TECHNOLOGY NEEDS ASSESSMENT REPORT FOR CLIMATE CHANGE ADAPTATION

Technology Action Plan for Adaptation

August 2024

TNA REPORT FOR CLIMATE CHANGE ADAPTATION IN THE WATER AND AGRICULTURE SECTORS OF SOMALIA

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List of Abbreviations and Acronyms

BMO	-	The British Meteorological Office
EWS	-	Early Warning Systems
FAO	-	Food and Agriculture Organization
FEWSNET	-	The Famine Early Warning Systems Network
FGS	-	Federal Government of Somalia
FSNAU	-	The Food Security and Nutrition Analysis Unit
GDP	-	Gross Domestic Product
ICAO	-	International Civil Aviation Organization
IDP	-	Internally Displaced Persons
LSDS	-	Livestock Sector Development Strategy
MoEWR	-	Ministry of Energy and Water Resources
NAPA	-	National Adaptation Programme of Action
NDP	-	National Development Plan
NGO	-	Non-Governmental Organisation
NWRS	-	National Water Resources Strategy
PPPs	-	Public-Private Partnership
RRWH	-	Rooftop Rainwater Harvesting
SARIS	-	Somali Agricultural and Inspection Services
SDGs	-	Sustainable Development Goals
SWALIM	-	Somalia Water and Land Information Management
TAP	-	Technology Action Plan
TNA	-	Technology Needs Assessment
UN	-	United Nations
UNICEF	-	United Nations Children's Fund
USAID	-	United States Agency for International Development
WASH	-	Water, Sanitation and Hygiene
WMO	-	World Meteorological Organization
WSS	-	Water Supply and Sanitation

EXECUTIVE SUMMARY

Somalia started its TNA process in 2021. Following exhaustive consultations with the sectoral stakeholder working group and other experts, the water and agriculture were identified as the most susceptible to climate change risks. Although these two sectors are vital to the country's progress, they are extremely susceptible to the effects of climate change. Technologies to enable adaptation will potentially benefit a large proportion of the population. Additionally, two climate adaptation technologies were identified as top priority in each sector. Two key technology priorities for the water sector were rooftop rainwater harvesting and solar-powered boreholes; the agriculture sector priority technologies were drip irrigation and early warning systems (EWS). Following this, technology barrier analysis was conducted to ascertain the various types of significant barriers that impede the diffusion and duplication of the technologies that had been prioritized. The results informed the development and proposal of a framework for fostering an atmosphere conducive to the technologies. For every technology in the priority areas, a Technology Action Plan (TAP) and Project Ideas were developed.

This report presents different TAPs and project ideas for water and agriculture sectors of Somalia. Below is a quick synopsis of the TAPs and project ideas for Somalia's water and agriculture sectors.

A1: Technology action plan for the water sector

The water sector bears the onus of ensuring adequate water supplies for critical economic sectors such as industry, agriculture, energy, housing, health, and services. It is anticipated that climate change will result in elevated temperatures and modifications to the patterns and intensity of precipitation. Droughts may become more common in Somalia's pastoral regions and rainfall may become less consistent or more unpredictable.

Chapter-1 in this report provides a concise overview of the Water Sector Technology Action Plan, including a discussion of the barriers and facilitators for the dissemination of two key water sector technologies. The future goals of the technologies that are given priority under the current policies and actions to lessen the effects of climate change in the water sector include the following.

i) Boosting rooftop rainwater harvesting (RRWH) by establishing rainwater harvesting systems for demonstration, and establishing RRWH systems through incentives by 2032
ii) Enhancing solar-powered boreholes by establishing new units by 2032
iii) Understanding and strengthening groundwater quality

Rooftop rainwater harvesting: The ambition for technology transfer of RRWH is to establish 261,000 rainwater collecting tanks, each measuring about 10 m³, to serve 1,500,000 people annually in Somalia. To that end, the courses of action in the following table matrix are suggested.

Summary matrix for Rooftop Rainwater Harvesting TAP

Sector	Water Sector	
Sub-Sector	Water, Sanitation and Hygiene (WASH)	
Technology	Rooftop Rainwater Harvesting (RRWH)	
Ambition	Establish 261,000 rainwater harvesting tanks of about 10m^3 to serve 1,500,000 persons in up to 18 regions by 2032	
Benefits	Help more people have access to potable water, lessen the strain on surface and underground water supplies, shorten the distances and time that women and children must travel, and makes more water available for irrigating crops and cattle, increase productivity.	
Action	**Activities to be implemented**	**Sources of funding**
	Activity 1.1: Develop national strategy for RRWH	Ministry of Finance, Development partners
Action 1: Improve coordination in RRWH implementation	Activity 1.2: Determine each region's RRWH potential through research	Ministry of Finance, Climate Fund, Development partners,
	Activity 1.3: Establish regional committees to coordinate RRWH	Ministry of Finance, Development partners
	Activity 1.4: Formulate RRWH strategies for the regions	Development partners
	Activity 1.5: Put the RRWH strategy into action	Development partners
	Activity 1.6: Integrate a data and information sharing platform at regional level	Development partners

Action 2: Create an information database/catalogue on RRWH technology	Activity 2.1: Conduct research to create a RRWH catalogue	Ministry of Finance, Development partners
	Activity 2.2: Translate and create awareness of the current catalogue and guidelines	Ministry of Finance, Development partners
Action 3: Enable effective private sector participation in RRWH	Activity 3.1: Lower taxes on RRWH equipment	Ministry of Finance, MoEWR
	Activity 3.2: Form alliances with RRWH funding organisations	MoEWR
	Activity 3.3: Provide capacity support to SMEs in RRWH.	Ministry of Planning, Investment and Economic Development, MoEWR, Development partners
	Activity 3.4: Draft proposal for communities to acquire financing for RRWH	Development partners
Action 4: Bolster RRWH's technical capabilities	Activity 4.1: Strengthen curricula of existing institutes/centres in RRWH exploitation, installation, and maintenance	Federal Government
	Activity 4.2: Conduct demonstration projects and research on the effectiveness of RRWH	Development Partners
	Activity 4.3: Develop RRWH curriculum for technical educational institutions	Federal Government

Solar-powered boreholes: The objective of technology transfer pertaining to solar-powered boreholes is to supply water to 25,000 households by 2032 via 300 solar-powered boreholes. The target areas consist of pastoral zones and the northern, eastern, and central plateaus, which are distinguished by an exceptionally prolonged arid season. The actions in the following table matrix are suggested to accomplish this.

Summary Matrix for Solar-powered Boreholes TAP

Sector	Water Sector
Sub-Sector	Water, Sanitation and Hygiene (WASH)
Technology	Solar-powered Borehole

Ambition	Supply 300 solar-powered boreholes to meet the water needs of 25,000 households especially those in drought-prone areas by the 2032	
Benefits	The provision of clean water to 25,000 households, with a particular emphasis on regions susceptible to drought	
Action	**Activities to be implemented**	**Sources of funding**
Action 1: Cut down on groundwater extraction costs	Activity 1.1: Enable local production of spare components.	MoEWR, Development partners
	Activity 1.2: Venture in large diameter boreholes.	Development partners, Ministry of finance
	Activity 1.3: Determine viability of solar-powered boreholes.	MoEWR, Development partners
	Activity 1.4: Establish alliances with the private sector.	MoEWR
	Activity 1.5: Introduce and implement tax waivers for solar-powered borehole equipment.	Ministry of Finance, Revenue Directorate
Action 2: Strengthen technical skills in solar PV systems and borehole management and installation	Activity 2.1: Create a hands-on example of model borehole setup.	MoEWR, Development partners
	Activity 2.2: Design specialised solar-powered borehole courses.	Ministry of Finance, Development partners
Action 3: Bolster institutions and organisations that manage groundwater and renewable energy	Activity 3.1: Strengthen water user committees' governance capacity.	MoEWR, Ministry of Finance, Development partners
	Activity 3.2: Support water users' committees with a recurrent budget.	MoEWR, Ministry of Finance, Development partners
	Activity 3.3: Secure legal land rights for solar-powered borehole establishment.	Ministry of Finance, Development partners

A2: Technology action plan for Agriculture sector

Agriculture is a key component of Somalia's economy, meeting most of the country's food requirements, making a substantial contribution to the Gross Domestic Product (GDP), and representing a considerable portion of the country's export revenue. The

inconsistent and unpredictable weather patterns are expected to disturb agricultural schedules, leading to significant losses.

This report's Chapter 2, on the Agriculture Technology Action Plan, begins with a brief overview of the industry before summarizing the obstacles and solutions for the two agriculture sector technologies that have been given priority. The chapter also lays out some goals for the country's technology transfer and dissemination efforts. The suggested targets are:

i) Over the next eight years, set up drip irrigation systems on 150,000 hectares of land.
ii) Establish 18 new meteorological observatories in 18 regions nationwide.
iii) Setup of a network of two hundred automated weather stations and the associated communication infrastructure.
iv) Establish Flood Warning Systems in High-Risk Areas.
v) Establish a national meteorological centre.

Drip irrigation systems have been recognized as a technology of priority in the agriculture sector due to their potential to increase agricultural productivity and facilitate more efficient water usage by farmers. A number of barriers to the spread of the technology were identified, including the expensive cost of technology and lack of technical skills. The action plan proposes activities for the diffusion of drip irrigation technology as shown in the following table.

Summary Matrix for Drip Irrigation TAP

Sector	Agriculture Sector	
Sub-Sector	Water and Irrigation	
Technology	Drip Irrigation	
Ambition	Set up drip irrigation systems on 150,000 hectares of land by 2032	
Benefits	Advancements in farming methods and the management of soil fertility, improved replenishment of ground water and less runoff, adaptability to climate change and food security.	
Action	**Activities to be implemented**	**Sources of funding**
Action 1:	Activity 1.1: Engage commercial enterprises to construct the drip irrigation infrastructure	Ministry of Finance, Private sector, climate fund

Invest public funds in drip irrigation systems	Activity 1.2: Offer direct support to farmers in the setting up and management of drip irrigation systems	Ministry of Finance, Climate fund
Action 2: Build capacity of extension officers and farmers in managing drip irrigation systems	Activity 2.1: Train extension personnel to provide advisory support for drip irrigation systems	Ministry of Finance, Climate fund
	Activity 2.2: Support extension personnel in establishing active relationships with farmers utilising drip irrigation	Ministry of Agriculture and Irrigation, development partners
	Activity 2.3: Conduct practical training and demonstrations on how to operate drip irrigation systems	Ministry of Finance, Ministry of Agriculture and Irrigation, climate fund
	Activity 2.4: Facilitate the management of drip irrigation systems by enhancing the capacity of water user communities and farmer groups	Ministry of Agriculture and Irrigation, MoEWR
Action 3: Mitigate the likelihood of disputes over water, land, and infrastructure ownership	Activity 3.1: Establish equitable principles	Ministry of Finance
	Activity 3.2: Engage the community in conversations about the requirements for drip irrigation management.	Ministry of Finance

Early warning systems are crucial for disaster preparedness and mitigation. There are four main operating components in the system: (i) Processes including monitoring, analysing, predicting, and creating alerts; (ii) Evaluation of possible hazards and incorporation of risk data into alert messages; (iii) Distribution of timely, trustworthy, and intelligible warning messages to authorities and the population at risk; (iv) Community-oriented emergency planning, readiness, and training initiatives. Key barriers to the development of this technology include high development and operation costs, as well as limited skilled human resources. The following actions are proposed for the development of early warning systems in Somalia.

Summary Matrix for Early Warning Systems TAP

Sector	Agriculture Sector	
Sub-Sector	Environment and Climate Change	
Technology	Early Warning Systems	
Ambition	Establish 18 new meteorological observatories in 18 regions nationwide; Setup a network of two hundred automated weather stations and the associated communication infrastructure; Establish Flood Warning Systems in High-Risk Areas; Establish a national meteorological centre; Strengthening the current mechanism for communicating hazards information	
Benefits	Emergency preparedness, response, and risk management from accurate early warning information and well qualified personnel; Enhanced warning and forecast products for use in effective planning and management systems for disaster risk reduction; Protecting a greater number of human lives through proper timing of disaster response	
Action	**Activities to be implemented**	**Sources of funding**
Action 1: Increase funding for the improvement of disaster monitoring, forecasting, and early warning services	Activity 1.1: Increase budgetary allocations for early warning systems in relevant departments	Ministry of Finance, Development partners, Climate Fund
	Activity 1.2: Mobilise funds and resources from development partners for modernization and automation of current observatories	Ministry of Finance, Development partners, Climate Fund
	Activity 1.3: Increase budgetary allocations and mobilise resources for establishment of a forecasting and warning system for flash floods in susceptible locations	Ministry of Finance, Development partners, Climate Fund
Action 2: Enhance technical capacity, particularly for human resources related to early waning of issuance, disaster preparedness, and response management	Activity 2.1: Conduct need-based training to professional staff from national meteorological, climate change, and disaster risk management institutions	Ministry of Finance, Development partners
	Activity 2.2: Carry out risk assessments to produce new, reliable location-based risk data and insights	Ministry of Finance, Development partners
	Activity 2.3: Organize specialised workshops for staff development and training	Ministry of Environment and Climate Change

	Activity 2.4: Improve modelling approaches by collaborating with WMO and other regional and international meteorological networks	Ministry of Finance, Development partners, Climate Fund
	Activity 2.5: Set-up additional meteorological observatories in regions prone to hazards	Ministry of Finance, Development partners, Climate Fund
Action 3: Enhance the country's mechanism for early warning communication and dissemination of vital information	Activity 3.1: Identify and involve the active community organisations that are already in place to assist with emergency preparedness drills	Ministry of Environment and Climate Change
	Activity 3.2: Train key stakeholders in information dissemination through social media platforms and networks	Ministry of Environment and Climate Change
Action 4: Strengthen and expand collaboration and coordination with other pertinent regional and international organisations	Activity 4.1: Foster knowledge transfer by developing collaborative programs and partnerships with meteorological research institution specialists from regional and international institutions	Ministry of Finance, Ministry of Environment and Climate Change, Development partners, Climate Fund
	Activity 4.2: Collaborate and partner with regional, national, and local initiatives to exchange information, knowledge, and data	Ministry of Environment and Climate Change, Development partners

B. Project ideas for agriculture & water sectors

Project idea-1: Expanding opportunities for joint investments and collaboration in rooftop rainwater harvesting.

The main objectives of the project are to i) boost cooperation across the housing, infrastructure, agriculture, and water sectors; ii) Create cooperation between the public and private sectors to overcome the high costs that are associated with installation of RRWH; iii) Strengthen RRWH's advisory support capabilities. The overall budget for the planned project is US $2.454 million, and it will be implemented over a three-year period.

Project idea-2: Advisory support and the enhancement of local fabrication capabilities for solar-powered boreholes.

The following are the objectives of the proposed project: i) give young people in rural areas the skills they need to start their own businesses in making solar-powered borehole equipment and accessories and fixing them; ii) promote and exhibit solar-powered borehole equipment and accessories that are manufactured locally; iii) enhance extension officers' capabilities to provide advisory support for solar-powered boreholes. The project will be carried out over a 3-year period with a budget of US $3.411 million.

Project Idea-3: Build capacity of extension officers and farmers in managing drip irrigation systems

The project's primary goals are to i) train extension personnel to provide advisory support for drip irrigation systems; ii) enhance the capacity of community organizations to manage drip irrigation systems. The proposed project has a budget of $990,000 and is set to be implemented over three years.

