



THE FEDERAL REPUBLIC OF SOMALIA

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE MITIGATION

ENERGY AND FORESTRY SECTORS

BARRIER ANALYSIS AND ENABLING FRAMEWORK

FINAL DRAFT

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EXECUTIVE SUMMARY

Somalia's energy sector is predominantly reliant on traditional biomass, such as firewood and charcoal, which accounts for over 80% of the country's energy consumption and contributes to environmental degradation and health issues from indoor pollution (FGS, 2020). Furthermore, access to electricity in Somalia is very low, with only 49.3% of the population connected. This figure drops to under 30% in rural areas, hindering socio-economic development, particularly in education, health, and economic sector (World Bank, 2022). The primary source of electricity is imported diesel, and without national grid, making it one of the most expensive worldwide. In addition, the sector's infrastructure is underdeveloped due to prolonged political instability, lack of investment, and the absence of a regulatory framework, resulting in inefficiencies and high electricity charges.

It is against this background that the TNA process prioritized the following technologies in the context of climate mitigation in the energy and in line with the country's NDC 2021: i) energy-efficient cookstoves, ii) Portable solar lighting devices, and iii) decentralized Solar Photovoltaics (PVs), which can drive this change, though their widespread adoption. All these technologies are characterized as consumer goods - meaning that the goods are specifically intended for the mass market including households, businesses and institutions.

Clean and efficient cookstoves represent a transformative technology for Somalia, addressing its dependence on traditional biomass for cooking, reduce environmental degradation, health risks, address gender inequalities and combat climate change linked to traditional biomass cooking methods. Transitioning to these efficient stoves can also substantially cut emissions in the household sector. The target in the NDC is to facilitate 30% penetration resulting in at least 5 million cookstoves. While the technology presents a viable and promising alternative to traditional cooking, there are barriers that require necessary enabling frameworks. The main ones are summarized below:

Barrier category	Specific barriers	Enabling framework
Financial barriers	High Upfront Costs	<ul style="list-style-type: none"> • Provide subsidies or grants to reduce the initial cost • Increased access international climate financing support
	Lack of Affordable Financing	<ul style="list-style-type: none"> • Partnering with local microfinance institutions to provide potential users with affordable finances including loans for production and use of cookstoves. • Introduce innovative finance methods
	Limited Return on Investment for Manufacturers and Distributors	<ul style="list-style-type: none"> • Establish manufacturing and distribution infrastructure • Facilitate bulk Purchasing and Distribution
Non-Financial barriers	Inadequate awareness and perception	<ul style="list-style-type: none"> • Awareness and education programme targeted at different stakeholders • Community Participation and Women Empowerment
	Cultural Preferences	
	Inadequate Skills and Technical Know-How Performance and Quality Concerns	<ul style="list-style-type: none"> • Training and capacity building for youth and women for local artisans • Establish quality assurance standards • Promote research and innovation

	Lack of Policy Support	<ul style="list-style-type: none"> • Develop and implement enabling policies • Strengthen institutional frameworks
	Weak Institutional Capacity	

Table 1: Barriers and enabling frameworks for clean and efficient cookstoves:

Portable solar lighting devices are environmentally-friendly, cost-effective solutions tailored for areas without reliable electricity access, like many parts of Somalia. These devices have a solar panel that absorbs sunlight, converting it into electricity for the built-in light bulb. Most use energy-efficient LED bulbs and are designed for portability, making them perfect for household use, pastoral lifestyle, IDPs and emergencies. Solar lighting devices reduce health risks associated with Kerosene lamps, are cost-effective in the long run and align with Somalia’s Nationally Determined Contributions (NDC) by reducing carbon emissions. The NDC target is at least 30% adoption by 2030, leading to approximately 5 million solar lanterns. Key barriers and appropriate enabling environment are summarized below:

Barrier category	Specific barriers	Enabling framework
Financial barriers	High Upfront Costs	<ul style="list-style-type: none"> • Provide subsidies or grants to reduce the initial cost • Increased access to international climate finance
	Lack of Affordable Financing	<ul style="list-style-type: none"> • Partnering with local microfinance institutions to provide shariah compliant products
	Limited Economic Incentives for Suppliers and Retailers	<ul style="list-style-type: none"> • Provide subsidies • Facilitate the development of distribution infrastructure network
Social-Cultural Barriers	Inadequate awareness	<ul style="list-style-type: none"> • Community awareness and education programme
	Cultural Habits and Perceptions	<ul style="list-style-type: none"> • Inclusive participation in all programme activities
Technical Barriers	Inadequate Skills and Technical Know-How	<ul style="list-style-type: none"> • Training and capacity building for youth and women on installation & maintenance • Establish quality assurance standards institutions
	Performance and Quality Concerns	
Institutional-Regulatory Barriers	Lack of Policy Support	<ul style="list-style-type: none"> • Develop and implement enabling policies • Support institutional strengthening
	Weak Institutional Capacity	

