuals who have taken a keen interest in climate change-related activities.

2.2 Stakeholder Engagement Process followed in TNA – Overall Assessment

The stakeholder engagement process followed during the TNA processes is as follows:

a) Through workshops and working sessions

These included the inception workshop where consultants engaged the key facilitators/stakeholders (DECC, TNA Coordinator, National Consultant) on the overall TNA process and way forward.

b) Through one-to-one engagement

The consultants, through the guidance of the Ministry of Environment and Climate Change, continually engaged different adaptation-relevant stakeholders to obtain the necessary information and build consensus on the process.

c) Involvement of sectors working group

The sectors working group included stakeholders from the two sectors (water and agriculture) and other relevant institutions critical to overall decision-making in climate change adaptation in Somalia, for example, the Directorate of Environment and Climate Change (DECC), Ministry of Livestock, Ministry of Women and Human Rights Development, private sector and CSO organisation. The sector's working group were consulted and involved at all stages for technical input during sector prioritisation, technology identification, process and quality control of outputs. The contribution of the sector working groups is presented in subsequent chapters.

2.3 Consideration of Gender Aspects in the TNA process

Gender was considered throughout the stakeholder's engagement process. The Ministry of Women and Human Rights Development (MoWHRD) was engaged in providing updated gender literature for the study and ranking the technologies considering the ministry's priorities. The Ministry play an important role as an entry point for gender-sensitive climate change adaptation planning and implementation of the priority technologies.

2.4 Sectors Prioritization

Climate change has an adverse negative impact on almost all critical sectors in Somalia, including agriculture, health, water, transport, energy, and the environment. However, the agriculture and water sectors have been considered more crucial due to their importance to day-to-day life and overall development agenda in Somalia in line with National Adaptation Plan, Updated NDC, and NDP 9. The contribution of the two sectorsis discussed below.

2.4.1 Agriculture

The agricultural sector (including livestock production) has historically been and continues to be, the backbone of the Somali economy. It employs nearly 80% of the population both directly and indirectly. Agriculture accounts for around 75% of GDP and 93% of total exports, owing largely to strong animal exports in the pre-drought years. Following the absolute collapse of banana exports, sesame is currently the most important crop export, followed by dried lemon. Coastal fishing in Somalia has remained small-scale and artisanal, despite the country's abundant fish reserves, while foreign commercial vessels have enjoyed both legal and illicit harvesting offshore.

Somalia does not maintain national food reserves, nor does it have an import policy to regulate food prices, which leaves the 69% of the population living below the poverty line exposed to food security risks when hit by the volatility of global food prices. Somalia's foreign trade was and still is mostly in agricultural products.

Due to the employment of outmoded technologies such as improper crop spacing, furrow planting, and crop rotation, the agriculture sector continues to be characterised by low production. Low productivity is also ascribed to a lack of access to finance, an overreliance on rain-fed agriculture despite periodic droughts, deteriorated irrigation infrastructure, weak or non-existent transportation infrastructure, and disputed property rights. Insecurity is also a serious issue, particularly in the southern portions of the country, where crop production is the main source of income.

In Somalia's agriculture sector, gender relations are crucial. Crop production is dominated by women, especially in small-scale and subsistence farming. Women are typically farm supervisors and contribute heavy labour for land preparation, weeding,

and harvesting with the support of children, depending on the area and custom. Still, they have no control over food resources and profits. In addition, women on large-scale farms are paid less than men on the national wage scale. On the plus side, the Food and Nutrition Policy proposes gender balance in all agriculture-related plans, projects, and enterprise activities, ensuring that vulnerable women have equal access to economic resources for increased food security.

2.4.2 Water

Somalia is considered a water-scarce country. The Shabelle and Juba rivers remain the two major surface water resources. Groundwater sources include boreholes, shallow wells, and springs accounting for most domestic water supply for small-scale irrigation and livestock production. Arid and semi-arid areas cover almost 80% of their geography, characterised by irregular rainfall and extended drought periods. Throughout the protracted era of Somalia's wars, the water sector has experienced great challenges, destroying infrastructure and existing water governance mechanisms. The main sources of livelihood, livestock and agricultural output, are still reliant on the sector, resulting in lower total productivity.

Climate change has further exacerbated the situation, with Somalia's water potential standing at less than 500 m3/per capita/year, below the 1000 m3 global water scarcity threshold. Increased drought frequencies led to a decline in groundwater resources, such as the drying up of shallow wells leading to water shortages and resultant increased water costs and conflicts among pastoralists over remaining water points. On the other hand, climate change-related floods destroy water infrastructure, increase runoff threatens the safety of underground water resources, and present storage challenges. Access to piped water and basic water supply at the National level is estimated at 19% and 40%, respectively, indicating the challenge of water accessibility in Somalia. The overall water shortage affects critical sectors, including agriculture, health, energy, transport, gender, and security, thus indicating the importance of water resources to Somalia's development agenda. Women and young girls are mostly tasked with trekking long distances in search of water, especially in rural areas, thus increasing the burden on women and undermining efforts towards gender parity in Somalia.

CHAPTER 3: TECHNOLOGY PRIORITIZATION FOR AGRICULTURE

Somalia's Updated NDC 2021 identified several priority areas in climate change adaptation for Somalia. These are informed by its 2020 Adaptation Baseline Assessment and based on Somalia's national and sub-national adaptation plans and policies, including The National Development Plan 2017-2019 and the subsequent NDP-9 (2020-2024), NAPA 2013, Initial National Communication 2018, National climate change policy that provides a climate change adaptation strategy and a climate change risk mitigation plan.

Somalia's priority climate change adaptation sectors include Agriculture and Food Security, Water resources management and public health, disaster preparedness and management, Coastal, marine environment and fisheries, Energy, Forestry and Environment, Human settlements, and Infrastructure, including roads and bridges. ***The agriculture*** and food security, ***water resources management***, public health, Coastal marine environment and fisheries sectors account for the highest number of adaptation interventions for the Federal Government of Somalia.

3.1 Key climate vulnerability in the Agriculture Sector

Agriculture, including livestock production, has been the backbone of the Somali economy, employing more than 80% of the population[7]. In the early 1980s, Somalia improved its agricultural potential significantly. Most of the population had food security until the collapse of the state, and the resulting loss of infrastructure and institutions resulted in a sharp reduction in agricultural output. In the last three decades, the sector faced many challenges, including instability and the resultant collapse of agricultural sector governance systems, destruction of infrastructure (such as water systems, roads, industries, and markets, among others), and massive environmental degradation coupled with climate change impact. The latter has led to increased mean and maximum temperatures and shifting of rainfall patterns resulting in droughts, floods, and storms[8]

Somalia has seen three prolonged droughts and two famines in the last quarter-century. In 1992, hunger killed approximately 300,000 people and forced 4 out of 5 individuals to flee their homes. It was believed that between one-quarter and one-third of all children had died by early 1992[9]. Over a quarter of a million people died in Somalia during the 2011 East Africa Drought, half of them children under the age of five. Due to the drought, 955,000 Somalis were forced to migrate to neighbouring countries of Kenya and Ethiopia, leading to a humanitarian crisis. In the last few years, the prevalent drought has

[7] Wilson, T. (2016). Economic recovery in Somalia. Bildhaan: An International Journal of Somali Studies, 15(1), 9.
[8] Thulstrup, A. W., Habimana, D., Joshi, I., & Oduori, S. M. (2020). Uncovering the challenges of domestic energy access in the context of weather and climate extremes in Somalia. Weather and Climate Extremes, 27, 100185.
[9] Briggs, E. D., & Soderlund, W. C. (2008). Somalia, 1992: UNOSOM I, UNITAF,"Operation Restore Hope," UNOSOM II. Humanitarian Crises and Intervention, Reassessing the Impact of Mass Media.

increased, with droughts occurring in 2016/2017 and extending to 2018, leading to the loss of crops and livestock displacement of 920,000 people. In 2020, Somalia witnessed droughts coupled with a swarm of desert locusts and the COVID-19 pandemic, thus undermining overall food security targets in the country. From 1980 to 2017, there were ten (10) big weather-related occurrences (in 1982–83, 1988, 1991–92, 1994–95, 1997–98, 2002–03, 2006–07, 2009–11, and 2015–17).

In addition, floods hit the country in 2018 and 2019. The flash floods and intense torrential rains impacted 570,000 people, killed more than 20 people, displaced 40% of Somalia's population, wrecked roads and other infrastructure, drove animals away, and ruined 207,000 hectares of land around the Juba and Shabelle rivers. In addition, the Deyr seasonal floods (October–December) displaced over 278,000 people across Somalia, resulting in deaths, livestock losses, and infrastructure destruction[10] The ability of vulnerable households to recover from shocks such as high temperatures, unpredictable precipitation, desert locusts, protracted crises, and COVID-19 has been weakened as a result of repeated bad events.

Because of topsoil depletion, even in the greatest agricultural seasons, domestic production only meets roughly 40–50% of per capita cereal needs. Severe droughts resulting in water scarcity, significant flash flooding, current and emerging pests and illnesses, and the collapse of most irrigation and flood-control infrastructure all contribute to poor performance. In the absence of humanitarian aid, about 3.5 million Somalis (27 per cent of the population) are likely to endure food insecurity or the depletion of livelihood assets that are suggestive of Crisis (IPC Phase 3) or worse outcomes by the end of 2021. (Figure 3.1).

