THE FEDERAL REPUBLIC OF SOMALIA

MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE ADAPTATION

BARRIER ANALYSIS AND ENABLING FRAMEWORK
WATER AND AGRICULTURE SECTORS

Supported by
UNEP Copenhagen Climate Centre

January 2024

Table of Contents

List of Tables

List of Figures

ABBREVIATIONS AND ACRONYMS

AfDB – African Development Bank

FAO – Food and Agriculture Organization

FEWSNET - Famine Early Warning Systems Network

FSNAU - Food Security and Nutrition Analysis Unit

IDP – Internally Displaced Persons

IMF – International Monetary Fund

MoEWR - Ministry of Energy and Water Resources

NGO – Non-Governmental Organization

NWRS – National Water Resource Strategy

RRWH – Rooftop Rainwater Harvesting

RWH – Rainwater Harvesting

SGDs – Sustainable Development Goals

SWALIM - Somalia Water and Land Information Management

UNCHR – United Nations High Commission for Refugees

EXECUTIVE SUMMARY

The first phase of the TNA process selected technologies for critical sectors for climate change adaptation (Water and Agriculture). Technology prioritising was achieved through stakeholder and expert input as well as an examination of national documents and literature review. The process was designed to ensure that the technologies chosen could effectively facilitate adaptation to anticipated vulnerabilities brought about by climate change and that the technologies were in line with national development aspirations.

A participatory process called the Technology Needs Assessment (TNA) is being used in Somalia to identify and rank environmentally friendly technologies for climate change adaptation and mitigation, and to suggest and describe possible measures and enabling frameworks to overcome the barriers that hinder the wider deployment of these technologies. The selection of sectors, consistent with the country's NDCs, and the prioritisation of technologies were described in a previous report. Somalia selected and prioritized four climate change adaptation technologies in the water and agriculture sectors; rooftop rainwater harvesting, solar-powered boreholes, drip irrigation and early-warning systems.

This report examines the barriers to the transfer and proliferation of prioritised adaptation technologies in the water and agriculture sectors. Additionally, strategies for removing obstacles are discussed, as well as the enabling framework. A standard methodology was used to describe and analyse technical constraints, identify solutions, and create an enabling framework for each of the four technologies selected for the water and agricultural sectors (UNEP, 2019 and Nygaard 2015). This process included:

- Establishing early goals for sector-scale technology development and dissemination.
- Providing a brief explanation of the characteristics of technology, its potential benefits for adaptation, and its current situation in the nation.
- Categorisation of financial and non-financial barriers to facilitate barrier analysis techniques applied to specific kinds of barriers.
- Determining strategies for overcoming the barriers and any connections that may exist between the various technological obstacles within a sector.

The method of analysing technological barriers revealed critical economic and financial barriers as well as non-financial impediments. The enabling framework for technology transfer and dissemination was also evaluated in each field.

The Water Sector

Somalia's water and development situations are challenging. The water sector is fragmented and requires cooperation in order to develop a working water governance structure that can address the majority of water challenges, including floods and droughts (Jama and Mourad, 2019). The identified barriers can be addressed by setting up suitable financial and technical resources for the development and spread of these technologies. The non-financial constraints can be overcome by creating a water strategy that has the support of all the relevant parties and by creating a regulatory framework that would address competing claims to natural resources.

Table 1: Barriers to the prioritized technologies and measures to address barriers in the Water Sector

Rooftop rainwater harvesting		
Barrier category	**Barrier**	**Measure**
Financial	Little private investment.	Enable effective participation of the private sector in RRWH
		Increasing household access to RRWH finance
Non-financial barriers	Low level of policy and legal backing	Guidelines, standards, and processes should be created to assist in the creation and implementation of policies. Study visits and the placement of RRWH best practise demonstration sites should also be identified.
	Social cultural obstacles	Boost community RRWH organisations
	Low level of extension advisory capability to assist RRWH	RWH's technical competence should be strengthened.
Solar-powered boreholes		
Barrier category	**Barrier**	**Measure**

Financial	High prices for solar PV, drilling operation and maintenance, and limited availability of replacement parts	Reduce costs of ground water extraction and Solar PV systems by reducing importation costs in the near term through elimination of importation taxes, while simultaneously working on a long-term plan of producing the parts domestically.
Non-financial	Low technical capacity to install solar panels, operate, and maintain boreholes	Improve technical skills of solar PV and borehole installation through training programs and vocational education.
	Weaknesses in institutional capacity	Institutions for renewable energy and ground water management should be strengthened.
	Concerns about water quality	Governments and donors should provide sufficient laboratory equipment and other logistical support.

Agriculture sector

In the face of climate change, the key focus in the agriculture sector is the adoption of technologies that aid and build community resilience, such as efficient water usage technologies and early warning systems in the event of natural catastrophes. Drip irrigation technologies and early warning systems were thus chosen for this purpose. The high initial cost of installation and maintenance for drip irrigation systems and early warning systems has been highlighted as the major financial barrier to their widespread adoption. A variety of enabling measures have been proposed to aid in the proliferation of these two technologies across the country.

Table 2: Barriers to the spread of targeted technologies, as well as methods to solve them, in the agricultural industry.

Drip Irrigation		
Barrier category	**Barrier**	**Measure**
Financial	For smallholder farmers, the costs of setting up, running, and maintaining a	Promotion of the adoption of these water-saving devices through the

	community-based irrigation system may be prohibitive.	provision of specific grants or subsidies on installation costs.
Non-financial	Farmers' organisational and management skills for drip irrigation systems are limited.	Determine ideal locations for a community-based irrigation project.
	Inadequate technical capacity to support planning, designing and construction of Drip Irrigation Systems	The current distributed drip irrigation knowledge must be gathered into a package that extension workers, organisations that give support, and future drip irrigation users may easily access.
	Potential conflict related to land, water, infrastructure ownership rights	Regulatory and enforcement mechanisms should be established or improved to govern the use of land, water, and other natural resources.
Early Warning Systems		
Barrier category	**Barrier**	**Measure**
Financial	High initial investment costs and insufficient government financial assistance.	Increase budget allocation to modernize early warning systems
Non-Financial	Low technical capacity to create and run complex numerical forecasting models.	Increase the technical capacity of the relevant ministry personnel.
	Scarcity of real time climate data	Use multidimensional and on-the-ground data, in addition to satellite imagery and GIS data.
	Communication challenges in dissemination and communication	Simplify early warning distribution to guarantee that all agencies communicate with the primary early warning agency on time and that warning messages reach users without modification.

CHAPTER 1: WATER SECTOR

Water is at the heart of Somalia's investment requirements. Somalia's challenge is to sustain resilient water delivery systems, with governance and infrastructure that is robust enough to absorb shocks, in a country with climate extremes, security, and socioeconomic instability. Climate change is causing recurring droughts in Somalia, endangering lives and the country's water supply. The water sector is in jeopardy due to droughts, desertification, and inefficient agricultural and pastoral activities (Mourad, 2023).

The following adaptation technologies were prioritised in the Technology Needs Assessment step:

- Rooftop water harvesting
- Solar powered boreholes

This chapter describes the steps used and the findings obtained in identifying and analysing the barriers to the acquisition, invention, and dissemination of these technologies; the strategies for removing these barriers and the supportive environment for the transmission and adoption of these technologies.

1.1 Preliminary Targets for Technology Transfer and Diffusion

The ability of Somalia to achieve the Sustainable Development Goals (SDGs) 1, 2, 3, 5, 6, 8, and 13, which pertain to eradicating poverty, ensuring healthy lives, ensuring gender equality, access to clean water and sanitation, fostering sustainable economic growth, and addressing climate change depends directly on the availability of sufficient and quality water. Water management may open development prospects if done well, but it can also hinder it, drive up poverty, and spark conflict if done incorrectly. Agropastoralists, nomadic pastoralists, internally displaced people (IDP) settlement occupants, and many inhabitants of bigger metropolitan centres like Mogadishu all experience high rates of poverty in Somalia, which averages 69 percent.

Additionally, over the past ten years, Somalia has experienced numerous and ongoing crises that have put at risk already vulnerable Somali communities, including 2.6 million internally displaced people (UNHCR, 2020), and nearly 70 percent of Somalis who live below the international poverty line of US$1.90 per day (IMF, 2020). The following are the first goals for the transfer and adoption of the prioritised technologies.

Rooftop Rainwater Harvesting (RRWH)

Rooftop rainwater harvesting is a market technology and has the ability to provide water for agriculture and household usage for many rural families during dry seasons in Somalia. Rainfall in Somalia is low and unpredictable, owing mostly to sinking air and low humidity. Additionally, Somalia is situated on the leeward side of the highlands between Kenya and Ethiopia, which exposes it to further low rainfall. The average annual rainfall in Somalia is roughly 123 mm, with the Gu season accounting for 75 percent of this total (Mourad, 2020). However, the Shabelle and Juba Basins have significant rainfall zones, with annual averages of roughly 460 and 427 mm, respectively. The potential of using RWH is vastly underutilized given that most dwellings in Somalia have not been installed with rooftop rainwater harvesting systems. Rainwater harvesting is not a new concept in Somalia. It has been in place since the beginning of time. *Berkads, waro*, and *xadlings* are evidence of a long history of rainwater harvesting for residential, animal, and crop usage.

Solar Powered Boreholes

Aside from those who live along the Juba and Shabelle Rivers, the Somali population is reliant on groundwater for residential water supplies, livestock, and agriculture. Boreholes, shallow wells, and springs are the primary groundwater sources in Somalia. Boreholes form the most strategic water sources in Somalia since the bulk of them have water all year and offer water when other sources run dry. The depth of most boreholes in Somalia range from 90m to 250m, although in exceptional situations, the depth might exceed 400m (FAO-SWALIM, 2012). The majority of the shallow wells are only 20 metres deep. Depending on the aquifer, the water production of these sources varies from region to region. When compared to most boreholes, which typically yield between 5 and 20m^3/hr, shallow wells typically produce between 2.5 and 10m^3/hr.

Throughout the year, Somalia experiences some of the most intense sunlight globally.. The average daily solar energy collected is around 5-7 kWh/m^2/day. Parts of Somalia have some of the highest daily average total solar radiation levels in the world, according to calculations based on the relative sunlight duration. There are between 2900 and 3100 hours of sunlight on average per year (8 to 8.5 hours per day). The average annual temperature of 27°C is not too high, which contributes positively to the efficiency of solar PVs.

To ensure the long-term viability of these technologies, preliminary objectives for technology transfer and diffusion in the water industry have been established, as shown below:

1. Develop solar powered boreholes by 2030 (Somalia NDC, 2021)
2. Promote rainwater harvesting and conservation of water, including improved water use efficiency (Somalia NDC, 2021).
3. Understanding and strengthening groundwater quality (NWRS 2021-2025)

1.2 Barrier analysis and possible enabling measures for rooftop rainwater harvesting

1.2.1 General description of rooftop rainwater harvesting

The idea of rainwater harvesting is to collect rainwater where it falls. Rainwater harvesting techniques include collecting rainwater from catchment surfaces such as a house's roof, flat and sloping land surfaces, and so on. The process by which rainwater is collected from roof catchments and stored in reservoirs is known as rooftop rainwater harvesting. The catchment region, conveyance method, storage and treatment, abstraction mechanism, and usage components are all parts of a RRWH system. The rainwater collected can be stored in subsurface ground water reservoirs using artificial recharge techniques to suit home demands via tank storage.

The primary goal of rooftop rainwater collection is to store water for future consumption. A roof catchment, gutters, downspouts, and the tank itself make up the RRWH system. Rainfall, roof area and size, surface conditions, roof slope, and the presence of communities must all be taken into consideration when building roof catchment systems. Roof water collecting is thought to be appropriate in regions with annual rainfall of more than 200 mm (Oduor, 2007). The amount of runoff created is determined by the type of roofing material or surface. Most buildings in Somalia, especially those in metropolitan areas, have corrugated galvanised iron roofs with runoff coefficients between 0.8 and 0.9. Roof pitch, defined as the slope determined by the vertical height of a roof truss to its half-length, is mild, ranging from 4 to 12. For such a ratio, the roof pitch factor is 1.05. Roof runoff losses from splashing are inversely correlated with roof pitches; the steeper the pitch, the smaller the losses from water flowing smoothly (Oduor, 2007). The primary benefit of RRWH is that it provides water close to the home, reducing the strain of gathering water on long treks. Rainwater harvesting might not only supplement and alleviate the shortage problem, but also help to environmental conservation.

For each of the four technologies identified for the water and agriculture sectors, a systematic approach of describing and analysing technology barriers, and identification of measures and enabling framework was adopted. The process included identifying preliminary targets for the technology development and diffusion, describing technology properties and its potential adaptation benefits, and identifying measures for overcoming the barriers (Annex 1.1).

1.2.2 Identification of barriers for rooftop rainwater harvesting

Technology category and market characteristics

The RRWH can be classified as a market good when the technology is established at the household level and needs support from the household level to develop and manage the system. The technology option in this research is a household-managed rooftop rainwater harvesting system, which is thus classified as a market good.

1.2.2.1 Economic and financial barriers

a) High cost and the limited availability of suitable financing.

As the technology is identified as a market good, so its development, operation and maintenance remain under the public/private domain. A government/private agency working with RRWH technology, for example, may find it challenging to obtain financing due to a lack of resources. This may be due to a low programme budget compared to the high cost of feasibility studies that gather sufficient data for sound decision-making. These studies may include cost-benefit analyses, financial analyses, or environmental impact assessments. Furthermore, the renovation and maintenance of water conveyance systems complicates the problem of keeping the operational budget low. When international funding institutions like the World Bank provide funding for such projects, there remains a degree of uncertainty regarding the project's success and continuity after it concludes and the majority of the project staff is either let go or transferred to other projects.

In Somalia, there is a considerable demand for RRWH, although investment in this technology is still modest. Economically, RRWH equipment and material expenses are significant. The initial cost of RRWH systems is expensive for the majority of individual households (Goyal, 2014). The most expensive item is a storage tank, whose price varies according to the material and storage capacity.

Because the choice of RRWH technologies is so limited, there are few possibilities to entice diffusers and end users. RRWH techniques in dense metropolitan areas tend to be economically beneficial only if implemented at the proper size to permit economies of scale and taking into account the predicted development of water costs. It has been reported that the average annual water savings from rainwater tanks are closely related to average yearly rainfall (Rahman, 2012).