Project Idea-4: Enhancing Somalia’s Capacity for Early Warning System

The proposed project intends to increase the Somalia Meteorological Department's capacity in of early warning systems. It is anticipated to accomplish the following significant goals: i) enhance technical capacity, particularly for human resources related to early warning issuance at regional centres; ii) improve the country's mechanism for early warning communication and dissemination of vital information; iii) enhance institutional capacity by establishing and reinforcing connections with partner organizations and important stakeholder groups. The proposed project is intended to be implemented over three years with a total budget of $14.96 million.

CHAPTER 1: Technology Action Plan and Project Ideas for the Water Sector

1.1 TAP for the Water Sector

1.1.1 Sector Overview

Water is crucial for Somalia's growth across social, economic, and environmental aspects. The National Development Plan 2020-2024 (NDP-9) highlights the need for Somalia's economy to grow in order to alleviate the country's extreme poverty. It also emphasises the importance of managing water resources well and developing them sustainably in order to support the country's growth and development.

The National Water Resources Strategy (NWRS) is anticipated to provide the water industry the much-needed boost it needs to reform holistically and to prioritise projects that address major issues impeding growth and development. With careful stakeholder participation, this NWRS was developed to help and bolster Somalia's National Development Plan 2020–2024 developmental goals (MoEWR, 2021). The process to regularise the Somalian water sector will require structured action over time. This first NWRS cannot accomplish all that the Federal Government of Somalia has to undertake in support of water sector reforms; rather, it demonstrates the government's commitment to performing incremental initiatives that reflect gradual realisation of the country's developmental goals. The availability of sufficient quality water has a direct impact on Somalia's ability to meet most of the Sustainable Development Goals (SDGs).

Vulnerability of the sector

As of 2017, Somalia had 411 m^3 of renewable fresh water per person, making it a water-scarce country (World Bank, 2020). With significant population increase, present per capita levels will fall further in the future decades. In certain parts of Somalia, the ongoing reduction in freshwater availability has led to conflicts and intense competition for the few available water resources. Somalia is a water scarce country, having roughly 411 m^3 of sustainable freshwater per capita in 2020 (World Bank, 2020), which is way below the UN suggested requirement of 1000 m^3 per capita per year. Furthermore, as a result of climate change, which has already been demonstrated by frequent floods and droughts, these problems will get worse. In 1962, the per capita sustainable freshwater in Somalia was estimated at 2,087 m^3 (MoEWR,

2021)). Future droughts and floods are predicted to be more severe due to rising variability and an anticipated little rise in the mean annual rainfall over the next several decades. The mean annual rainfall is anticipated to rise by 1%, 3%, and 4% by 2030, 2050, and 2080, respectively (using the 1981–2000 reference period) (FGS, 2019). Water scarcity and shortage are the possible outcomes, which might result in long-distance trekking, consumption of unsafe water, population migration, conflicts, and interruption of hydroelectricity output.

The recent COVID-19 pandemic refocused attention on water, sanitation, and hygiene, which become critical components in the fight against disease transmission. As a result, it became evident how urgent it was to improve water quality standards, equitable water supply, management and control of water resources, and water infrastructure, as more than 47% of Somalis lack access to WASH services (Mourad, 2020). Water governance in Somalia suffers from a lack of horizontal and vertical cooperation between water sector organisations and entities that support socioeconomic development. These institutions frequently operate with constrained resources and overstretched capacity to support development and address climate extremes.

Outside of the more stable regions of Puntland and Somaliland, there is very little activity in the water supply and sanitation (WSS) sector in Somalia. Two-thirds of the country (South-Central Somalia), including rural regions, lack any formal WSS institutional framework or governance. Boreholes and shallow wells provide water to the majority of Somalis. Shallow wells are generally found in areas where water quality is frequently degraded as a result of surrounding latrines leaking their contents into the groundwater. This results in regular epidemics of waterborne illnesses including cholera and diarrhoea (USAID, 2022).

The situation in Somalia is thus complicated, but it also offers an opportunity to create a future that is more robust. Climate shocks and the resulting risks will progressively aggravate social and political disruptions as well as economic shocks, with the capacity to manage the repercussions across sectors becoming increasingly difficult (UNICEF, 2020). This will necessitate the continuous cooperation of the international development community, as well as the corporate sector and civil society. Recognizing the numerous issues confronting Somalia's decreasing water resources, the Federal

Government of Somalia continue to take proactive steps to protect Somalia's water resources as shown in Table 1. Non-State Actors and development partners are also funding water projects to increase availability and access to freshwater sources.

Table 1: Existing policies and measures related to the sectors development and technology deployment.

Policy	**Main content**	**Target**
Somalia NDC	Somalia NDC identifies the water resources management as one of the priority sectors for intervention	Establish and maintain strategic water reserves mega-dams, shallow wells to capture runoffs Invest in basic and portable water supply households for households Construct and operationalise water pans Promote rainwater harvesting and conservation of water, including improved water use efficiency Implement integrated Water resources Management strategy
National Water Resources Strategy (NWRS), (2021)	The main objective of the NWRS's provisions is to contribute to the strategic plan for the various activities that are needed to address challenges in the water sector in the short- and long-term. Its goals include a) establishing a functional water sector governance framework, b) Operationalising Integrated Water Resources Management, and c) Improving the Provision of Priority Water Services	Develop Policies, legislation, and strategies for improved water sector governance by 2025. Implement water conservation and water demand management by 2025. Ensure gender and equity is integrated into water service delivery by 2025.

		Plan and develop water sector infrastructure by 2025.
WASH Sector Policy, (2019)	The Federal Government's strategy to enhance water and sanitation services nationwide is embodied in the national WASH policy. It includes a number of policy initiatives pertaining to the provision of water services, including water quality, community-level water resource management, and urban and rural water supply.	To improve water supply coverage for the urban and rural population from the current average level of 40% to 70% by year 2023. Provision of adequate safe water (25 litres/person/day) to all urban and rural households and on-site sanitation systems.
Livestock Sector Development Strategy (LSDS), (2019).	The LSDS outlines several complementary policy actions that are important to the livestock and water sectors. It specifically recommends the restoration of water resources associated with rangelands, the creation of land use methods to reduce conflict over resource sharing, and the improvement of animal nutrition by increasing availability to water and feed for cattle.	Initiate a national program for building small dams and water catchments in rangelands.
National Climate Change Policy (2020).	This policy elaborates on the critical role of water in the country's socioeconomic growth, as well as the impact of climate change on this dynamic. It identifies thirteen sub-policies that address climate change resilience in the water industry.	Promote and strengthen the implementation of adaptation and disaster risk reduction measures to reduce vulnerability to climate change.'
National Adaptation Programme of Action (NAPA) (2013)	The NAPA lays out priority action areas for the following key sectors: water, agriculture and food	Improve access to water by providing piped water to urban areas and IDP camps.

	production, livestock, and natural resources, among others. The NAPA also suggests adaptations measures for these sectors.	Improve water capture and natural storage through improved land management. Improve water quality through water treatment plants that should be constructed alongside large-scale water storage projects, low-cost water treatment at the community level and legislation for water pollution control

Table 2: Selected Technologies

Technology	**Current level of uptake**	**Future Targets**
Rooftop Rainwater Harvesting	Less than 5% of water supply	RRWH will be boosted by establishing rainwater harvesting systems for demonstration, and establishing RRWH systems through incentives by 2032 (Somalia NDC 2021)
Solar-powered boreholes	Less than 5% of water supply	Solar-powered boreholes are to be enhanced by establishing new units by 2032, and understanding and strengthening groundwater quality (NWRS 2021-2025, Somalia NDC, 2021)

1.1.2. Action Plan for Rooftop Rainwater Harvesting

The process of rooftop rainwater harvesting involves collecting rainwater from roof tops, court yards, and low-traffic roadways, and storing it near homes (Goyal, 2014). The primary benefit of RRWH is that it supplies water close to the home, reducing the

need for long excursions to collect water (Kahinda et al., 2007). Harvested rainwater is a clean, renewable supply of water that may be utilised for residential uses, gardening, and small-scale activities. It also helps lessen the likelihood of flooding and the strain on sewage systems. The affordability, accessibility, and ease of maintenance of a rainwater harvesting system at the household level are what make it so appealing.

Roof top rainwater harvesting appears to be a useful approach for reducing water shortages in developing countries. It allows households to directly manage their water supply without relying on electricity or chemicals to purify the water. To increase system performance and water supply reliability, the RRWH system must be designed and evaluated properly (Mun and Han, 2012). The primary design characteristics for a RRWH system are rainfall, catchment area, collection efficiency, tank volume, and water demand. A basic RRWH system consists of a roof surface, gutters, pipes, a storage tank, filters, waterproofing agents, and tap fittings. First-flush diverters, a pump, firm or concrete ground under the taps, and channels to drain off surplus water in ways that reduce muddy conditions and soil erosion are other essential accessories.

Rainfall in Somalia often fluctuates, with the middle and lower Juba and coastal portions of the middle Shabelle receiving 700-800 mm/year, while other locations farther inland receive up to 400 mm/year (Muchiri, 2007). One millimetre of harvested rainwater is equal to one litre of water per square metre, according to Helmreich and Horn (2009). Systems for collecting rainwater can be created on both a local and big scale. Storage tanks are prefabricated or built-in structures on the surface, underground, or partially submerged. Based on an expected daily per capita water use of 20 litres, a rural home of six people should have a storage tank size of more than 10 m^3 to assure an all-year supply in a bimodal rainfall area.

RRWH's socioeconomic benefits include expanded work possibilities, investment opportunities in the production of RRWS components, an increase in the number of harvesting seasons, and greater revenue. Environmental benefits include the elimination of the requirement for energy and chemicals typically utilised in clean water production. By reducing runoff and hence the risk of floods, extensive rainwater harvesting can lessen the strain on rivers and groundwater.

1.1.2.1 Ambition for the TAP

Rainwater harvesting may possibly provide water for home consumption, animal watering, and irrigation to many rural communities in Somalia with an average annual rainfall of 400 to 800 mm; however, adoption of this technology is still in its infancy. In order to adapt to climate change, the goal is to transfer and use RRWH by 2032, with the aim of establishing 261,000 rainwater collecting tanks, each measuring about 10 m^3, to serve 1,500,000 people annually in Somalia.

1.1.2.2 Actions and Activities selected for inclusion in the TAP

Table 3: Barriers and measures to overcome barriers.

Barrier Category	Barrier	Measure
Financial	The private sector has not shown interest in investing in rooftop rainwater harvesting	Enable effective private sector participation in RRWH.
	Low-income households can't afford to venture into RRWH	▪ Improve households' access to funding for RRWH ▪ Make available affordable RRWH systems
Non-financial barriers	Low extension advisory capability to assist RRWH	Bolster RRWH's technical capabilities
		Boost local understanding of RRWH
		Demonstrate the worth of RRWH under various climatic scenarios.
		Create a database or catalogue with information about RRWH technology.

Actions selected for inclusion in the TAP

The actions indicated in the TNA for overcoming obstacles to technology adoption served as the foundation for the actions chosen in this section. The previously defined measures in the TNA were converted into a list of Actions, which were then developed

into a collection of particular activities required to carry out an Action. The set of actions prioritised in this section are designed to enhance market penetration and ensure government and non-state actor involvement.

a) Boost cooperation to ensure that RRWH policy provisions are implemented

Cooperation between the government and non-governmental organisations promoting RRWH is necessary to prevent excess in certain regions and neglect in others. The agricultural and water sectors must collaborate closely and harmonise their planning and regulatory procedures in order to fully fulfil the potential of acquiring water for domestic and agricultural use. RRWH projects should prioritise gender inclusion as well (Baguma et al. 2012, Staddon et al. 2018, Grant et al. 2017).

b) Create a database or catalogue with information about RRWH technology

The current rainwater harvesting guidelines by Odour and Gadain (2007), which provide technical specifications for design and construction as well as alternatives for varying home sizes, materials, and related accessories, should be extensively publicised and translated into local languages. Additionally, communities require a RRWH catalogue to learn about supplementary equipment and accessories, a database on the cost and availability of various designs, service provider connections, and specific information for locations such as the livestock corridor (Durodola et al. 2020, Kiggundu et al. 2018).

c) Improve households' access to funding for RRWH and make available affordable RRWH systems through private sector engagement

Financial assistance is required to help rural households build RRWH systems. These include providing subsidies for the installation of RRWH technology, improving local savings and credit institutions, and merry-go-round initiatives. This may make it easier for low-income households to make initial investments in RRWH. Encouraging local producers of RRWH systems may also lower import expenses and boost RRWH system availability.

d) Bolster RRWH's technical capabilities

Create a thorough training programme for RRWH and a job structure to hire technical staff at the local government level. This may also be accomplished by providing

training to rural masons, households, and communities in RRWH, including how to fabricate parts and build storage tanks using materials that are readily accessible (Adler et al. 2014). Groups of households can also be organised to finance the purchase of shared storage for nearby households that have limited roof spaces.

Activities Identified for Implementation of Selected Actions

a) Boost cooperation to ensure that RWH policy provisions are implemented

- Establishing a network with all of the important RRWH players
- Non-governmental organizations, private sector players, farmers, and other pertinent players should be organised to create a local RRWH coordination committee, along with technical specialists from the water, agricultural, and other relevant government sectors.
- Determine the potential volume predicted, the socioeconomic potential to invest under various climatic scenarios, and the potential sites and stakeholders for RRWH by conducting research on the potential of RRWH at each district.
- Mobilize resources and implementation players to carry out the RRWH plan.

b) Create a database or catalogue with information about RRWH technology

- Create an information sharing centre on RRWH
- Create a RRWH catalogue with data that will allow for business development between sellers and customers of RRWH equipment and services.
- Create awareness for current handbook and catalogue
- Translate the current handbook and catalogue into important local languages
- Add e-version features like audio and video, and an interactive Q&A platform with input from technology users.

c) Improve households' access to funding for RRWH and make available affordable RRWH systems through private sector engagement

- Establish leasing schemes, soft loans, and subsidies.

- Lower taxes on finished tanks and other RRWH components to encourage suppliers to expand.
- Draft proposals for community organisations obtain funding for RRWH at phases that require a lot of capital.
- Train small and medium-sized businesses in building their ability to invest in the provision of equipment and services for RRWH.
- Form alliances with players in the private sector to offer soft loans, either in cash or in kind, for RRWH harvesting equipment.

d) Bolster RRWH's technical capabilities

- Strengthening curricula of existing institutes or centres in RRWH exploitation, installation, and maintenance.
- Conduct demonstration projects and research on the effectiveness of RRWH.
- Develop RRWH curriculum for technical educational institutions.

Actions to be implemented as Project Ideas

A concerted, cross-sectoral effort will be needed to promote RRWH to make sure that Somalia fully utilises its rainfall endowment, particularly in areas where bimodal seasons are common. Apart from facilitating government sector cooperation, it is imperative to allow the private sector to effectively participate in the transfer and dissemination of RRWH technology. Lack of knowledge, particularly on available alternatives and technical assistance for installation and operation, is a major obstacle to the adoption of RRWH. As a result, the following actions have been selected to be carried out as project ideas:

1. Enhance collaboration and coordination across sectors for RRWH implementation.
2. Create a database or catalogue with information about RRWH technology.
3. Provide accessible, reasonably priced RRWH systems by working with the private sector.
4. Bolster RRWH's technical capabilities

1.1.2.3 Stakeholders and Timeline for implementation of TAP

Table 4: Overview of Stakeholders for the implementation of the TAP

Stakeholder	Role
MoEWR	Improve coordination for developing national strategies and budgets for RRWH
Ministry of Finance	▪ Organize and assist with the RRWH equipment and enforcement tax adjustments. ▪ Reach soft loans agreement for RRWH equipment.
Local administration, water and agricultural officers	▪ Organize and form district- and lower-level stakeholder committees for RRWH planning, implementation, monitoring, and assessment. ▪ Provide advisory and extension support for RRWH.
Vocational institutes, Technology Centres and universities	▪ Strengthen curricula on RRWH. ▪ Conduct research on RRWH.
Private sector	▪ Supply the essential equipment and materials. ▪ Provide recommendations on regulatory issues affecting enterprises. ▪ Provide specifics on the RRWH equipment and materials. ▪ Inform users of the benefits of RRWH to boost demand for equipment and supplies. ▪ Create a plan for promoting commercial rainwater storage products and offer guidance.
NGOs	▪ Capacity building and monitoring of RRWH implementation data. ▪ Participate in developing and popularizing a guide for RRWH and evaluating its efficacy. ▪ Encourage the establishment of financial community organisations to get funding for RRWH
Media	▪ Increase awareness of RRWH technology
Men, women and youth farmers	▪ Incorporate farmer requirements into RRWH strategies and encourage cooperation among farmers.