[10] The United Nations Office for the Coordination of Humanitarian Affairs, 2020

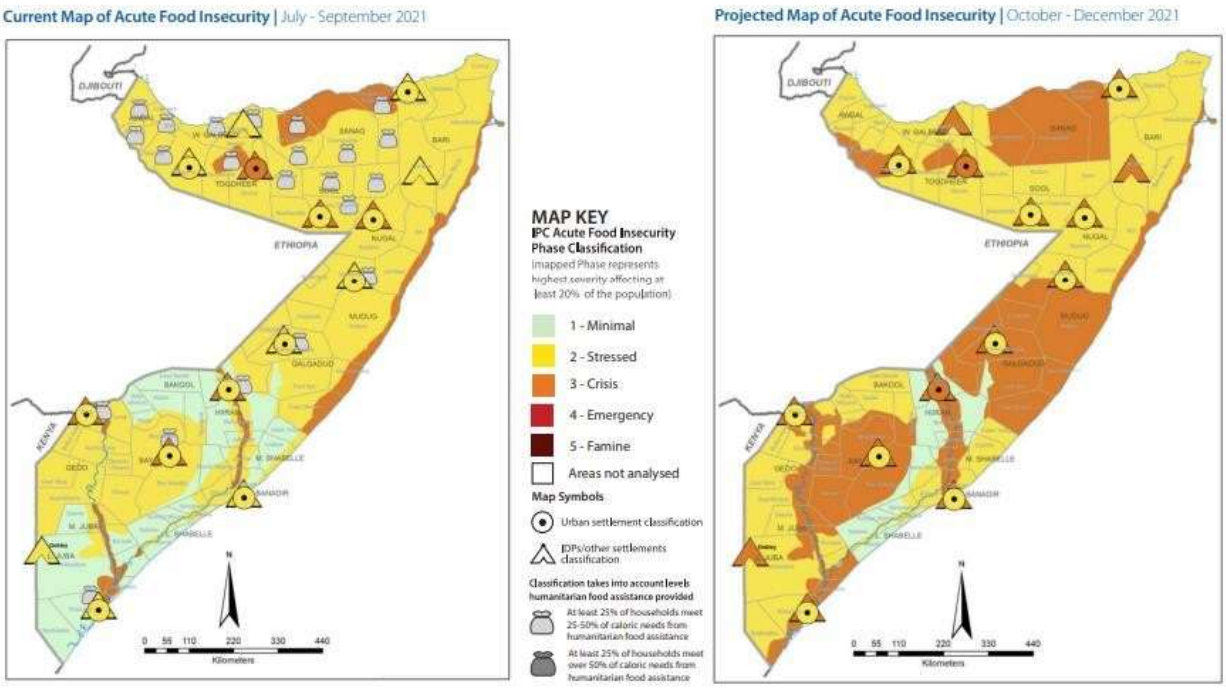

Figure 3.1. Somalia's Food security situation in 2021

According to climate estimates, the temperature in Somalia will rise from 0.4°C to 3.2°C by 2050[11]. In the years leading to 2050 and 2080, IPCC Fifth Assessment Report forecasts show a large rise in high rainfall extremes. The projected rainfall and temperature change scenarios for 2030, 2050, and 2070 show that climate extremes will continue to threaten Somalia's future development and main livelihoods (livestock) unless effective climate-smart adaptation systems become integral components of national development strategies[12] Previous corrective initiatives were primarily emergency-based and not long-term. Somalia must establish a legal framework to adopt a sharia-compliant market-oriented risk management tool to preserve livestock assets and other climate-resilient technologies, innovations, and practices.

3.2 Decision Context

The agriculture sector accounts for 60% of Somalia's GDP, with livestock accounting for 40% of the total. With a value of 6.58 billion dollars in 2013, milk is Somalia's most economically important animal commodity, accounting for 81 per cent of the livestock contribution to the economy. The sector accounts for more than 90% of the overall exports and employs more than 80% of the workforce (ICPALD, 2016). The livestock sub-sector accounts for over 85% of export revenues, while agriculture employs roughly 49%

[11] IPCC. (2014) Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, 1173.
[12] Federal Government of Somalia, Adaptation Baseline Report 2020

of the population. Due to the employment of obsolete farming methods, poor access to finance, overdependence on rain-fed agriculture amid periodic droughts, insufficient infrastructure, and disputed property rights, the agriculture industry is still characterised by low productivity. Insecurity is still a big issue, particularly in the south of the country, where grain production is the main source of income (AfDB, 2021)

Only 22% of Somalia's per capita food demands are met by indigenous food production. It is categorised as phase 3 by the Integrated Food Security Phase Classification (IPC), making it a country with severe food insecurity (IPC, 2021). For example, the IPC study for December 2021 shows that the crisis continues to worsen, with 27 per cent of the population experiencing severe acute food insecurity. In January 20201, the overall rate of food insecurity was 22 per cent, with the areas to the north being the hardest hit. The repercussions of climate change, such as poor and extremely unpredictable rainfall distribution and flooding, are substantially to blame for the current food insecurity situation.

To reduce the overall impacts of climate change on Somalia's agricultural sector, there is a need for significant investments in agriculture infrastructure, which was heavily impacted by the instability; the upscaling of community-based adaptation initiatives in agriculture; capacity enhancement in the agriculture, livestock and fisheries and aquaculture agencies; and advancing research and development in crops and livestock production in Somalia which has enormous potential.

Somalia's Updated NDC 2021 identified several adaptation priorities in the agricultural (food security and livelihood) sector. Therefore, technology options for the agriculture sector focus on prioritising these technologies already identified in the Updated NDC 2021 as informed by national priority and Somalia's climate action agenda in line with UNFCCC and Paris Agreement.

3.3 Overview of Existing climate-related Technologies in the Agriculture Sector

Local communities involved in farming and livestock production in Somalia have developed several adaptation mechanisms to cushion themselves against climate change. Circular migration has remained a long-time traditional approach to climate variability, especially among most pastoral communities in Somalia. Some key Climate Smart Agriculture practices among rural populations in Somalia include tree planting to conserve soil and water resources, raising mixed herds and cultivating drought-resistant crops. To deal with climate change-related weather variability, some farmers have adopted the habit of listening to local radios for weather forecasts to time their planting seasons.[13] Provision of seedlings by Federal /State Governments to farmers, and communities, are encouraged to build and maintain food storage facilities. Increase local food production and prioritise it over exports by providing incentives to farmers through small grants, agricultural inputs, strong institutional support, and increased extension services. Creating an agricultural finance system for farmers, agricultural cooperatives, and agricultural groups Drought-resistant plants and agroforestry, as well as diversified food sources appropriate to the natural ecology, are being introduced.

[13] FAO Climate-smart agriculture Projects from around the world case studies 2021

Using Integrated Pest Management, farmers can protect their crops while lowering their risk. Increased support from Government and development partners focusing on Reforestation and sustainable land management strategies to help reduce soil erosion. Diversion of water from streams to fields for irrigation, drilling of boreholes to supply irrigation water, and community-level support for water harvesting utilised for agricultural production.

Other critical interventions include establishing policies and regulations for rotational grazing and preventing deforestation and charcoal burning Government support for livestock keepers providing veterinary services, encourage cultivation of drought resistant fodder that can be utilized during extended drought periods, providing training to market animal products such as processed milk, yoghurt and cheese, hides among others.

3.4 Adaptation Technology Options for Agriculture Sector

In the assessment of technology options for the Agriculture sector in Somalia, the Updated NDC 2021 report was the foundation of technologies considered. The report was informed by Adaptation Baseline Assessment 2020 and Somalia's National and Sub-national adaptation plans and policies, including NDP-9 (2020-2024), NAPA 2013, Initial National Communication 2018, National climate change policy which provided a climate change adaptation strategy and a climate change risk mitigation plan for Somalia. The priority adaptation technologies identified in the Updated NDC report 2021guided the different technologies identified while additional and/or substitute technologies were included in consultation with sectors working group. The technologies were further reduced to seven (7) as prioritized by the sectors working group. The TNA Factsheets for selected shortlisted technologies are given in Appendix I.

Table 3.1. Long List of Priority Adaptation Technologies for the Agriculture Sector

Adaptation sector	Implementation Timeline 2022-2030
Agriculture/Livelihood Priority technologies 1. Sustainable crop management 2. Seed and grain storage 3. Drip irrigation 4. Agro-economic zones 5. Building marketing facilities and infrastructure for crops and livestock urban centres 6. Sustainable production systems 7. Promote weather-based insurance scheme for farmers and pastoralists 8. Livestock disease management 9. Establishment of disease-free zones to enhance quality for export of livestock products 10. Build adaptation capacity in climate-resilient agronomic practices for smallholder farmers 11. Improve animal productivity and animal breeds to increase resilience to climate change 12. Manage the grazing areas, and rangelands in a sustainable manner and enhancing the development of livestock infrastructures and services including feed storage 13. Improve access to agro-weather information services/Early Warning system 14. Conservation tillage	

Table 3.2. Short List of Priority Adaptation Technologies

Agricultural Sector Adaptation Technologies		Description
1	*Drip irrigation systems*	Drip irrigation is a method of water irrigation inwhich water passes through a filter and into customized drip pipes with spaced emitters. Aparticular slow-release system distributes waterstraight into the soil near the roots through theemitters. Advantages of drip irrigation includes high water application efficiency and lower labour costs, minimised fertiliser/nutrient loss dueto localised application and reduced leaching,Allows safe use of recycled (waste-) water and allows operation at lower pressure than other types of pressurised irrigation, reducing energycosts
2	*Agro-economic Zones*	Agro-ecological Zones are land resource mapping units that are characterized by climate, landform and soils, and/or land cover, and have a predefined range of land usepotentials and limits (FAO 1996).
3	*Sustainable production systems*	Sustainable production systems refer to the capacity of the system to maintain its productivity in spite of economic and natural,external or internal limitations.
4	*Conservation tillage*	conservation tillage (CT) is a practice wherebyseed availability from the previous crop and soilis less disturbed when the new crop is established. The main advantage of CT includessignificantly less soil erosion due to wind andwater and reduced fuel and labourrequirements.
5	*Livestock disease management*	This strategy prevents disease from entering and spreading among livestock populations by enforcing rigorous controls governing cattle movement and housing as part of a disease prevention. The strategy also allows quarantineswhen animals are added to the herd.
6	*Seed and grain storage*	Seed storage is preservation of seed with initial quality until it is needed for planting. Grain storage is a location or physical structure that isregularly used to store grain for producers orgrain that is purchased from producers for resale.
7	*Early warning systems*	This is a method of conveying meteorological information on seasonal rainfall patterns and climate change and variability. This enables farmer and other stakeholders get information on seasonal rainfall characteristics and patternsin order to adapt to climate variability[14]

3.5 Criteria and process of Technology prioritisation

The process and criteria were conducted in a participatory and all-inclusive way. It was also based on the sector's contribution to national development and its relationship to climate change adaptation. The following steps were undertaken:

a) Detailed literature review and use of expert knowledge: A detailed literature review of the national development plans and programs and strategies; past and current documents and activities concerning climate change and adaptation; sectoral reports, plans and strategies and IPCC documents and other climate change-related activities.

b) Involvement of stakeholders through meetings, workshops, and one-to-one engagement.