1.2.2.2 Non-financial barriers

a) Low social culture of RRWH

Even though RRWH is a beneficial strategy for locations with limited water supplies, there are certain challenges to its integration and application. The technology is frequently either too expensive or insufficient to satisfy the users' needs. Users occasionally show a lack of acceptance, drive, and participation. Furthermore, social and economic issues such as land tenure and unemployment are frequently overlooked. Many times, people's understanding of RRWH and utilisation is insufficient and out of date, so that they are unaware of the advantages of RRWH. Another disadvantage is the absence of long-term government policies.

Rural households with hard roof surfaces rarely have enough gutters and pipes to control the flow of rainwater. Water harvesting is through crude methods, and the technology's potential is unknown and dismissed lightly. As a way of life, they have been acclimated to the cycles of water excess and shortage. There is a low level of investment willingness in RRWH because potential users do not take into account the possibilities it opens up or the alternative costs. Additionally, there is reluctance to install RRWH initially in the neighbourhood. This is due to the limited possibility to sell to neighbours in order to recover the costs of the investment since societal norms call for sharing water to foster good social ties.

b) Inadequate Quality Craftsmanship and infrastructure

Inadequate quality craftsmanship contributes to an underdeveloped market for the rainwater harvesting sector. Retailers in rural regions prefer to stock minimal storage choices with a capacity of 250 litres or less. Urban customers may buy larger ready-made water storage tanks of 500 litres or more, while better-off households often only need up to 3000 litres. Consumers are discouraged by the fact that these cost-effective storage options cannot meet all of their household's water demands. The small roof surface area of many rural homes makes this worse. Many rural households are unaware of the many RRWH possibilities in terms of design and building processes, materials, related accessories, parts availability, construction services, and pricing. Additionally, not many people are aware of technological additions like pumps and first flush diverters for enhancing water quality. Raising awareness of RRWH as a key source of clean water has received little attention at the planning and policy levels. Little funding has also been allocated to this sector.

c) Low policy/legal support for RRWH

Rainwater harvesting has received little attention in government programmes and initiatives, despite the government having formed lead ministries to coordinate other line ministries in the administration of water policy. This is in contrast to irrigation or groundwater resources that have received much attention. Following 16 years of civil unrest, Somalia's management capacity to run and maintain water delivery systems is limited. As a result, governments have begun institutional and policy development programmes for rainwater harvesting such as functional private sector engagement in RRWH. The majority of the policies are still in the planning phases and have not yet been put into action. Rooftop rainwater collection promotion and monitoring infrastructure is crude and underfunded. Raising awareness of RWH as a key source of clean water has also received little attention at the planning and policy levels, as well as little funding. Currently, foreign non-governmental organisations carry out the majority of RWH initiatives.

RRWH is not highly prioritised as an alternate water supply source due to low water quantity and quality, as well as a lack of effective demonstration projects. Despite community demonstrations, there are no specialised policies or legislation requiring adoption, nor are there any incentives. There is a lack of understanding of RRWH optimal management practices. Free donations without any type of recompense from recipients result in a lower commitment to managing the offered system. Additionally, because local water committees receive little recognition from governmental organisations, they have trouble accessing financial and technical help.

1.2.3 Identified measures

1.2.3.1 Economic and financial measures

a) Financial Incentives and Empowerment

To discover challenges and solutions appropriate to each context, technology promotion through demonstration must be done for diverse income sectors with direct contact with local populations. Regarding the adoption and marketing of RRWH technology, Australia, Germany, Japan, Korea, and other nations provide a wealth of lessons. These include sharing of information, giving out subsidies and other incentives, and exempting RWH facilities from paying taxes. It is equally vital to empower individuals financially rather than merely technically in order to sustain the implementation of the RRWH technology, for example, through educating on self-funding and self-supply projects. In order to overcome the difficulty created by the expense of RWH development, as well as to eliminate the free water mentality and inculcate a feeling of responsibility, it is necessary to expand the involvement of beneficiaries through a variety of techniques (Han and Park, 2009).

Individual households or organisations can launch a self-supply effort, which is a low-cost way to service delivery. Such initiatives have been made possible in the promotion of RRWH in Thailand's rural districts (Lockwood and Smits, 2011). After seeing internal attempts to raise the living standards, self-supply projects can act as a stimulus for external help from the government and the business sector as well. Self-supply-financed systems provide the potential for improved maintenance and administration. Co-financing, gifts in kind or cash, labour, and microfinancing are a few examples. The Somali government should engage in providing incentives and subsidies to individuals who are working to address local water supply concerns through RRWH.

b) Revitalize private sector

By strategically including private-sector participants in government and NGOs planning of interventions, it is possible to overcome the extremely limited supply of equipment and staff, resulting in very high per capita costs of setting up and managing RWH. Consumer education on the advantages of better access to potable water will increase demand for services and supplies for private RRWH installations. Developing the local community's potential for creativity in the manufacture of necessary parts and the construction of storage tanks from readily accessible materials may be some of the options.

c) Improve household access to financing for RRWH

This may be done by offering favourable financial assistance to rural households so they can afford to install RRWH. In attempts to build sustainable RRWH initiatives, local ownership and engagement are crucial considerations. Potential RRWH users' local economic bases and livelihoods, as well as their capacity to invest, must be strengthened through expanding income generation choices. One of the key requirements is social and economic sustainability, which takes into account cost recovery and the community's willingness to provide resources or labour. The inclusion of gender concerns in project design and implementation is critical. Women are essential in water provision since they are the ones who gather water. Their opinions and experiences must be taken into consideration during the implementation process since they have the greatest interest and benefit from water projects.

1.2.3.2 Non-financial measures

a) Develop a catalogue or database of information on RRWH technology

There is currently no rainwater harvesting guideline that provides technical specifications for building and design as well as alternatives for various home sizes. In Somalia, RRWH materials and related accessories need to be widely publicized and translated into several local languages. A RWH catalogue is also required to advise communities about complementing accessories and equipment for improving water quality. Additionally, the catalogue might offer specialized information for regions with unusual RWH circumstances.

b) Demonstrate the value of RWH under different climate scenarios

Research on the cost-benefit analysis of the current RRWH practices in Somalia should be commissioned by concerned parties. As well as serving as a resource for developing and redesigning RRWH technologies, the data gathered from such studies will be helpful in determining the feasibility of RRWH initiatives or practises. There is also need to create awareness of the potential economic and social advantages of investing in RRWH by conducting value evaluations under forecasted climate scenarios under the Representative Concentration Pathway (RCP). Community members need more hands-on instruction in the various RWH techniques.

c) Strengthen technical capacity in RWH

There is insufficient capacity for planning, building, and maintaining rainwater collection systems. There is therefore a need to promote rainwater harvesting standards that include technical specifics for building and design, as well as possibilities for various home sizes and materials. A framework for building capacity for technical institutions and at local level must be created that considers all facets of education and skill development for various RRWH components as well as for various practitioner groups. Capacity training for government personnel on developing and implementing RRWH policies should be prioritised.

d) Strengthen coordination for implementation of RWH policypProvisions

Policy formulation and implementation should be aided by the development of guidelines, standards, and processes, as well as study trips and the identification of demonstration locations for RRWH best practises. Government and non-governmental organizations aiming to promote RRWH must work together to realize optimum benefits. The main players in RRWH technology should also prioritise gender equality and inclusion in their marketing campaigns (Grant, 2017).

e) Strengthen community organization for RRWH

It is important to create RRWH associations and connect them to regional, continental, and international networks. Plans for participatory RRWH investments should be created with thoughtful and relevant help. To enable local communities to self-organize for RWH, guidelines must be devised. Approaches for promoting RWH should sensitize men on the importance of water provision at household level and involve women in the selection of manageable options. Water officers can provide assistance to low-income homes by beginning with minimal water storage volumes and gradually increasing them to adequate levels.

1.3 Barrier analysis and possible enabling measures for solar-powered boreholes

1.3.1 General description of solar-powered boreholes

For many years, electricity generated by solar panels (photovoltaic power) has been used to power pumps. The technique is already being routinely deployed in remote location where it can provide water with little monitoring. Solar pumping depends on the weather and operates on an 8–11-hour "solar day" (for example, production will be lower under overcast or rainy circumstances). Because of the comparatively modest power output of currently available systems, solar power is only suited for serving very limited populations. It is also regarded necessary that solar systems always have a sufficiently big storage tank, as well as a reserve (e.g., a two-level draw-off structure) in case of unusual weather conditions.

Figure 1: Solar Powered Borehole Pumps in Somalia
Source: Islamic Relief, UK

Solar panel arrays can be fixed to a vertical pole or a ground-level support structure. The use of a tracking solar array, which moves with the sun and is often controlled by an electronic (GPS) or gas system, may boost water output by about 25–30%. A solar-powered borehole system can serve roughly 2,000 people for a borehole with a dynamic (pumping) water level of 50 metres and a surface pipe delivering into a tank 5 metres above ground level (Lorentz, 2012). The following criteria can be used to determine if solar energy will be viable: reliable solar conditions, a high water level for pumping, reasonably flat terrain, and pipes should be as large as feasible to minimize friction losses. Technology for solar-powered homes is the pinnacle of sustainable growth. If properly implemented, it can lift rural populations out of poverty while being ecologically benign (AfDB, 2016). Data on the solar-powered boreholes in Somalia is difficult to obtain. The customs department does not formally gather data from businesses. This makes it challenging to estimate the size and features of the market in detail, especially when combined with the unofficial nature of the distribution routes. However, uncorroborated data from the Somalia Electricity Access Project (SEAP) indicate a growth in sales of stand-alone solar systems from 2019 to 2020.

1.3.2 Identification of barriers for solar-powered boreholes

Technology category and market characteristics

Solar-powered borehole technology can be categorized as a market public good when established at a household or community level and requires individual/community level support to develop and manage the system. The technology option in this report is individual or community managed technology and thus considered as a market public good.

1.3.2.1 Economic and financial barriers

a) High costs related to Solar PV equipment and drilling

Without a doubt, PV pumping systems have a high capital cost, a significant percentage of which is related to the cost of the photovoltaics (Samatar et al., 2023). This could be due to various factors, including limited infrastructure, limited demand, political instability, and low economies of scale. Unless external entities like governments, aid groups, or non-governmental organisations (NGOs) become involved, current costs appear to exclude people who need the water the most. Since PV panels are expensive, the lowest capital cost option is frequently pursued, regardless of dependability, long-term expenses, or efficiency. The economic feasibility of PVs varies both within and between nations, and anyone wishing to implement them must be aware of this

(Kiprono and Llario, 2022). However, because solar-powered systems do not require fuel, operational costs are restricted to component maintenance and replacement at the end of life.

b) High maintenance costs

Site selection, drilling, and equipment are some of the direct expenses of boreholes. Other expenses include significant personal costs for hydrogeologists, technicians, and temporary workers. When feasible drilling locations are far from target populations, hilly, or bushy, access development expenditures, including clearing and maintaining access roads, must be considered. Because replacement parts and technical expertise are hard to come by, borehole maintenance is complex and quite expensive. However, there have been instances of improper borehole drilling and well digging in Somalia as a result of water scarcity and the need to provide water to vulnerable communities (FAO-SWALIM, 2012).

c) Weak access to funding mechanisms

Due to the absence of a thriving banking industry, most small- to medium-sized firms in Somalia have few choices for funding. Despite recent expansion in the financial sector, access to credit in Somalia is still constrained. This lack of access to funding has an influence on the renewable energy sector as well. In the renewable energy industry, around 50% of Somalis say that access to financing is a major barrier to their growth (KIMS, 2016).

1.3.2.2 Non-financial barriers

a) Low technical capacity for PV installation and constructing operating and maintaining deep wells

Generally, the Renewable Energy industry often has technical capacity shortfalls in Somalia. Nearly all categories of technical skills have equally urgent needs to be filled in terms of particular technical abilities. There are several value chains in the solar energy industry, each of which has its own set of skills needs (AfDB, 2015). To successfully collaborate with water specialists in the installation and maintenance of these systems, solar technicians must have complementary abilities in hydraulics, at least at a basic level.

Because of a lack of hydrogeological information, it is difficult and unpredictable to determine the amount of subsurface water as well as the physical demarcation and dynamics of aquifers (Denis, 2018). Drilling firms sometimes exploit ground water from confined, underdeveloped areas due to inadequate skills, which results to overexploitation. Because service providers sometimes lack the necessary skills and tools to distinguish between real and fake products, cases of defective infrastructure throughout the building and operation phases are relatively prevalent. The inability of available technicians to perform repairs and maintenance results in the boreholes' restricted functionality. Deep borehole extraction training is costly since it requires specialised tools and equipment. As a result, relatively few people have access to this form of training. The universities don't provide any courses specifically on groundwater extraction. Topics related to groundwater development are covered in other courses. The absence of adequate training programmes in the renewable energy sector is a significant barrier to the industry's expansion. It is also challenging for this industry to inspire and retain experts due to limited funding allocation.

b) Underground water quality concerns

The quality and chemical composition of groundwater are determined by the soil and geological formations through which the water flows, as well as the effective recharge, groundwater depth, and contaminants present in the catchment region. Field measurements reveal variances in the pH (acidity and alkalinity) of tested waters between 6 and 10, water temperatures between 19 and 38 ^{o}C, and electrical conductivity between 160 and 11 000 µS/cm (FAO-SWALIM, 2012). This indicates that the salinity of groundwater from particular formations may be quite high. Although levels of calcium, magnesium, salt, potassium, and other components are typically higher than the WHO's recommended guidelines for drinking water, accepting these waters is sometimes the only option available (Mohamed, 2022; Quiroga, 2023).

Groundwater in Somalia can potentially be polluted by a variety of chemical contaminants such as fluorides. Explosives and other hazardous items are present in some regions as a result of the civil conflict. Shallow aquifers are frequently polluted, which can lead to severe water-related illnesses, as is often the case in Somaliland and Puntland. Groundwater pollution is the most serious hazard to humans and cattle in Somaliland and Puntland (Araya et al., 2023).

c) Institutional weaknesses

A number of sectors, such as water, mining, electricity, and irrigation, are impacted by groundwater. However, cooperation between these sectors is lacking. The regulations and legislation controlling groundwater abstraction are poorly understood and implemented. Drilling and abstraction operations are not adequately regulated, and some abstraction firms work without licenses or oversight.

There are several obstacles this industry must overcome before it can expand institutionally and organizationally. These include: poor implementation of current regulations; uncoordinated sector activities mainly due to weak sector institutions; a donor-driven sector as a result of inadequate sector financing due to the appallingly low availability of government revenues; a scarcity of industry specialists since most professionals have emigrated. One of the primary causes of fragility is a lack of institutional ability to provide fundamental services. The government's solar-powered borehole initiatives may be in jeopardy due to insufficient institutional capability and a lack of the necessary legislative framework. The efficacy of the solar-powered boreholes, however, is strongly reliant on the organisational ability of the local water user groups to maintain mobilisation.