Table 2: barriers and enabling framework for portable solar lighting devices

Decentralized Solar Photovoltaic (PV) systems are the third priority energy sector technology that utilizes sunlight to produce electricity. The systems comprise solar panels, inverters, and optional battery storage. This technology can serve both small-scale residential households and large businesses. In the context of Somalia, Solar PVs present a significant potential due to the country's abundant sunlight. The decentralized nature of these systems offers a solution for the country without grid access, promoting sustainability and reducing imported fossil-fuel dependency. The Somalia Power Master Plan 2018 estimates that installed PV capacity in Somalia, as of 2023, was 41 MW, accounting for 11.9% of total electricity. The National Determined Contributions (NDC) sets a target to integrate an additional 200MW of renewable energy by 2030 including Solar and wind, specifically in major cities like Mogadishu, Hargeysa, and Boosaaso. Below is a summary of the key barriers and Enabling Environment for decentralized Solar PVs:

Barrier category	Specific barriers	Enabling framework
Financial barriers	High Upfront Costs	<ul style="list-style-type: none"> • Provide subsidies or grants to reduce the initial cost • Access to International climate financing
	Lack of Affordable Financing	<ul style="list-style-type: none"> • Partnering with local microfinance institutions to provide affordable loans and other relevant products • Innovative financing PAYG
	Economic instability	<ul style="list-style-type: none"> • Public -private partnership framework established • Strengthen the policy environment and provide incentives
Non Financial Barriers	Inadequate awareness and understanding	<ul style="list-style-type: none"> • Community awareness and education programme especially among rural communities and urban developers on various platforms including on print, TV and social media
	Limited technical capacity	<ul style="list-style-type: none"> • Capacity Building and Training including establishing training centres for youth • Research and development
	Lack of Policy Support Weak Institutional Capacity	<ul style="list-style-type: none"> • Develop policies and incentives • Support institutional strengthening • Develop standards and establish quality control institutions

Table 3: Barriers and enabling framework for decentralized solar PVs

The report also identifies sets of common barriers for the three technologies including financial barriers, technical barriers, lack of awareness, regulatory and institutional barriers. Addressing these barriers will require an integrated and harmonized approach that considers the linkages between the different barriers and the ways in which addressing one barrier can contribute to overcoming others. Implementing measures such as financial incentives, awareness campaigns, regulatory reforms, capacity building initiatives, gender inclusion strategies, and quality assurance mechanisms will be crucial in promoting the adoption of these priority technologies in Somalia's energy sector.

As of 2021, Somalia's forest cover represented a mere 9.4% of the country's total land area, as reported by the World Bank. This stark reduction is evident when compared to historical data; in the 1980s, the forest cover in Somalia constituted a significant 62% of the nation's total land mass. The sector has experienced challenges such as extended conflicts, over-exploitation, unsustainable land use practices, and impacts of climate change resulting in substantial deforestation and degradation, threatening biodiversity, increasing soil erosion, and rendering local communities vulnerable to climate impacts. Furthermore, with the national reliance on biomass fuels and commercial pressures, particularly from the charcoal industry, Somalia's remaining forests face continued threats. The priority technologies for the sector are: i) afforestation and reforestation of degraded forests ii) agroforestry.