Table 5: Scheduling and sequencing of specific activities

Activity	Scale	Year							
		2024-2025	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032
Develop national strategy for RRWH	National	xxx	xxx						
Investigate the potential of RRWH	Regional	xxx	xxx						
Establish regional committees to coordinate RRWH.	Regional			xxx					
Formulate regional RRWH strategies	Regional				xxx	xxx	xxx		
Put the RRWH strategy into action	Regional						xxx	xxx	xxx
Integrate a data and information sharing platform	Regional							xxx	xxx
Create an information database/catalogue on RRWH technology									
Research to create the RRWH catalogue	National	xxx	xxx						
Translate and create awareness of the current catalogue and guidelines	National			xxx	xxx				
Facilitate the active involvement of the private sector in RRWH									
Lower taxes on RRWH equipment	National		xxx	xxx					
Form alliances with RRWH funding organisations	National			xxx	xxx	xxx			
Provide capacity support to SMEs in RRWH.	Regional					xxx	xxx		
Draft proposals for communities to acquire financing for RRWH.	Regional						xxx	xxx	xxx
Bolster RRWH's technical capabilities									

Strengthen curricula of existing institutes/centres in RRWH exploitation, installation, and maintenance.	National	xxx	xxx						
Conduct demonstration projects and research on the effectiveness of RRWH.	Regional			xxx	xxx				
Develop RRWH curriculum for technical educational institutions.	National	xxx	xxx						

1.1.2.4 Resource Needs Estimation

Needs for capacity building

Critical government and non-government organisations are involved in the formulation of regional-level coordination committees as part of the plan for RRWH diffusion. Collaboration with non-governmental organisations and vocational colleges to educate and teach local artisans and community members in the construction and installation of RRWH may also be required. It's also important to have the capacity to collect and direct water from different roofs, especially in areas with small houses, into a common reservoir that can then be shared out.

Table 6: Estimations of costs of actions and activities

Action	**Activity**	**Cost (USD)**
Improve coordination in RRWH implementation	Develop national strategy for RRWH	**7,000**
	Determine each region's RRWH potential through research	**21,000**
	Establish regional RRWH coordinating group	**36,500**
	Formulate RRWH strategies for the regions.	**66,000**

	Put the RRWH strategy into action	**45,000**
	Integrate a data and information sharing platform at regional level	**232,000**
Sub Total		**407,500**
Create an information database/catalogue on RRWH technology	Conduct research to create a RRWH catalogue	**7,200**
	Translate and create awareness of the current catalogue and guidelines	**8,000**
Sub Total		**15,200**
Enable effective private sector participation in RRWH	Lower taxes on RRWH equipment	**43,000**
	Form alliances with RRWH funding organisations	**48,000**
	Provide capacity support to SMEs in RRWH.	**852,000**
	Draft proposal for communities to acquire financing for RRWH	**30,000**
Sub Total		**973,000**
Bolster RRWH's technical capabilities	Strengthen curricula of existing institutes/centres in RRWH exploitation, installation, and maintenance	**7,200**
	Conduct demonstration projects and research on the effectiveness of RRWH	**105,000**
	Develop RRWH curriculum for technical educational institutions	**7,200**
Sub Total		**119,400**
Total		**1,515,100**
Project Admin Cost (15%)		**227,265**
Grand Total		**1,742,365**

Table 7: Risks and Contingency Planning

Activity	Risks	Contingency Plan
Improve RRWH coordination		
Develop national strategy for RRWH	▪ Delay in decision making. ▪ Uncertain allocation of financial resources and responsibilities	▪ Establish a schedule of action that is mutually agreed upon. ▪ Establish a committee and budget that spans multiple sectors. ▪ Precisely define roles and responsibilities.
Investigate the potential of RRWH in each region	Insufficient and unreliable data regarding the current state of RRWH	Determine the RRWH potential of sample regions through field research.
Establish regional committees to coordinate RRWH.	▪ Reluctance by community members to serve in committees. ▪ Disengaged members of the committee. ▪ The politicisation of committees	▪ Elucidating the value of the committees. ▪ Providing benefits beyond monetary compensation. ▪ Careful screening of committee members. Outlining the roles and tasks of the committee.
Formulate regional RRWH strategies	▪ Not much action taken on issues. ▪ Delays in budgetary allocation.	▪ Report on issues discussed. ▪ Encourage those taking up follow-up responsibilities.
Execute the RRWH strategy	▪ Actors not working together. ▪ Unreasonable demands from actors.	▪ Disclosing and discussing the conditions of implementation with all actors. ▪ Motivating actors to work together.
Integrate a data and information sharing platform at regional level	▪ Outdated information ▪ Low maintenance of the data platform. ▪ Insufficient resources to operate the data and information platform. ▪ Low utilisation of the information.	▪ Make regular updates to the data and information platform. ▪ Customize information and data for various users.

	▪ Inadequate access to digital platforms.	▪ Utilize widely accessible radio to disseminate information updates.
Create an information database/catalogue on RRWH technology		
Research to create the RRWH database/catalogue	Users not having easy access to database/catalogue information.	Raise awareness of the manual via radio and other easily accessible media.
Translate and create awareness of the current catalogue and guidelines	Limited channels for information dissemination	Involve the local government in the dissemination of information.
Facilitate the active involvement of the private sector in RRWH		
Lower taxes on RRWH equipment and materials	▪ The tax cut may not be adequate to render RRWH equipment affordable. ▪ No political goodwill	▪ Subsidies for service installation. ▪ Involve lobby groups and policy influencers
Form alliances with RRWH funding organisations	Financial institutions may find it unprofitable	In-kind loans
Provide capacity support to SMEs in RRWH.	Disinterest among SMEs to enter the RRWH industry	Offer incentives to encourage SME participation in RRWH.
Draft proposals for communities to acquire financing for RRWH	Insufficient financial management skills	Develop the financial management and governance expertise of community leaders
Bolster RRWH's technical capabilities		
Strengthen curricula of existing institutes/centres in RRWH exploitation, installation, and maintenance.	Bureaucracies within and outside the institutions.	Raise awareness on the need to strengthen curricula.
Conduct demonstration projects and research on the effectiveness of RRWH.	Inadequate financing and expertise.	Seek funding from development partners.
Develop RRWH curriculum for technical educational institutions.	Bureaucracies within the institutions and outside the institutions.	Raise awareness on the need to strengthen curricula.

Next Steps

To meet the immediate requirements for increasing the diffusion of rooftop rainwater harvesting for purposes of climate change adaptation, the following will be necessary:

- To design a collaborative RRWH plan for specialised groups of users, coordination between the appropriate Ministries, such as the MoEWR, the Ministry of finance, and the Ministry of environment and climate change, is required.
- Approaches for involving the private sector in a manner that justifies expanding access to RRWH equipment from a business perspective.

Critical requirements include:

- Consultation with building and water engineers and technicians to ensure that RRWH is incorporated in house plans.
- Rules, regulations, and incentives that encourage RRWH.

TAP Overview Table

Table 8: Rooftop Rainwater Harvesting Overview Table

Sector	Water Sector
Sub-Sector	Water, Sanitation and Hygiene (WASH)
Technology	Rooftop Rainwater Harvesting (RRWH)
Ambition	Establish 261,000 rainwater harvesting tanks of about 10m^3 to serve 1,500,000 persons in up to 18 regions by 2032
Benefits	Help more people have access to potable water, lessen the strain on surface and underground water supplies, shorten the distances and time that women and children must travel, and makes more water available for irrigating crops and cattle.

Action	**Activities to be implemented**	**Sources of funding**	**Responsible body and focal point**	**Time frame**	**Risks**	**Success criteria**	**Indicators for Monitoring of implementation**	**Budget (USD)**
Improve coordination in RRWH implementation	Develop national strategy for RRWH	Ministry of Finance, Development partners	MoEWR	Years 1-2	Delay in decision making. Uncertain allocation of financial resources and responsibilities	A National Strategy Developed	A National Strategy report published	7,000
	Determine each region's RRWH potential through research	Ministry of Finance, Climate Fund, Development partners,	MoEWR	Years 1-2	Insufficient and unreliable data regarding the current state of RRWH	A study on RRWH conducted	Study reports and published results	21,000

	Establish regional committees to coordinate RRWH	Ministry of finance, Development partners	MoEWR, Ministry of Planning, Investment and Economic Development	Years 3	Reluctance by community members to serve in committees.	Functional RWH committees	Recordings and documents of the establishment of committees, reports, by-laws	36,500
	Formulate RRWH strategies for the regions	Development partners	MoEWR	Years 4-6	Not much action taken on issues	RRWH draft strategy	Minutes and reports of meetings	66,000
	Put the RRWH strategy into action	Development partners	Water Supply & Sanitation Department.	Years 6-8	Actors not working together	Functional committee of RRWH actors established and strategy put into action	MOU documents	45,000
	Integrate a data and information sharing platform at regional level	Development partners	Ministry of Information	Years 7-8	Insufficient resources to operate the data and information platform	Users utilizing the data and information platform	Number of user visits, information, data and material added to the platform	232,000
Create an information database/catalogue on RRWH technology	Conduct research to create a RRWH catalogue	Ministry of Finance, Development partners	MoEWR, Ministry of Information	Years 1-2	Users not having easy access to database/catalogue information	Findings utilized in improving the RRWH catalogue	Reports and publications on the study findings	7,200

	Translate and create awareness of the current catalogue and guidelines	Ministry of Finance, Development partners	MoEWR, Media	Years 3-4	Limited channels for information dissemination	Adverts running on mainstream media, Guidebook translated in local languages	Number of languages translated, number of adverts	8,000
Enable effective private sector participation in RRWH	Lower taxes on RRWH equipment	Ministry of Finance, MoEWR	Somalia Revenue Directorate	Years 2-3	The tax cut may not be adequate to render RRWH equipment affordable	Tax reduced on RWH equipment	Tax review reports and minutes, Percentage of tax reduced	43,000
	Form alliances with RRWH funding organisations	MoEWR	MoEWR, Federal Government	Years 3-5	Financial institutions may find it unprofitable	Alliances formed, Increased access to finance for RRWH	MOU documents on alliances, number of loans disbursed	48,000
	Provide capacity support to SMEs in RRWH.	Ministry of Planning, Investment and Economic Development, MoEWR, Development partners	MoEWR, Regional administration, Technical Support departments	Years 5-6	Disinterest among SMEs to enter the RRWH industry	SME workshops conducted, Equipment for RRWH	Number of RWH systems sold by suppliers' workshop	852,000

	Help communities acquire financing for RRWH	Development partners	MoEWR, Federal Government	Years 6-8	Insufficient financial management skills	Financial Community groups established	The number of RRWH financial community groups that have obtained financing	30,000
Bolster RRWH's technical capabilities	Strengthen curricula of existing institutes/centres in RRWH exploitation, installation, and maintenance	Federal Government	Ministry of Education	Years 1-2	Bureaucracies within and outside the institutions	Curriculum strengthened on RRWH	The number of institutions whose curriculum was on RRWH	7,200
	Conduct demonstration projects and research on the effectiveness of RRWH	Development partners,	Technical support departments, Higher Education Institutions	Years 3-4	Inadequate financing and expertise	Demonstration projects mounted and research conducted	Number of demonstration projects mounted	105,000
	Develop RRWH curriculum for technical educational institutions	Federal Government	Ministry of Education	Years 1-2	Bureaucracies within and outside the institutions.	Curriculum developed on RRWH	Number of institutions the developed curriculum was mounted	7,200

1.1.3 Action Plan for Solar Powered Boreholes

1.1.3.1 Introduction

The solar water pump technology has been in mass production since 1983. Research has demonstrated that the technology has undergone substantial advancements in the last three decades, as systems have become more versatile, cost-effective, and efficient (Hossain et al., 2015). Presently, the market offers a wide variety of pumps and systems that are appropriate for pumping shallow wells, deep wells, ponds, and streams.

Solar-powered boreholes have the capacity to work autonomously and convey water over a prolonged duration. This can aid in borehole pressure reduction by distributing yield over the course of the day. Moreover, in situations of severe demand, low cloud cover, or overnight, the tank storage capacity of such systems may serve as an essential buffer, allowing for the utilisation of surplus water. Although solar-powered systems can be appropriately sized to reach depths of 250 metres, they are often employed in boreholes that are less than 150 metres deep (Bamford and Zadi, 2016). A solar-powered borehole system capable of pumping water to a depth of 50 metres through a surface pipe that supplies a tank positioned 5 metres above ground level can serve around 2,000 individuals (Lorentz, 2012).

In contrast to motorised pumps, which are not only noisy but also polluting in terms of greenhouse gases emission, and are extremely subject to fluctuations in fuel prices, solar-powered pumps have been demonstrated to have nearly negligible operating expenses (Khan et al., 2014). Despite the initial expenditure being somewhat greater than that of motorised systems, solar powered systems are progressively gaining price competitiveness in markets with intense competition.

It is challenging to find information and data about Somalia's solar-powered boreholes. It is not the customs department's practice to formally collect data from local businesses. This complicates the task of precisely determining the market's dimensions and characteristics, especially in light of the unofficial distribution routes. However, unverified data sources from the Somalia Electricity Access Project (SEAP) suggests that there has been an upward trend in the purchase of standalone solar systems between the years 2019 and 2020. Despite this, Somalia has an ambition to

develop solar-powered boreholes as outlined in the countries NDC and the National Water Strategy 2021-2025 (MoEWR, 2021)

1.1.3.2 Ambition for the TAP

Meet the water needs of 25,000 households and farmers through 300 solar-powered boreholes by the 2032. The pastoral zones, as well as the northern eastern, and the central plateaus, which are characterised by a significantly extended dry season, are the target areas.