1.3.3 Identified measures

1.3.3.1 Economic and financial measures

*a) Reduce importation costs of equipment*As the demand for water increases, it is critical to create inexpensive solutions that reach all regions in order to support continuous renewable energy growth in the water sector. The financial feasibility of solar PV vs manual pumps has been extensively studied, and the results show significant promise (Fresnaye, 2018 and Samatar et al., 2023). Because the expenses are mostly tied to the usage of imported equipment, the government must seek measures to reduce importation costs in the near term, maybe by eliminating importation taxes by more than 50%, while simultaneously working on a long-term plan of producing the parts domestically.

b) Establish public-private partnerships

Additionally, cooperation with the private sector is required for the creation of viable commercial firms associated in groundwater resource development sector. Provide incentives to developers and users of solar-powered boreholes to encourage the market to make room for green infrastructure tools, equipment, and initiatives by including private investors in public-private partnerships or stand-alone private projects.

c) Build technical capacity

More technical personnel ought to be trained, which will increase their availability thus lowering their recruiting costs. There is need to strengthen research and development initiatives at the state and local government levels. It is also important to ensure that programme managers have a dedicated source of financing for staff training and the acquisition of any other essential equipment. GIS and groundwater mapping techniques ought to be introduced to track and assess the effectiveness of the boreholes that are currently in use. More large-diameter boreholes should be drilled since they are more cost-effective in the long term and can serve much more people than smaller ones.

d) Provide subsidies for solar technologies

Authorities must take a significant role in managing the industry and can strengthen their position by using subsidies. The government should give incentives for the adoption of efficient water technology in order to meet climate objectives. In order to lower greenhouse gas emissions, there is also a need for incentives to decrease the usage of conventional energy sources. Subsidies for energy technology must be redirected toward this goal.

1.3.3.2 Non-Financial Measures

a) Strengthen technical skills for solar-powered borehole installation and management

Create new training programmes and improve current ones that are focused on improving students' technical proficiency in solar energy technologies, engineering, project design and management, installation, and maintenance. It is also necessary to align sector demands with workforce supply by working with stakeholders in the solar and underground water sectors to identify skill shortages in the current labour force and by designing and enhancing training programmes that focus on filling these gaps. To assist the integration of internationally recognised curriculum into new and current training programmes on designated priority areas, establish networks with technical training programmes and institutions in other nations. To close the skills gap, include diaspora with technical expertise and credentials who are linked to solar energy and underground water businesses or educational institutions in their host nation. A process for technical competence certification is of the utmost importance. Create a certification scheme with all partner institutions that would include uniform testing and examinations throughout Somalia (Maia and Saskia, 2016).

To guarantee that the functioning of existing wells is maintained, community training in borehole operation and maintenance is also necessary. A well-established GIS Geo database is required for the collecting and analysis of data from multiple sources (FAO-SWALIM, 2012). This database would illustrate the current state of groundwater, the quantities available, the quality, and the prospective prospects it provides for climate adaptation, farming modernization, and business growth.

b) Strengthen institutions for Solar PV and groundwater management

To solve institutional and organisational development and capacity deficit concerns, institutions must be strengthened, and sector capacity built. This would involve cooperation between the government and essential sectors like agriculture, water, and energy, as well as coordination between the government and NGOs. It will also entail increased coordination and collaboration among various sectors in the management of solar-powered boreholes by establishing a central authority or forum for ongoing multijurisdictional communication, planning, and monitoring. Members of the water user association committee must have access to adequate management, mobilisation, and oversight funds.

If solar energy is produced in excess of what is needed for water pumping, there may be additional applications for it on farms. Planning alternate power usage aids in the valuation of produced electricity, reducing pump abuse and increasing income sources. Additionally, it might ensure that the solar technology is used to its full potential and provide farmers the freedom to choose how best to use water and energy on their own farms. Hydrogeology research must be expanded in order to determine the present state of groundwater. It also is necessary to conduct feasibility assessments for various groundwater resource development strategies.

c) Improve underground water quality assurance

There is a critical need for regulatory frameworks and assistance for current water utilities and medical facilities to frequently sample and analyse the water drawn from subterranean sources using chemical and bacteriological analyses. Governments and donors should provide enough laboratory equipment and other logistical support. Other measures to be undertaken include: testing aquifer and groundwater before tapping; maintaining a groundwater monitoring network; designing and constructing groundwater control and conservation structures; removing existing major pollutants by chemical treatment and remediating their previous locations; and strengthening sanitary education in schools. Collaboration with other sectors such as energy and environment can also result in changes that lessen water pollution, such as rules that guarantee sewage and wastewater are discharged in a manner that is friendly to groundwater.

1.4 Linkages of the Barriers Identified

This section assessed common barriers for both the roof-top rainwater harvesting and solar-powered boreholes. Both technologies in the water sector aim at enhancing water security for humans, livestock and farming. Rooftop rainwater harvesting (RTRWH) is the most common technique of rainwater harvesting (RWH) for domestic consumption. It is a simple, low-cost technique that requires minimum specific expertise or knowledge and offers many benefits. Rainwater harvesting can supplement water sources when they become scarce or are of low quality, like brackish groundwater or polluted surface water in the rainy season.

Solar-powered boreholes are a simple technology where water is pumped from the ground using electricity generated from solar panels, making it a reliable, clean, sustainable solution – even in the most remote areas.

Barriers common for both technologies include high cost of establishment, limited capacity, and information gaps. Although the demand for water access has increased tremendously in the last few years due to climate change-related extended droughts and flash floods, the rate of adoption of water harvesting techniques, especially in rural areas of Somalia, remains very low. The cost of installation of the technologies in both the rural and urban populations remains a challenge due to the fact that 69% of the population lives below the poverty line. This pushes much of the infrastructure installation costs to the government. Still, maintenance cost for solar-powered boreholes remains a challenge for local communities despite government interventions aimed at creating sustainable models in some parts of the country with support from development partners.

Limited capacities to operate and maintain the water harvesting technologies remain a challenge. Although there are Water Users Associations in some regions, it has not translated to sustainable water harvesting and management practices. The Water Users Association's skills need to be continuously enhanced as they are a barrier to ensuring the diffusion of water harvesting technologies. Choosing the membership of the association should be based on basic literacy level and basic knowledge of water management so that they can work well with the government, development partners and communities efficiently. The low literacy level, especially among rural, IDPs and poor urban, has created challenges in enhancing knowledge and information sharing using mobile phones, which can be harnessed to reach even remote regions of the country. There is a need for coordinated capacity development by the government in collaboration with the Water Users' Associations and local administrations.

.

1.5 Enabling framework for overcoming the barriers in the Water Sector

The water harvesting technologies are aligned with Somalia’s constitution, National Water Resource Strategy 2021-2025, NAP Framework and the National Development Plan 2020-2024.

An essential element that facilitates the removal of obstacles to adopting technologies that are prioritised in the water sector is the operationalisation of the current Water Resource Management Strategy 2021-2025, NAP Framework and Updated NDC 2021-2030 and the suggestions made by its implementation framework. The next action should be to allocate more funds in the budget to help the communities that are most at risk from the effects of climate change on water supplies. This may be accomplished by ensuring that social, economic, and environmental aspects of water are incorporated into sectoral policies and strategies. These plans and programs should be guided by the cross-cutting themes of water access, equality, and hazards. Access to international climate finance funds, particularly the GCF and the Adaptation Fund, and the mobilisation of external donor agencies can support the proliferation of the aforementioned prioritised technologies. The enabling framework for addressing barriers common to the three technologies is summarized in table 3.

Table 3: Enabling framework for addressing barriers common to the three technologies.

Barrier	**Enabling framework**	**Responsible**
High cost of installation	Developing facilities under public-private partnerships (PPP) arrangement where private rural and poor urban households can acquire technology construction equipment at a subsidised price	Ministry of Finance, Ministry of Water and Energy Minister of Planning, Investment and Economic Development
Inadequate capacity of Water Users Associations	Many local and international NGOs are involved in the water sector development across the country. This can be harnessed to train and support Water Users Associations	Federal Member States, Ministry of Water and Energy, Ministry of Environment and Climate Change
Low level implementation of relevant water harvesting policies	The Water Resource Management Strategy 2021-2025 and the Updated NDCs emphasise the need for prioritization of water harvesting technologies. This can be achieved through implementation of the strategy and by formulation of enabling	Ministry of Environment and Climate Change, Ministry of Water and Energy

	policies.	
Inadequate community support for sustainable operation and maintenance of installed water infrastructure	The Water Resource Management Strategy 2021-2025 of Somalia emphasizes the importance of providing technical support in enhancing access to clean and safe drinking water. Guiding Principle 16 of the Water Strategy states: “Plan and Develop Water Sector Infrastructure” …Community and Socio-Economic needs are included in the development of infrastructure solutions…”	Ministry of Water and Energy
Low private sector investment	The strategy for public-private partnerships in all stages of the development of water projects - formulation, implementation, monitoring and evaluation (Water Resource Management Strategy 2021-2025)	Ministry of Water and Environment, Ministry of Finance

CHAPTER 2: AGRICULTURE SECTOR

2.1 Preliminary targets for technology transfer and diffusion

In a technological prioritising process involving national stakeholders, the following technologies were prioritised for climate change adaptation in the agriculture sector:

- Drip Irrigation
- Early Warning Systems

This chapter outlines the steps taken, the findings from a study on the barriers preventing the transfer and adoption of these technologies, the countermeasures, and the supporting framework. These technologies' respective aims in terms of national aspirations are listed below.

Drip Irrigation

The establishment of the Jowhar Sugar Estate in Somalia in 1920 marked the beginning of irrigated agriculture. Small scale farmers in Southern Somalia have traditionally used the Juba and Shabelle rivers for irrigation. The Shabelle and Juba River Basins are critical resource bases for Somalia, since they supply the country's rice bowl and development. Irrigation barrages were built in the middle and lower Shabelle and Juba River Basins of Somalia to irrigate land for commercial and food crops. Gravity irrigation was possible because of the good topography and a network of canals. A well-established system of canals and drains provided irrigation regions with a steady water supply that supplemented the infrequent and unpredictable rainfall. The Shabelle and Juba Rivers' 10 barrages are perhaps Somalia's most important irrigation infrastructure components. They were built to improve the river's depth and redirect the flow for agriculture reasons. Many farmers in Somalia still rely on rain-fed agriculture and are therefore susceptible to climate changes. In order to build community-based drip irrigation systems throughout all areas, certain sociological and climatic requirements must be taken into account. Promoting irrigated agriculture must take into account issues such as water-stressed areas, underprivileged groups, and gender-related issues.

The preliminary targets identified for the transfer and diffusion of these technologies in agriculture sector are:

1. By 2025, five million hectares of agricultural farmlands in arid and semi-arid regions to have drip irrigation systems installed;
2. Farmers to be trained on effective irrigation practices and water management.
3. Up grading of existing agriculture research and development centers;

Early Warning Systems

Natural disasters have become more common and complicated in Somalia over the past several decades, and their effects have had a big influence on the nation. The two natural cyclical catastrophes that commonly afflict the nation and cause recurring losses of people, crops, and cattle are floods and droughts (Gure, 2021). In Somalia, several early warning structures have been established around the country. The National Multi-Hazard Early Warning Center was established in Mogadishu in 2020, and it was given responsibility for coordinating disaster risk management efforts across the nation. The centre has assumed leadership roles in state, local and municipal emergency management initiatives. One of the center's key responsibilities is to regularly generate climate-related information products, such as predictions for temperature and rainfall, early warnings for cyclones and floods, and estimates for the spread of illnesses and desert locusts (Lubogo, 2022).

The early warning system's goal is to alert the public to impending natural hazards so that those who are most at risk are aware of their possible effects and may take necessary action to limit harm. Owing to the complexity of the global climate and weather systems, countries like Somalia, where the frequency and intensity of extreme and erratic weather patterns are increasing due to climate change, particularly depend on regular measurement of specific variables provided by climate monitoring and early warning systems. The early warning systems are crucial for supporting the country in preparedness, planning and adaptation for disasters arising from extreme weather events as a result of climate change shocks.

Upon detection of a possible hazard such as floods or droughts, the competent persons, most commonly the first responders or emergency response workers, are informed and take immediate action thereby averting possible disasters. Additionally, SWALIM, an information management initiative run by the UN Food and Agriculture Organization in Somalia, offers frequent updates on water resources with an emphasis on early warnings for drought and flood risk. To help with flood management in

Somalia, it SWALIM has also created the Flood Risk and Response Management Information System (FRRMIS). In order to enhance and assist decision-making in sustainable natural resource management, planning, disaster preparedness and response, and resilience building, humanitarian and development organisations largely rely on SWALIM information and early warning. The Famine Early Warning Systems Network (FEWSNET) is another source of early warning systems in Somalia.

With extensive climate monitoring and an effective prediction and early warning system in place, this technology improves vulnerability monitoring, allowing individuals and communities to plan for climate change-related risks. It also allows for the early identification of at-risk populations in disaster-prone areas, as well as the provision of information to decision makers for effective adaptation planning and integration into national development goals.

Somalia’s NDC spells out that the priority contribution to addressing climate change includes building resilience to climate change impacts by establishing effective early warning systems and disaster risk management policies to improve resilience to extreme weather events. The budgeted adaptation actions under the NDC include establishing meteorological networks to enhance early warning systems and strengthening the adaptive capacity of the most vulnerable groups, including women, children, elderly persons and IDPS communities.

Somalia’s National Development Plan 2020-2024 recognised the need to strengthen disaster risk management through the National Disaster Management Policy. The Somalia Disaster Management Agency (SODMA) is the lead agency for emergency planning and response including the establishment and operation of early warning systems.

The preliminary targets identified for the transfer and diffusion of these technologies in the agriculture sector are:

1. Upgrading and modernization of climate monitoring and forecasting system in Somalia by 2025.
2. Developing and promoting the use of drought tolerant seed varieties by 2025

2.2 Barrier analysis and possible enabling measures for drip irrigation

2.2.1 General description of drip irrigation

In fields with a broad range of soil types, on steep and undulating slopes, with porous or shallow soils, in situations where water is scarce, costly, or of poor quality, drip irrigation is frequently the preferred technique of irrigation. In drip irrigation, water is injected into the soil either directly on the soil surface or buried in the soil through a small aperture. Drip irrigation provides water to the roots of individual plants as often as required and at a reasonably cheap cost by administering water at a very slow rate. Drip irrigation is effective in a variety of field and water settings because it allows for the exact placement of water when and where it is needed with a high degree of consistency and efficiency (90% or higher). Additionally, compared to other irrigation techniques, a well-designed, well-maintained drip irrigation system can distribute water more uniformly. These characteristics result in more consistent and greater agricultural yields per land unit (Jimale et al., 2023).