Afforestation and reforestation of degraded forests are pivotal for environmental restoration and climate resilience. The overall objective to expand forest cover, combat land degradation, provide sustainable livelihoods for locals while contributing to climate mitigation. The technology entails establishing tree nurseries for consistent seedling supply, focusing on tree planting in degraded areas, and maintaining the planted areas through regular care and

monitoring. The key barriers and enabling frameworks for the technology are summarized below:

Barrier category	Specific barriers	Enabling framework
Financial barriers	<ul style="list-style-type: none"> Limited Funding High costs Competing land uses and opportunity costs 	<ul style="list-style-type: none"> Mobilisation of domestic and international finance Promote Public private partnerships in forestry Explore innovate financing Develop carbon projects and secure financing
Non-financial Barriers:	Inadequate Public awareness	<ul style="list-style-type: none"> Community awareness and education programme
	In effective policy and regulatory framework	Policy and Legal Framework Development
	Weak Institutional Capacity	Support institutional strengthening including staffing at the MoECC & FMSs
	Climate change Challenges	<ul style="list-style-type: none"> Establish community watering infrastructure including for water harvesting and storage Establish nurseries and promote climate resilient seedlings varieties
	Security Concerns	Community forestry initiatives promoted, use forests as a means for peace building

Table 4: Barriers and enabling framework for afforestation and reforestation.

Agroforestry is an agricultural practice with the concurrent growth of trees, crops, and livestock on shared land, leveraging the synergies between trees and crops to boost sustainability and productivity. In Somalia, this includes fruit trees, fodder, and medicinal trees with crops or pastures, especially in semi-arid zones, to combat climate change. Agroforestry conserves soil, preserves biodiversity, and increases carbon capture, aiding climate change counteraction. It also fosters rural food security and livelihoods through diverse products like timber and fruits. The NDC goal is to transition 5%, or 400,000 hectares, to agroforestry by 2030. Below is a summary of the barriers and enabling environment of agroforestry in Somalia.

Barrier category	Specific barriers	Enabling framework
Financial barriers	<ul style="list-style-type: none"> Lack of access to credit High costs of initial investments Lack of market access and value chains 	<ul style="list-style-type: none"> Develop appropriate financial products in collaboration with Microfinance institutions. Secure grants financing through international climate financing Carbon financing through developing carbon projects Strengthen agroforestry value chains
Non-financial Barriers:	Lack of Public awareness	<ul style="list-style-type: none"> Community awareness and education programme
	Lack of effective policy and regulatory framework	<ul style="list-style-type: none"> Develop Agroforestry policy and integrate into environment and agriculture policies
	Weak Institutional Capacity	Support institutional strengthening including staffing at the MoAI & FMSs Capacity building and training of institutions

		<ul style="list-style-type: none"> • Strengthen extension services and integrate agroforestry practices including establishing pilot farms
	Climate change Impacts	<ul style="list-style-type: none"> • Establish community watering infrastructure including for water harvesting and storage • Promote climate resilient seedlings varieties

Table 5: Barriers and enabling framework for agroforestry.

The Barrier Analysis and Enabling Framework (BAEF) process followed a participatory and consultative approach to ensure comprehensive and relevant results. The BAEF process used the institutional arrangements for the TNA process including National Coordinator and Project Steering Committee and Adaptation and Mitigation working groups. The identified barriers and measures for the priority technologies in the two sectors were identified through comprehensive review of relevant sectors literature including policy documents and research papers and consultations with various stakeholders through virtual meetings. The stakeholders engaged include representatives from relevant Federal Government Ministries, Federal Member states, private sector and NGOs in Somalia and coordinated by the Ministry of Environment and Climate Change. The draft report was summarised in a presentation was presented to stakeholders at a national validation workshop for the BAEF.

Problem trees each indicating the core problem and causal-effect relationship, the solution trees and market maps for measures indicating market actors, enabling framework and inputs/support services of the prioritized technologies have been annexed (Annex I-XII) to the report. The list of stakeholders involved in the identification of barriers and enabling measures is attached to this report as Annex XIV.

LIST OF ABBREVIATIONS/ACCRONYMS

BAEF	Barrier Analysis and Enabling Framework
CO ₂	Carbon dioxide
CBOs	Community Based Organisations
CSOs	Civil Society Organisations
FAO	Food and Agriculture Organisation of the UN
FGS	Federal Government of Somalia
FMSs	Federal Member States
GCF	Green Climate Fund
GBV	Gender based violence
GHGs	Greenhouse gases
IDPs	Internally Displaced Persons
INC	Initial National Communications
LED	Light-emitting diode
MtCO ₂ eq	Million Tonnes of carbon dioxide equivalent
MoECC	Ministry of Environment & Climate
MoAI	Ministry of Agriculture and Irrigation
MoEW	Ministry of Energy and Water
NDC	Nationally Determined Contributions
NDP	National Development Plans
NGOs	Non-Governmental Organizations
R&D	Research and Development
Solar PVs	Solar Photovoltaic technology
TNA	Technology Needs Assessment
TAPs	Technology Action Plans
UNFCCC	United Nations Framework Convention on Climate Change
UNEP CCC	UN Environment Programme (UNEP)'s Copenhagen Climate Centre