1.1.3.3 Actions and Activities selected for inclusion in the TAP

Table 9: Summary of barriers and measures to overcome barriers

Barrier category	Barrier	Measure
Financial	The costs are quite high, notably for the equipment, drilling operations, and maintenance, and there is also a limited supply of spare parts.	Cut down on groundwater extraction expenses through. ▪ Tax exemptions for drilling equipment. ▪ Investing in the production of components locally. ▪ Providing incentives for the private sector to tap into groundwater resources. ▪ Proliferation of technical service providers. ▪ Prioritizing boreholes with large diameter. ▪ Enhancing road connectivity to prospective borehole locations.
Non-financial	Low technical capacity for solar PV installation and constructing operating and maintaining deep wells	Strengthen knowledge in the technical aspects of managing and installing solar PV systems and boreholes.
	Underground water quality concerns	Improve subterranean water quality assurance
	Institutional weaknesses	Bolster institutions and organisations that manage

		groundwater and renewable energy

Actions selected for inclusion in the TAP

The actions indicated in the TNA for overcoming obstacles to technology adoption served as the foundation for the actions chosen in this section. The previously defined measures in the TNA were converted into a list of Actions, which were then developed into a collection of particular activities required to carry out an Action. The set of actions prioritised in this section are designed to enhance market penetration and ensure government and non-state actor involvement.

a) Cut down on groundwater extraction expenses

In situations where the expense of adequate standard parts is prohibitive, consumers may resort to using subpar parts. Promotion of strategies that facilitate local fabrication is required. There are areas where government funding is scarce, and private sector is not incentivized to invest in solar-powered borehole technology. Changing from small diameter wells to larger diameter wells, which can be mechanised and are more cost-effective in the long run, is essential.

b) Strengthen knowledge in the technical aspects of managing and installing solar PV systems and boreholes

The installation and performance of solar-powered deep wells have been severely hindered by a lack of sufficient capabilities. Users in the community, as well as those working in government and non-government organisations, require technical expertise on solar-powered boreholes. Major manufacturers of solar pumps should take the lead in certifying and educating private sector partners. Community Operators would benefit from supplementary and consistent training in solar pump operation (particularly in regard to day-to-day maintenance). Hydrogeology research must be bolstered in order to produce the knowledge necessary to locate suitable areas where enough groundwater development is both practical and profitable. This kind of information has to be compiled and shared into formats that everyone can understand.

c) Bolster institutions and organisations that manage groundwater and renewable energy

Incorporating groundwater recharge and contamination avoidance into water catchment management plans requires enhanced institutional and administrative frameworks as well as legal enforcement. Coordination is necessary to ensure the sustainability of solar-powered boreholes. This needs to happen across critical government sectors such as water, agriculture, and energy, as well as private and non-governmental organisations. Water user associations should be adequately trained to take responsibility of the technology, and then provided with funds for administration, mobilisation, and oversight to guarantee the installations' continued usefulness (Asaba et al. 2015). Creating and implementing regulations to control the use of groundwater is another area where they should receive adequate training. Also requiring streamlining are the institutions governing land title rights under the solar-powered borehole distribution strategy.

Activities Identified for Implementation of Selected Actions

a) Cut down on groundwater extraction costs

- To cut costs associated with borehole repair and to maintain rigorous quality regulations, enable local capability for the manufacturing of spare parts and the development of solar energy that will be more affordable and available for water users locally.
- Drill more large diameter boreholes than those with smaller diameter. Large diameter boreholes will reduce on the expenses of the equipment and will be able to supply a large number of households.
- Establish alliances with the private sector by offering incentives for the provision of necessary equipment.
- Introduce and implement tax waivers available for solar-powered borehole equipment.
- Determine through research places where solar-powered boreholes are viable from a hydrogeological and socioeconomic standpoint.

b) Strengthen knowledge in the technical aspects of managing and installing solar PV systems and boreholes

- Create a hands-on example of setting up and managing a model borehole in order for all to benefit from mutual learning.
- Adapt hydrogeology training for extension personnel to address the specific requirements of solar-powered boreholes, with the aim of enhancing their proficiency in ground water resource surveying.

c) Bolster institutions and organisations that manage groundwater and renewable energy

- Enhance the organisational capabilities of water user committees with regard to ground water management.
- Fund the operation of solar-powered boreholes by providing recurring financial assistance to water user committees.
- Get the legal right to use land in areas that could be good for solar-powered boreholes.

1.1.3.4 Stakeholders and Timeline for implementation of TAP

Table 10: Overview of TAP Implementation Stakeholders

Stakeholder	Role
MoEWR	▪ Formulate a strategy and budget for solar-powered boreholes at the national level. ▪ Control the installation of solar-powered boreholes by means of licencing. ▪ Facilitate the coordination of solar-powered boreholes by providing information and communication platforms. ▪ Assist with the acquisition of land necessary for solar-powered boreholes development.
Water user committees	Exercise local leadership in the administration, use, and maintenance of solar-powered boreholes.
Private sector	Producing and supplying accessories and equipment
Vocational institutes, Technology Centres and Universities	▪ Carry out studies to determine the feasibility of solar-powered boreholes.

	▪ Educate and train advisory officials and craftspeople on how to maintain solar-powered boreholes.
Development partners	Offer financial assistance
NGOs	▪ Help strengthen capacity for solar-powered borehole. ▪ Hold the government responsible for setting up and managing solar-powered boreholes.
Ministry of Finance, Somalia Revenue Directorate	Review and enforce tax adjustments

Table 11: Scheduling and sequencing of specific activities

Activity	**Scale**	**Year**							
		2024-2025	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032
Cut down on groundwater extraction costs									
Enable local production of spare components	Regional				xxx	xxx			
Drill more large diameter boreholes	Regional						xxx	xxx	xxx
Establish alliances with the private sector	Regional	xxx	xxx						
Determine viability of solar-powered boreholes	National		xxx	xxx					
Introduce and implement tax waivers for solar-powered borehole equipment	National	xxx							
Strengthen technical skills in solar PV systems and borehole management and installation									
Create a hands-on example of model borehole setup	National		xxx	xxx	xxx				
Design specialised solar-powered borehole courses	National	xxx	xxx						
Bolster institutions and organisations that manage groundwater and renewable energy									

Strengthen water user committees' governance capacity	National				xxx	xxx	xxx		
Support water users' committees with a recurrent budget	National						xxx	xxx	xxx
Secure legal land rights for solar-powered borehole establishment	National					xxx	xxx		

1.1.3.5 Estimation of Resources Needed for Action and Activities

Estimation of the needs for capacity building

For the purpose of enhancing the transfer and diffusion of solar-powered boreholes technology, the following capacity requirements are essential:

- Creating and implementing local management structures for solar-powered boreholes and providing operational and management training to water user group leaders. Clearly defined rules of governance should be in place for local leadership organisations. In order to keep committees functioning, it is necessary to keep them motivated and provide them with essential information on a regular basis.
- Providing the means for local production of solar and borehole equipment components and accessories and teaching fundamental mechanical troubleshooting skills.
- Increasing the competence of water advisory officers to encourage community involvement in the construction and maintenance of solar-powered boreholes.
- Developing a system for sharing data and information and showcasing solar-powered boreholes in action.

Table 12: Estimations of costs of actions and activities

Action	Activity	Cost (USD)
Cut down on groundwater extraction costs	Enable local production of spare components	**62,000**
	Venture in large diameter boreholes	**40,000**
	Determine viability of solar-powered boreholes	**31,000**
	Establish alliances with the private sector	**41,000**
	Introduce and implement tax waivers for solar-powered borehole equipment	**12,000**
Sub Total		**186,000**
Strengthen technical skills in solar PV systems and borehole management and installation	Create a hands-on example of model borehole setup	**394,000**
	Design specialised solar-powered borehole courses	**11,000**
Sub Total		**405,000**
Bolster institutions and organisations that manage groundwater and renewable energy	Strengthen water user committees' governance capacity	**235,400**
	Support water users' committees with a recurrent budget	**12,500**
	Secure legal land rights for solar-powered borehole establishment	**12,500**
Sub Total		**260,400**
Total		**851,400**
Project Admin Cost (15%)		**127,710**
Grand Total		**979,110**

1.1.3.6 Management Planning

Table 13: Risks and Contingency Planning

Activity	Risks	Contingency Plan
Cut down on groundwater extraction costs		
Enable local production of spare components.	Locally manufactured components may not be in high demand or may not be widely accepted.	Showcase locally made parts at water points to build trust.
Venture in large diameter boreholes.	▪ High costs of large diameter boreholes ▪ Costs of land acquisition	Plan a method of recouping costs by imposing fees on end users.
Determine viability of solar-powered boreholes.	Research timeframe misaligned with project timeline.	Expanding upon prior knowledge and employing a collaborative workforce of researchers.
Establish alliances with the private sector.	Disinterest from the private sector.	Use of non-financial incentives such as certification.
Introduce and implement tax waivers for solar-powered borehole equipment.	Noncompliance with decisions that have been agreed upon.	Involve the concerned authorities in decision making.
Strengthen technical skills in solar PV systems and borehole management and installation		
Create a hands-on example of model borehole setup.	▪ Lack of sufficient capital or personnel for the facility. ▪ Model out of sync with local circumstances.	▪ Work in tandem with non-governmental organisations and other development partners. ▪ Seek advice to tailor the model to specific local requirements.
Design specialised solar-powered borehole courses.	Inadequate logistics and trained manpower.	▪ Training of trainers in specialised solar-powered borehole courses. ▪ Provide time schedules for trainings
Bolster institutions and organisations that manage groundwater and renewable energy		

Strengthen water user committees' governance capacity.	Inadequate logistical support.	Supporting trained professionals in applying skills and knowledge.
Support water users' committees with a recurrent budget.	Inappropriate use of resources.	Frequent meetings to discuss accountability
Secure legal land rights for solar-powered borehole establishment.	Landowners' reluctance to cede their land for the project.	Demonstrate value of the project to landowners/community by showcasing the model projects.

Next Steps

The technology of solar-powered boreholes is currently being promoted by development partners, although there are challenges involved. Strengthening and improving local capacity is a first priority when it comes to spreading solar-powered borehole technology. This can be achieved through;

- Facilitating and endorsing local fabrication, expanding availability of spare parts and accessories, and imparting technical expertise in equipment operation.
- Fortifying existing local management frameworks by stablishing and sustaining water users' committees with transparent participation guidelines and responsibility to all affected parties.

Critical requirements

- Encouraging water advisory officers to become more proficient in solar-powered borehole maintenance through community participation.
- By performing a biophysical and socioeconomic feasibility analysis on solar-powered boreholes, it will be possible to identify situations in which private investment assistance might complement government investment in order to ensure long-term operation.
- A demonstration of solar-powered technology, particularly the big diameter model, will increase confidence in setting up and managing new systems and facilitate a greater comprehension of what is necessary.

TAP Overview Table

Table 14: Solar-Powered Borehole Overview Table

Sector	Water Sector
Sub-Sector	Water, Sanitation and Hygiene (WASH)
Technology	Solar-powered Borehole
Ambition	Supply 300 solar-powered boreholes to meet the water needs of 25,000 households especially those in drought-prone areas by the 2032
Benefits	The provision of clean water to 25,000 households, with a particular emphasis on regions susceptible to drought

Action	**Activities to be implemented**	**Sources of funding**	**Responsible body and focal point**	**Time frame**	**Risks**	**Success criteria**	**Indicators for Monitoring of implementation**	**Budget (USD)**
Cut down on groundwater extraction costs	Enable local production of spare components.	MoEWR, Development partners	MoEWR	Year 4-5	Locally manufactured components may not be in high demand or may not be widely accepted.	Locally made and installed solar-powered borehole equipment and accessories.	The number of locally based craftspeople that are technically capable of making borehole tools and accessories. The number of local factories that make solar-powered borehole tools and accessories.	62,000

	Venture in large diameter boreholes.	Development partners, Ministry of finance	Department of Water Development	Year 6-8	High costs of large diameter boreholes. Costs of land acquisition.	The water extraction facilities for large diameter boreholes are up and running.	Number of operational large-diameter boreholes drilled. Number of households that are utilising the service.	40,000
	Determine viability of solar-powered boreholes.	MoEWR, Development partners	MoEWR	Year 2-3	Research timeframe misaligned with project timeline.	Publicly published report on the viability of solar-powered boreholes that informs installers.	Report on the viability of solar-powered boreholes.	31,000
	Establish alliances with the private sector.	MoEWR	Department of Water Development	Year 1-2	Disinterest from the private sector.	Interest from the private sector in solar-powered boreholes.	Number of privately owned businesses engaged in solar-powered boreholes.	41,000
	Introduce and implement tax waivers for solar-powered borehole equipment.	Ministry of Finance, Revenue Directorate	Somalia Revenue Directorate	Year 1	Non-compliance with decisions that have been agreed upon.	Implementation of a tax exemption law for solar-powered borehole equipment.	Documentation of solar-powered borehole equipment that reflects exemption from tax.	12,000

Strengthen technical skills in solar PV systems and borehole management and installation	Create a hands-on example of model borehole setup.	MoEWR, Development partners	MoEWR, universities, Technical and Vocational institutions.	Year 2-4	Insufficient capital or personnel for the facility. Model out of sync with local circumstances.	A functional example of a borehole that facilitates information sharing about solar-powered boreholes and showcases the technology.	No. of operational solar-powered borehole demonstrations set up at the local level.	394,000
	Design specialised solar-powered borehole courses.	Ministry of Finance, Development partners	MoEWR, universities, Technical and Vocational institutions.	Year 1-2	Inadequate logistical support.	Integration of solar-powered borehole courses into curricula and their subsequent implementation.	Number of individuals trained. Number of courses offered.	11,000
Bolster institutions and organisations that manage groundwater and renewable energy	Strengthen water user committees' governance capacity.	MoEWR, Ministry of Finance, Development partners	WASH Department, Technical Support Units	Year 4-6	Inadequate logistical support.	Water users' committees that are both effective and robust.	The number of robust and operational water users' committees.	235,400
	Support water users' committees with a recurrent budget.	MoEWR, Ministry of Finance, Development partners	MoEWR	Year 6-8	Inappropriate use of resources.	Funding is sufficient for water users' committees to carry out their responsibilities.	The number of committees comprised of solar-powered borehole water users that consistently obtain and	12,500

							effectively utilize funds.	
	Secure legal land rights for solar-powered borehole establishment.	Ministry of Finance, Development partners	MoEWR, Local, governments	Year 5-6	Landowners' reluctance to cede their land for the project.	Solar borehole development land obtained	Land titles of possible solar-powered borehole regions.	12,500

1.2 Project Ideas for the Water Sector

1.2.1 A synopsis of the proposed projects in the water sector

The subsequent project ideas are founded upon technologies that were given precedence in a multi-criteria assessment including pertinent stakeholders, with the aim of facilitating adaptation to climate change and attaining national development objectives.

- Expanding opportunities for joint investments and collaboration in rooftop rainwater harvesting.
- Advisory support and the enhancement of local fabrication capabilities for solar-powered boreholes.

1.2.2 Specific Project Ideas

1.2.2.1 Expanding opportunities for joint investments and collaboration in rooftop rainwater harvesting

Through RRWH, it is possible to significantly increase the availability of water on a variety of scales and to strengthen resistance to drought. The technology can be applied on a small scale in homes and larger scale in institutions to supply water for agricultural purposes and individual needs. It has the potential to be cost-effective for local communities and might achieve greater success if the government implement measures such as subsidised equipment for RRWH systems and private sector collaborations. Nevertheless, the technology's complete potential remains unrealized, as it provides water for less than 5% of the total water needs. A summary of the barriers and suggested strategies to overcome them can be found in Table 14.

Objectives

1. Boost cooperation across the housing, infrastructure, agriculture, and water sectors.
2. Create cooperation between the public and private sectors to overcome the high costs that are associated with installation of RRWH.
3. Strengthen RRWH's advisory support capabilities.

Outputs

Objective 1

- The housing, water, infrastructure, and agriculture sectors collaborating to advance RRWH.
- Strategies and budgets for RRWH created jointly by federal, state, and regional governments.
- RRWH-specific regulations or by-laws formulated or fortified.

Objective 2

- Incentives devised with the purpose of encouraging private businesses, non-governmental organisations, and development partners to supply a wide variety of RRWH materials, equipment, and services.
- Plans, financial estimates, and operating procedures developed for RRWH installations in farms, institutions, and residents.

Objective 3

- Specialised training for extension agents and administrative assistance for RRWH advisory support.