The following were identified as key technologies for Climate Change adaptation in the agriculture sector: -

- ☐ Seed and grain storage (TA1)
- ☐ Drip irrigation systems (TA2)
- ☐ Agro-economic zones (TA3)
- ☐ Sustainable production systems (TA4)
- ☐ Conservation Tillage (TA5)
- ☐ Livestock Disease Management (TA6)
- ☐ Early warning systems (TA7)

Fact sheets were then prepared for the seven technologies, using information from relevant literature and consultation with stakeholders. Fact sheets for the selected technologies are presented in Annex 1.0.

[14] Gure, A. (2021). The Role of Climate information and Early Warning Systems in Supporting Disaster Risk Reduction in Somalia (p. 50) [Technical Report No WC-007].

3.6 Results of Technology Prioritization

The seven identified Climate Change Adaptation Technologies were then prioritised using Multi-Criteria Analysis Method. Multi-Criteria Analysis (MCA) is designed to give decision-makers a practical, evidence-based approach to setting priorities and choosing between choices.

The process is interactive and uses an EXCEL sheet to aid the process and provide feedback to participants on the effects of changes as they explore decision options. The criteria used were: cost of technology, contribution to economic development, social and environmental benefits and climate resilience contribution. During MCA multi-criteria analysis, scores and weighting and standardisation concepts were applied for technology prioritisation.

The following technologies were subjected to MCA for prioritisation.

Provision of seeds and seedlings community

- Seed and grain storage
- Drip irrigation systems
- Agro-economic zones
- Sustainable production systems
- Conservation Tillage
- Livestock Disease Management
- Early warning systems

The multi-criteria analysis, Weight Effects, sensitivity analysis and the Ranking of the Technologies are given in Tables 3.3, 3.4, 3.5, 3.6, 3.7, and 3.8 below:

Agriculture sector: Scoring matrix

Table 3.3. Agriculture Sector: Multi-Criteria Analysis Scores

	Costs	Economic		Social	Environmental	Climate related	Other: Institutional/Implementation		Other: Political
	*V1	V2	V3	V4	V5	V6	V7	V8	V9
TA1	75	50	25	50	60	62	70	80	100
TA2	40	100	80	100	60	100	85	100	100
TA3	50	75	80	80	20	70	70	70	80
TA4	70	60	55	60	20	45	80	70	80
TA5	45	80	65	70	60	80	75	85	100
TA6	90	50	55	75	10	55	85	75	80
TA7	60	90	70	75	55	80	80	90	100
Scoring scale	S1	S2	S3	S4	S5	S6	S7	S 8	S 9
Criterion weight	11	9	8	17	16	20	8	5	6

*v1 is the Cost to set up and operate the technology per beneficiary /year;
v2 is Improving farmer income and ability to reinvest;
v3 is Trigger private investment;
v4 is Poverty reduction potential;
v5 is the Contribution of the technology to protect and sustain ecosystem services;
v6 is Improvement of Resilience to Climate Change (i.e. to what extent the technology will contribute to reduce vulnerability to climate change impacts);
v7 is the ease of implementation;
v8 is replicability; and
v9 is Coherence with national development policies and priority

Table 3.4. Standardisation of criteria and description of scoring scales using the tabulated scoring codes

	Costs	Economic		Social	Environmental	Climate related	Other: Institutional/Implementation		Political
	V1	V2	V3	V4	V5	V6	V7	V 8	V9
Scoring code	S1	S2	S3	S4	S5	S6	S7	S8	S9
Scoring scale	0=very high cost --> 100=very low cost	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0=Very Difficult -->100= Very Easy	0=Very Difficult -->100= Very Easy	0=Very Difficult -->100= Very Easy	0= Very low --> 100= Very high
Criterion weight	11	10	8	16	17	19	8	5	6

The weighted score we generated is shown in Table 3.5 below.

TABLE 3.5. DECISION MATRIX: WEIGHTED SCORES

	Costs	Economic		Social	Environmental	Climate related	Other: Institutional/Implementation		Political	Total Score	TechnologyRank
	*V1	V2	V3	V4	V5	V6	V7	V8	V9		
TA1	825	450	200	850	960	1240	560	400	600	6085	5
TA2	440	990	640	1700	960	2000	680	500	600	8510	1
TA3	550	675	640	1360	320	1400	560	350	480	6335	4
TA4	770	540	440	1020	320	900	640	350	480	5460	7
TA5	495	720	520	1190	960	1600	600	425	600	7110	3
TA6	990	450	440	1275	160	1100	680	375	480	5950	6
TA7	660	810	560	1275	880	1600	640	450	600	7,475	2
Criterion weight	11	9	8	17	16	20	8	5	6		

Sensitivity Analysis

Sensitivity analysis can be used to determine whether and how much the ranking of the options will vary as a result of the weights or preference allocation.

TABLE 3.6. SENSITIVITY ANALYSIS

	Costs	Economic		Social	Environmental	Climate related	Other		
							Institutional/Implementation		Political
	*V1	V2	V3	V4	V5	V6	V7	V8	V9
TA1	75	50	25	50	60	62	70	80	100
TA2	40	100	80	100	60	100	85	100	100
TA3	50	75	80	80	20	70	70	70	80
TA4	70	60	55	60	20	45	80	70	80
TA5	45	80	65	70	60	80	75	85	100
TA6	90	50	55	75	10	55	85	75	80
TA7	60	90	70	75	55	80	80	90	100
Scoring scale	S1	S2	S3	S4	S5	S6	S7	S 8	S 9
Criterion weight	11	9	8	17	16	20	8	5	6
Criterion Weight, Sensitivity	11	9	7	20	14	18	10	5	6

Sensitivity Analysis Decision Matrix: Weighted Scores

TABLE. 3.7 SENSITIVITY A DECISION MATRIX

							Other				
	Costs	Economic		Soc	Environmental	Climate related	Institutional/Implementation		Political	TotalScor	TechnolyRank
	*V1	V2	V3	V4	V5	V6	V7	V8	V9		
TA1	825	450	175	1000	840	1116	700	400	600	6106	6
TA2	440	990	560	2000	840	1800	850	500	600	8,580	1
TA3	550	675	560	1600	280	1260	700	350	480	6455	4
TA4	770	540	385	1200	280	810	800	350	480	5615	7
TA5	495	720	455	1400	840	1440	750	425	600	7125	3
TA6	990	450	385	1500	140	990	850	375	480	6160	5
TA7	660	810	490	1500	770	1440	800	450	600	7520	2
Criterion Weight	11	9	7	20	14	18	10	5	6		

Results from the sensitivity analysis indicated much of the results of the technology ranking stayed the same except for Livestock Disease Management (TA6) moving one rank up while Seed and grain storage (TA1) moved one rank down.

After the scoring process, the following ranking resulted:

TABLE. 3.8: RANKING OF TECHNOLOGIES

	Technology	Weight
1	Drip irrigation systems	**0.86**
2	Early warning systems	**0.75**
3	Conservation Tillage	**0.71**
4	Agro-economic zones	**0.64**
5	Livestock Disease Management	**0.61**
6	Seed and grain storage	**0.61**
7	Sustainable production systems	**0.56**

3.7 Recommended Technologies

After stakeholder consultation on the relevance of the technologies to the social and economic welfare of the country, the following technologies were recommended:

1. Drip irrigation

2. Early Warning System.

Importantly, the recommended technologies align with Somalia's Updated NDC ,which adovocates for the development of irrigation systems, including dams, channels & water reticulation systems, as a priority adaptation action between 2021-2030. Irrigation is considered a critical intervention to address climate change-related water shortages undermining agricultural production. NDP 9 2020-2024 recommended; Rehabilitating the pre-war irrigation and flood control infrastructure in southern Somalia to improve the supply of surface water availability and Improving irrigation techniques to reduce soil salinisation and waterlogging through effective water use planning and regulation. Also, the development and enhancement of early warning systems have been recommended by NDP 9 2020-2024, Recovery and Resilience Framework (RFP)National climate change policy, NAP Framework and Updated NDC submitted to UNFCCC in 2021.