By not completely soaking the soil surface between rows or trees, direct evaporation from the soil surface and intake of water by weeds are decreased. Drip irrigation makes it feasible to manage challenging soils, from crusting soils to porous sandy soils, by reducing or eliminating runoff and deep percolation. Drip irrigation is classified into two types: surface drip irrigation and subsurface drip irrigation (Postel et al., 2001). The subsurface type employs a buried emitter, which has the ability to conserve irrigation water by decreasing the quantity of water applied to the plant.

Figure 2: Drip irrigation farm in Somalia

Source: Axel Fassio

Depending on the operational pressure of the drip emitters, drip irrigation systems function within specific pressure ranges. As a result, a drip system should be built to satisfy the needed demand in terms of water scarcity resulting from climate change effects. The water is discharged from the emitters into the soil under the influence of pressure. If the available head is greater than or equal to the total head needed for the irrigation system, no pump is needed for a water source that is higher up than the irrigated area. A pump is needed to provide the desired pressure in cases when it is lower.

2.2.2 Identification of barriers of drip irrigation system

Technology category and market characteristics

The drip irrigation technology options examined in this report are systems owned by farmers and, depending on the scale of application, can be classified as a market consumer goods. A market map (Annex-1.2) is created to depict the operating aspects of the technology market and how their interconnectedness influences technology diffusion and success on the field level.

The process of identifying barriers to the diffusion of drip technologies is primarily based on literature reviews, interviews with sector experts, and consultation and brainstorming sessions with stakeholders at the workshop, including technology market suppliers. The identified barriers and measures were assessed utilising market mapping and solution trees presented in Annex 1.2. The identified barriers are divided into two main categories- economic/financial barriers & non-financial barriers.

2.2.2.1 Economic and financial barriers

High cost of establishment, operation and management

For smallholder farmers, the costs of setting up, running, and maintaining a community-based irrigation system may be prohibitive. Many factors influence the choice to switch to drip irrigation, including the cost of cultivation, productivity, yield gain factor, cost of producing energy prices, and irrigation demand. These characteristics differ from crop to crop, location to location, plot size to plot size, and farmer to farmer. The expense of a drip irrigation system is considered to be considerable. The cost and advantages of investing in a drip irrigation system are determined by ecological and geographical factors (Postel et al., 2001). However, when compared to traditional sprinkler systems, dripline installations have a lower average material expenditure. Dripline maintenance is minimal, consisting of only occasional flushing and system evaluations (Ameer et al., 2019).

Repairs, desilting and unclogging irrigation canals, electricity supplies, and management expenditures are examples of recurring costs. Due to a paucity of technical expertise in rural locations, maintenance and repair expenses tend to rise. This causes service delays and, eventually, breakdown. Community mobilisation, planning, and training, feasibility studies including assessments of the ecological and social effect, monitoring and oversight of operations, and protection of the infrastructure from overuse and vandalism are all associated expenditures. Due to significant administration and operating expenses, these setups may fail to remain operational for a duration that is economically sustainable.

2.2.2.2 Non-financial barriers

a) Limited farmer capacity in organizing and managing drip irrigation systems

Drip irrigation needs additional maintenance and constant monitoring during operation. It needs a large investment capital as well as highly trained labour. Water user committees lack the necessary expertise in normal maintenance, repair, and troubleshooting. There is also lack of well-trained local technicians for sustainable operation and maintenance of these systems.

Local experts who are well-trained are required for the long-term operation and maintenance of these systems. There is a scarcity of technical ability to take into account soil type, field size, slope, and field characteristics. There has been relatively little study on communal irrigation. Water and agricultural work plans and budgets are prepared independently. Rarely do extension agents possess the comprehensive hydrogeological and socio-economic expertise needed to provide drip irrigation consulting help. Drip irrigation systems are not widely used. As a result, there is limited experience knowledge to back it up. For instance, where to get equipment of high quality at reasonable cost; what components may be made locally; what costs the community can afford and is willing to pay, and if this is enough to operate and administer the system; and the expenditures associated with the system's day-to-day operation.

b) Insufficient water and infrastructure

Some of the difficulties encountered include water storage issues and animal damage. Water availability, quality, and storage are significant issues related with drip irrigation adoption. There could also be uneven water distribution on unleveled plots, causing over or under irrigation to some plants.

c) Information and awareness barriers

Critical information gaps exist about the water requirements of various crops and irrigation schedules that are effective in mixed cropping compositions, which are typical in smallholder systems. Small-scale farmers also choose flood irrigation systems over other irrigation strategies (Friedlander et al., 2013).

Communities must have the ability to balance the requirements of agricultural irrigation with those of fish farming, livestock watering, and household water needs since irrigation reservoirs sometimes serve several purposes. Given the unstable market circumstances for agricultural commodities, there is little information available on the business potential of a drip irrigation project. There is inadequate awareness about the existence and usefulness of drip irrigation. Farmers also have limited access to training services and information.

e) Potential conflict related to land, water, infrastructure ownership rights

Scarcity of grazing land is one of the land-related proximal determinants of conflict; the excessive expansion of cattle; ambiguous and unacknowledged pastoralist communities' land rights; the failure of the regulatory frameworks governing the use of natural resources; the use of community land for private pasture enclosures. Droughts are the most frequent causes of violent land disputes; farms being destroyed by livestock; excessive use of pasture or water by one group at the expense of another; and damage done to grazing land by charcoal producers (UN-Habitat, 2020).

Illegal or irregular land purchases are among the land-related proximal drivers of conflict linked to exploitative or uncontrolled investment. Others include land grabbing; corruption among land experts and land-related institutions; greater competition for precious land; land is under excessive pressure because to a lack of banks and alternative investment institutions; and a lack of safeguards for landowners and occupiers (UN-Habitat, 2020). Women, especially those with smaller landholdings or uncertain land rights, are also more prone to experience unfair treatment, which might reduce their motivation to practice drip irrigation. Water sharing between upstream and downstream consumers, as well as between producers of crops, animals, and fish, might pose difficulties.

2.2.3 Identified Measures

The measures required to remove the barriers to the adoption of efficient irrigation technology in Somalia that were noted in the preceding section are covered in this section. The main methodology employed for the identification of appropriate measures is the development of problem and solution trees (Annex 1.2) through the stakeholders’ participation. A careful examination of existing national and international practices in the relevant field was also conducted.

2.2.3.1 Economic and financial measures

a) Provide access to a range of financial choices

The following economic and financial measures might assist in reducing drip irrigation's expenses. Offering loans with low or no interest for equipment installation and purchase; Promotion of the adoption of these water-saving devices through the provision of specific grants or subsidies on installation costs. The subsidies will support progressive farmers and organized farmer groups to set up micro irrigation schemes. Targeted subsidies are needed when introducing farmers to new technologies and ensuring that marginal farmers are not excluded. Providing liberal tax breaks or tax incentives and financial disincentives to discourage the use of irrigation systems that waste water can also serve as an economic measure to promoting drip irrigation. By eliminating import taxes and, if feasible, supporting locally produced goods through strengthening policies, laws and regulations, smallholders' costs for irrigation equipment can be decreased. Additionally, it is necessary to develop local manufacturing skills for creating and customizing equipment to match the demands of users. Tax reductions on water and energy expenses will lower operating costs.

2.2.3.2 Non-Financial Measures

a) Training of water users and service providers in design, installation, operation and maintenance of drip irrigation systems

The focus of education should be on how technology will improve the lives and provide women who utilise and manage water resources more authority. Farmers should be trained on how to utilise current weather and soil data to predict crop water requirements and to manage irrigation water and schedule irrigation. From performing feasibility studies through establishing, running, and monitoring drip irrigation initiatives, complete farmer involvement is required. Through demonstrations and hands-on training, farmers must be made aware of drip irrigation equipment such as pumps, pipes, and drip lines. This may be accomplished by creating useful recommendations for managing and designing drip-irrigation systems. To expose farmers, organise an exposure trip to a drip irrigation demonstration location, and supply them with all products, suppliers, pricing, and economic benefit of drip irrigation.

It is also necessary to refocus the ability of water users' groups toward operating an irrigation system as a business.

b) Develop institutional capacity

To conduct required research and pilot demonstration projects, the government may offer the necessary financial support to its research and development and other pertinent organisations. Government agencies may conduct active communication and awareness campaigns regarding the utility of drip irrigation technology. Institutions for research and development may be bolstered and given the responsibility of creating the long-term water and climate scenarios for the country. Institutions that are concerned should establish standards for drip irrigation equipment parts.

c) Create informational packets for small-scale irrigation.

The existing dispersed information on drip irrigation has to be compiled into a package that extension workers, organisations that provide assistance, and potential users of the drip irrigation technique may readily access. These modules should include details like a description of the drip irrigation technology and any advantages it could have, the necessary equipment, where to obtain it and how much it will cost, necessary skills and service provider connections, maps showing prospective drip irrigation locations, as well as the regulations for installing drip irrigation. Such information must be provided in accessible formats and in local languages that are spoken.

d) Mitigate and avoid potential conflict related to land, water, and infrastructure ownership rights

It's important to lessen the effects of land degradation, including droughts, especially in conflict-prone regions, and to analyse the ability of the territory and its resources to maintain the primary land uses in order to minimise disputes over the use, control, and exploitation of natural resources. To regulate the use of land, water, and other natural resources, regulatory and enforcement systems should be put in place or enhanced. A collaborative process should be used to determine or demarcate migratory pathways in order to control livestock and farming operations. Regulating charcoal production and enhancing conflict resolution procedures are also necessary. Large-scale charcoal production has been linked to dangers of deforestation, land degradation and climate change. The destruction of farmlands and pasturelands due to deforestation and associated land degradation is a major factor in the decline of Somali pastoralism and food security and a source of land conflicts (Said, 2022). For refugees, displaced people, and landless poor, suitable land and tenure security should be offered. There is a need to rethink the way the land rights system is set up and the relevant land tenure categories, incorporating the notion of the continuum of land rights, to guarantee that land and land-based resources become drivers of social and economic growth and support peace rather than disputes. The legislative, religious, and customary conflict resolution systems in Jubaland need to be brought into coherence. Religious and traditional practices should not uphold unjust laws and discriminatory practices against women and other vulnerable groups.

2.3 Barrier analysis and possible enabling measures for early warning systems

2.3.1 General description of early warning system technologies

The transmission of timely and effective information through recognised institutions that allows those exposed to hazards such as drought and floods to take action to minimise or decrease their risk and prepare for successful reaction is referred to as an early warning system (Gure, 2021). An early warning system's is a non-market technology whose main goal is to enable people and communities to react to threats quickly and appropriately in order to lower the chance of fatalities, serious injuries, property loss, and other damages. An early warning system is made up of four fundamental components, each of which is essential to the system's effectiveness, namely; risk knowledge, Monitoring and warning service, dissemination and communication, and communications and response capability (Mercer et al., 2009).

The high level of uncertainty associated with the lack of precise and trustworthy data severely hampers accurate and reliable forecasts of day-to-day weather, and notably future implications of climate change. Since weather and climate systems across the world are complicated, for countries like Somalia, constant assessment of specific variables given by climate monitoring and early warning systems is especially crucial because climate change is increasing the frequency and intensity of extreme and irregular weather patterns. With a strong climate monitoring network in place, as well as an excellent forecast and early warning communication system, this technique improves vulnerability monitoring's efficiency and enables community and individual preparedness for risks.

Technology Category and Market Characteristics

Early warning systems can be classified as a nonmarket public good when established at the state level. The technology option being considered in this report is a state-run and state-provided early warning system which is a non-market public good. The analysis was done using problem tree (Annex-1).

2.3.1.1. Technology Status in Somalia

Despite considerable progress in the development of early warning systems in Somalia, little has been achieved in their mainstreaming into national development plans due to the comparatively late implementation of disaster risk reduction measures in Somalia. The Ministry of Energy and Water Resources has pledged to lead the Flood and Drought Task Force in reducing the effects of recurring droughts and floods. This task force will improve coordination and partnerships, operate a reliable flood and drought management system among all pertinent stakeholders, and address the effects of floods and droughts on the socioeconomic growth of the nation as a whole. The task force performs a variety of duties, including:

- Planning and coordinating flood and drought-related actions;
- Enabling flood/drought management contingency mechanisms at the national, district, and neighbourhood levels;
- Building confidence and establishing a credible Flood and Drought Management system among all essential parties to improve collaboration and partnerships;
- Using a monitoring and evaluation system that is efficient and effective for planning and directing flood and drought-related operations.

In Somalia, examination of risks trends has historically been done using historical data. However, because hazard features are changing as a result of climate change, employing these crude techniques as early warning systems in Somalia to decrease catastrophe risk is no longer sufficient. Therefore, significant accomplishments may be made with the proper application of meteorological, hydrological, and climatic information. There are chances to extend the lead times of early warnings as a result of the development of climate prediction models (Hillbruner & Moloney, 2012).

Early Warning Systems strive to mitigate the effects of natural disasters by delivering timely and relevant information in a systematic manner. Early warning systems, if implemented well, can help Somalia become more resilient to climate-related hazards and natural catastrophes. They can also help the country fulfil its national adaptation plans by reducing the loss of life and livelihood.

Since this technology is not yet fully developed in Somalia, the assessment will be useful for the implementation of Somalia's NDC, which also identifies the development of early warning systems as a necessary action for climate adaptation. This assessment will aid the NDC by outlining the possible barriers to implementing early warning systems and the possible mitigation measures for those barriers. Significantly, it will further aid the implementation of the National Disaster Management Policy led by SODMA.

2.3.2 Barriers of Early Warning Systems

The identification of barriers to technology dissemination was mostly based on literature reviews, interviews with sector experts, and consultation and brainstorming sessions with stakeholders. The identified barriers and measures were analyzed using the starter problem and solution trees presented in Annex 1.2. The identified barriers are divided into two main categories- economic/financial barriers and non-financial barriers.

2.3.2.1 Economic and financial barriers

This report's technological alternative is a non-market public good: a government-run and -provided climate monitoring and early warning service. A significant financial barrier to the dissemination of technology is the high initial investment cost and insufficient government financial assistance. Thus, the following are the main financial barriers that the aforementioned procedure revealed:

- The setup of an advanced forecasting system and effective early warning system requires a significant initial expenditure.
- Such an early warning and forecasting system has high operating and maintenance costs.

2.4.2.2 Non-Financial Barriers

Non-financial barriers to an effective early warning system in Somalia were highlighted as follows.

a) There is insufficient technical capacity to create and run complex numerical forecasting models.