Relationship with the country's national objectives for sustainable development

This technology is in excellent accordance with the purpose of the Somalia National Water Resource Strategy (2021-2025), which is to enhance the delivery of priority water services. The Puntland Water Resources Act (2018) emphasizes the need to "increase access to water in an equitable and sustainable manner in different forms of utilization, while following the most appropriate environmental protection measures". Through public-private partnerships (PPPs), the government subsidises the construction of facilities so that private farmers can buy technologically advanced construction equipment. A fundamental objective of the strategy for managing flood and drought waters outlined in the Somalia Emergency Response and Preparedness Plan 2021 is the storage and utilisation of rainwater.

Project Deliverables

- Stakeholder engagement across sectors to determine the present state of RRWH technology deployment, important players, enabling policy framework at the federal, state and regional levels, and necessary interventions to boost adoption of RRWH.
- Recommendations for encouraging technology providers, promoters, and users to generate demand for the RRWH technology, capacity, and incentives, as well as a map of private enterprises and actors along the market value chain.
- Enhanced RRWH rollout by bolstering end-user and extension worker capacities and facilitating logistical support.

Project Scope and Possible Implementation

The project will be a three-year undertaking and will require substantial participation from private sector organisations and NGOs.

Project activities

- Mapping important players who actively participate in or support RRWH.
- Gathering information on RRWH strategies, present state, and potential technology deployment routes by reviewing relevant documents and consulting with industry officials.
- Market value chain mapping of private enterprises and actors involved in the provision of RRWH equipment and services.
- Provide suggestions for enhancing the adoption of RRWH in Somalia, potential avenues for collaboration and partnership formation, chances to raise general awareness and build capacities, and viable financing mechanisms.
- Improve RRWH's capabilities while simultaneously assisting extension agents in the water sector.
- Evaluation of the requirements of the end-users and development of a programme to fill the any identified gaps.

Table 15: Resource requirements

Activity	Amount (USD)		
	Year1	Year 2	Year 3
Boost cooperation across the housing, infrastructure, agriculture, and water sectors.	360,000		
Create cooperation between the public and private sectors to overcome the high costs that are associated with installation of RRWH.	48,000	48,000	
Strengthen RRWH's advisory support capabilities.	696,000	696,000	348,000
Monitoring & Evaluation		86,000	172,000
TOTAL	1,104,000	830,000	520,000

Measurement/Evaluation

- Examination and analysis of the results and actions taken during a consultation session that involved multiple sectors – year 1.
- Technology deployment map incorporating both public and private actors, the existence of incentives for the private sector, shift in the number and composition of stakeholders providing RRWH equipment, material and services.
- Reference point for RRWH recommendations and user capacity needs; user and extension workers capacity building activities; existence of extension support for RRWH.

Possible Challenges

- Absence of facilitating procedures or resistance to intersectoral RRWH deployment.
- The inter-sectoral arrangement for RRWH plagued by hazy leadership and sluggish decision-making.
- The private sector not receiving sufficient incentives to develop a strong business case for RRWH.
- Rooftop rainwater harvesting strategies underappreciated in the building industry.

- Lack of consistent logistical assistance for extension workers to offer RRWH advisory services.

Table 16: Responsibilities and Coordination

Stakeholder	Role	Time	How
MoEWR, Department of water Development	Coordinate the RRWH's national budgeting, strategy formulation, and planning	Year 1	Call meetings to discuss the development of strategy.
Ministry of Finance	▪ Offer assistance and cooperation in the process of amending tax laws pertaining to RRWH equipment. ▪ Negotiate lenient lending terms for RRWH. ▪ Suggest financial incentives for private sector.	Year 1	Forge alliances between the public and private sectors
Water officers, local administration	▪ Form local-level RRWH stakeholders committees. ▪ Offer advice and help to RRWH	Year 1-2	Community meetings
Vocational Institutes, Technology Centres and Universities	▪ Train artisans and extension workers. ▪ Carry out research on the uptake and utilization of RRWH	Year 1-2	Trainings, surveys, and reviews
Private sector	Develop a business plan for RWH materials, equipment and services.	Year 2	Collaborating with government and non-governmental organisations
Non-governmental organizations	Strengthen capacities and monitor progress of RRWH implementation	Year 2-3	Meetings with government and community actors

1.2.2.2 Enhancing local manufacturing capacities and providing guidance for solar-powered boreholes

Even though wells and boreholes are now being utilised in some locations throughout the country, majority of installations are not effective due to poor siting, the use of substandard materials and equipment, and limited local capacity to support their

operation. Increasing local fabrication capacity will make it easier to obtain spare parts and professional knowledge, making it possible to operate and maintain boreholes in a sustainable manner. To strengthen local leadership and organisational capabilities for solar-powered borehole management, strong advisory support is also required.

Objectives

- Give young people in rural areas the skills they need to start their own businesses making solar-powered borehole equipment and accessories and fixing them.
- Promote and exhibit solar-powered borehole equipment and accessories that are manufactured locally.
- Enhance extension officers' capabilities to provide advisory support for solar-powered boreholes.

Outputs

Objective 1

- Young people in rural areas trained and skilled to start their own businesses in making soler-powered borehole equipment and accessories.

Objective 2

- An increase in the market and demand for solar-powered borehole equipment and accessories that are manufactured locally.

Objective 3

- Extension agents assisting solar-powered borehole management committees in their communities using their newfound knowledge and skills.

Relationship to the country’s sustainable development priorities

In Somalia, boreholes are the most strategic water sources because they supply water year-round and when other sources run dry. Boreholes exhibit a reduced susceptibility to contamination in comparison to surface water supply alternatives and have the potential to be used as water sources for industrial, domestic, and agricultural

purposes (Foster et al., 2012). With their demonstrated capacity to provide access to potable water in isolated regions, boreholes have been aggressively advocated for in water supply initiatives. Nonetheless, the exploration and extraction of fresh groundwater resources in Somalia is beset with obstacles, with inadequate water quality being a significant one. This necessitates the technical abilities to precisely control the quality and sources of underground water. Currently, borehole operations and maintenance are undercapitalized due to a lack of available technicians and replacement components.

Project Deliverables

- Enhanced local capacity in the production and maintenance of solar-powered borehole equipment and accessories, in addition to the consolidation of water user committees for improved management of solar-powered boreholes.
- An increase in the supply of locally made components could potentially result in price reductions and make these components more accessible to a wider audience.
- Increased work opportunities particularly among the youth, in the fabrication of equipment and parts and maintenance of solar-powered boreholes.

Project Activities

- Working together with the MoEWR, identify the regions where boreholes have been failing and where new installations are needed.
- Train young people locally to build, install, and maintain solar and borehole equipment in collaboration with federal, state, and regional administrations, private sector, and non-governmental organisations.
- Assist trained youths in establishing businesses that provide solar and borehole equipment and services.
- Strengthen the organisational capacity of water users' associations with regard to the administration and management of solar-powered boreholes.
- Bolster the capacity of extension agents to provide advisory support for solar-powered boreholes.
- Assessing, monitoring and evaluating the implementation of capacity building.

Project Timelines: Three years

Table 17: Resource requirements

Activity	Amount (USD)		
	Year1	Year 2	Year 3
Train young people locally to build, install, and maintain solar pump and borehole equipment	35,000	61,000	
Assist trained youths in establishing businesses that provide solar and borehole equipment and services.		417,000	
Promote and exhibit solar-powered borehole equipment and accessories that are manufactured locally.			829,000
Strengthen the organisational capacity of water users' associations with regard to the administration and management of solar-powered boreholes.	427,000		
Bolster the capacity of extension agents to provide advisory support for solar-powered boreholes.	692,000	692,000	
Monitoring & Evaluation		86,000	172,000
TOTAL	1,154,000	1,256,000	1,001,000

Measurement and evaluation

- The number of locals skilled in solar-powered borehole installation and maintenance, and fabrication of equipment and accessories.
- The number of trained locals helped to start solar and borehole service equipment and accessory businesses.
- The number of promotional activities for solar-powered borehole equipment and accessories that are manufactured locally.
- The number of water user committees tasked with operating and administering solar-powered borehole installations strengthened.
- The number of extension officers that have been trained and are providing advisory support for solar-powered boreholes.

Possible Challenges

- Tools, equipment, and raw materials that are excessively expensive for local artists.
- Disregard for local capacity in favour of capacity originating from urban centres.

Table 18: Responsibilities and Coordination

Stakeholder	Role	Time	How
MoEWR, Department of water Development	Develop a plan to aid in the capacity building of local youth in solar-powered borehole equipment and services.	Year 1	Interactions with water user's committees and the local administration
	Showcase and market solar-powered borehole accessories, equipment, and services from the local area.	Year 3	Sites for demonstration
Ministry of Finance	Offer assistance and cooperation in the process of amending tax laws pertaining to solar and borehole equipment.	Year 1	Forge alliances between the public and private sectors
Water officers, local administration	▪ Encourage the use of locally made equipment and services. ▪ Mobilise people for training.	Year 1	Community meetings
Vocational Institutes, Technology Centres and Universities	Train the populace in the art of fabricating services for solar-powered boreholes.	Year 2	Training programs
Private sector	Assist in the local production and provision of solar-powered borehole components and services.	Year 2-3	Collaborating with government and non-governmental organisations
Non-governmental organizations	Assist water user associations in their capacity-building efforts.	Year 2-3	Meetings with community actors

CHAPTER 2. Technology Action Plan and Project Ideas for the Agriculture Sector

2.1 TAP for the Agriculture Sector

2.1.1 Sector Overview

Somalia's agricultural sector now accounts for as much as 75% of the country's gross domestic product, up from 62% before the conflict. Recent estimations indicate that the proportional economic significance of livestock in Somalia has increased dramatically. Rural areas continue to be home to approximately 49% of the population, while agriculture employs 46% of the employed (25% in crop cultivation, 9% in herding, 4% in fishing, and 7% in other related activities) (FAO, 2018).

Second-largest exports of Somalia consist of sesame. In 2014, they attained an all-time high of $40 million, which was followed by a 15% decline in 2015. The aggregate export value of fruits and vegetables is barely around 20% of prewar levels, with the exception of dry lemon, which has become a significant export commodity due to the collapse of banana exports. Somalia is perpetually short on food crops. Local production of cereals only fulfils 22% of the per capita need. During optimal agricultural seasons, domestic cereal output meets only 40–50% of per capita requirements (FAO, 2018).

Vulnerability

The crop and livestock subsectors have been greatly hampered by Somalia's increasingly frequent and severe droughts and floods, as well as the country's already severely damaged natural environment. The 2016-17 drought caused food insecurity for the vast majority of Somalia's population. During the peak of the drought, an estimated 6.7 million people, or more than half of the population, were severely food insecure and in need of humanitarian aid (World Bank, 2018). During the drought, Somalia experienced more than $1.6 billion in agricultural losses and destruction (UNDP, 2018). Crop output has been drastically lowered in the Southern regions due to recurrent droughts, a lack of research and extension services, and, most importantly, insecurity, a lack of government, and the ensuing deterioration of the irrigation, transportation, and flood control infrastructure. The estimated overall loss in

production volume was 59% for cowpea, 34% for corn, 83% for sesame, and 50% for sorghum (World Bank, 2018).

Climate change-induced temperature increases may alter rainfall seasonality and intensity, as well as disrupt agricultural crops and livestock. In comparison to pre-industrial levels, temperatures in Somalia are expected to rise by 1.4–1.9 °C by 2030, 1.5–2.3 °C by 2050, and 1.4–3.4 °C by 2080, with coastal regions being less affected than the rest of the country (Binder et al., 2022). Drought conditions will be worsened by an increase in evapotranspiration if temperatures continue to rise. A shift in rainfall seasons will result in alternating periods of extended drought and heavy precipitation. Heavy rains can exacerbate problems like waterlogging and flooding in valleys, as well as soil erosion and landslides on hilly terrain.

The IPCC AR4 climate forecasts indicate that there is an anticipated 15–20% increase in the average annual precipitation for Somaliland and Puntland (Petersen and Gadain, 2012). The seasonal unpredictability and the frequency of intense rainfall events are predicted to rise, regardless of whether the amount of rainfall experiences an increase or reduction (ICPAC, 2017). Disease and pest attacks, which cause crop losses both during and after harvest, are likely to increase as a result of the combination of erratic rainfall and higher temperatures (World Bank, 2023).

Similar to other developing countries, climate change is a significant impediment to Somalia's progress towards attaining the Sustainable Development Goals and alleviating poverty and hunger. Climate change endangers agricultural output and is therefore an immediate and serious threat to the country's food supply.

Table 19: Existing policies and measures related to the sector’s development and technology deployment.

Policy	**Main content**	**Target**
Agricultural Land Use and Irrigation policies	Regulates agricultural water usage and deals with the economic, governmental, legal, physical, and planning dimensions of agricultural land use.	Provide recommendations for sustainable land use on the basis of soil and topography study, agroecological principles, and social and demographic assessment.

Somali Agricultural and Inspection Services (SARIS)	SARIS was established as a national plant protection organisation with the purpose of facilitating international trade as an agricultural regulatory body.	Implement the Somali Agrochemical Policy; the Seeds and Varieties Act; the Plant Protection and Quarantine Law; the National Fertilizer Policy; and the National Pesticide Policy.

Table 20: Selected technologies

Technology	**Current level of uptake**	**Future Targets**
Drip Irrigation	Less than 5% of irrigated farms	Over the next eight years, set up drip irrigation systems on 150,000 hectares of land.
Early Warning Systems	Not developed	▪ Establish 18 new meteorological observatories in 18 regions nationwide. ▪ Setup of a network of two hundred automated weather stations and the associated communication infrastructure. ▪ Establish Flood Warning Systems in High-Risk Areas. ▪ Establish a national meteorological centre.

2.1.2 Action Plan for Drip Irrigation

2.1.2.1 Introduction

Drip irrigation is a high efficiency irrigation technology that is particularly well-suited for arid and semi-arid regions where water scarcity is a significant concern. Through a network of pipes, emitters, drippers, and other essential components that transport water from water sources to the roots of the crop, drip irrigation ensures that a concentrated and precise amount of water is applied to the roots of the crop on a consistent basis (Singh, 2012). By keeping the soil at a consistent moisture level in the root zones, the system promotes optimal nutrient utilisation and creates an ideal setting for robust root systems in plants. This irrigation system is capable of producing

greater crop yields due to its enhanced uniformity and increased application efficiency (Van Der Kooij et al., 2013).

The implementation of this technique yields numerous advantages for adaptability, including enhanced water management and reduced susceptibility to plant diseases, such as fungi. Furthermore, the technology is able to perform well in a wide variety of topography and soil conditions, with the exception of soil that is composed of thick clay. From an ecological perspective, drip irrigation is preferable since it reduces runoff and evaporation, boosts groundwater recharge, enhances soil quality, and slows erosion. Some of the social and economic advantages include an increase in yields and farmer income (Taylor & Zilberman, 2017), a boost to food security, new jobs in system installations and maintenance, and the production of components.

2.1.2.2 Ambition for the TAP

Drip irrigation is an exceptionally well-suited technological solution for the arid and semi-arid regions of Somalia, where the lack of a perennial surface water source throughout the year poses a significant obstacle to maintaining a consistent water supply. Farmers are obligated to preserve the meagre water supply that is received from intermittent rainfall and flash floods. The proposed target is to set up drip irrigation systems on 150,000 hectares of land by 2032.