Early Warning Systems (EWS) are key elements of climate change adaptation and disaster risk reduction and aim to avoid or reduce the damages caused by hazards. The detection, analysis, and prediction phases of EWS are followed by warning distribution, responsible decision-making, and implementation. Droughts, tropical cyclones, floods, storms, tsunamis, severe thunderstorms, forest fires, drought, and other natural disasters can all be detected early with such systems. An early warning system must include four interconnected aspects to be successful and complete: I risk knowledge, (ii) monitoring and warning services, (iii) distribution and communication, and (iv) response capacity.

CHAPTER 4: TECHNOLOGY PRIORITISATION FOR WATER SECTOR

4.1 Key Climate Change Vulnerabilities in the Water Sector

Water is the primary channel through which climate change's effects are felt. This is owing to the numerous threats it poses to various sectors, including health, agriculture, energy, transportation, and gender. Non-climatic drivers of change, such as diminishing water availability or growing demand, impact these, posing a danger to resource sustainability. Non-climatic reasons include population growth, economic development, urbanisation, migration, and land-use changes.

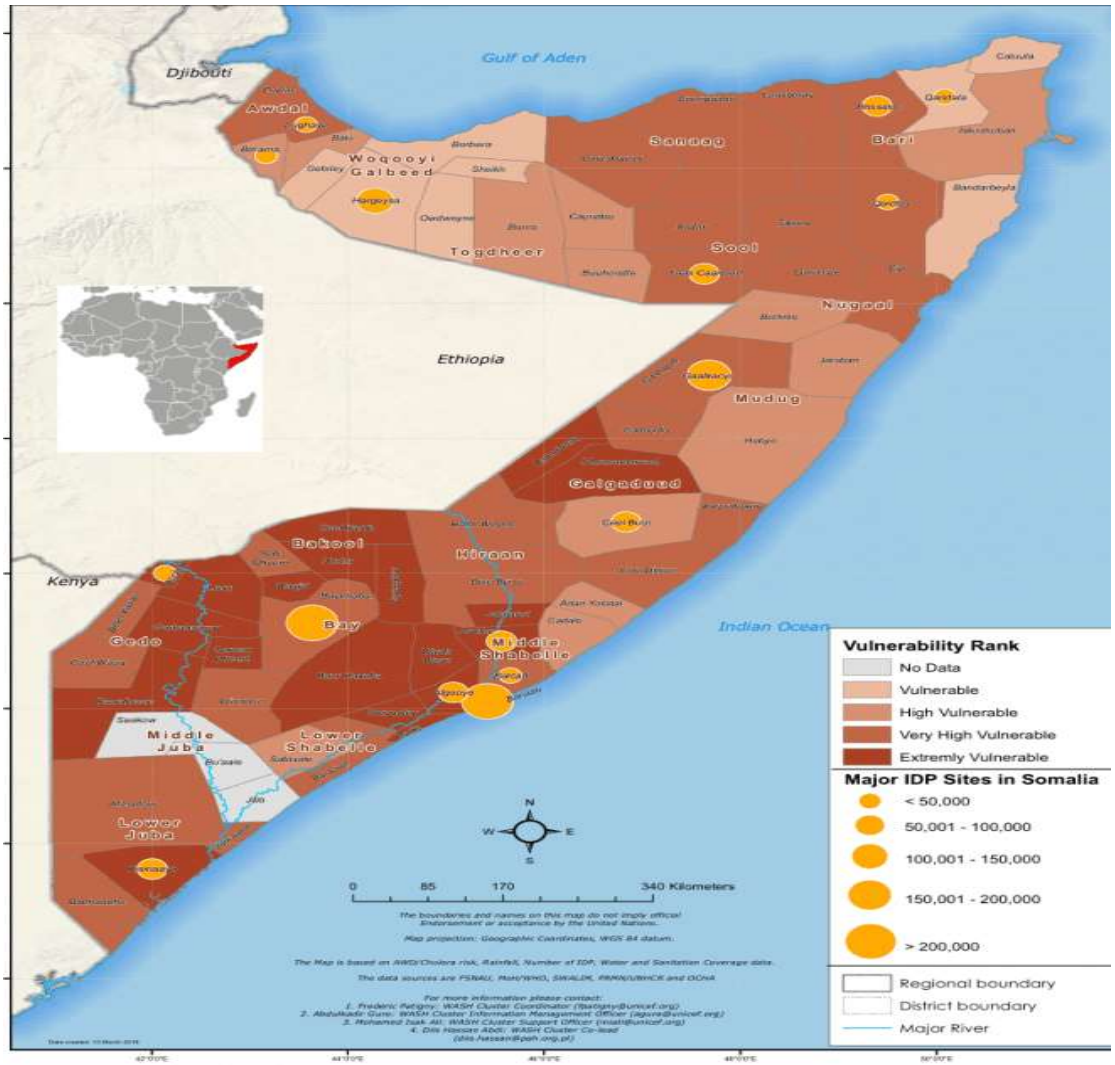

Figure 4.1: Water sector Vulnerability Assessment in Somalia (Source: Relief Web 2019)

Declining water resources, lower agricultural production, the spread of climate-sensitive vector-borne diseases to new places, changes in population and biodiversity distribution, turbulent weather, and climatic disasters are all examples of climate change's impact on the water sector (FGS, 2020). Coastal regions are more vulnerable to tsunamis as sea levels rise. Several climatic disasters have already struck the country, the most recent of which were flash floods in the Hiiraan, Middle/Lower Shabelle, and Bari (Qardho) regions, which claimed lives and displaced people[15]

According to the World Bank (2020), Somalia is a water-scarce country, with approximately 411 m3 of renewable freshwater per capita in 2017, a dramatic decrease from 2087 m3 in 1962. (ibid). This is well below the UN-recommended annual quota of 1000 m3 per capita. The existing per capita levels will continue to drop in the future decades due to high population increases, thus adding to the complexity of finding solutions to avail sufficient water in Somalia. FAO Somalia Water and Land Information Management (SWALIM) predicts that there were roughly 3,733 water points during the baseline period of 2013-2015, with 61 per cent (2,261 sources) perennial. According to estimates, Somalia has 14.7 km3 of water, with the river Shabelle and Juba accounting for the majority of it and an annual depletion rate of roughly 3.3 km3[16]Somalia is divided into nine major water basins, including the Juba and Shabelle rivers, the latter being referred to be Somalia's breadbasket[17]. The surface water resources of Somalia are limited, primarily along the two perennial rivers, the Juba and Shabelle, which run through the country's southern areas[18] The amount of renewable water resources available are projected to be 6 billion cubic meters. Only 3% of this resource is set aside for urban and home usage, with 97% for animals and agriculture. As a result, only slightly more than 26% of Somalis have access to potable water[19]

The effects of climate change have been manifested in the form of recurring floods and droughts. With mean annual rainfall anticipated to rise by 1%, 3%, and 4% by 2030, 2050, and 2080, respectively (using the 1981-2000 reference period) (FGS, 2015), more severe droughts and floods are expected in the future. Over 47% of Somalis do not have access to clean drinking water, sanitation, and hygiene (WASH) services. Regardless of this, The Covid -19 pandemic, which has increased the water, sanitation, and hygiene agenda as a defence measure against the disease's spread, has exacerbated Somalia's water needs.

Rainwater gathering using Waro and Berkads for human and livestock consumption is prevalent, however unreliable over time because of rainfall season sensitivity. The country's freshwater aquifers are being depleted due to frequent droughts and uncontrolled water flow. The Shabelle River endured unprecedented dryness in more than three decades during the 2016/2017 drought, resulting in a severe water deficit across the country. In addition, extended drought periods cause 80 percent of shallow

[15] FGS. (2021). National Water Resource Strategy 2021-2025. Minister of Energy and Water Resources, Federal Government of Somalia.
[16] Africa Development Bank 2016
[17] Jama, A. A., & Mourad, K. A. (2019). Water services sustainability: Institutional arrangements and shared responsibilities. Sustainability, 11(3), 916.
[18] Mohamed, A. E. (2013). Managing shared basins in the horn of Africa-Ethiopian projects on the Juba and Shabelle rivers and downstream effects in Somalia. Natural Resources and Conservation, 1(2), 35-49.
[19] World Bank 2020

wells to dry up and borehole water levels to drop dramatically, resulting in water scarcity. Women in rural communities sometimes bear the burden of obtaining water for their families during these dry periods, travelling over 10 kilometres to reach the nearest water source[20].

Climate-related shocks result in a shortage of water which is critical for human, livestock, and agricultural production in Somalia. This undermines efforts towards achieving household food security, addressing public health challenges, and increases the burden on already vulnerable populations, especially women, children, and Internally displaced persons[21]

The importance of improving water infrastructure, water resource management, governance, and equitable water delivery has been emphasised as critical. The lack of horizontal and vertical coordination between water sector agencies and those supporting socioeconomic development is a feature of Somalia. These institutions also lack resources and capacity, posing a challenge to the country's water administration.

4.2 Decision Context

Climate change is expected to harm Somalia's water resources, including quantity and quality. Reduced rainfall results in declining groundwater levels, drive up water prices and increase the likelihood of a conflict over water. Extended drought periods, especially in the last few years, have resulted in the loss of livelihood among pastoralists and farmers. On the other hand, intermittent floods result in disruption or damage of wells or water supply infrastructure and directly introduce the contaminated water into main water points leading to pollution and diseases.

Due to climate change, geological, geomorphological, and hydrogeological effects, this will be especially severe in some regions of the country, particularly in the northwest (Somaliland) and northeast (Puntland), leading to a significant reduction of rainfall and increased risk of desertification (FAO SWALIM 2016). The projected recurrent droughts and floods on varying spatiotemporal scales are expected to worsen, having a greater negative impact on water resources.