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CHAPTER 1: ENERGY SECTOR

1.1 Energy Sector context in Somalia

Energy plays a pivotal role in driving economic development, enhancing livelihoods, and ensuring overall societal well-being. The energy sector in Somalia has historically been characterized by its reliance on traditional biomass and imported petroleum products, with limited access to modern energy services by the majority of the population. According to the World Bank 2020, more than 13.8 M (over 80%) Somalis lack access to clean cooking, with majority of Somalia's energy consumption comes from traditional biomass, such as firewood and charcoal (AfDB, 2015). This has contributed to rapid deforestation, environmental degradation and climate change. The lack of access to clean energy also inhibits socio-economic development, particularly in education, health, and economic productivity sectors.

Infrastructure for energy generation, transmission, and distribution is severely underdeveloped, largely due to the prolonged civil unrest and lack of investment. The sector is also affected by security challenges, poor policy and regulatory framework as well as weak institutional capacities. Addressing the energy sector challenges is critical to expanding access to modern energy services and reducing the climate, environmental and health impacts of current energy practices.

Somalia's Power Master Plan (FGS, 2018) outlines plans to increase energy production, increase the supply of renewable energy, and establishment of regulatory authorities and a legislative framework to improve the market efficiency. The government has a plan to expand electricity generation and distribution system in the country. The Master Plan 2018 indicates that the base scenario assumes about 1,000 MW of installed capacity by the year 2037. The contribution of renewable power mainly solar energy and wind and hydro will also contribute to the electricity demand.

Investment in clean and renewable energy sources is considered to play a major role as key driver of economic growth in Somalia's NDP-9 (FGS, 2020). Other policy related interventions include promotion of clean cooking and lighting technologies for the rural population, strengthening policy and institutional frameworks and targeted energy interventions to support vulnerable populations particularly women, youth and the displaced populations.

In Somalia, the energy sector's contribution to GHG emissions stands at 3% of the overall national emissions according to the Initial National Communication (FGS, 2018) with biomass use in the rural areas and commercial sectors will account for the largest share of the total emissions. Emissions from the sector is expected to increase sharply with increasing demand for energy with the implementation of the National Development Plan-9 and other national

policies.

Through the Somalia NDC 2021(FGS, 2021), the country is committed to remain low emitter and contribute to global climate change efforts in the context of sustainable development and poverty eradication. Key policies and measures for mitigation in the energy sector highlighted in the NDC are: promotion of clean and efficient cookstoves, potable lighting technologies, promotion of investments in renewable energy such as solar and wind and energy efficiency in the transmission of power.

The Ministry of Energy and Water Resources of the Federal Government of Somalia defines, regulates and coordinates the implementation of overall energy sector policies. The Ministry maintains direct relations with the state-level governments and the authorities there are mandated with overseeing the sector. The ministry has limited staff and budget to carry out its mandate. At the Federal member state level, only Somaliland and Puntland have relatively well-developed state level energy policies and institutional arrangements compared to the other states.

1.2 Preliminary targets for technology transfer and diffusion

The following mitigation technologies were prioritised through the Technology Needs Assessment for the energy sector of Somalia: i) clean and energy-efficient cookstoves, ii) potable solar lighting devices, and iii) decentralized Solar Photovoltaics (PVs).

Technologies are categorized according to the types of goods and services they belong to or contribute to because the different types of goods and services have distinct market characteristics. In this report we have considered four generic categories based on Nygaard, I. and Hansen, U. (2015):

- Market goods: i) consumer goods ii) capital goods
- Non-market goods: iii) publicly provided goods iv) other non-market goods

All the three prioritised technologies in the energy sector fall under consumer goods under the broad category of Market goods. Consumer goods are intended for the mass market, households, businesses and institutions. Some specific characteristics of consumer goods include:

- a high number of potential consumers
- interaction with existing markets and requiring distribution, maintenance and installer networks in the supply chain.
- large and complicated supply chains with many actors, including producers, assemblers, importers, wholesalers, retailers and end consumers.
- barriers may exist in all steps in the supply chain.
- demand depends on consumer awareness and preferences and on commercial marketing and promotional efforts.