2.1.2.3 Actions and Activities selected for inclusion in the TAP

Table 21: Summary of barriers and measures to overcome barriers

Barrier category	Barrier	Measure
Financial	A market that is not competitive, underdeveloped, and relatively small leading to high cost of establishing, operating, and managing drip irrigation systems	▪ Investments made directly by the government. ▪ Provide assistance to farmers in setting up and managing drip irrigation systems. ▪ Encourage more private investment in the market through the use of subsidies, reduced tariff

		rates, and other incentives.
Non-financial	Limited capabilities of farmers in terms of organising and managing drip irrigation systems.	Develop the capacity of farmers to manage and organise irrigation systems.
	Lack of sufficient capacity among extension officers to provide support for drip irrigation.	Both extension officers and farmers should get training in the planning, designing, and implementing drip irrigation.
	Possible conflicts concerning the ownership rights of land, water, and infrastructure.	Reduce the likelihood of disputes over water, land, and infrastructure ownership and work to eliminate them.

Actions selected for inclusion in the TAP

a) Investments made directly by the government in drip irrigation or through private investment

The establishment of new drip irrigation systems and the provision of requisite materials and equipment necessitate both public and private investment. Community engagement in the stages of design, installation, and operation further fosters comprehension of this technology. This could be achieved by means of direct financial assistance and technical support provided to farmers via the engagement of private firms to implement drip irrigation systems and enhance local capabilities.

b) Facilitate increased farmer engagement in drip irrigation system management.

The potential role that drip irrigation could play in assisting farmers in adapting to climate change needs to be brought to the attention of farmers. It is necessary to refocus the capacities of water users' groups so that they can effectively manage drip irrigation schemes as businesses. Methods such as organising training sessions, site visits, and talks on the pros of drip irrigation can help achieve this goal. It is necessary to educate farmers about irrigation equipment, such as drip lines, pumps, pipelines, and channels, by use of instructive, experiential, and demonstrative activities.

Throughout the whole project, including the irrigation system's design, execution, monitoring, and evaluation, gender equality should be promoted.

c) Build capacity of extension personnel in irrigation skills

Training is required for farmers and extension workers to operate drip irrigation systems and agricultural water management technology, including knowing when to release water in the right amounts based on the weather and the agronomic requirements of crops. Additionally, local artisans should be trained in the fabrication, repair, and maintenance of irrigation equipment. Tertiary education ought to offer engineering students courses that cover the planning, design, and implementation of drip irrigation systems. Furthermore, farmer groups require skill sets to assess the social acceptability, commercial rationale, and enabling conditions of drip irrigation investments. Proficiency is also required in the execution of topographic surveys, and evaluation of the scheme's social and environmental repercussions.

d) Reduce the likelihood of disputes over water, land, and infrastructure ownership and work to eliminate them

Land titles are necessary for farmers to protect their ownership rights and to encourage their investment in drip irrigation infrastructure. Using the micro and medium irrigation systems that are already in place, research should be conducted on the management requirements, and the results should be communicated in order to generate reasonable expectations for drip irrigation users in addition to making certain that they have adequate support. When it comes to irrigation, having access to and control over land and water is of the utmost importance (Theis et al. 2017). Purposeful provisions are required to ensure that women and others who are disadvantaged are included in drip irrigation projects.

Activities identified for implementation of selected actions

a) Invest public funds in drip irrigation systems

- Engage commercial enterprises to construct the drip irrigation infrastructure, and subsequently delegate its operation to members of the community.

- Offer direct support to farmers in the setting up and management of drip irrigation systems.

b) Build capacity of extension officers and farmers in managing drip irrigation systems

- Train extension personnel to provide advisory support for drip irrigation systems.
- Support extension personnel in establishing active relationships with farmers utilising drip irrigation.
- Conduct practical training and demonstrations on how to operate drip irrigation systems.
- Facilitate the management of drip irrigation systems by enhancing the capacity of water user communities and farmer groups.

c) Reduce the likelihood of disputes over water, land, and infrastructure ownership and work to eliminate them.

- Establish equitable principles of participation, delineate ownership of assets, allocation of managerial duties, and distribution of benefits.
- Engage the community in conversations about the requirements for drip irrigation management.

Actions to be implemented as Project Ideas

To optimise the utilisation of drip irrigation technology, project concepts could be devised around the subsequent activities:

1) Invest public funds in drip irrigation systems.
2) Build capacity of extension officers and farmers in managing drip irrigation systems.
3) Mitigate the likelihood of disputes over water, land, and infrastructure ownership.

2.1.2.4. Stakeholders and timeline for implementation of TAP

Table 22: Overview of Stakeholders for the implementation of the TAP

Stakeholder	Role
Ministry of Agriculture and Irrigation, MoEWR	▪ Establish the necessary infrastructure to support drip irrigation. ▪ Provide community organisations and farmers with training on drip irrigation system operation and management. ▪ Contract private sector in setting up infrastructure for drip irrigation. ▪ Develop irrigation schemes. ▪ Management of drip irrigation systems: mobilisation, advice, regulation.
Local administration, water user committees, farmer groups	▪ Offer guidance and support on drip irrigation. ▪ Establish local regulations for drip irrigation. ▪ Strengthen drip irrigation management and organisational capacity. ▪ Illustrate effective drip irrigation management. ▪ Engage the community in discussions on the management of drip irrigation.
Vocational institutes, Technology Centres and universities	▪ Provide training on drip irrigation management to community leaders and extension agents. ▪ Carry out studies to determine the viability of drip irrigation.
Private companies	▪ Collaborate with government agencies and NGOs to fund the installation of drip irrigation systems. ▪ Provide services and equipment for drip irrigation installation and management.
NGOs	▪ Develop local expertise in drip irrigation management

Table 23: Scheduling and sequencing of specific activities

Activity	Scale	Year							
		2024-2025	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032
Invest public funds in drip irrigation systems									
Engage commercial enterprises to construct	Regional					xxx	xxx	xxx	

the drip irrigation infrastructure									
Offer direct support to farmers in the setting up and management of drip irrigation systems	Regional				xxx	xxx	xxx		
Build capacity of extension officers and farmers in managing drip irrigation systems									
Train extension personnel to provide advisory support for drip irrigation systems	National	xxx	xxx						
Support extension personnel in establishing active relationships with farmers utilising drip irrigation	Local			xxx	xxx	xxx	xxx	xxx	xxx
Conduct practical training and demonstrations on how to operate drip irrigation systems	Local			xxx	xxx				
Facilitate the management of drip irrigation systems by enhancing the capacity of water user communities and farmer groups	Local	xxx	xxx						
Mitigate the likelihood of disputes over water, land, and infrastructure ownership									
Establish equitable principles	Local		xxx	xxx					
Engage the community in conversations about the requirements for drip irrigation management.	Local	xxx							

2.1.2.5. Estimation of Resources Needed for Action and Activities

Needs assessment for capacity development

The subsequent capacity building measures will be necessary for the installation, operation, and management of drip irrigation systems:

- Train extension personnel to provide advisory support for drip irrigation systems.
- Support extension personnel in establishing active relationships with farmers utilising drip irrigation.
- Conduct practical training and demonstrations on how to operate drip irrigation systems.
- Facilitate the management of drip irrigation systems by enhancing the capacity of water user communities and farmer groups.

Table 24: Estimations of costs of actions and activities

Action	Activity	Cost (USD)
Invest public funds in drip irrigation systems	Engage commercial enterprises to construct the drip irrigation infrastructure	**800,000**
	Offer direct support to farmers in the setting up and management of drip irrigation systems	**2,800,000**
Sub Total		**3,600,000**
Build capacity of extension officers and farmers in managing drip irrigation systems	Train extension personnel to provide advisory support for drip irrigation systems	**32,000**
	Support extension personnel in establishing active relationships with farmers utilising drip irrigation	**105,000**
	Conduct practical training and demonstrations on how to operate drip irrigation systems	**2,100,000**
	Facilitate the management of drip irrigation systems by enhancing the capacity of water user communities and farmer groups	**41,000**

Sub Total		**2,278,000**
Mitigate the likelihood of disputes over water, land, and infrastructure ownership	Establish equitable principles	**75,000**
	Engage the community in conversations about the requirements for drip irrigation management.	**52,000**
Sub Total		**127,000**
Total		**6,005,000**
Project Admin Cost (15%)		**900,750**
Grand Total		**6,905,750**

2.1.2.6 Management Planning

Table 25: Risks and Contingency Planning

Activity	Risks	Contingency Plan
Invest public funds in drip irrigation systems		
Engage commercial enterprises to construct the drip irrigation infrastructure	▪ A weak argument for doing business in the private sector. ▪ Poor sense of responsibility	Make a strong business case for the private sector; Accountability procedures that are clear
Offer direct support to farmers in the setting up and management of drip irrigation systems	▪ Lack of sufficient local expertise to install and manage drip irrigation systems ▪ Absence of a robust community organisation to manage drip irrigation systems	▪ Develop training programs for farmers. ▪ Capacity building for farmer groups ▪ Offer advisory support and monitoring
Build capacity of extension officers and farmers in managing drip irrigation systems		
Train extension personnel to provide advisory support for drip irrigation systems	▪ Failure to utilise learned skills ▪ Insufficient logistical support	▪ Create a need for skills ▪ Advocate for budgetary support of extension personnel
Support extension personnel in establishing	▪ Community members having high expectations.	Collaborate with avenues like established

active relationships with farmers utilising drip irrigation	▪ Apathy	organisations and development officers at the local level
Conduct practical training and demonstrations on how to operate drip irrigation systems	Inadequate context for practical training and demonstration	Include prospective clients on the consulting team
Facilitate the management of drip irrigation systems by enhancing the capacity of water user communities and farmer groups	Farmers unable to mimic technology because it is too sophisticated.	Utilisation of locally accessible resources and the provision of advisory support
Mitigate the likelihood of disputes over water, land, and infrastructure ownership		
Establish equitable principles	Low capacity to implement regulations	Raising awareness of drip irrigation rules and regulations
Engage the community in conversations about the requirements for drip irrigation management.	▪ Unclear procedures to guarantee that all parties follow on what is agreed. ▪ Insufficient representation of crucial parties' perspectives	▪ Showcase the capabilities of a drip irrigation system in operation. ▪ Ensuring the substantive and meaningful involvement of stakeholders

Next Steps:

Immediate requirements

- Establishing and enhancing the capacity of local farmer organisations to operate and manage and drip irrigation.
- Provide training, demonstrations, and opportunities for local farmers to become familiar with drip irrigation systems that are operational and businesses that have evolved around them.
- Train extension workers to advise and assist farmers with drip irrigation installation and maintenance.

Critical requirements

Direct public funding, commercial sector partnerships, or joint ventures with local farmer groups to build drip irrigation systems.

TAP Overview Table

Table 26: Drip Irrigation Overview Table

Sector	Agriculture Sector
Sub-Sector	Water and Irrigation
Technology	Drip Irrigation
Ambition	Set up drip irrigation systems on 150,000 hectares of land by 2032
Benefits	Advancements in farming methods and the management of soil fertility. Improved replenishment of ground water and less runoff. Adaptability to climate change and food security.

Action	**Activities to be implemented**	**Sources of funding**	**Responsible body and focal point**	**Time frame**	**Risks**	**Success criteria**	**Indicators for Monitoring of implementation**	**Budget (USD)**
Invest public funds in drip irrigation systems	Engage commercial enterprises to construct the drip irrigation infrastructure	Ministry of finance, Private sector, climate fund	MoEWR	Year 5-7	A weak argument for doing business in the private sector	Drip irrigation systems established by private enterprises are well-managed by local communities.	Private enterprises' contracts for drip irrigation systems	**800,000**
	Offer direct support to farmers in the setting up and management of drip irrigation systems	Ministry of Finance, Climate fund	Ministry of Agriculture and Irrigation, MoEWR, Local administration	Year 4-6	Absence of a robust community organisation to manage drip irrigation systems	Communities helped build and manage drip irrigation systems	Number of government-established drip irrigation schemes	**2,800,000**

Build capacity of extension officers and farmers in managing drip irrigation systems	Train extension personnel to provide advisory support for drip irrigation systems	Ministry of Finance, Climate fund	Ministry of Agriculture and Irrigation, Higher education institutions	Year 1-2	Failure to utilise learned skills	Robust local irrigation management organisations	Number of farmers using drip irrigation systems advised	**32,000**
	Support extension personnel in establishing active relationships with farmers utilising drip irrigation	Ministry of Agriculture and Irrigation, development partners	Ministry of Agriculture and Irrigation, MoEWR	Year 3-8	Community members having high expectations	Drip irrigation advisory is being provided by extension staff.	Number of drip irrigation participatory mechanisms established and used.	**105,000**
	Conduct practical training and demonstrations on how to operate drip irrigation systems	Ministry of finance, Ministry of Agriculture and Irrigation, climate fund	Ministry of Agriculture and Irrigation, MoEWR, Local administration	Year 3-4	Inadequate context for practical training and demonstration	Recognized business justification for drip irrigation among farmers	Number of locations where drip irrigation has been showcased	**2,100,000**
	Facilitate the management of drip irrigation systems by enhancing the capacity of	Ministry of Agriculture and Irrigation, MoEWR	Ministry of Agriculture and Irrigation, MoEWR, Private sector	Year 1-2	Farmers unable to mimic technology because it is too sophisticated	Communities trained and the drip irrigation system exhibited	Reports of community training	**41,000**

	water user communities and farmer groups							
Mitigate the likelihood of disputes over water, land, and infrastructure ownership	Establish equitable principles	Ministry of finance	Ministry of Agriculture and Irrigation, MoEWR, Local administration	Year 2-3	Low capacity to implement regulations	Regulations for construction of irrigation systems set	Draft drip irrigation regulations	**75,000**
	Engage the community in conversations about the requirements for drip irrigation management.	Ministry of finance	Ministry of Agriculture and Irrigation, MoEWR	Year 1	Unclear procedures to guarantee that all parties follow on what is agreed.	Community conversations about managing drip irrigation held everyone involved	Count of meetings devoted to discussing drip irrigation	**52,000**

2.1.3 Action Plan for Early Warning Systems

2.1.3.1 Introduction

Somalia is extremely susceptible to a wide range of natural disasters, including those that are known to be associated with climate change, such as heat waves, drought, and flash floods. Early warning systems are a crucial component of disaster prevention and planning and constitute a substantial part of climate monitoring and forecasting technology. The system is intended to systematically provide timely and pertinent information to affected communities prior to the occurrence of a disaster, so that they may be better equipped to make decisions and undertake appropriate actions. The system's efficacy and efficiency are highly dependent on the numerous entities and agencies operating at different governmental levels working in tandem. These institutions include, for instance, those that help with emergency preparation, hazard mitigation, and hazard detection, monitoring, and forecasting. Additionally, operational procedures, financial, policy and regulatory frameworks, planning and budgetary support are required for the system.

The World Meteorological Organization (WMO) specifies that four operational components are necessary for an early warning system to be effective:

i) Developing, detecting, monitoring, analysing, and anticipating hazards as well as conducting observation.

ii) Evaluation of possible risks and incorporation of risk data into alert messages.

iii) The dissemination of prompt, dependable, and comprehensible alerts to relevant authorities and the vulnerable population.

iv) Community-based disaster preparedness, training, and planning initiatives aimed at reducing the potential impact on lives and livelihoods by encouraging an effective reaction to warnings.

Meteorological and hydrological data are the initial step toward developing high-quality weather, flood, and drought predictions. The first weather station was established at Kismayo in late 1894, marking the beginning of the collecting and monitoring of meteorological and hydrological data in Somalia. The hydro-meteorological network grew swiftly, with additional stations established in coastal locations where Italian and

British colonizers arrived at the start of the twentieth century. Despite sporadic data collection at certain sites, the majority of Somalia was covered by rainfall stations. The two oldest hydrometric stations are the topmost stations of Luuq in Jubba and Belet Weyne in the Shabelle river basins, respectively. Records of water level data for the two stations date back to 1951. Following independence in 1960, several of the ancient stations were upgraded. Between 1963 and 1989, all hydrometric agencies conducted direct river flow measurements. Previously, no direct discharge measurements were done (MoEWR, 2021).