Somalia lacks the technical and organisational capabilities to distribute timely early warnings and accurate hydrological information required for efficient and cost-effective responses to disasters. The FEWSNET, FSNAU, and FAO-SWALIM initiatives, which are donor funded, issue alerts and early warnings. Regular updates on water resources, with a focus on early warning of drought and flood risk, are provided by

FAO-SWALIM. In all zones of Somalia, technical and operational flood and drought preparedness capacity is severely low because this sector is not well established and it lacks the necessary support. For the MoEWR and other stakeholders, establishing a professional and technical staff is a significant task.

The absence of proper professional training or education for early warning systems is the principal course of knowledge and skill gaps. Currently, no educational institution or organisation in the country offers a comprehensive storms, floods, and drought early warning system learning and training curriculum. Leadership's ability to lead and create a learning environment and culture for early warning systems is likewise limited.

b) There is a scarcity of real-time climate data.

The Somalian civil war, which lasted for a long time, caused the climate monitoring network, which had been collecting data between 1963 and 1990, to disintegrate. The lack of data beyond 1991 makes reliable flood and drought predictions difficult. There are inadequate in-situ hydro-meteorological monitoring stations in many regions of Somalia to support the reliable provision of hydro-meteorological services. The early warning systems' effectiveness is seriously hampered by the lack of real-time data transmission.

c) Challenges in dissemination and communication

Lack of clear duties and responsibilities amongst the line ministries and agencies continues to be a major gap for communicating the warnings to those who are at danger (MoEWR, 2021). At the moment, early warning information is communicated to communities in an ad hoc, unorganised way by texting or talking between themselves. Because of their remoteness, all of the targeted agropastoralists are unaware of and unprepared for extreme disasters. The impact information about the danger and user-supportive instructions to help them take action on the ground are missing from the issued alert, leaving the warning threshold level open to debate. Unclear warning statements are more likely to be ignored by groups and people, which reduces the value of the warning.

d) Lack of response capacity

The existing response plans and strategies are concentrated on post-disaster situations due to the lack of a systematic early warning system and standard operating procedure at the national level (MoEWR, 2021). The early warning system is only capable of providing forecasts, issuing alerts, and disseminating such alerts on a national scale. A comprehensive strategy for responding to the given warnings is lacking throughout the country. The present predictions and warnings do not include information on the effect of the dangers, as well as advise on what a specific community or group should do, when and how. The coordination needed to facilitate reaction interventions to early warnings has not yet been created among the various entities (Maxwell, 2019).

Other barriers include; limited ability to locally evaluate forecast; there has been little studies in the field of weather and climate change science; free data interchange between national user organisations is absent; there is a lack of coordination between key government organisations, such as the provincial and federal departments of agriculture, water management, and disaster management.

2.4.3 Identified measures

2.4.3.1 Economic & financial measures

a) Increase budget allocation to modernize early warning systems

It is crucial to allocate the additional funds required for the modernization, development, and improvement of Somalia's climate monitoring, forecasting, and early warning system. According to the Federal Ministry of Finance, Somalia's 2023 annual budget was estimated at One Billion US Dollars. Additional funds of not less than 50 million US Dollars (5% of the total budget) should be utilized for enhancing overall early warning systems due to Somalia's vulnerability to climate shocks such as droughts and floods. Between 2020-2023, it faced nearly six failed rainfall seasons, followed by massive *El niño* floods in November 2023, creating a humanitarian crisis. Therefore, it is critical for the government to continue investing and modernizing its early warning systems. Additionally, funds are required to carry out research and scenario analyses for early warning systems with the purpose of comprehending the situation, choosing the best course of action, and monitoring how these improve farmers' capacity to adapt to climate change. Partnerships between the public and private sectors are needed to improve investment in certain procedures.

2.4.3.2 Non-financial measures

a) Ensuring accurate and timely data

This is especially true in sparsely populated areas where satellite data may be very beneficial as a supplement to in-situ systems. Satellite data should be adequately incorporated into the country's hydro-meteorological monitoring network to provide optimum utility and cost-effectiveness. Geographical characteristics and present security issues in Somalia make remote sensing technologies an ideal tool for data collecting. Indeed, due to either the limited or nonexistent in-situ systems or the ongoing security difficulties or dangers, such systems may be the only information source in some regions of Somalia. Besides satellite imagery, multidimensional and on-the-ground data, in addition to satellite imagery and GIS data are critical for better estimating the implications of prospective dangers.

b) Build staff capacity in early warning systems

It is critical to increase the technical ability of the relevant ministry personnel so that they can use and expand on this knowledge. Dependence on outside forecasters prevents the development of national capacity within the ministries to continue autonomous national hydrological and meteorological monitoring and forecast development in conjunction with all states. Investment in importing new technologies and developing the capabilities of national specialists to use and maintain these technologies is crucial if the nation is to progress in tandem with the rest of the world.

c) Inclusive Early Warning Systems

To have a better understanding of the consequences of a risk, it is necessary to conduct inclusive risk assessments in which members of the community are included. A risk assessment that is focused on the needs of the people involved and encourages participation will not only help with data gathering but also enable the inclusion of traditional knowledge.

d) Create proper dissemination and communication channels

The warnings should, first, anticipate a potential risk and, second, clearly state what specific individuals should do. To guarantee that the communities at risk receive the warnings, a variety of communication channels and mechanisms such as mainstream media should be employed for warning dissemination. Somalia should simplify early warning distribution to guarantee that all agencies communicate with the primary early warning agency on time and that warning messages reach users without modification. For the supply of data and information products, each agency should have its own system. Although several methods for disseminating information are advised, it would be prudent to send all warning signals from agencies through a single delivery system. When prediction experts issue a warning, the appropriate agency should be notified for further warning distribution with the community in mind so that the final information is understood with clarity.

e) Improve Response Capacity

Early warnings must be followed by the activation of coping mechanisms before a disaster occurs. This includes the risky communities' preparation plans and initiatives. With the warning declaration, many entities involved in disaster preparedness at the national and local levels must be prompted to coordinate their readiness and emergency plans, including the community that is under threat. Before a disaster occurs, there are possible governmental institutions and non-governmental groups that might help national and local response plans.

2.5 Linkages of the Barriers Identified

The high expense of establishing and executing the selected technologies is a significant shared barrier. Very little funding is provided to the agricultural sectors to carry out their activities, and this funding is sometimes not driven by necessity. The expense of setting up and running technologies is further increased by the inadequate road system and insufficient connectivity to utility services.

The scarcity of specialists and technicians, as well as their technical capacity, is a major impediment to technology transfer and diffusion. This is due to low budget allocations and ineffective processes for identifying and addressing capacity shortages.

2.6 Enabling framework for overcoming the barriers in Agriculture Sector

The section that follows delves into the precise strategies required to help the country overcome the identified barriers to prioritised agricultural technology. The suggested enabling framework is organised into the following main categories:

a) Providing a suitable funding framework to promote the development and dissemination of targeted agricultural technologies in order to offset the high capital and operation and maintenance costs. Efforts should be undertaken to seek grants/soft loans from overseas donors, notably from international climate funding sources, for agricultural sector technology.
b) Training specifically designed to teach local specialists how to operate and maintain agriculture's top technology.
c) Provide enough funding to research and development organisations so that they may expand their operations to educate stakeholders about technology through research and training.

Table 4 lists the obstacles that have been found and the steps that must be taken to spread each of the technologies that are given priority in the agriculture sector.

Table 4: Enabling framework for overcoming the barriers in the agriculture sector

Barrier	**Enabling Framework**	**Responsible institution**
High purchase, operating, and maintenance expenses for technology. Supply networks that are underdeveloped, a limited market size, and a lack of market knowledge	▪ Provide financial aid to technology users in the form of subsidies, reduced taxes, and interest-free loans. ▪ Enhance trade policies and give incentives for supply and demand side development	Ministry of Agriculture, Ministry of Water and Energy Ministry of Finance

Inadequate technological capability	▪ Increase the number of employees working in agricultural extension ▪ A thorough capacity-building initiative for the sector to identify knowledge and skill deficiencies. ▪ Putting the extension staff's capacity-building initiatives into action ▪ collaboration with non-state entities, the commercial sector, and development partners	Ministry of Agriculture and Irrigation Ministry of Water and Energy
Inadequate farmer involvement	▪ Conduct inclusive risk assessments in which members of the community are included. ▪ Risk assessment should be focused on the needs of the local community and encourages participation. ▪ Enhance access to technological information	Ministry of Agriculture, Ministry of Water and Energy
Insufficient adaptation of technology to various situations	▪ The needs of particular groups, including as pastoralists, internally displaced people, women, young people and people with disabilities are given priority in terms of social protection.	Ministry of Agriculture, Ministry of Water and Energy Ministry of Internal Security Ministry of Livestock, Forestry and Range

Inadequate institutional capacity	▪ Extension system institutionalisation, including farmer institutions. ▪ Institutions for research and development might be strengthened and assigned the task of developing the nation's long-term water and climate forecasts.	Ministry of Agriculture and Irrigation , Ministry of Water and Energy
There has been little research in the field of weather and climate change science. Absence of free data exchange among national users organizations	▪ Fund R&D organisations and increase their capabilities ▪ Collaborations and sharing of data with national, regional, and worldwide organisations and R&D agencies	Ministry of Education, Ministry of Finance, Ministry of Agriculture and Ministry of Water and Energy

References

AfDB (2015). Somalia Energy Sector Needs Assessment and Investment Programme.

AfDB (2016). Water Infrastructure Development Program for Resilience in Somaliland. Appraisal Report. OWAS Department.

Ameer H. J., Xiaoyan W., Long W., Naimatullah M., Qifeng M., and Fan S. (2019). Performance and Evaluation of Drip Irrigation System, and Its Future Advantages. *Journal of Biology, Agriculture and Healthcare. Vol.9, No.9*

Araya, D., Podgorski, J., & Berg, M. (2023). Groundwater salinity in the Horn of Africa: Spatial prediction modeling and estimated people at risk. Environment International, 176, 107925. https://doi.org/10.1016/j.envint.2023.107925

Denis Le Sève .M (2018). A political economy analysis of Uganda's rural water supply sector. ODI Report.

FAO-SWALIM (2012). Hydrogeological Survey and Assessment of Seletced Areas in Somaliland and Puntland. Technical Report No. W-20, FAO-SWALIM (GCP/SOM/049/EC) Project, Nairobi, Kenya.

Friedlander, L., Tal, A., & Lazarovitch, N. (2013). Technical considerations affecting adoption of drip irrigation in sub-Saharan Africa. Agricultural Water Management, 126, 125–132. https://doi.org/10.1016/j.agwat.2013.04.014

Fresnaye, E. D. L. (2018). A financial and technical assessment of solar versus hand water pumping for off-grid area -the case of Burkina Faso. https://doi.org/10.13140/RG.2.2.21803.59684

Goyal, Rohit (2014). Rooftop Rainwater Harvesting: Issues and Challenges. Indian Plumbing today. 125 Collector's Edition. 148-161.

Grant, M. L., Huggett, C., Willetts, J., & Wilbur, J. (2017). Gender Equality and Goal 6: The Critical Connection. Australian Water Partnership.

Gure, Abdulkadir (2021), The Role of Climate Information and Early Warning Systems in Supporting Disaster Risk Reduction in Somalia. Technical Report No WC-007, WASH Cluster Somalia, Mogadishu, Somalia.

Han, M.Y. and Park, J. (2009) Innovative Rainwater Harvesting and Management in the Republic of Korea. Consulting Meeting for Development of Guidelines for Eco-Efficient Water Infrastructure, Seoul, 30-31st March 2009

Haselip J, Narkevičiūtė R, Rogat J and Trærup S (2019). TNA Step by Step. A Guidebook for Countries. Conducting a Technology Needs Assessment and Action Plan. UNEP DTU Partnership, Copenhagen.

Hillbruner, C., & Moloney, G. (2012). When early warning is not enough—Lessons learned from the 2011 Somalia Famine. Global Food Security, 1(1), 20–28. https://doi.org/10.1016/j.gfs.2012.08.001

IMF (2020). Enhanced heavily-indebted poor countries (HIPC) initiative - preliminary document. IMF

Jama, A.A.; Mourad, K.A. (2019). Water Services Sustainability: Institutional Arrangements and Shared Responsibilities. Sustainability 2019, 11, 916.

Jimale, A. D., Abdullahi, M. O., Ahmed, Y. A., Nageeye, A. Y., Jama, A. A., & Abdullahi, B. S. (2023). Dryness of Somalia's Agriculture: Modernizing the Irrigation System. International Journal of Engineering Trends and Technology, 71(6), 303–309. https://doi.org/10.14445/22315381/IJETT-V71I6P230

KIMS (2016). Kaah International Microfinance Services Bringing Electricity to Somalia through Solar Microfinance

Kiprono, A W., Llario, A I., (2020) Solar Pumping for Water Supply: Harnessing solar power in humanitarian and development, Rugby, UK: Practical Action Publishing http://dx.doi.org/10.3362/9781780447810

Lockwood, H. and Smits, S. (2011) Supporting Rural Water Supply Moving towards a Service Delivery Approach. Practical Action Publishing Ltd, IRC International Water and Sanitation Centre and Aguaconsult.

Lorentz (2012). Solar-powered Drinking Water Pumps for Communities and Villages. Case study 2, 02. Henstedt-Ulzburg: Lorentz. [Available at: https://www.lorentz.de/pdf/lorentz_casestudy_undp_pakistan_en-en.pdf]

Lubogo, M., Karanja, M.J., Mdodo, R. (2020). Evaluation of the electronic Early Warning and Response Network (EWARN) system in Somalia. Confl Health 16, 18 (2022). https://doi.org/10.1186/s13031-022-00450-4

Maia B. and Saskia W. (2016). Somali Renewable Energy Skilled Workshop Survey Report. Shuraako.

Maxwell D. (2019). Famine Early Warning and Information Systems in Conflict Settings: Challenges for Humanitarian Metrics and Response. Feinstein International Center

Mercer JD, Dominey-Howes I, Kelman, Lloyd K. (2009). The Potential for Combining Indigenous and Western Knowledge in Reducing Vulnerability to Environmental Hazards in Small Island Developing States. Environmental Hazards 2009; 7 (4): 245–56.

MoEWR (2021). Comprehensive Assessment of Existing Centralized and Decentralized Early Warning Systems in Somalia

Mohamed Adawe, A., O. Yusuf, A., Onyattac, J., & A. Wafulad, G. (2022). Concentration Levels of Heavy Metals and Other Parameters in Water Borehole around Mogadishu Area, Somalia. Asian Journal of Applied Chemistry Research, 11(2), 1–10. https://doi.org/10.9734/ajacr/2022/v11i230249

Mourad, K. A. (2020). A Water Compact for Sustainable Water Management. Sustainability, 12(7339), 1-18.