Among the key activities in the water sector related to climate change adaptation in Somalia is the updating of the country's primary legal instrument, the Water Act. Along with this, the development of the National Water Resource Strategy is being prioritised, as there is a recognition of the need to strategically plan for various activities that are required in the short term while working towards longer-term goals. Somalia has made the development and implementation of national and regional water resource management plans a top priority.

[20] Fanning, E. (2018). Drought, Displacement and Livelihoods in Somalia/Somaliland: Time for gender-sensitive and protection-focused approaches.
[21] Sneyers, A. (2017). Food, drought and conflict evidence from a case-study on Somalia (No. 252). Households in Conflict Network.

Construction of medium to large-scale water storage infrastructure (reservoirs), including irrigation, livestock watering points, and boreholes; construction and rehabilitation of community-level infrastructure, including *Berkeds*, shallow wells, ponds, and other appropriate technologies

Somalia has created a roadmap that specifies the creation of appropriate cooperative platforms to support and steer action programming, as well as to monitor and assess progress. The Roadmap outlines 13 project charters that specify Flagship Projects that will facilitate interventions to support the stepwise and progressive implementation of the NWRS (GOS -NWRS 2021). Establishing a Functional Water Sector Governance Framework, Operationalizing Integrated Water Resources Management, and Improving the Provision of Priority Water Services are the three goals of the NWRS. On February 13, 2020, the Somali Cabinet approved the National Environmental Policy to improve people's health and quality of life. (Source: World Bank 2020)

Somalia's NDP 2020-2024, Initial National Communication 2018, NAPA 2015, NAP Framework 2021 and Updated NDC 2021 all considered the need for sustainable management of Somalia's water resources through the implementation of water strategies and relevant climate change adaptation actions and plans. The need for water diversification to minimise water shortages during drought seasons and protection of underground and surface water sources from over-exploitation, contamination, and siltation, among others, have been recognised as critical to overall water resource management in Somalia.

4.3 Overview of Existing climate-related Technologies in the Water Sector

More than 80% of the Somali landmass is made of Arid and Semi-Arid land and is faced with water shortages. Climate change has further exacerbated the water crisis through droughts leading to the drying up surface and groundwater sources and intermittent floods destroying already fragile water infrastructures and the resulting pollution and siltation, among others[22]. Local communities are forced to adapt to the challenges of water shortage. Some adaptation strategies include water tracking, dependence on remittance to purchase water, and community self-help groups, among others.
The most common technologies in the water sectors include small-scale water storage mechanisms, construction of gabions, small catchment area management, construction of dams and reservoirs by the Federal Government, and Developing Partners, among others. The government also supports efforts towards enhancing water access among urban populations by providing piping systems, supports sustainable Land Management (SLM) to improve water capture and storage, construction of water treatment plans, rehabilitates dams and boreholes and irrigation infrastructure and livestock watering points and Protection of flood-prone areas through the construction of water embankments, check dams and retaining walls.

[22] Beier, A. C., & Stephansson, E. (2012). Environmental and Climate Change Policy Brief Somalia.

Somalia's National Development Plan nine (NDP9) for 2020-2024 considers sustainable management of water resources and the need to provide safe drinking water and sanitation services to vulnerable populations as critical to the development agenda. The National Climate Change Policy 2020 supports the conservation and protection of water catchments and freshwater sources, supports efforts towards facilitation and promotion of water recycling, reuse, and efficiency to secure a steady supply of fresh water, undertaking research in the water sector, mainstreaming climate change, Prioritize community-level infrastructure including berkeds, shallow wells, and ponds, Strengthen the use of Geoinformation Science (GIS) and Earth Observation Technologies in water resources assessment, Develop and introduce flood and drought monitoring and control systems among others. Somalia's National Water Resource Strategy 2021-2025 targets the overall vision of providing sustainable, equitable and secure water for national unity, growth and well-being for all and in harmony with nature.

4.4 Overview of Adaptation Technology Options for the Water Sector

In assessing technology options for the Water sector in Somalia, the Updated NDC 2021 report was the foundation of technologies considered. The report was informed by Adaptation Baseline Assessment 2020 and Somalia's National and Sub-national adaptation plans and policies, including NDP-9 (2020-2024), NAPA 2013, Initial National Communication 2018, National climate change policy which provided a climate change adaptation strategy and a climate change risk mitigation plan for Somalia. The priority adaptation technologies identified in the Updated NDC report 2021 guided the technology options while additional and/or substitute technologies were included in consultation with the adaptation sector working group. The technologies were further reduced to seven (7) as prioritised by the adaptation sector working group. The TNA Factsheets for selected shortlisted technologies are given in Appendix I.

Table 4.1. Long List of Priority Adaptation Technologies for the Agriculture Sector

Adaptation sector	Implementation Timeline 2021-2030)
Water Resources Priority Technologies 1. Assessment of the water system 2. Water conservation and management 3. Mega dams 4. Solar powered boreholes 5. Household drinking water treatment and safe storage 6. Water pans 7. Rain water harvesting 8. Development of drainage and storm water systems 9. Integrated Water Resources Management strategy 10. Public health awareness campaign, targeting rural areas on climatechange effects and public health related issues 11. Establish and operationalize public health facilities in rural areas	

Table 4.2: Short List of Priority Adaptation Technologies

Water Sector Adaptation Technologies		Description
1	*Water conservation and management.*	This technology aid at improving water governance by advocating for sustainable approaches through implementation of water related policies, strategies and actions
2	*Mega dams*	They are large structures over 15 metres in height generating over 400 megawatts of power on average.
3	*Solar powered boreholes*	Renewable energy is employed in thistechnology, making use of a drilling rig to sink aborehole for water abstraction using solarpower. It is therefore deemed a green technology.
4	*Household drinking water treatmentand safe storage*	This technology focuses on providing safe and sustainable basic household water supply
5	*Water pans*	This technology uses small scale water storage reservoirs to retain rainwater
6	*Rainwater harvesting*	This technology involves collection and storing of rainwater from rooftops and surface using simple techniques water holding tanks .
7	*Integrated Water Resources Management strategy*	This technology uses strategic watermanagement by engaging an integrated approach to water resources

4.5 Criteria and process of Technology prioritization

The process and criteria were conducted in a participatory and all-inclusive way. It was also based on the sector's contribution to national development and its relationship to climate change adaptation. The following steps were undertaken:

a) Detailed literature review and use of expert knowledge: A detailed literature review of the national development plans and programs, and strategies; past and current documents and activities concerning climate change and adaptation; sectoral reports, plans, and strategies; and IPCC documents and other climate change-related activities.

b) Involvement of stakeholders through meetings, workshops, one-to-one engagement,

The following were identified as key technologies for Climate Change adaptation in the water sector: -

- ☐ Water conservation and management – (TW1)
- ☐ Mega dams (TW2)
- ☐ solar powered boreholes (TW3)
- ☐ Household drinking water treatment and safe storage (TW4)
- ☐ Water pans (TW5)
- ☐ Rainwater harvesting (TW6)
- ☐ Integrated Water Resource Management (TW7)

Fact sheets were then prepared for the seven technologies, using information from relevant literature and consultation with stakeholders. Fact sheets for the selected technologies are presented in Annex 1.0.

4.6 Results of Technology Prioritization

The seven identified Climate Change Adaptation Technologies were then prioritised using Multi-Criteria Analysis Method. Multi-Criteria Analysis (MCA) is designed to give decision-makers a practical, evidence-based approach to setting priorities and choosing between choices.

The process is interactive and uses an Excel Sheet to aid the process and provide feedback to participants on the effects of changes as they explore decision options. The criteria that were used were: The criteria that were used were: cost of technology, contribution to economic development, social and environmental benefits and climate resilience contribution. During MCA multi-criteria analysis, scores and weighting and standardisation concepts were applied for technology prioritisation (see tables 4.1, 4.2, 4.3, 4.4 and 4.5)

The following technologies were subjected to MCA for prioritisation.
Provision of seeds and seedlings community

- ☐ Water conservation and management – (TW1)
- ☐ Mega dams (TW2)
- ☐ solar powered boreholes (TW3)
- ☐ Household drinking water treatment and safe storage (TW4)
- ☐ Water pans (TW5)
- ☐ Rainwater harvesting (TW6)
- ☐ Integrated Water Resource Management (TW7)

The multi-criteria analysis, Weight Effects and the Technologies Ranking are given below.

Table 4.3 Water Sector: Multi-Criteria Analysis Scores

							Other		
	Costs	**Economic**		**Social**	**Environmental**	**Climate related**	**Institutional/Implementation**		**Political**
	*V1	V2	V3	V4	V5	V6	V7	V8	V9
TW1	60	45	50	70	60	60	55	70	80
TW2	50	80	60	70	80	70	60	70	80
TW3	60	95	80	90	85	85	85	90	100
TW4	50	75	75	80	80	70	70	75	80
TW5	60	75	70	80	70	75	60	70	85
TW6	85	85	70	90	85	85	90	95	100
TW7	60	40	50	60	85	75	60	65	80
Scoring scale	S1	S2	S3	S4	S5	S6	S7	S 8	S 9
Criterion weight	11	9	8	17	16	20	8	5	6

The weighted score we generated is shown in Table 4.4 below.