The national weather monitoring network was taken over by the Ministry of Agriculture. Substantial quantities of data were discovered, including rainfall data, however the documentation was out of date because the data was taken from various, not necessarily credible sources (MoEWR, 2021). Weather data collection was carried out by organizations such as the International Civil Aviation Organization (ICAO), the British Meteorological Office (BMO), and other then-existing development foreign-aid initiatives. Prior to 1990, Somalia had one of the most advanced meteorological surveillance systems in the region. Significant data was lost when the weather recording system failed due to the escalation of the civil conflict in Somalia, and the majority of the equipment were destroyed or rendered non-operational (Muchiri, 2007).

In an effort to revive the network of weather observations, the FAO re-established a few additional rainfall stations in Somalia in 1997 in cooperation with a few NGOs and UN organizations. Unfortunately, due to widespread insecurity and poor maintenance, this network did not last very long. The FAO Somalia Water and Land Information - SWALIM project began work in 2002 to establish new weather stations throughout Somalia and restore the network of inoperable ones. Still, the network is quite thin, with groundwater sensors and radar sensors measuring river level not operating in the southern regions. There are four different kinds of hydrometeorological monitoring stations now in use, some of which are not operational (SWALIM, 2021). These stations include nine synoptic stations that gather a range of data, 110 manual rain gauges, and automated weather stations.

Somalia is classified as a least developed member of the World Meteorological Organization. The collecting and analysis of hydrometeorological data has just recently resumed. Somalia has inadequate institutional and technological capacity to

provide correct hydrological information and timely early warnings. Alerts and early-warnings are produced by the donor-driven FEWSNET, FSNAU and FAOSWALIM programs (MoEWR, 2021).

2.1.3.2 Ambition for the TAP

The country endeavours to enhance and broaden the institutional and technical facets of the early warning system with the purpose of enhancing readiness for prospective disasters (MoEWR, 2021). Some of the primary preliminary targets established for the dissemination and diffusion of early warning systems are as follows:

a) Establish 18 new meteorological observatories in 18 regions nationwide.
b) Setup a network of two hundred automated weather stations and the associated communication infrastructure.
c) Establish Flood Warning Systems in High-Risk Areas.
d) Establish a national meteorological centre.
e) Strengthening the current mechanism for communicating hazards information

2.1.3.3 Actions and Activities selected for inclusion in the TAP

Table 27: Summary of barriers and measures to overcome barriers.

Barrier category	Barrier	Measure
Financial	High initial investment cost and insufficient government financial assistance	Increase budget allocation for modernising, expanding, and upgrading the country's early warning system
	High operating and maintenance costs.	Increase budget allocation for running the early warning system
Non-financial	Insufficient technical capacity	Strengthen the human and technical capacities of relevant national and local organisations engaged in disaster preparedness and response.

	Scarcity of real-time climate data	Incorporate other data sources, including satellite data, to guarantee accurate and up-to-date information.
	Challenges in dissemination and communication	Enhance and broaden the current system for early warning communication and dissemination

Actions selected for inclusion in the TAP

a) Increase funding for the improvement of disaster monitoring, forecasting, and early warning services

In line with the NDC, funding for the creation and maintenance of early warning systems can be expanded to support staff recruitment and training, logistical support, observations, and ICT. Allocating an additional minimum of 50 million US dollars (about 5 percent of the overall budget) towards the improvement of early warning systems is imperative in light of Somalia's susceptibility to climate-related disasters, including floods and droughts. Furthermore, funding is required to conduct research and scenario assessments for early warning systems in order to understand the situation, determine the best course of action, and monitoring. While this technology is generally classified as a public good under the purview of the national government due to its non-market nature, collaborations between the public and private sectors are necessary to enhance funding for certain operations.

b) Enhance technical capacity, particularly for human resources related to early waning of issuance, disaster preparedness, and response management

Enhancing the technical proficiency of the pertinent ministry workers is of utmost importance to enable them to apply and further develop this knowledge. The capacity of the ministries to continue autonomous national hydrological and meteorological monitoring and forecast development cannot be developed if they rely on external forecasters.

c) Enhance the country's mechanism for early warning communication and dissemination of vital information

To ensure that the advisories reach the vulnerable communities, it is imperative to utilise an array of communication channels and procedures, including mainstream media, to disseminate the information. The early warning dissemination process should be streamlined to ensure timely communication between all agencies and the principal early warning agency, as well as to ensure that warning messages reach consumers unaltered. It is necessary to develop technological applications and digitalized resources for mobile phones in order to increase users' access to information.

d) Strengthen and expand collaboration and coordination with other pertinent regional and international organisations

A close collaboration with pertinent international institutions to exchange expertise, data, and other essential information would contribute to the enhancement of the country's technological and knowledge foundation in early warning systems.

Activities identified for implementation of selected actions

a) Increase funding for the improvement of disaster monitoring, forecasting, and early warning services.

- Increase budgetary allocations for early warning systems in relevant departments.
- Mobilise funds and resources from development partners for modernization and automation of current observatories.
- Increase budgetary allocations and mobilise resources for establishment of a forecasting and warning system for flash floods in susceptible locations.

b) Enhance technical capacity, particularly for human resources related to early waning of issuance, disaster preparedness, and response management.

- Conduct need-based training for professional staff from national meteorological, climate change, and disaster risk management institutions.

- Carry out risk assessments to produce new, reliable location-based risk data and insights.
- Organize specialised workshops for staff development and training.
- Improve modelling approaches by collaborating with WMO and other regional and international meteorological networks.
- Set-up additional meteorological observatories in regions prone to hazards.

c) Enhance the country's mechanism for early warning communication and dissemination of vital information.

- Identify and involve the active community organisations that are already in place to assist with emergency preparedness drills.
- Train key stakeholders in information dissemination through social media platforms and networks.

d) Strengthen and expand collaboration and coordination with other pertinent regional and international organisations.

- Foster knowledge transfer by developing collaborative programs and partnerships with meteorological research institution specialists from regional and international institutions.
- Collaborate and partner with regional, national, and local initiatives to exchange information, knowledge, and data.

Actions for Project Ideas

- Enhance technical capacity, particularly for human resources related to early warning issuance, disaster preparedness, and response management.
- Enhance the country's mechanism for early warning communication and dissemination of vital information.
- Strengthen and expand collaboration and coordination with other pertinent regional and international organisations.

2.1.3.4 Stakeholders and Timeline for implementation of TAP

Table 28: Overview of Stakeholders for the implementation of the TAP

Stakeholder	Role
Ministry of Environment and Climate Change	▪ Assist in the development of capacities, personnel, and institutions to support early warning systems. ▪ Establish a sufficient personnel framework and appoint capable officers and assistance to manage early warning systems. ▪ Conduct review and monitoring of the early warning system.
Ministry of Finance	▪ Mobilise and provide financial resources for setting up the early warning system.
Department of Meteorology, Department of Climate change.	▪ Formulate and execute a strategy for early warning system that is responsive. ▪ Establish connections with critical stakeholders in the early warning system. ▪ Make climate and weather data and tools more accessible.
Local community groups (farmer groups, water users' associations etc..)	▪ Take part in developing and executing the plan for the early warning system. ▪ Provide active feedback. ▪ Help in communication and dissemination.
Higher education institutions and research centres.	▪ Generate knowledge and tools for early warning systems. ▪ Conduct studies on the efficacy of early warning systems in the country

Table 29: Scheduling and sequencing of specific activities

Activity	Scale	Year							
		2024-2025	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032
Increase funding for the improvement of disaster monitoring, forecasting, and early warning services									
Increase budgetary allocations for early warning systems in relevant departments	National	xxx	xxx	xxx	xxx	xxx			

Mobilise funds and resources from development partners for modernization and automation of current observatories	National		xxx	xxx	xxx				
Increase budgetary allocations and mobilise resources for establishment of a forecasting and warning system for flash floods in susceptible locations	National			xxx	xxx	xxx			
Enhance technical capacity, particularly for human resources related to early waning of issuance, disaster preparedness, and response management									
Conduct need-based training to professional staff from national meteorological, climate change, and disaster risk management institutions	National	xxx	xxx						
Carry out risk assessments to produce new, reliable location-based risk data and insights	National	xxx	xxx	xxx					
Organize specialised workshops for staff development and training	National			xxx	xxx	xxx			
Improve modelling approaches by collaborating with WMO and other regional and international meteorological networks	National					xxx	xxx	xxx	xxx
Set-up additional meteorological observatories in	National		xxx	xxx	xxx				

regions prone to hazards									
Enhance the country's mechanism for early warning communication and dissemination of vital information									
Identify and involve the active community organisations that are already in place to assist with emergency preparedness drills	National			xxx	xxx	xxx			
Train key stakeholders in information dissemination through social media platforms and networks	National	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Strengthen and expand collaboration and coordination with other pertinent regional and international organisations									
Foster knowledge transfer by developing collaborative programs and partnerships with meteorological research institution specialists from regional and international institutions	National				xxx	xxx	xxx	xxx	xxx
Collaborate and partner with regional, national, and local initiatives to exchange information, knowledge, and data	National		xxx	xxx	xxx	xxx			

2.1.3.5 Estimation of Resources Needed for Action and Activities

Table 30: Estimations of costs of actions and activities

Action	Activity	Cost (USD)
Increase funding for the improvement of disaster	Increase budgetary allocations for early warning systems in relevant departments	**1,100,000**

monitoring, forecasting, and early warning services	Mobilise funds and resources from development partners for modernization and automation of current observatories	**1,100,000**
	Increase budgetary allocations and mobilise resources for establishment of a forecasting and warning system for flash floods in susceptible locations	**10,000,000**
Sub Total		**12,200,000**
Enhance technical capacity, particularly for human resources related to early waning of issuance, disaster preparedness, and response management	Conduct need-based training to professional staff from national meteorological, climate change, and disaster risk management institutions	**51,000**
	Carry out risk assessments to produce new, reliable location-based risk data and insights	**39,000**
	Organize specialised workshops for staff development and training	**11,000**
	Improve modelling approaches by collaborating with WMO and other regional and international meteorological networks	**51,000**
	Set-up additional meteorological observatories in regions prone to hazards	**600,000**
Sub Total		**752,000**
Enhance the country's mechanism for early warning communication and dissemination of vital information	Identify and involve the active community organisations that are already in place to assist with emergency preparedness drills	**37,000**
	Train key stakeholders in information dissemination through social media platforms and networks	**11,000**
Sub Total		**48,000**
Strengthen and expand collaboration and coordination with other	Foster knowledge transfer by developing collaborative programs and partnerships with meteorological research institution	**35,000**

pertinent regional and international organisations	specialists from regional and international institutions	
	Collaborate and partner with regional, national, and local initiatives to exchange information, knowledge, and data	**27,000**
Sub Total		**62,000**
Total		**13,062,000**
Project Admin Cost (15%)		**1,959,300**
Grand Total		**15,021,300**

2.1.3.6 Management Planning

Table 31: Risks and Contingency Planning

Activity	Risks	Contingency Plan
Increase funding for the improvement of disaster monitoring, forecasting, and early warning services		
Increase budgetary allocations for early warning systems in relevant departments	Low funding Political shift in priorities	Demonstrate how the early warning system will benefit the country
Mobilise funds and resources from development partners for modernization and automation of current observatories	Low funding	Collaborate with non-state entities
Increase budgetary allocations and mobilise resources for establishment of a forecasting and warning system for flash floods in susceptible locations	Inadequate technical human capacity to run the system Low funding	Provide adequate staff training and retooling on a regular basis
Enhance technical capacity, particularly for human resources related to early waning of issuance, disaster preparedness, and response management		
Conduct need-based training to professional staff from national meteorological, climate	Insufficient funding, poor training quality	Collaboration with global actors

change, and disaster risk management institutions		
Carry out risk assessments to produce new, reliable location-based risk data and insights	Inadequate trained staff	Collaborate with research centres and institutions of higher education
Organize specialised workshops for staff development and training	Low staff involvement and turnout	Communicate potential benefits to staff
Improve modelling approaches by collaborating with WMO and other regional and international meteorological networks	Inadequate trained staff	Collaborations with international actors in exchange programmes
Set-up additional meteorological observatories in regions prone to hazards	Poor maintenance, limited funding	▪ Devise appropriate monitoring and evaluation programs ▪ Demonstrate value of the observatories
Enhance the country's mechanism for early warning communication and dissemination of vital information		
Identify and involve the active community organisations that are already in place to assist with emergency preparedness drills	The reluctance of community organisations to participate	Elucidate prospective benefits associated with early warning systems
Train key stakeholders in information dissemination through social media platforms and networks	Rural communities use contemporary social media platforms at a low rate	Involve local leaders and extension workers in raising awareness
Strengthen and expand collaboration and coordination with other pertinent regional and international organisations		
Foster knowledge transfer by developing collaborative programs and partnerships with meteorological research institution specialists from regional and international institutions	Influence of geopolitical factors on technology transfers	Establish partnerships to facilitate the exchange of knowledge and information
Collaborate and partner with regional, national, and local initiatives to exchange	Influence of geopolitical factors on technology transfers	Establish partnerships to facilitate the exchange of knowledge and information

information, knowledge, and data		

Next Steps

The establishment of a functioning early warning system requires the following immediate steps:

- Increasing budgetary allocations for early warning systems in relevant departments.
- Setting-up additional meteorological observatories in regions prone to hazards.
- Establishment of a forecasting and warning system for flash floods in susceptible locations.

Critical requirements

- Conducting need-based training to professional staff from national meteorological, climate change, and disaster risk management institutions.
- Improving modelling approaches by collaborating with WMO and other regional and international meteorological networks.
- Carry out risk assessments to produce new, reliable location-based risk data and insights.
- Identify and involve the active community organisations that are already in place to assist with emergency preparedness.