Mourad, K.A. (2023). Post-conflict development, reviewing the water sector in Somalia. Environ Dev Sustain 25, 1326–1350. https://doi.org/10.1007/s10668-021-02096-3

Nygaard, I. and Hansen, U. (2015). Overcoming Barriers to the Transfer and Diffusion of Climate Technologies: Second edition. UNEP DTU Partnership, Copenhagen.

Oduor A.R. Gadain, H. M. 2007: Potential of Rainwater Harvesting in Somalia, A Planning, Design, Implementation and Monitoring Framework, Technical Report NoW-09, 2007,FAO-SWALIM, Nairobi, Kenya.

Postel, S. (1999). Pillar of Sand- can the irrigation miracle last? New York.

Quiroga, E., Bertoni, C. & Ruden, F. (2023). Deep low-salinity groundwater in sedimentary basins: petrophysical methods from a case study in Somalia. Hydrogeol J 31, 685–705. https://doi.org/10.1007/s10040-022-02589-z

Rahman, A., Keane, J. and Imteaz, M.A., (2012). “Rainwater harvesting in Greater Sydney: Water savings, reliability and economic benefits”, Resources, Conservation and Recycling, 61, pp. 16–21.

Said M. A. (2022) Effects of Charcoal Production on Environment in the Lower Shebelle Region, Somalia. *Department of Geography, Population and Environmental Studies, University of Nairobi.*

Samatar, A. M., Mekhilef, S., Mokhlis, H., Kermadi, M., Diblawe, A. M., Stojcevski, A., & Seyedmahmoudian, M. (2023). The utilization and potential of solar energy in Somalia: Current state and prospects. Energy Strategy Reviews, 48, 101108. https://doi.org/10.1016/j.esr.2023.101108

UNEP. (2019). TNA step by step: A guidebook for countries conducting a Technology Needs Assessment and Action Plan. UNEP DTU Partnership.

Un-Habitat (2020). Land and Conflict in Jubaland: Root Cause Analysis and Recommendations. UNON, Publishing Services Section, Nairobi.

UNHCR (2020). Conflict and heavy floods force tens of thousands of people to flee their homes in Somalia, amidst COVID-19 threat. Retrieved April 02, 2020, from https://www.unhcr.org/news/briefing/2020/5/5eb50d2d4/conflict-heavy-floods-force-tensthousands-people-flee-homes-somalia-amidst.html

ANNEX 1. MARKET MAPS AND PROBLEM TREES

Market Mapping: Market mapping is limited to technologies that are recognised as consumer goods in the market, such as drip irrigation systems and solar-powered boreholes.

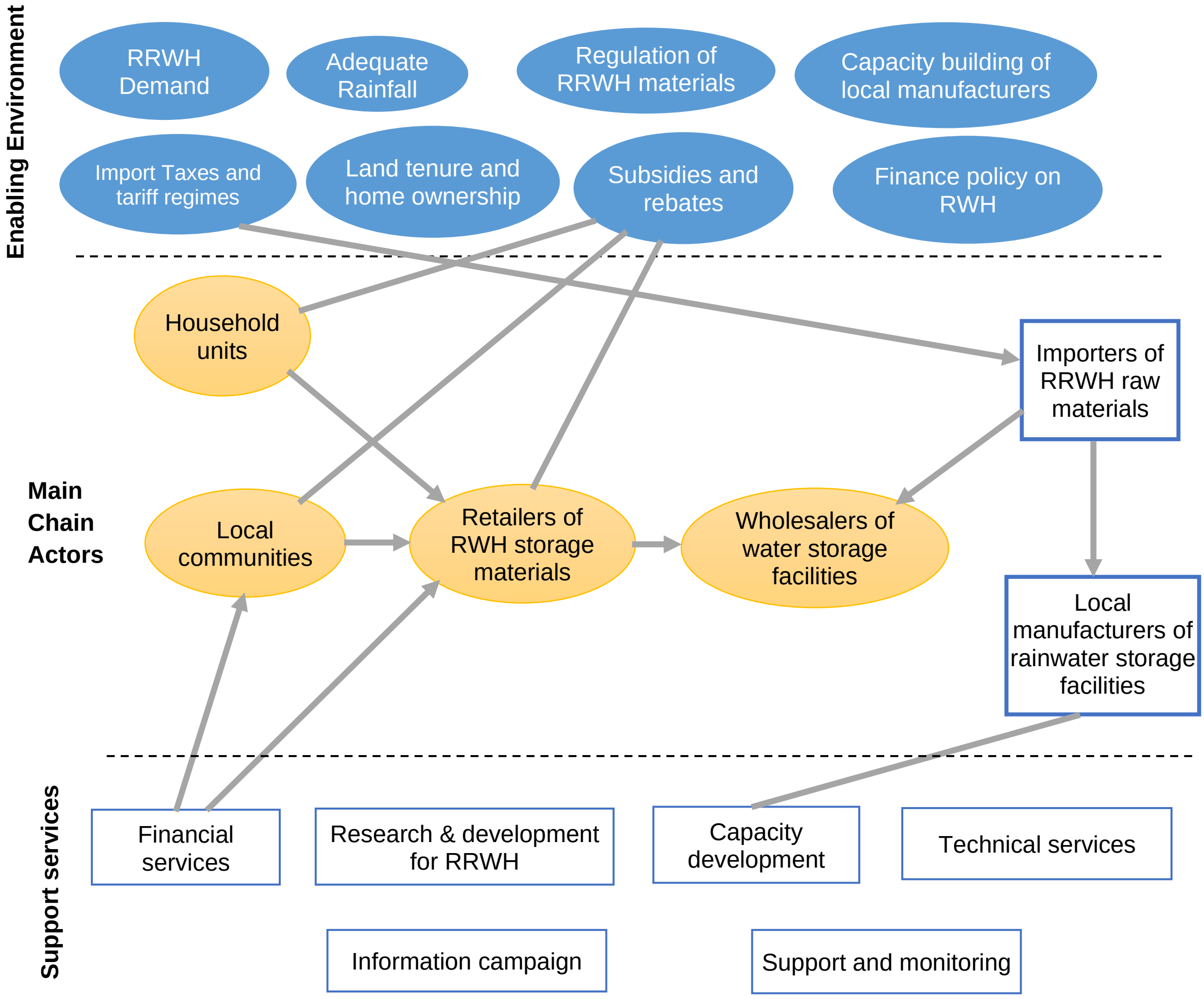
The stakeholders identified many components of market chains and how they interacted with one another during the market mapping exercise. The market map identifies weaknesses, bottlenecks or failures in the transaction chain which can then be addressed by specific interventions. The market mapping exercise allows a better understanding of the enabling environment and general context in which a given technology developer, user and manager operates and impacts the technology demand and supply chains by retaining or disclosing the necessary information.

The main market mapping elements considered are: enabling environment- legal, organizational, market chain developers, wholesaler, retailer and consumer, etc. The specific market maps for the technologies of the market are given in Annex 1.1.1, 1.1.4 and Annex 1.2.1.

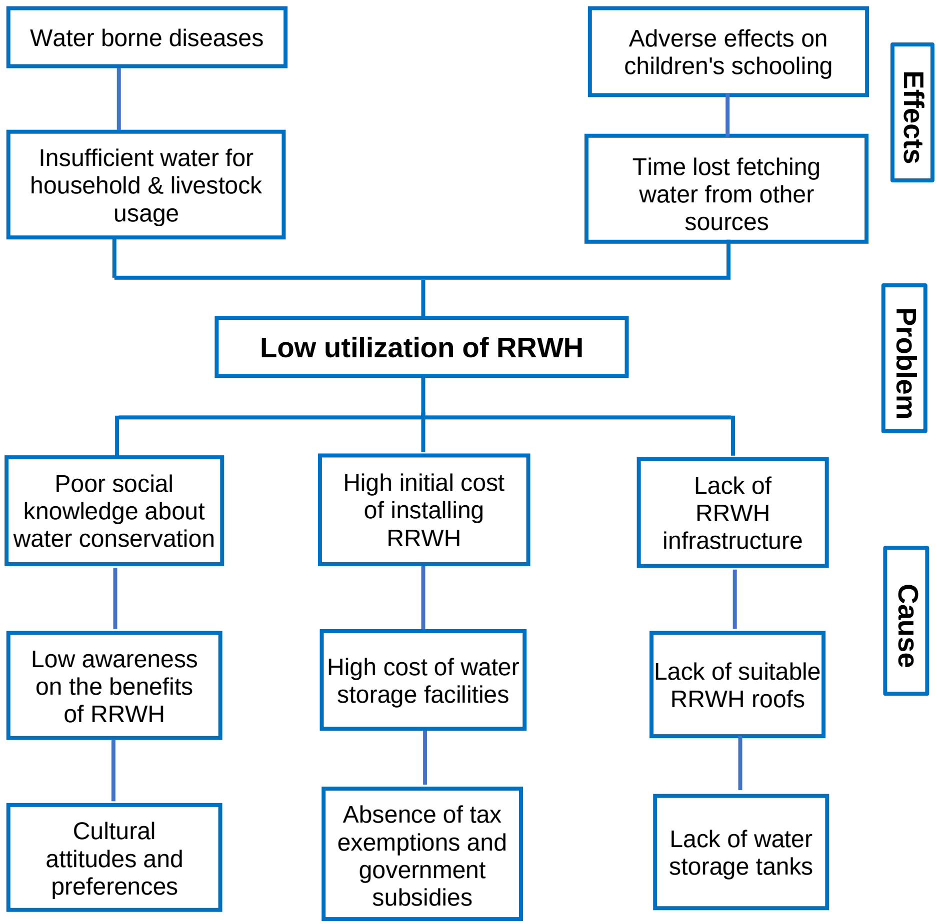
Problem and Solution Trees: The problem and solution trees for each technology were prepared and used by experts to identify and analyse the barriers and to find measures to overcome the identified obstacles to the diffusion of each technology. Problem/Solution trees for all the prioritized adaptation technologies are presented in the Annex section as well.

ANNEX 1.1: WATER SECTOR

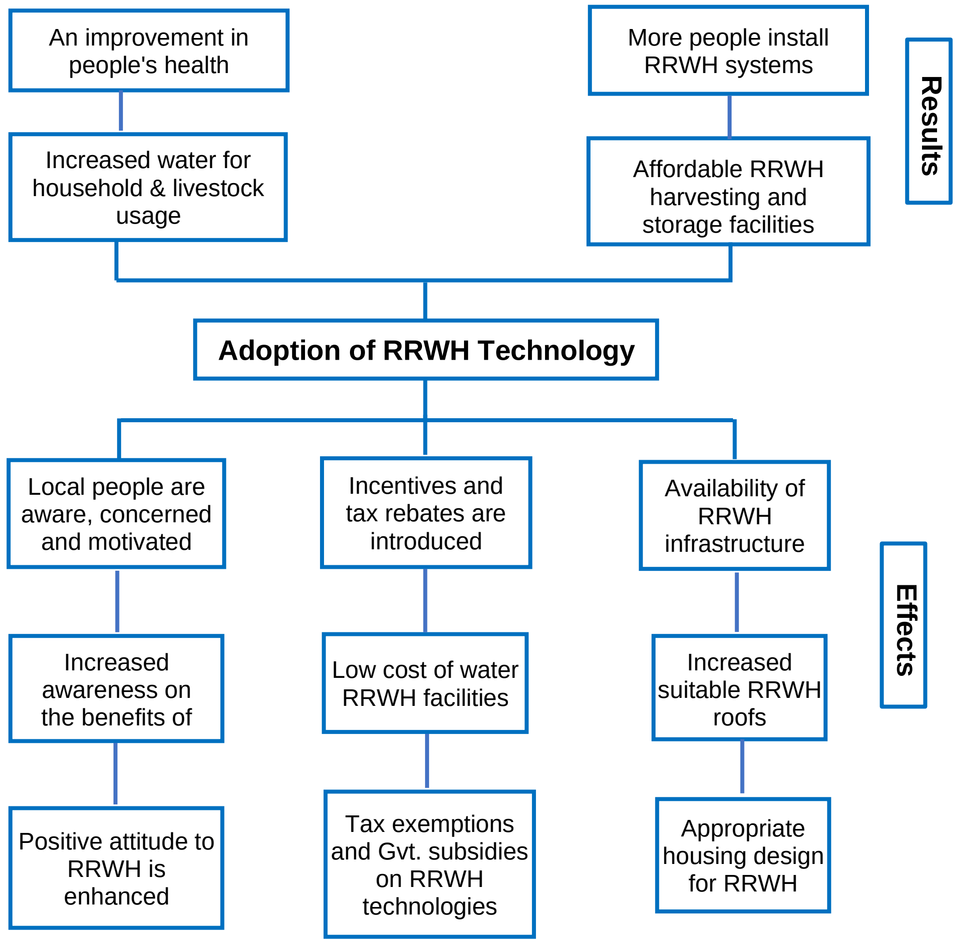
Annex 1.1.1: Rooftop Rainwater Harvesting Market Map