Table 4.4 Decision Matrix: Weighted Scores

	Costs	Economic		Social	Environment	Climate related	Other			Total Score	Technology Rank
							Institutional/Implementation		Political		
	*V1	V2	V3	V4	V5	V6	V7	V8	V9		
TW1	660	405	400	1190	960	1200	440	350	480	6085	7
TW2	550	720	480	1190	1280	1400	480	350	480	6930	5
TW3	660	855	640	1530	1360	1700	680	450	600	8475	2
TW4	550	675	600	1360	1280	1400	560	375	480	7280	3
TW5	660	675	560	1360	1120	1500	480	350	510	7215	4
TW6	935	765	560	1530	1360	1700	720	475	600	8645	1
TW7	660	360	400	1020	1360	1500	480	325	480	6585	6
Criterion weight	11	9	8	17	16	20	8	5	6		

Sensitivity Analysis

Sensitivity analysis can be used to determine whether and how much the ranking of the options will vary as a result of the weights or preference allocation.

TABLE 4.5: SENSITIVITY ANALYSIS

	Costs	Economic		Social	Environmental	Climate related	Other: Institutional/Implementation		Other: Political
	*V1	V2	V3	V4	V5	V6	V7	V8	V9
TW1	60	45	50	70	60	60	55	70	80
TW2	50	80	60	70	80	70	60	70	80
TW3	60	95	80	90	85	85	85	90	100
TW4	50	75	75	80	80	70	70	75	80
TW5	60	75	70	80	70	75	60	70	85
TW6	85	85	70	90	85	85	90	95	100
TW7	60	40	50	60	85	75	60	65	80
Scoring scale	S1	S2	S3	S4	S5	S6	S7	S 8	S 9
Criterion weight	11	9	8	17	16	20	8	5	6
Criterion Weight, Sensitivity	11	9	6	20	18	16	9	5	6

Sensitivity Analysis Weighted score generated is shown in Table 4.6 below.

TABLE. 4.6: SENSITIVITY ANALYSIS DECISION MATRIX

	Costs	Economic		Social	Environmenta	Climate related	Other			Total Score	Technology Rank
							Institutional/Implementation		Political		
	*V1	V2	V3	V4	V5	V6	V7	V8	V9		
TW1	660	405	300	1400	1080	960	495	350	480	6130	7
TW2	550	720	360	1400	1440	1120	540	350	480	6960	5
TW3	660	855	480	1800	1530	1360	765	450	600	8500	2
TW4	550	675	450	1600	1440	1120	630	375	480	7320	3
TW5	660	675	420	1600	1260	1200	540	350	510	7215	4
TW6	935	765	420	1800	1530	1360	810	475	600	8695	1
TW7	660	360	300	1200	1530	1200	540	325	480	6595	6
Criterion weight	11	9	8	17	16	20	8	5	6		

Results from the sensitivity analysis of the water sector technology rankings stayed the same with all the technologies maintaining their original ranking number.

The scoring process produced the following rankings:

TABLE. 4.7: RANKING OF TECHNOLOGIES

	Technology	Weight
1	Rainwater harvesting	0.87
2	Solar powered boreholes	0.85
3	Household drinking water treatment and safe storage	0.73
4	Water pans	0.72
5	Mega dams	0.69
6	Integrated Water Resource Management	0.65
7	Water conservation and management	0.61

4.7 Recommended Technologies

After stakeholder consultation on the relevance of the technologies to social and the economic welfare of the country, the following technologies were recommended:

- **Rainwater harvesting**
- **Solar powered boreholes**

Somalia Updated NDC 2021, National Water Resource Management Strategy 2021, NAP Framework, and NDP 9 2020-2024 recognised the challenge of water shortage in Somalia due to its Arid and Semi-Arid nature coupled with the impact of climate change. Rainwater harvesting is highly recommended so stored water is utilised during extended drought periods. Establishing solar-powered boreholes is also a mitigation action prioritised under the Updated NDC submitted to UNFCCC and Somalia's energy policy.

CHAPTER 5: SUMMARY AND CONCLUSIONS

Evidence shows Somalia remains susceptible to climate change impacts with increased frequencies of shocks, especially droughts, floods, and storms. Therefore, assessing technology needs concerning climate change adaptation is crucial to enhance the resilience of critical sectors of Somalia's economy.

A consultative process has informed the Technology Needs Assessment (TNA) report for Somali of prioritising technologies in key sectors adaptation, including agriculture (including livestock) and water. The prioritised technologies for the agricultural sector are drip irrigation and Early Warning Systems, and the Water sector prioritised technologies included Rainwater harvesting and Solar powered boreholes. The TNA Adaptation report for Somalia will serve as the foundation for the project's next phase, which includes the Barrier Analysis and Enabling Framework Report and Technology Action Plans.

Although Somalia is vulnerable to climate change, significant progress in setting policies and institutional frameworks relevant to climate change has been made, including the establishment of the Directorate of Environment and Climate Change, Federal and State Level Ministries and policies, including the national climate change policy 2020, National Adaptation Framework 2021, NDP 2020-2024, Updated NDC 2021 among others. The TNA project provides an opportunity for Somalia to benefit from technology transfer and diffusion in climate change adaptation, capacity enhancement, and secure climate finance to implement the priority technologies identified in the crucial sectors of agriculture and water. This will, in turn, enhance efforts towards the attainment of Somalia's National Development Plan (NDP,9) 2020-2024 and the implementation of the Updated NDC 2021 for Somalia.

LIST OF REFERENCES

[1] Parry, M. L., Canziani, O., Palutikof, J., Van der Linden, P., & Hanson, C. (Eds.). (2007). Climate change 2007-impacts, adaptation and vulnerability: Working group II contribution to the fourth assessment report of the IPCC (Vol. 4). Cambridge University Press.

[2] Warsame, A. A., Sheik-Ali, I. A., Ali, A. O., & Sarkodie, S. A. (2021). Climate change and crop production nexus in Somalia: an empirical evidence from ARDL technique. Environmental Science and Pollution Research, 28(16), 19838-19850.

[3] UNEP (2005), The State of the Environment Somalia, 2005

[4]Ogallo, L. A., Omondi, P., Ouma, G., & Wayumba, G. (2018). Climate change projections and the associated potential impacts for Somalia.

[5]Africa Development Bank, Africa Economic Outlook 2021

[6] Food Agriculture Organization SWALIM, 2009

[7] Wilson, T. (2016). Economic recovery in Somalia. Bildhaan: An International Journal of Somali Studies, 15(1), 9.

[8] Thulstrup, A. W., Habimana, D., Joshi, I., & Oduori, S. M. (2020). Uncovering the challenges of domestic energy access in the context of weather and climate extremes in Somalia. Weather and Climate Extremes, 27, 100185.

[9] Briggs, E. D., & Soderlund, W. C. (2008). Somalia, 1992: UNOSOM I, UNITAF,"Operation Restore Hope," UNOSOM II. Humanitarian Crises and Intervention, Reassessing the Impact of Mass Media.

[10] The United Nations Office for the Coordination of Humanitarian Affairs, 2020

[11] Federal Government of Somalia, Adaptation Baseline Report 2020

[12] FAO Climate-smart agriculture Projects from around the world case studies 2021

[13] Gure, A. (2021). The Role of Climate Information and Early Warning Systems in Supporting Disaster Risk Reduction in Somalia (p. 50) [Technical Report No WC-007].

[14] FGS. (2021). National Water Resource Strategy 2021-2025. Minister of Energy and Water Resources, Federal Government of Somalia.

[15] Africa Development Bank 2016

[16] Jama, A. A., & Mourad, K. A. (2019). Water services sustainability: Institutional arrangements and shared responsibilities. Sustainability, 11(3), 916.

[17] Mohamed, A. E. (2013). Managing shared basins in the horn of Africa–Ethiopian projects on the Juba and Shabelle rivers and downstream effects in Somalia. Natural Resources and Conservation, 1(2), 35-49.

[18] World Bank 2020

[19] Fanning, E. (2018). Drought, Displacement and Livelihoods in Somalia/Somaliland: Time for gender-sensitive and protection-focused approaches.

[20] Sneyers, A. (2017). Food, drought and conflict evidence from a case study on Somalia (No. 252). Households in Conflict Network.

[21] Beier, A. C., & Stephansson, E. (2012). Environmental and Climate Change Policy Brief Somalia.

ANNEX 1. TNA SOMALIA STAKEHOLDERS

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Annex 1.2: National Climate Change Committee (NCCC) Somalia

	NAME	INSTITUTION	CONTACT
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	Director General	DECC	
	Representative	Federal level Sectoral Ministries	
	Representative	State level Sectoral Ministries	
	Representative	Directors of Governmental Agencies	
	Representative	civil society organizations	
	Representative	private sector.	

Annex 1.3: Members of Sector Working Group

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ANNEX 2: TECHNOLOGY FACTSHEETS

TECHNOLOGY FACT SHEETS ON ADAPTATION

Annex 2.1: Technology Fact sheet For the Agriculture sector

2.1.1 Technology	**Drip irrigation**
Introduction	Drip irrigation involves the constant application of a specific and calculated quantity of water to soil crops (localized area). This significantly reduces water runoff through deep percolation or evaporation.
Technology Characteristics	In drip irrigation, water is applied under pressure, dripping one drop at a time through the small emitters. Advantages of drip irrigation include: • Allows the rows between plants to remain dry, improving access and reducing weed growth. • It saves time, money, and water because the system is so efficient. • Decreases labour.
Country Specific Applicability and Potential	The agricultural sector in Somalia has continued to be the major driver of the economy. The cultivatable land in Somalia is in the order of 3 million hectares, of which it is estimated that 2.3 million hectares could produce crops under dryland conditions. Of the remaining 700 000 hectares that could be developed under irrigation practices, currently, less than 115 000 hectares are being cultivated. Apart from the people living along the Juba and Shabelle Rivers, the Somali population depends on groundwater for domestic water supply, livestock, and small-scale irrigation.
Benefits to Environmental, Economic/ Social Development	Drip irrigation is more sustainable due to how precisely water can be delivered without much waste. Reduced wastage of water allows for saving resources (financial and time) that can be utilised for other benefits such as investment in health care or education.
Climate Change Adaptation Benefits	Irrigation technology can support farmers to adapt to climate change by providing efficient water supply use, especially during water stress periods. During droughts and seasonal dry spells, irrigation provides the necessary water resources directly to the plant when required.
Financial Requirements and Costs	Drip irrigation systems have a higher initial cost than other systems. Irrigation technology is diverse, ranging from low-cost to high-end, high-priced systems. A drip irrigation system costs around the US $ 250 on average (GOK, 2013). Drip irrigation has massive potential to result in high yields recouping the cost of installation.