The goal of the Draft National Energy Policy (FGS, 2018) is to provide all Somalis with adequate, affordable and sustainable access to efficient energy, with a commitment to environmental stewardship, while also improving quality of life, promoting socio-economic growth, developing clear policies, regulations, building strong institutions, and unlocking the country’s renewable energy potential. The policy does not give specific targets but provides policy interventions to spur investments in each of the prioritised technologies. Additionally, the Somali updated NDC 2021 gives more detailed preliminary targets for each of technologies. Below is a summary of preliminary targets for the technologies:

1.2.1 Energy Efficient cookstoves:

The Somalia Initial National Communication (INC 2018) acknowledges that the majority (80-90%) of the population use firewood and charcoal for cooking, and therefore proposes the use of clean and efficient cookstoves as a key measure to reduce emissions in the household and commercial sectors. The INC 2018 estimates that increased penetration of improved cookstoves stoves from 2% in 2015 to 30% in 2040 will result in the emission reduction from 6.92 Mt CO₂eq to 4.53 MtCO₂eq (2.38MtCO₂eq) in 2040.

According to the Somalia NDC 2021, Somalia has a target of achieving at least 30% penetration of energy efficient cookstoves (both household and institutions), which is about 5 million cookstoves from 2021-2030 and this will result in an estimated emissions reduction of 2.15 MtCO₂eq per year in 2030. The proposed target also aims to increase awareness of improved cooking practices, stove quality, increase access to soft loans particularly for youth and women, building capacity of stove producers, and improving access to testing facilities among others. The table below summarizes the preliminary targets for clean and efficient cookstoves:

Table 6: Preliminary targets for clean and energy efficient cookstoves

Target	Overall: 30% penetration in the country (5 million cookstoves) Households: 90% = 4.5m cookstoves Institutions: 500,000 cookstoves
Required Investment	Capital costs: USD 200million. Additional costs: Awareness: 5million, institutional strengthening: 5Million Key assumptions: <ul style="list-style-type: none"> • Cost per cookstove: USD 50 • Implementation period will be 6 years
Economic benefits	<ul style="list-style-type: none"> • Reduced fuel costs • Improved health and reduced healthcare costs • Time savings and increased productivity especially among women and girls • Employment opportunities at local levels
Environmental/climate benefits	<ul style="list-style-type: none"> • Reduced GHG emissions and contribute to meeting the NDC targets: 2.15 MtCO₂eq per year in 2030 • Reduced deforestation and degradation

	<ul style="list-style-type: none"> Improved air quality
Expected lifetime	<p>The project will be implemented for the next 6 years</p> <p>The lifetime of cookstoves is 5-7 years</p>

1.2.2 Portable solar lighting devices

The Draft Energy Policy acknowledges the challenges associated with Kerosene lamps in Somalia and proposes interventions to support affordable access to clean energy in the country.

Considering pastoralism and the significant internally displaced people (IDP) constituting about 60% of the population in Somalia and the negative health effects of kerosene, replacement of Kerosene lamps with mobile renewable lighting technologies is considered a high priority technology. The preliminary target in the updated NDC is 30% adoption of portable solar lighting devices (for off-grid applications) by 2030, which is about 5 million solar lanterns.

Table 7: Preliminary targets for Portable solar lighting devices

Target	Overall: 30% penetration (5 million portable lighting devices) replacing use of firewood and kerosene lamps
Required Investment	<p>Capital costs: USD 150 million.</p> <p>Additional costs: Awareness: 5million, institutional strengthening: 5Million</p> <p>Key assumptions:</p> <ul style="list-style-type: none"> Cost per portable lighting device: USD 30 Implementation period will be 6 years
Economic benefits	<ul style="list-style-type: none"> Cost savings compared to polluting kerosene lamps Increased productivity as a result of reliable lighting for businesses and households Improved health and reduced healthcare costs Education improvements due to long hours for studies Employment and income generation opportunities at local levels
Environmental/climate benefits	<ul style="list-style-type: none"> Reduced GHG emissions and contribute to meeting the NDC targets: 1.58 MtCO₂eq per year in 2030 Reduced deforestation and degradation Improved air quality
Expected lifetime	<p>The project will be implemented for the next 6 years</p> <p>The lifetime of solar portable lighting devices is 5-7 years</p>

1.2.3 Decentralized Solar Photovoltaics (PVs).

The Somalia Power Master Plan of 2018 promotes a shift towards decentralized Solar PVs as one of the most viable power development options given Somalia's high solar potential owing to its geographical location near the equator.