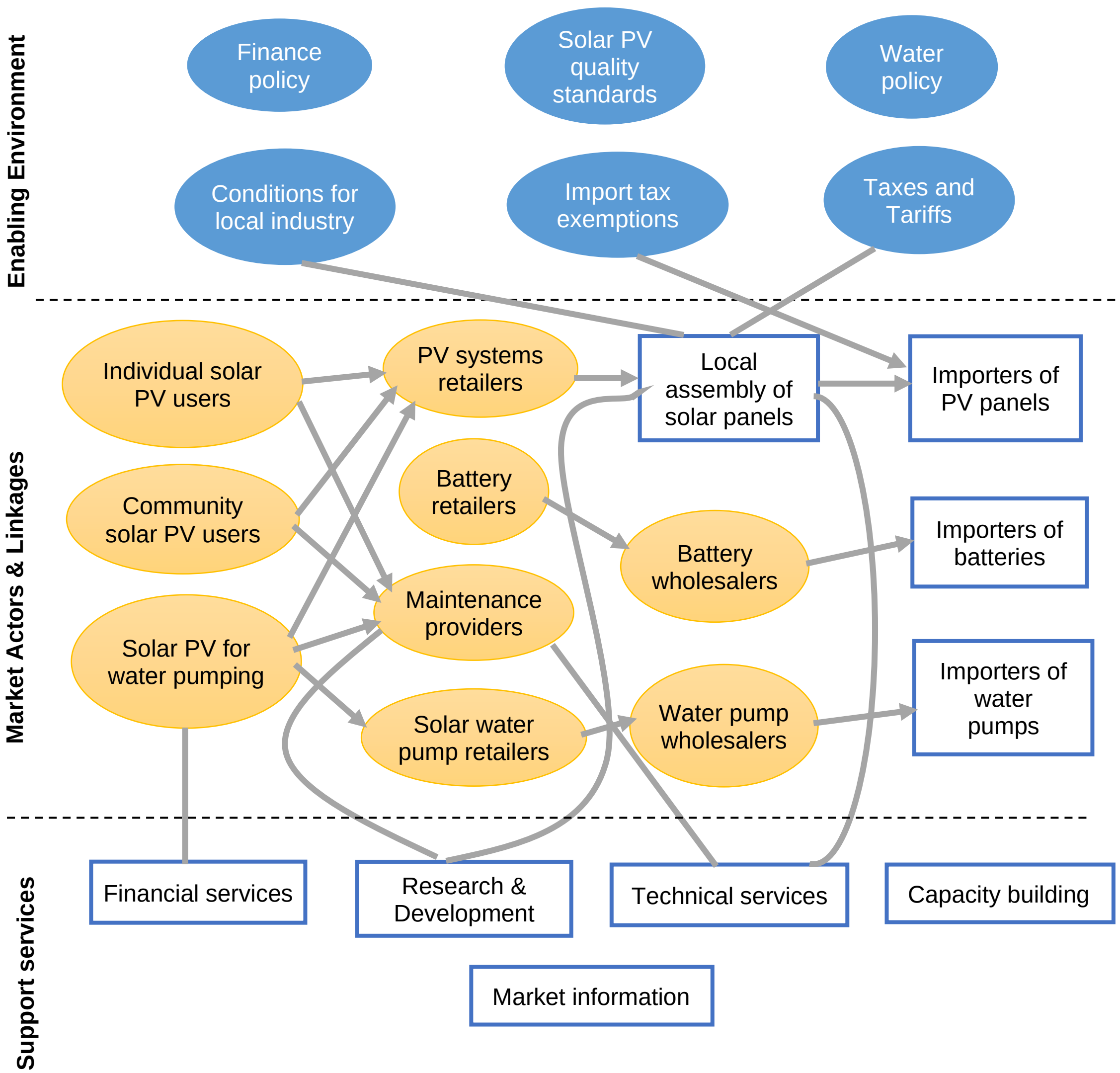
Annex 1.1.2: Rooftop Rainwater Harvesting: Logical Problem Analysis



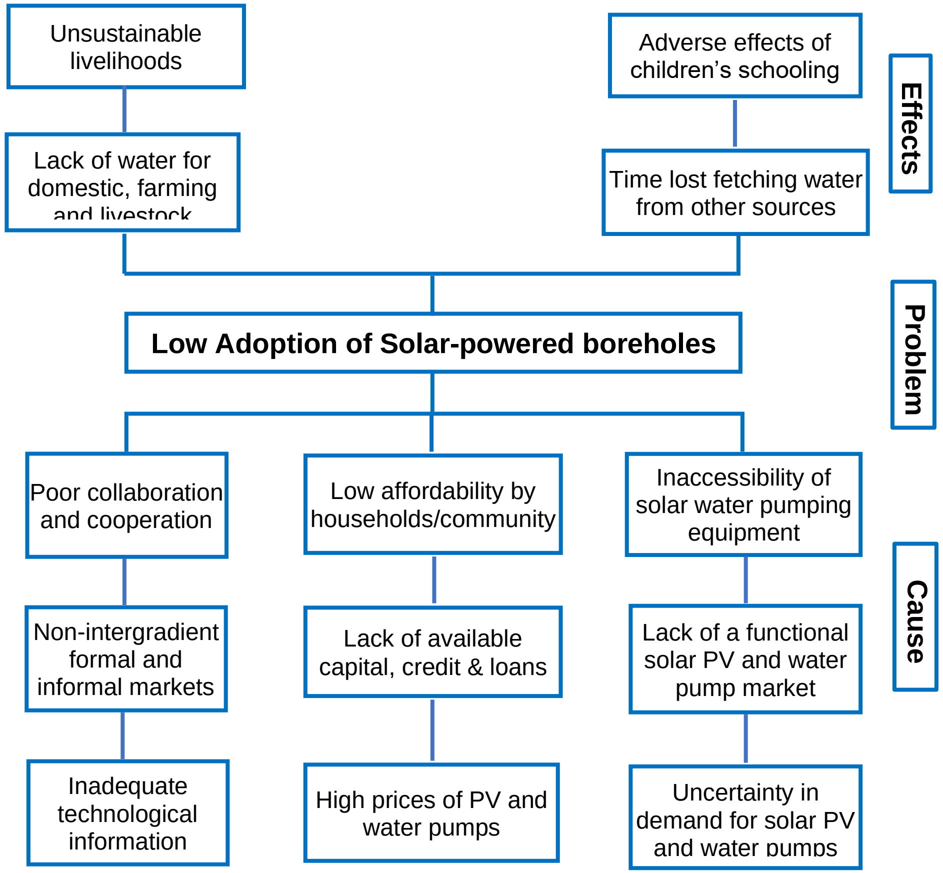
Annex 1.1.3: Rooftop Rainwater Harvesting: Objective Tree Analysis



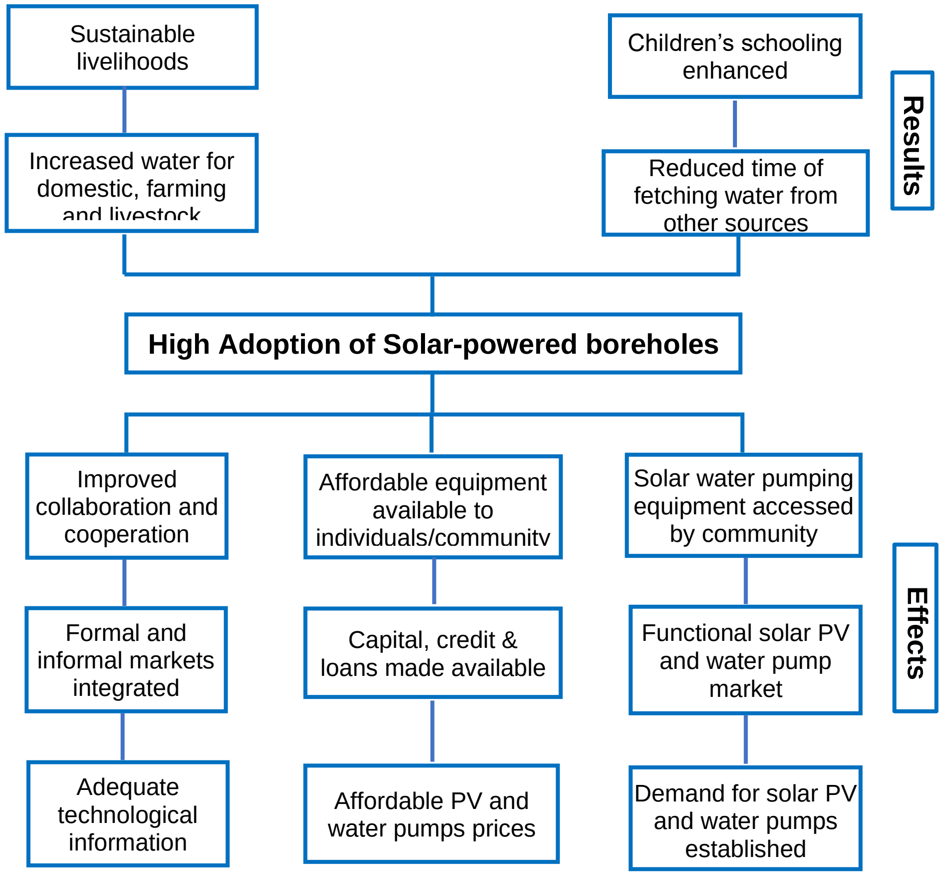
Annex 1.1.4: Solar-powered Boreholes Market Maps