2.1.2 technology	Early warning systems
Introduction	The Indian, Atlantic and Pacific Oceans influence the climate of Somalia. The Indian Ocean is the main source of moisture that provides rain over most of the country. The Sub- Tropical pressure patterns over the Indian and Atlantic Oceans strongly influence the seasonal rainfall because they control the movement and strength of the ITCZ. The warming (El- Nino) or cooling (La- Nina) phase of the Pacific Ocean influences the rainfall patterns in the country, causing floods in some areas and droughts in others. Sea surface temperatures of the oceans change relatively slowly. Their monitoring can provide information that can be used to assess the performance of the seasonal rains in good time for early warning and preparedness. To develop effective information products for early warning, the country needs to: • Establish and strengthen International cooperation in climate data exchange • Strengthen the climate monitoring systems in the country • Strengthen Climate information dissemination to the users. The information can be disseminated in innovative ways.
Technology Characteristics	The surface atmospheric parameters are essential for an Early Warning System. An early Warning System is generally a series of inter-connected procedures through which information on foreseeable hazards is collected and analysed for predicting the possible future occurrence of a natural phenomenon such as drought and floods. There are two basic types of Early Warning Systems, i.e. formal and informal. The national government executes the formal and centralised systems, while a volunteer operates the informal, decentralised community system at the community level. Basic weather instruments such as a thermometer and a pyranometer for measuring solar radiation are used. With appropriate use of meteorological, hydrological and climate information, substantial progress towards a strong and better disaster risk reduction can be achieved. The informal system uses Indigenous knowledge through bio-indicators to help farmers maintain productive farming practices to adapt to longer periods of suitable weather for crop cultivation or crop type selection. Local farmers observe to enable them to decide on their agricultural production. Observation of certain bio-indicators for several months to make weather forecasts and predictions to adjust, say, planting and cultivation activities.
Country Specific Applicability and Potential	Effective drought early warning systems must integrate precipitation and other climatic parameters with water information such as stream flow, groundwater levels, reservoir and lake levels, and soil moisture into a comprehensive assessment of current and future drought and water supply conditions. Indigenous Knowledge by communities is also very important
Benefits to Environmental, Economic/ Social Development	The development of effective Early Warning Systems in Somalia is vital for promoting livelihood resilience by improving adaptive capacity. Therefore, a complete and effective early warning system can play a pivotal role in preventing the loss of lives and properties by providing useful information that allows communities to protect their lives and assets. A reliable, accurate Early Warning System is very important for the Agricultural Sector to assist farmers and pastoralists take better decisions on agricultural operations and activities with the following possible resultant benefits: Reduction of agricultural and livestock losses due to adverse climatic events; and Increased productivity of different value chains.
Climate Change Adaptation Benefits	Weather and climate data is important for preparedness of such activities like land preparation, plant time, harvest time and possible yield levels. This in turn translates to improved livelihood at household level
Financial Requirements and Costs	The estimated cost of a low cost weather station in the developing world is average US $ 5,000 (Mwangi 2017).

2.1.3 Technology	Conservation Tillage (CT)
Introduction	CT refers to any minimal tillage system that leaves sufficient crop residue to cover the soil surface by at least 30%. No-till farming, in which the soil is left undisturbed by tillage and the residue is left on the soil surface, is the most effective soil conservation system.
Technology Characteristics	Conservation tillage, which includes ZT (Zero Tillage) and minimum tillage, has the capacity to disrupt the surface compact zone in the soil while reducing soil disturbance, resulting in improved soil conditions and crop yields with minimal environmental effect. Soil erosion control is a focus of this technology. Combining conservation tillage (ripping) for planting holes/farrows with the possibility of intercropping maize/green manure cover crops to conserve moisture and improve soil fertility.
Country Specific Applicability and Potential	There is minimal uptake of CT in Somalia although low scaled practices exist in some parts of Puntland, Hiraan and Somaliland.
Benefits to Environmental, Economic/ Social Development	Improvement of soil moisture and water use efficiency through mulching. Enhanced quality of life (lower labour, greater planting flexibility); increased profitability (reduces wear and tear on equipment, saves fuel and fertilizer, improved productivity, carbon credits); and improved animal habitat are among the economic and societal benefits.
Climate Change Adaptation Benefits	Growing crops with minimal soil disturbance reduces soil erosion and increases carbon sequestration reducing global warming threats.
Financial Requirements and Costs	The cost of implementation is varied and depends on insurance service providers in the market. I may be a s low as tens of dollars per household per year

2.1.4 Technology	Agro-Economic Zones
Introduction	A self-sustaining economic zone that aids in the growth of the area in which it is established and offers local employment possibilities, therefore adding to the national economy's overall GDP
Technology Characteristics	Key elements on an AEZ include: - Water management and irrigation facilities Procurement of modern farm equipment Allows for closer research in agriculture Capacity building for farmers Allows for storage infrastructure Allows for branding and marketing
Country Specific Applicability and Potential	AEZ has been implemented at a small scale in Somalia, especially in the border region with Ethiopia.
Benefits to Environmental, Economic/ Social Development	Allows resource efficiency, Promotes local, regional and international trade, Promotes investments in agribusiness, Increasing the contribution of the agriculture sector to GDP, wealth and employment creation.
Climate Change Adaptation Benefits	Reduced poverty through economic diversification leads to reduced pressure on forest resources as a source of income thus conserving carbon sinks.
Financial Requirements and Costs	

2.1.5 Technology	Livestock Disease Management
Introduction	Livestock disease management is made up of two key components: Prevention (biosecurity) measures in susceptible herds Control measures are taken once infection occurs. Preventing diseases entering and spreading in livestock populations is the most efficient and cost-effective way of managing disease (Wobeser, 2002)
Technology Characteristics	Focus on prevention Animal health production oriented Existence of surveillance of livestock systems
Country Specific Applicability and Potential	Technology is common in Somalia and has massive potential for upscaling
Benefits to Environmental, Economic/ Social Development	Reduced poverty lead to reduced pressure on the natural environment Sustainable income from sale of livestock and livestock products, thus improving farmers' income. This plays a significant role in improving livelihoods of small scale farmers.
Climate Change Adaptation Benefits	Value addition increases shelf life and value of products thus averting post-harvest losses. This is a climate-smart attribute that can help deal with food scarcity.
Financial Requirements and Costs	Value addition in livestock-industries can be achieved with the right support from local authorities and the national government. The main upfront cost is the initial investment cost.

2.1.6 Technology	Seed and grain storage
Introduction	Seed storage is preservation of seed with initial quality until it is needed for planting. Grain storage is a location or physical structure that is regularly used to store grain for producers or grain that is purchased from producers for resale.
Technology Characteristics	These storage structures are comparatively cheap, eco-friendly and impart high shelf life to the stored commodities. These traditional storage systems could be applied in modern storage areas with minor modification, could save food commodities that would be damaged by insects
Country Specific Applicability and Potential	There have been attempts to increase the adoption of improved seed varieties in Somalia, such as The Somaseed project. However, advances in research and development are crucial in realising the complete uptake of the technology.
Benefits to Environmental, Economic/ Social Development	Seed storage helps restore lands devastated by wildfires, natural disasters, and invasive weeds. Increase the adoption and access of farmers to better post-harvest seed storage technologies. These technologies promote environmentally sustainable agricultural practices.
Climate Change Adaptation Benefits	Contributes to reduced pressure on land and forest resources, increase carbon sinks (soils and forest).
Financial Requirements and Costs	The cost of seed and grain storage is minimal, depending on the storage scale.

2.1.7 Technology	Sustainable production systems
Introduction	Sustainable production systems refer to the capacity of the system to maintain its productivity in spite of economic and natural, external or internal limitations
Technology Characteristics	Conserving of energy and natural resources. Economically viable and long term oriented
Country Specific Applicability and Potential	National policies and development plans geared towards establishing and enhancing sustainable production systems despite the challenges of insecurity, lack of finance, capacity and climate change impact
Benefits to Environmental, Economic/ Social Development	Sustainably production systems increase income and builds the resilience of smallholder farmers and agribusinesses. The system is Non-polluting. Allows Conserving of energy and natural resources. Economically viable. Safe and healthful for workers, communities, and consumers.
Climate Change Adaptation Benefits	Enhances the adaptive capacities, strengthens resilience and reduces the vulnerability of smallholder farmers and agribusinesses to climate change risks.
Financial Requirements and Costs	The technology is old and widespread, therefore requiring only small upfront costs. Affordable to small scale farmers.