TAP Overview Table

Table 32: Early Warning Systems Table

Sector	Agriculture Sector
Sub-Sector	Environment and Climate Change
Technology	Early Warning Systems
Ambition	Establish 18 new meteorological observatories in 18 regions nationwide; Setup a network of two hundred automated weather stations and the associated communication infrastructure; Establish Flood Warning Systems in High-Risk Areas; Establish a national meteorological centre; Strengthening the current mechanism for communicating hazards information
Benefits	Emergency preparedness, response, and risk management from accurate early warning information and well qualified personnel; Enhanced warning and forecast products for use in effective planning and management systems for disaster risk reduction; Protecting a greater number of human lives through proper timing of disaster response

Action	**Activities to be implemented**	**Sources of funding**	**Responsible body and focal point**	**Time frame**	**Risks**	**Success criteria**	**Indicators for Monitoring of Implementation**	**Budget (USD)**
Increase funding for the improvement of disaster monitoring, forecasting, and early warning services	Increase budgetary allocations for early warning systems in relevant departments	Ministry of Finance, Development partners, Climate Fund	Ministry of Environment and Climate Change, Department of Meteorology	Year 1-5	Low funding	Enhanced operational early warning system	Regular early warning alerts	**1,100,000**
	Mobilise funds and resources from development	Ministry of Finance, Development	Ministry of Environment and Climate Change,	Year 2-4	Limited funding	Operational technology	Number of observatories modernized and automated	**1,100,000**

	partners for modernization and automation of current observatories	partners, Climate Fund	Department of Meteorology					
	Increase budgetary allocations and mobilise resources for establishment of a forecasting and warning system for flash floods in susceptible locations	Ministry of Finance, Development partners, Climate Fund	Ministry of Environment and Climate Change, Department of Meteorology, Department of Climate Change	Year 3-5	Insufficient technical human capacity to run the system Low funding	Operational technology for flash flood forecasting	Consistent updates and warnings from the flash flood system	**10,000,000**
Enhance technical capacity, particularly for human resources related to early waning of issuance, disaster	Conduct need-based training to professional staff from national meteorological, climate change, and disaster risk management institutions	Ministry of Finance, Development partners	Ministry of Environment and Climate Change, Department of Meteorology, Department of Climate Change	Year 1-2	Low funding, poor training quality	The availability of qualified professionals	The number of professionals trained	**51,000**

preparedness, and response management	Carry out risk assessments to produce new, reliable location-based risk data and insights	Ministry of Finance, Development partners	Ministry of Environment and Climate Change, Department of Meteorology, Department of Climate Change	Year 1-3	Inadequate trained staff	Access to dependable localised risk data	Number of new risk locations identified	**39,000**
	Organize specialised workshops for staff development and training	Ministry of Environment and Climate Change	Ministry of Environment and Climate Change, Department of Planning	Year 3-5	Low staff involvement and turnout	Availability of highly skilled and competent professionals	Number of specialised workshops organised	**11,000**
	Improve modelling approaches by collaborating with WMO and other regional and international meteorological networks	Ministry of Finance, Development partners, Climate Fund	Ministry of Environment and Climate Change, Department of Meteorology	Year 5-8	Inadequate trained staff	Availability of reliable local climate forecasts	Collaboration MoUs signed with other meteorological agencies	**51,000**
	Set-up additional meteorological observatories in	Ministry of Finance, Development partners, Climate Fund	Ministry of Environment and Climate Change,	Year 2-4	Poor maintenance, limited funding	Enhanced network of observatories	Number of observatories in each region	**600,000**

	regions prone to hazards		Department of Meteorology					
Enhance the country's mechanism for early warning communication and dissemination of vital information	Identify and involve the active community organisations that are already in place to assist with emergency preparedness drills	Ministry of Environment and Climate Change	Ministry of Environment and Climate Change, Ministry of Agriculture and Irrigation, Local Administration	Year 3-5	The reluctance of community organisations to participate	Fully functional community groups engaged in communication and dissemination	Number of community groups engaged	**37,000**
	Train key stakeholders in information dissemination through social media platforms and networks	Ministry of Environment and Climate Change	Ministry of Environment and Climate Change	Year 1-8	Rural communities use contemporary social media platforms at a low rate	Fully involved media groups	Social media campaigns done	**11,000**
Strengthen and expand collaboration and coordination with other pertinent regional and	Foster knowledge transfer by establishing research collaborations among meteorological research institution	Ministry of Finance, Ministry of Environment and Climate Change, Development partners, Climate Fund	Ministry of Environment and Climate Change, Department of Meteorology		Influence of geopolitical factors on technology transfers	New collaborative international research initiatives	Number of collaborative research initiatives	**35,000**

international organisations	specialists from regional and international institutions							
	Work together and interact with regional, national, and local initiatives to exchange information, knowledge, and data	Ministry of Environment and Climate Change, Development partners	Ministry of Environment and Climate Change	Year 2-5	Influence of geopolitical factors on technology transfers	Credible risk information	Number of interactions and collaborations	**27,000**

2.2 Project Ideas for the Agriculture Sector

2.2.1 A synopsis of the proposed projects in the agriculture sector

The subsequent project ideas are founded upon technologies that were given precedence in a multi-criteria assessment involving pertinent stakeholders, with the aim of facilitating adaptation to climate change and attaining national development objectives. The project proposals took into account ways that may encourage non-governmental organizations to co-invest, have a large impact in places that really need it, and speed up relevant national processes of technology transfer and diffusion.

- Build capacity of extension officers and farmers in managing drip irrigation systems.
- Enhance technical capacity, particularly for human resources related to early warning issuance.
- Enhance the country's mechanism for early warning communication and dissemination of vital information.

2.2.2 Specific Project Ideas

2.2.2.1 Build the capacity of extension officers and farmers in managing drip irrigation systems

Drip irrigation offers an opportunity for farmers to become more adaptable to changes in rainfall seasons and expand their businesses. The study on barriers to the dissemination and adoption of drip irrigation technology in Somalia identified several barriers, including inadequate farmer skills, lack of infrastructure, and information awareness barriers. Communities must be assisted in organizing and carrying out this task collaboratively, including receiving advice on the time and amount of water required for their crops. Individual farmers and community organizations also require assistance with the operation and management of irrigation systems.

Objectives

a) Train extension personnel to provide advisory support for drip irrigation systems.

b) Enhance the capacity of community organizations to manage drip irrigation systems.

Outputs

a) As part of the capacity building initiatives, 200 local government extension department personnel and 6,000 farmers receive training on the various facets and applications of technology.
b) Community organizations that are in operation and managing drip irrigation systems.

Relationship to the country's sustainable development priorities

Compared to other industries, Somalia's agricultural sector is more susceptible to climate and weather extremes, such as fluctuations in temperature, unpredictability in rainfall patterns, and an increase in the frequency of floods and droughts. It is common for Somalia to have droughts in the agricultural sector, which has a significant impact on the country's irrigation infrastructure and leads to food insecurity (Dahir et al., 2023; Jimale et al., 2023).

Water scarcity continues to be a significant contributor to the aforementioned issues. Somalian farmers have seen a dramatic decline in agricultural yields and livestock due to the outdated architecture of the country's irrigation systems. The Somali people struggle to meet their own water needs despite the critical nature of this resource. Part of the problem with water shortage is that the technology to recover water from land and sea is not developed. The irrigation systems established by Italian settlers in the 20th century have deteriorated due to the disintegration of the socialist Somali government prior to the civil war. Spate irrigation is the predominant crop irrigation method in Somalia, constituting 75% of irrigation operations. However, this approach is susceptible to soil erosion and seawater intrusion during the monsoon season. Various irrigation technologies exist to combat water shortage, however not all are feasible or practical given the current conditions. It has been demonstrated via scientific research that drip irrigation systems are an excellent method of irrigating crops in semi-arid and arid locations (Hu, 2020).

Project Deliverables

1) Decreased susceptibility to seasonal changes in the patterns and intensity of rainfall.
2) Enhanced and consistent output and revenues.
3) Farm business diversification.

Project Scope and Timeline: National; 3 years

Project activities

- Train extension personnel to provide advisory support for drip irrigation systems.
- Enhance the capacity of community organizations to manage drip irrigation.
- Monitor the implementation of drip irrigation.

Resource Requirements

Table 33: Resource Requirements

Activity	**Amount (USD)**		
	Year 1	**Year 2**	**Year 3**
Train extension personnel to provide advisory support for drip irrigation systems	500,000		
Enhance the capacity of community organizations to manage drip irrigation	150,000	180,000	
Monitor the implementation of drip irrigation			160,000
Total	650,000	180,000	160,000

Measurement/Evaluation

- The number of extension personnel who have received training to offer advisory assistance.
- Number of local community management committees set up and trained in organisational development.

Possible challenges

- Since these systems are expensive, farmers may not adopt them as widely if there are no compelling financial incentives.
- Lack of enthusiasm for the training initiatives by local company owners could result to weak human capacity.
- Operational risks, such as the project's inadequate technical design, have the potential to jeopardize its long-term viability.

Table 34: Responsibilities and Coordination

Activity	Key Stakeholder	Time	How
Train extension personnel to provide advisory support for drip irrigation systems.	Ministry of Agriculture and Irrigation	Year 1	Training
Enhance the capacity of community organizations to manage drip irrigation	Ministry of Agriculture and Irrigation, MoEWR, Local administration	Year 1-2	Training, mobilisation, meetings, benchmarking visits
Monitor the implementation of drip irrigation	Ministry of Agriculture and Irrigation, MoEWR	Year 3	Studies, surveys, interviews

2.2.2.2 Enhancing Somalia's Capacity for Early Warning System

Somalia, by virtue of its distinctive physical and demographic attributes, is exceptionally susceptible to a broad spectrum of catastrophes, including but not limited to sudden floods, droughts, cyclones, and heatwaves. Somalia ranks among the most disaster-affected nations globally, based on the quantified consequences of severe weather phenomena, encompassing both human lives lost and economic outlays. This serves as a signal to the country that it is at a high danger of experiencing future calamities and, as a result, need an early warning system that is robust and efficient.

In the most recent years, Somalia has been experiencing the effects of climate change and variability in the form of floods and other catastrophes that occur on a regular basis. In order to address these risks, it is critical that the nation's early warning system be significantly enhanced. This entails developing and improving the capacities of the

organizations and institutions responsible for overseeing various components of the early warning system.

Objectives

The proposed project aims to enhance the capabilities of the Metrological Department, which falls under the purview of the Ministry of Environment and Climate Change. This department is tasked with the development and administration of an early warning system in Somalia. The project aims to:

a) Enhance technical capacity, particularly for human resources related to early warning issuance at regional centres.
b) Improve the country's mechanism for early warning communication and dissemination of vital information.
c) Enhance institutional capacity by establishing and reinforcing connections with partner organizations and important stakeholder groups.

In order to better adapt to and control the effects of climate change, these goals seek to expand the reach of hydro-meteorological observational systems so that they can provide accurate weather forecasts and early warnings that are timely and relevant.

Outputs

a) Meteorological professionals with skills that enable early warnings.
b) Enhanced communication and dissemination of early warning alerts

Relationship to the country’s sustainable development priorities

It is critical for nations to have robust disaster management systems and strategies in order to safeguard at-risk populations and assist them in becoming more resilient in the face of climate-related catastrophes. Somalia recognizes the capacity of catastrophes to undermine both local and national economies, thereby eroding the cumulative benefits of socioeconomic development in the country. The significance of early warning systems within the broader domain of disaster management is emphasized in several policy frameworks and strategies.

For the purpose of achieving climate-resilient development, the Somali National Adaptation Programme of Action recognizes and acknowledges the important connections that exist between climate change and the disaster risk reduction. This is through establishment of robust early warning systems to ease disaster reduction efforts. In order to increase communities' ability to adapt to climate variability, the government is recommended to prioritize disaster preparedness and management as one of its key climate policy areas.

The National Water Resource Strategy (2021-2025) intends to address climate variability and its effects on water resources by implementing strategies for adaptation, mitigation, and recovery. The strategy delineates the approaches, which comprise fortifying early warning systems and enhancing hydro-meteorological monitoring and supporting data and information management systems.

Project Deliverables

- Enhanced technical capacities by installing automatic weather stations, automating existing observatories, and establishing observatories in 18 regions nationwide.
- An effective communication and dissemination system is set up.

Project Scope and Timeline: National; 3 years

Project activities

- Strengthening the human resource and institutional framework, including the research departments
- Setting up meteorological observatories in 18 regions nationwide
- Deployment of a network of 200 automatic weather stations together with their communication system
- Modernization and automation of existing observatories
- Strengthen the method for communicating risks
- Establish flood warning and forecasting system in the nation's most susceptible locations
- Monitoring and evaluating the early warning system deployment

Table 35: Resource requirements

Activity	**Amount (USD)**		
	Year 1	**Year 2**	**Year 3**
Strengthening the human resource and institutional framework, including the research departments	1,000,000	500,000	500,000
Setting up meteorological observatories in 18 regions nationwide		1,600,000	1,600,000
Deployment of a network of 200 automatic weather stations together with their communication system		900,000	
Modernization and automation of existing observatories		1,500,000	1,000,000
Strengthen the method for communicating risks	800,000	200,000	
Establish flood warning and forecasting system in the nation's most susceptible locations	2,500,000	1,500,000	1,200,000
Monitoring and evaluating the early warning system deployment			160,000
Total	4,300,000	6,200,000	4,460,000

Measurement/Evaluation

- Number of meteorological professionals trained
- Number of new meteorological observatories set-up
- Number of automatic weather stations set-up
- Number of existing observatories modernized
- Number of flood warning and forecasting centres established

Possible challenges

- The necessary financial support for the acquisition of technological equipment not being made immediately available.
- Scarce human resources with the necessary training to operate and maintain state-of-the-art technical systems and equipment.

Table 36: Responsibilities and Coordination

Activity	Key Stakeholder	Time	How
Strengthening the human resource and institutional framework, including the research departments	Ministry of Environment and Climate Change, Higher Education Institutions	Year 1-3	Training and retooling
Setting up meteorological observatories in 18 regions nationwide	Ministry of Environment and Climate Change, Department of Meteorology	Year 2-3	Deploy equipment and technology
Deployment of a network of 200 automatic weather stations together with their communication system	Ministry of Environment and Climate Change, Department of Meteorology	Year 2	Deploy equipment and technology
Modernization and automation of existing observatories	Ministry of Environment and Climate Change, Department of Meteorology	Year 2-3	Deploy equipment and technology
Strengthen the method for communicating risks	Ministry of Environment and Climate Change, Department of Meteorology	Year 1-2	Deploy equipment and technology
Establish flood warning and forecasting system in the nation's most susceptible locations	Ministry of Environment and Climate Change, Department of Meteorology	Year 1-3	Deploy equipment and technology
Monitoring and evaluating the early warning system deployment	Ministry of Environment and Climate Change, Department of Meteorology	Year 3	Studies, surveys, interviews

Chapter 3: Cross-cutting Issues

The subsequent measures and policies can assist in surmounting barriers for technologies originating from various sectors:

a) Conduct research to comprehend the context and evaluate the viability of the technology

It is necessary to have substantial research support in order to meet the requirements of adapting technology to local settings and responding to changing climatic circumstances. Recognizing the variations in biophysical, social, and economic contexts allows for the customization of technology and involving the appropriate stakeholders to enhance adoption. It is possible to make the required modifications to the manner in which technologies are disseminated and transmitted via the use of context maps, which in turn makes it feasible to give the necessary technical support.

b) Enhancing the capacity of community organizations

The success of technological endeavours frequently hinges on the ability of local communities to work together effectively. This allows communities to utilize services and bargain more effectively to ensure that the technology benefits them. Robust local organizations that are inclusive and responsible empower communities to develop a variety of advances in technology and establish networks with relevant businesses and companies, enhancing their ability to withstand unexpected events. To make sure that technology helps those who need it most, it's important to build community ownership and the ability to run and administer the technologies.

c) Enhancement of extension officers' capacity, skills and professionalism

When it comes to the transfer and dissemination of technology, one of the most typical barriers is inadequate technical capacity for offering advisory help. A capacity development program is necessary for extension officers since the technologies that are prioritized require a continuous engagement with communities. Extension officers are required to give assistance to communities for them to jointly install, operate, and manage technology, as well as provide input for further improvements.

d) Collaborations and partnerships with the private sector

Private sector collaborations provide potential for joint investment in technology transfer and dissemination, expanding access beyond areas and populations served only by governmental agencies. Additionally, the provision of equipment, accessories, and technical services falls within the purview of the private sector. In the near term, communities may overcome financial obstacles by forming partnerships with private businesses that provide financial services.

e) Raising awareness of the technologies

One of the most important steps should be taken for all of the technologies that have been prioritized is to raise knowledge and awareness about the technologies, how they function, and the potential that they have for the changing climate. This entails not solely disseminating the information, but also showcasing the functionality of the technologies, introducing prospective users to environments where they operate, and initiating a discourse on the challenges and advantages of integrating the technology into the local environment.

f) Monitoring and evaluation

The assessment and analysis of performance of technologies are critical in determining the extent to which technologies aid in adaptation to climate change. Approaches and frameworks to accomplish this objective may be standardized and coordinated across sectors.

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