Annex 1.1.5: Solar-powered Boreholes: Logical Problem Analysis

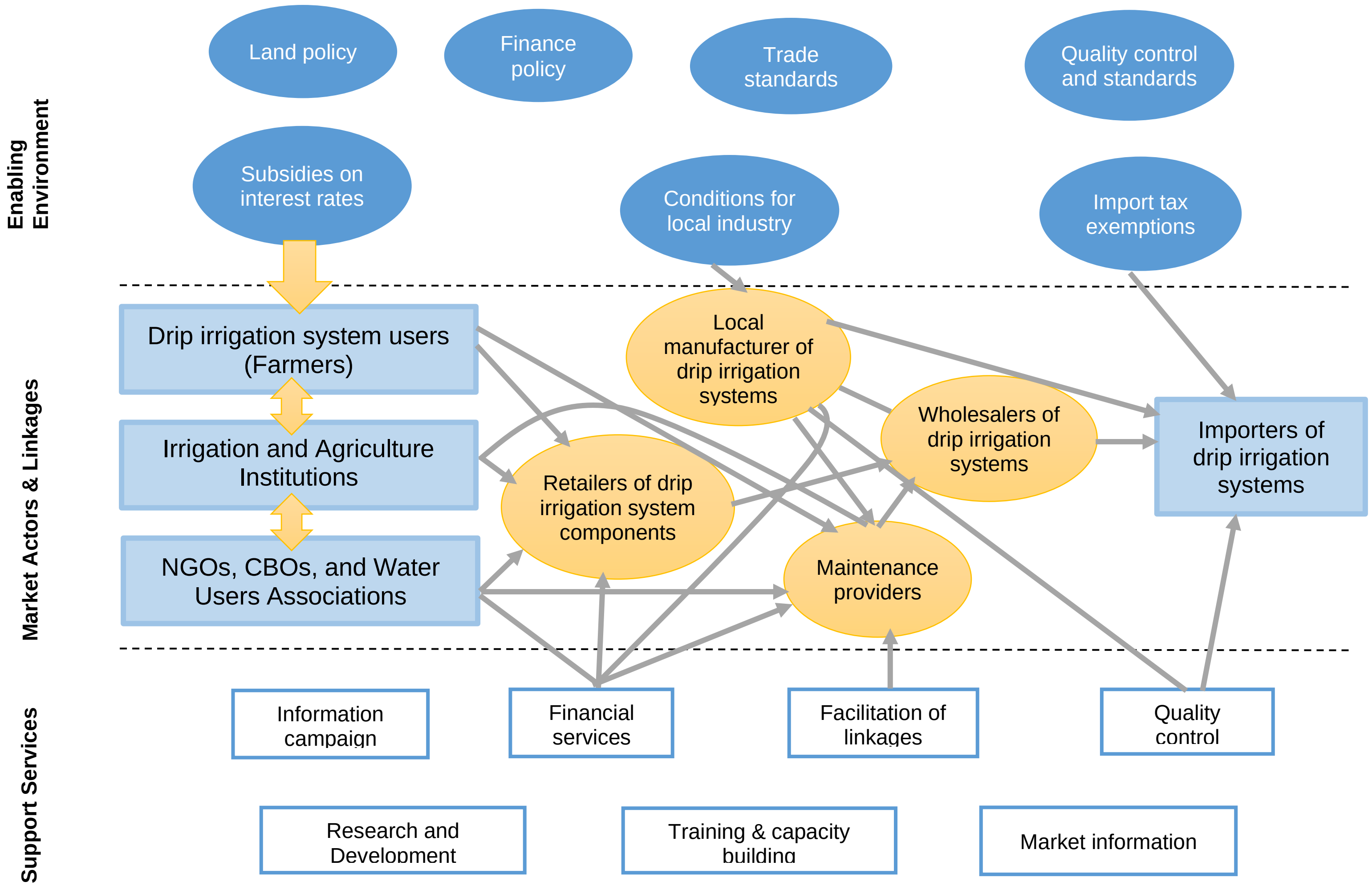


Annex 1.1.6: Solar-powered Boreholes: Objective Tree Analysis

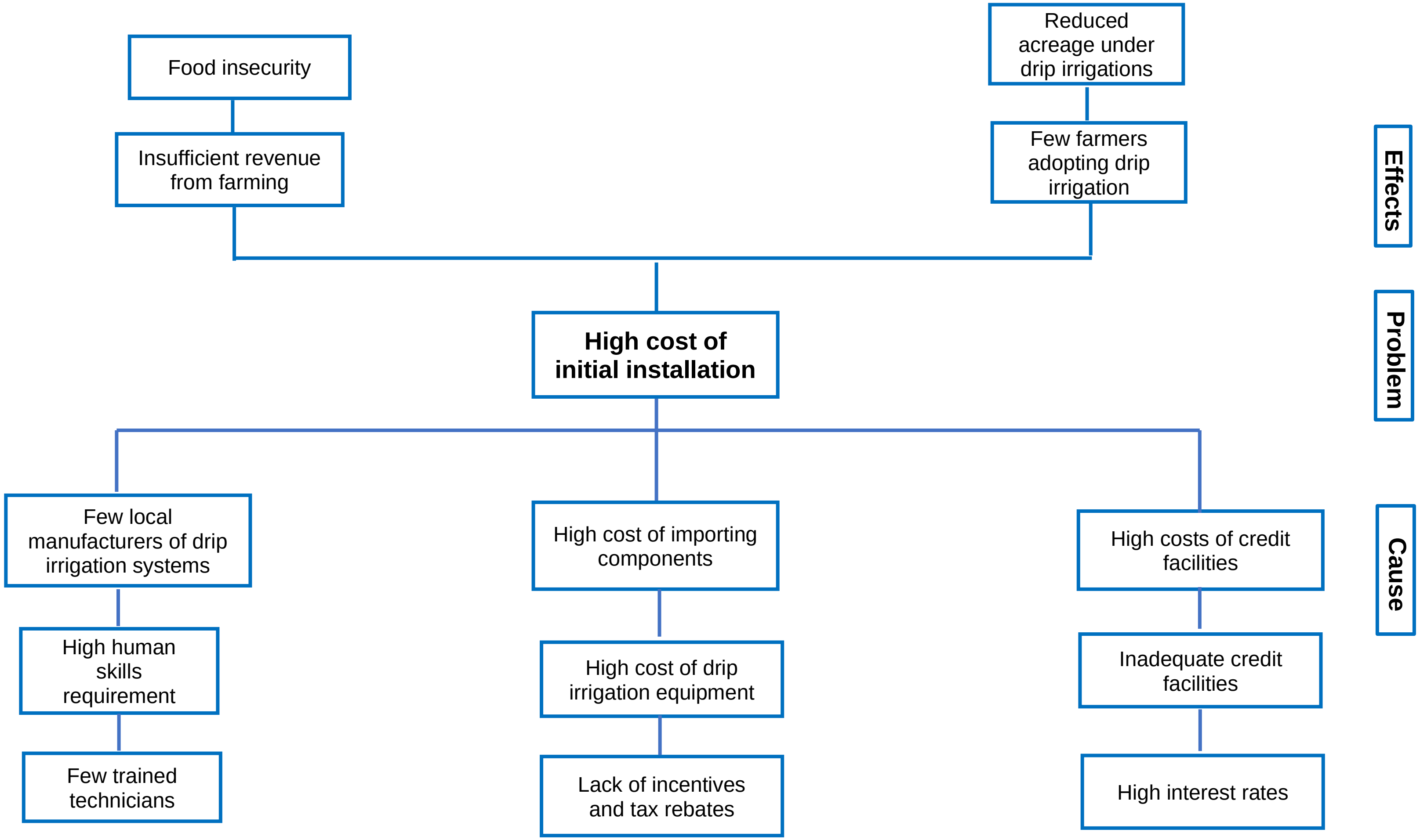


ANNEX 1.2: AGRICULTURE SECTOR

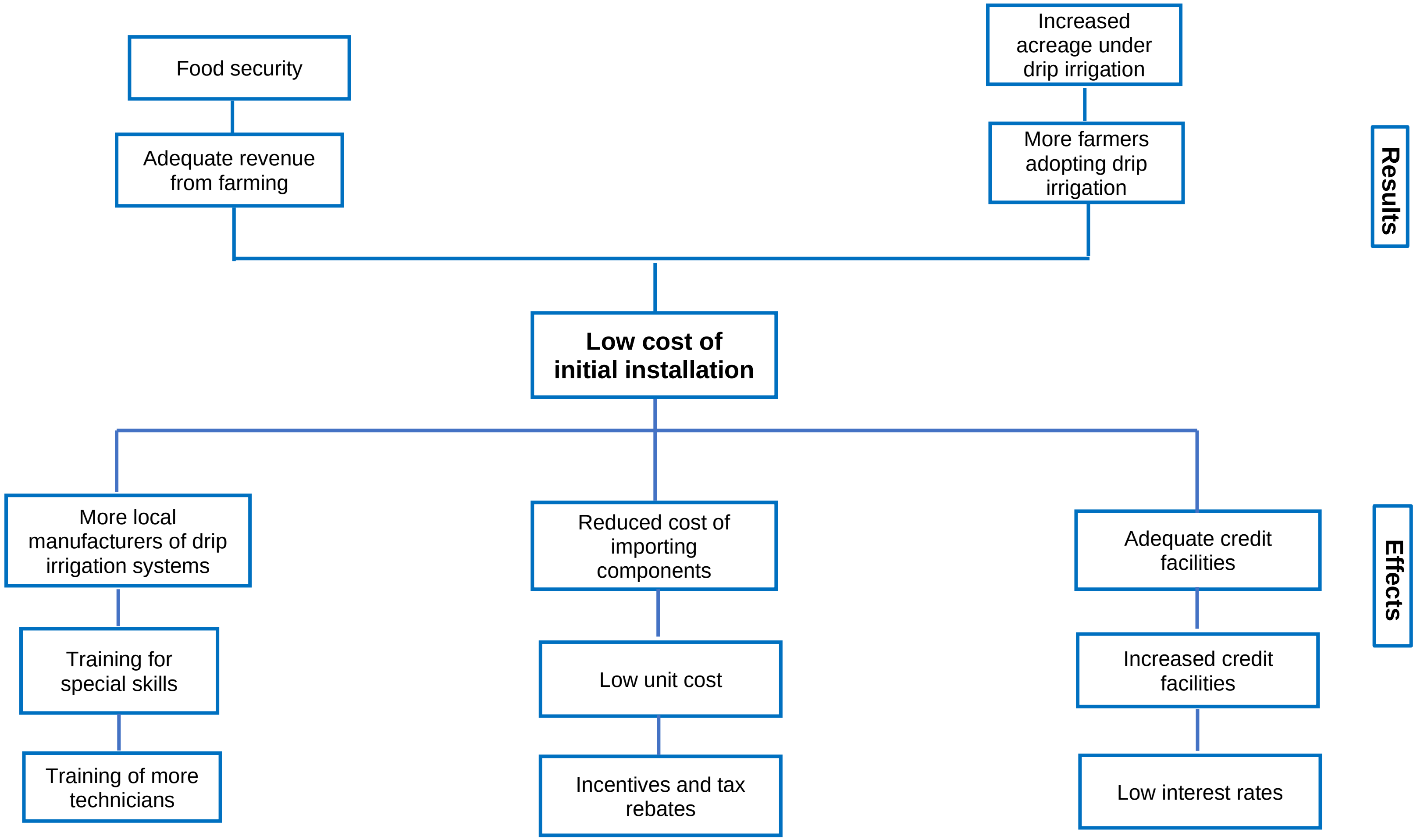
Annex 1.2.1: Drip Irrigation Systems Market Map



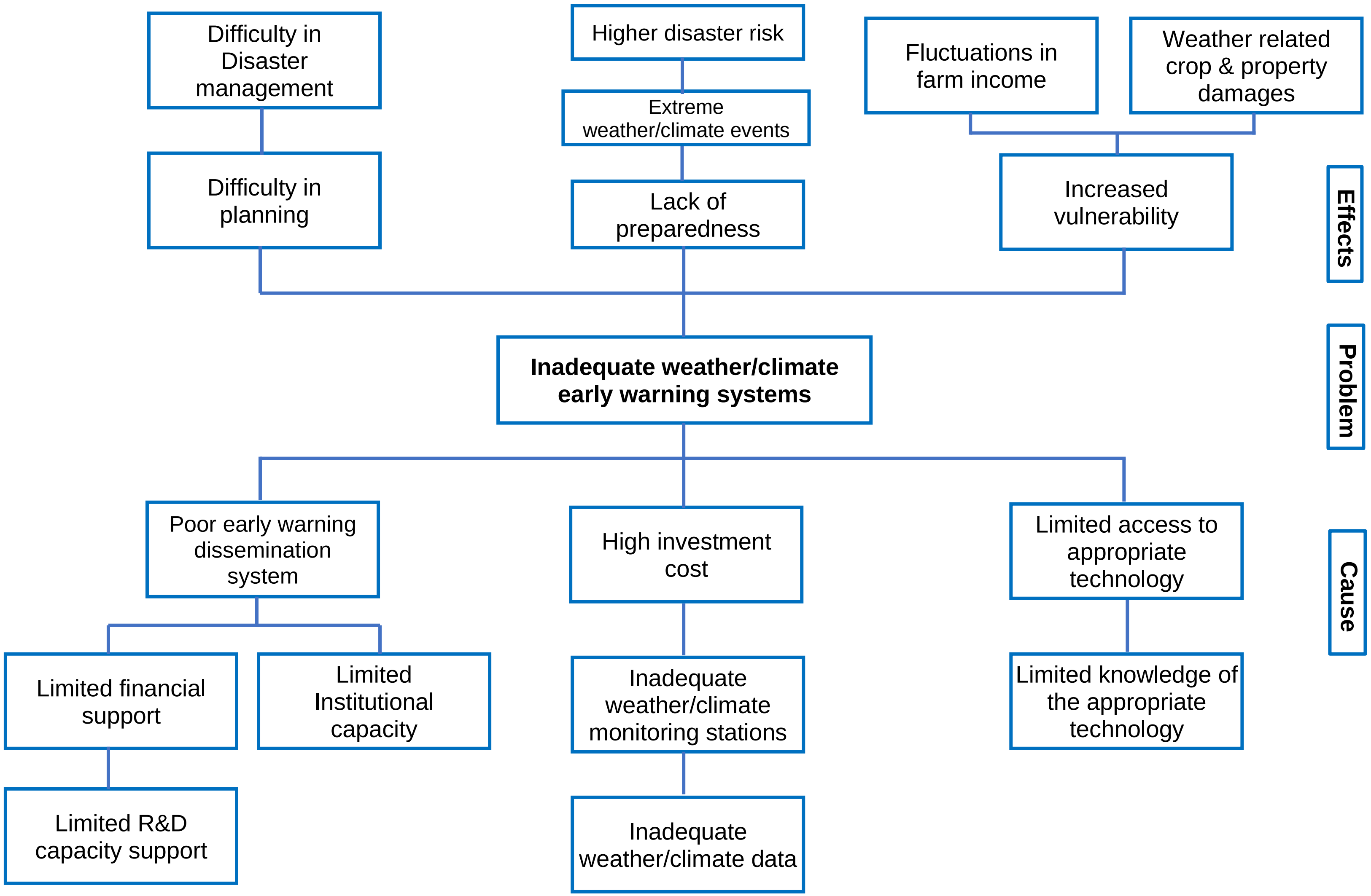
Annex 1.2.2: Drip Irrigation Systems: Logical Problem Analysis



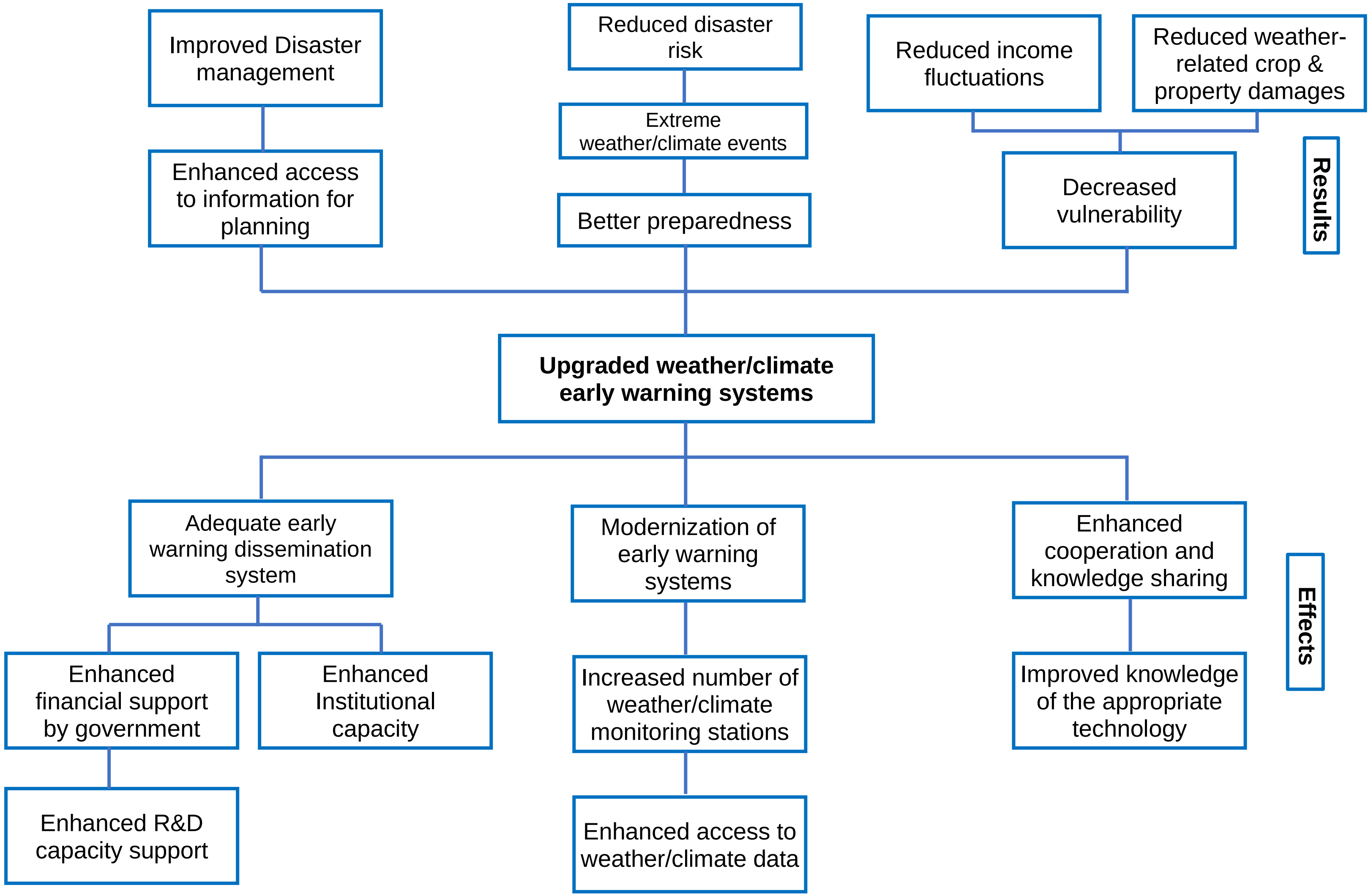
Annex 1.2.3: Drip Irrigation Systems: Objective Tree Analysis



Annex 1.2.4: Early Warning Systems: Logical Problem Analysis



Annex 1.2.5: Early Warning Systems: Objective Tree Analysis



ANNEX 2: BAEF LIST OF PARTICIPANTS

S/N	Name	Institution	Email
1	Hafsa Omar Abdilahi	Ministry of Environment and Climate Change	climate@moecc.gov.so
2	Eng Muna Mohamed Abdilahi	Ministry of Environment and Climate Change	Muna.mohamed@moecc.gov.so
3	Abdirahim Barre Mohamed	Ministry of Environment and Climate Change	abdirahim.barre@moecc.gov.so
4	Dr Mohmaed Awale	Ministry of Environment and Climate Change	Mohamed.ali@moecc.gov.so
5	Eng Naiim Mohamed	Ministry of Water and Energy	laradesigs88@gmail.com
6	Asli Ismail Duale Mohamed Moalim Ali	Water Resources	aslisomalia@yahoo.com Planning@moewr.gov.so
7	Rooble Mahamoud Ahmed	MoLRM	ahmed4845333@gmail.com
8	Abdulahi Ahmed	Ministry of Agriculture and Irrigation	irrigationdept@moa.gov.so
9	Ahmed Dubow Keinan	Ministry of Agriculture and Irrigation	k.ahmed@moa.gov.so
10	Shuaib Isse Nur	Action Somalia (CSO)	info@actionsomalia.org
11	Khadra Omer Hassan	Barwaaqo Voluntary Organisation (BVO)	Khadra.Hassan@bvo.org
12	Abdiwali Mohamud	Dahabshiil Group South and Central Somalia, Business Development and Corporate Clients manager. (Private Sector)	
13	Abdikani Sheikh Omar Hassan	Ministry of Women and Human Rights Development	
14	Abdimajid Nuunow	Consultant	abdimajidnunow@gmail.com
15	Fatima Husein	Consultant	famzahra80@gmail.com