Annex 2.2: Technology Fact Sheet For the Water Sector

2.2.1 Technology	Solar powered boreholes
Introduction	Renewable energy is employed in this technology, making use of a drilling rig to sink a borehole for water abstraction using solar power. It is therefore deemed a green technology.
Technology Characteristics	Simple – only moving parts are pump/motor. Plug and-play electrical connections. • No fuel costs. • No routine maintenance. • Minimal supervision. • Capital costs increasingly competitive with diesel power. • Environmentally friendly.
Country Specific Applicability and Potential	Solar powered boreholes already exist in different parts of Somalia for example, Sool, Galmudug, Puntland, Jubaland and Puntland regions.
Benefits to Environmental, Economic/ Social Development	• Women and girls are empowered by providing readily available water and making use of more available time for family and other socio-economic activities • Availability of good quality water for domestic and agricultural purposes through an energy-efficient method • The practice of agroforestry leads to trees conservation
Climate Change Adaptation Benefits	Using green pumping technology reduces dependence on diesel powered generators which contribute to emissions.
Financial Requirements and Costs	The costs of drilling boreholes and installing solar power vary widely depending on many factors such as geological formation, aquiver depths, and the design. In the long run effectiveness is realized. OXFAM estimates the cost of solar powered pump inclusive of everything at around 12,000 pounds.

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2.2.2 Technology	Rain water Harvesting
Introduction	Rainfall harvesting is the process of collecting and storing rainwater in natural reservoirs or tanks, or the process of infiltrating surface water into subterranean aquifers (before it is lost as surface runoff). Rooftop rainwater gathering is one way of rainwater harvesting. Almost any surface — tiles, metal sheets, plastics — may be utilized to catch rainfall and provide a family with water that is easily accessible and available year-round with rooftop harvesting. Although not every single drop of rain can and should be harvested, rainwater is still an underutilized water source in Somalia.
Technology Characteristics	Rainwater harvesting is the collection, accumulation, treatment or purification, and storing of rainwater for its eventual reuse. If properly designed, runoff catchment systems can collect large quantities of rainwater. The main challenge Surface runoff water harvesting poses is the removal of pollutants to make this water available for reuse. Small reservoirs with earthen bunds or embankments to contain runoff or river flow are built from soil excavated within the pool to increase storage capacity. A spillway or weir allows controlled overflow when storage capacity is exceeded.
Country Specific Applicability and Potential	The major water sources in Somalia include river water in the Juba and Shabelle rivers, water stored in pans, sand dams and berkeds, boreholes as well as hand-dug wells, springs and rainwater harvesting from roofs. These have a range of infrastructural requirements and need to be contextually relevant as well as maintained accordingly. There is a potential for improved rain fed agriculture system through conjunctive water use and develop rainfed water harvesting
Benefits to Environmental, Economic/ Social Development	• Water for irrigation will be available and will not compete with other users. This water can also contribute to productive and economic livelihood purposes. • Reduce public and private expenditures associated with water infrastructure • Increases per capita water availability for irrigation purposes. • Creation of jobs as this technology will require trained staff to operate and maintain the system.
Climate Change Adaptation Benefits	Harvesting runoff during rainy season, under changing climate, and storing it for use during the dry season will play a cushioning role in contributing to adaptation to water shortage occasion by prolonged droughts associated with climate change. Additionally, widespread rainwater storage capacity can greatly reduce land erosion and flood inflow to major rivers. Rainwater collection can also contribute greatly to the stabilization of declining groundwater tables
Financial Requirements and Costs	The cost of construction of a rainwater harvesting system will varying depending on the size of the catchment and the targeted communities.

2.2.3 Technology	Water conservation and management
Introduction	Climate change continues to disrupt existing water supplies, thus underlining the importance of the conservation and management of water resources. Water conservation and management are essential in protecting and sustainably utilising limited water resources. Control of water resources entails using the available water resources efficiently. However, the biggest challenges in water conservation and management have been pollution due to human activities and water shortages due to drought.
Technology Characteristics	Conservation and management technologies involve using the available water efficiently while minimizing the losses in reservoirs and distribution networks. This also entails higher-level management of multiple watersheds and interconnected water systems. Water management is approached from a coordinated development and management of water, land and other related resources as prescribed by the Global Water Partnership.
Country Specific Applicability and Potential	Water conservation and management in Somalia face systemic and Institutional challenges. There is limited Institutional capacity in terms of prioritizing, managing, and delivering ongoing or proposed conservation opportunities. The institutions involved in the water sector do not have clear or documented roles. This creates a conflict of responsibilities among the institutions involved in the water sector. Nevertheless, there are still opportunities for implementation of integrated water resources management (IWRM)
Benefits to Environmental, Economic/ Social Development	• Better water conservation and management has economic benefits and helps protect the environment. • Some water management practices can affect water stock for maintaining environmental resources and supporting future water uses. • Improves environmental performance by a reduction in the environmental impact of the water sector through the efficient use of water and land resources
Climate Change Adaptation Benefits	Better water management and conservation practices can positively mitigate the impacts of climate change, including dealing with drought and water scarcity.
Financial Requirements and Costs	Properly constituted institutions require budgeting by the national government

2.2.4 Technology	Mega dams
Introduction	they are large structures over 15 metres in height generating over 400 megawatts of power on average. Strategic water reserves are crucial in planning for resilience against adverse climate change effects and reducing the risks associated with extreme weather events such as drought.
Technology Characteristics	• Provide water storage opportunity • Flood Control. In addition to helping farmers, dams help prevent the loss of life and property caused by flooding. • Irrigation • Electrical Generation. • Debris Control.
Country-Specific Applicability and Potential	There has been limited development of mega-dams and other large water reservoirs. Shallow wells and surface dams are common, however, they do not help much during periods of drought. There is potential for scaling up the small water reservoirs to large reservoirs.
Benefits to Environmental, Economic/ Social Development	• Mega-dams and large reservoirs can be used in flood control • Water reservoirs provide enhanced environmental protection, including retention of sediments and other hazardous materials • They facilitate water conservation to meet future requirements
Climate Change Adaptation Benefits	Water reserves play a critical role in mitigating and adapting to climate change impacts such as drought.
Financial Requirements and Costs	Financial requirements depend on the type and scale of the water dam, for example, Grand Ethiopian Renaissance Dam is estimated to cost $5 billion USD (Government of Ethiopia) and will generate 5,000 MW of electricity along the Blue Nile. In Kenya, Thwake Dam at the border of Makueni and Kitui – has been estimated to cost around $700,000 million.

2.2.5 Technology	Household drinking water treatment and safe storage
Introduction	Household water treatment and safe storage is an important intervention for improving the quality of drinking water particularly among those who rely on unimproved sources of water and, in certain situations, dangerous or unreliable piped water supplies.
Technology Characteristics	Comprise a collection of technologies, including household water treatment, community water treatment, wells and sand dams, water storage techniques, and manual/powered pumps.
Country-Specific Applicability and Potential	Only 52% of Somalia's population have access to basic water supply. The low water access rate is exacerbated by the fact that the private water supply sector is unregulated, leading to high prices, forcing households to rely on unsafe open wells. However, there is great potential for portable water supply if suitable regulations are put in place.
Benefits to Environmental, Economic/ Social Development	Household access to clean water is crucial in achieving some of the environmental, economic and social gains, including averting water resource conflicts, good hygiene practices, and economic gains realised by saving the time that would have been used to fetch water from distant places
Climate Change Adaptation Benefits	Portable water supply for households is a means of adapting to water scarcity arising from climate change effects.
Financial Requirements and Costs	Initial investment requires upfront costs for setting up the infrastructure. Maintenance and operational costs are minimal. Setting up cost can range from $500,000 to $1.5 million depending on the system

2.2.6 Technology	Water pans
Introduction	Water pans are used to collect storm water throughout the country but are common in the southern parts of Somalia because of favourable soils for their construction. They are mainly used to supplement livestock water needs and irrigation crops.
Technology Characteristics	Pans are small reservoirs excavated in the open ground to collect and store surface runoff from uncultivated grounds, hillsides, rocky areas and open rangelands. They rely on surface runoff only and do not receive groundwater recharge.
Country-Specific Applicability and Potential	Water pans are commonly utilised in dry areas, and Somalia offers a perfect case for their application. Although they are utilised throughout the country, their full potential is yet to be realised.
Benefits to Environmental, Economic/ Social Development	Water pans help in improving the livelihoods of those in dry areas, especially pastoral communities, by improving livestock productivity. They ensure water availability at minimum costs. They also help in reducing surface water run-off and flash floods
Climate Change Adaptation Benefits	Water pans can be used to adapt to climate change extremes such as fluctuating rainfall and extreme temperatures.
Financial Requirements and Costs	Water pans are not expensive ventures as they only require human capital for construction. However, financial requirements depend on the nature and extent of the water pans.

2.2.7 Technology	integrated Water Resources Management strategy
Introduction	Being among the vulnerable countries in Africa, Somalia needs to build resilience to climate change by managing water resources sustainably. One strategy that can achieve this is integrated water resources management. Integrated Water Resources Management (IWRM) aims to manage water resources comprehensively and holistically based on the principles of social equity, economic efficiency, and environmental sustainability.
Technology Characteristics	IWRM is an integrated approach that involves all water partners and stakeholders in managing and solving water-related issues. IWRM entails coordinated development and management of water and related resources.
Country-Specific Applicability and Potential	After years of civil war and unclear state structures, Somalia has now initiated the process of establishing institutions and water infrastructure. This new structure and institutions are expected to bring policy reforms for the establishment of IWRM.
Benefits to Environmental, Economic/ Social Development	▪ IWRM increases awareness of the importance of sustainable development by incorporating social, economic and environmental considerations in water management. ▪ IWRM encourages co-operation, thus reducing the risk of conflicts over water resources
Climate Change Adaptation Benefits	IWRM strategy can help curb the effects of climate change by supporting households and communities to mitigate and adapt to the adverse effects of climate change. This is because this strategy requires that the management and development of the water sector take into account the water needs of a wide range of people.
Financial Requirements and Costs	Successful implementation of IWRM strategy will require budgeting for the concerned institutions by the national government