Further, the draft Energy policy 2018 and the National Development Plan 2020 promote investments in renewable energy and in particular use of off-grid and mini-grid solar products

and systems in the country as a faster way to increase energy access. The NDP acknowledges significant technical challenges to establishing decentralized solar PVs in the country.

The target in the NDC is to increase renewable energy with an additional 200MW in Major cities of Somalia (Mogadishu, Hargeysa, Boosaaso). The programme will encourage private sector investment including through additional grants, access to loans for early-stage development, risk mitigation, capacity building programmes, and harmonization and improvement of the regulatory framework. According to the updated NDC 2021, the target is to add renewable energy generation capacity to the baseline capacity and thus emissions reductions achieved by investing in renewable energy technologies for electricity will result 3.1 MtCO₂eq being avoided in 2030. The table below provides a summary of the preliminary targets for decentralized Solar PVs in Somalia:

Table 8: Preliminary targets for decentralised Solar PVs

Target	<ul style="list-style-type: none"> • A total 200MW ((200,000 kW) of decentralised solar PV capacity across the country • 40,000 Solar Home systems and PVs for institutions of each 5kw
Required Investment	<p>Capital costs: USD 300 million. Additional costs: Maintenance, institutional strengthening – USD 20Million Key assumptions:</p> <ul style="list-style-type: none"> • average cost of \$1,500 per installed kW • Implementation period will be 6 years
Economic benefits	<ul style="list-style-type: none"> • reduced energy costs • Income generation and economic growth • Increase in job opportunities in manufacturing, installation, maintenance, and related sectors, contributing to local and national economies. • Energy independence of local communities
Environmental/climate benefits	<ul style="list-style-type: none"> • Reduced GHG emissions and contribute to meeting the NDC targets: 3.1 MtCO₂eq being avoided in 2030 • Reduced degradation and biodiversity enhanced • Improved air quality • Climate resilience
Expected lifetime	<p>The project will be implemented for the next 6 years The lifetime of solar PVs is 25 years</p>

1.3 Analysis of barriers and favourable measures of Clean and Efficient Cookstoves

1.3.1 General Description of Clean and Efficient Cookstoves for Somalia

Clean and efficient cookstoves represent a pivotal technology for Somalia, aimed at addressing the country's heavy reliance on traditional biomass (approximately 80-90% of households) for cooking and lighting purposes.

Clean and efficient cookstoves come in various designs, fuel types, and sizes, suitable for different cooking practices and local conditions. The most common designs feature improved combustion chambers that significantly reduce fuel usage through improved combustion efficiency and transfer the heat to the cooking device more efficiently and harmful emissions. These cookstoves can run on a variety of fuels, including sustainably harvested wood, charcoal, pellets, and even renewable fuels like biogas or ethanol, depending on the specific design and local availability of these fuels.

The transition to cleaner cookstoves like BURN's JIKOKOA is currently undertaken at small scale by organizations such as Ecologi and initiatives like WIRES (Women In Renewable Energy Somalia). These efforts not only aim to reduce deforestation and greenhouse gas emissions but also focus on improving indoor air quality, thereby enhancing the health of the population.

JIKOKOA (produced mainly in Kenya) is a regional Eastern Africa brand of efficient cookstoves which has also been introduced in Somalia. According to the Gold Standard Somalia project, JIKOKOA, reduces charcoal consumption by 64% – slowing deforestation and saving Somalian families \$130 million. It also reduces indoor air pollution by 65%, with families reporting that they get ill less often (Ecologi website). These health benefits, tied with fuel and time savings, help reduce gender inequities, improve lives, and save forests.

Moreover, the adoption of cleaner cookstoves has a ripple effect on the community, empowering women and children by minimizing the time spent on cooking and firewood collection, thus allowing more time for education and other productive activities. It also supports environmental conservation efforts and aligns with global sustainability goals, such as ensuring access to affordable, reliable, sustainable, and modern energy for all.

Despite these benefits, the penetration of clean and efficient cookstoves in Somalia is still in its early stages, necessitating continued support from local and international stakeholders to ensure widespread adoption. During stakeholders' consultations, some referred to the success stories from a section of the country, mainly Somaliland, where there is significant uptake (with more than 80% of the households using it) of clean and efficient cookstoves. This is largely attributed to a focused campaign and support by the government. Additionally, there is small scale production centre of *Jiko biogas* in Jowhar, Hirshabelle state. However, the majority of the population in the other regions largely rely on traditional stoves or three stones for cooking.



1.3.2 Identification of Barriers to Clean and efficient cookstoves

While encouraging the widespread adoption of clean and efficient cookstoves in Somalia is a critical development and climate imperative with far-reaching health and environmental benefits, there remains critical economic, financial, and non-financial barriers both in terms of access and utilization that should be addressed. Below is a detailed analysis of these barriers that were identified during the TNA process. These barriers were identified through comprehensive literature review of energy sector and related reports, consultations with various stakeholders including Ministry of Energy and Water, Ministry of Environment and Climate Change, Federal Member states representatives and NGOs working in Somalia. By identifying and understanding these barriers, targeted strategies can be developed to overcome them and promote the adoption of cleaner and more sustainable cooking technologies.

1.3.2.1 Economic and Financial Barriers

Economic and financial barriers represent one of the most significant challenges impeding the wide-scale adoption of clean and efficient cookstoves in Somalia. These barriers occur at various levels, affecting both the supply and demand sides of the market.

1. High Upfront Costs: As elaborated in the problem tree Annex I, high costs of cookstoves is a key barrier. According to World Bank Somali Poverty and Vulnerability Assessment (World Bank, 2019), nearly 7 in 10 Somalis live below the poverty line, particularly those in rural areas and IDP settlements. This limits their disposable income, making major household expenditure a challenging decision. The prospect of investing a significant amount in a clean cookstove becomes daunting. Clean and efficient cookstoves typically have higher initial purchase prices (about US\$ 50) than traditional stoves (less than US\$10). While these costs may be offset in the long term through fuel savings and health benefits, the upfront expense may still be prohibitive for many low-income households in Somalia.

2. Lack of Affordable Financing: Most consumers in Somalia lack access to affordable financing options to manage the initial cost of the stove and the ongoing costs of fuels. The limited reach of formal financial institutions, particularly in rural areas, and high interest rates compound this issue. This also presents a major financing gaps for producers seeking to enter the market as and working capital is also a challenge across the distribution value chain.

3. Limited Return on Investment for Manufacturers and Distributors: The high production and distribution costs with the vast rural areas, coupled with low consumer purchasing power, limits the profitability of clean and efficient cookstove businesses, discouraging potential manufacturers and distributors in the country. Additionally, there are costs associated with distributing the stoves to target audiences and for monitoring and impact reporting. These high costs can limit the profitability for manufacturers and distributors, especially in markets with lower purchasing power (Filmanovic M(2023)

The private sector actors believe that the local market as oversaturated with low-priced, traditional stoves, offering limited room for efficient models. Additionally, the absence of

established supply chains for clean cookstoves also results in increased costs and inefficiencies. This, in turn, reduces the availability and accessibility of these stoves in the market, especially in many rural areas.

According to London T & Fay C 2018, while investments in this sector have grown, they are still not at the level required to fully realize market opportunities. Additionally, the clean cookstove market is fragmented and immature, requiring investors to be ready to provide both funds and technical assistance to small companies.

4. Economic Risk Perception: Consumers perceive clean and efficient cookstoves as risky investments due to uncertainties about their performance, durability, and maintenance costs. The same applies to potential manufacturers, distributors and retailers across the country. Given the economic challenges facing many Somali households, their ability to invest in clean and efficient cookstoves is limited. This uncertainty about consumer purchasing power further fuels the economic risk perception for potential investors. It is therefore essential to undertake targeted campaigns and raise public awareness about the economic savings for consumers and profitability of the businesses related to clean and efficient cookstoves.

5. Economic Instability: Somalia's overall economic instability and uncertainties, partly due to political instability, also factor into the financial barriers for cookstoves. This barrier has a causal effect resulting in low bargaining power amongst the population with many unable to afford the clean and efficient cookstoves as highlighted in the problem tree- Annex I. The economic instability and related high poverty rate limit the disposable income of households, making it challenging for them to afford clean and efficient cookstoves. The cost of using traditional stoves, such as open fires or inefficient stoves, is high, both in terms of fuel expenses and health impacts. However, the initial investment required for more efficient cookstoves is a significant barrier for many families.

The economic instability in Somalia, coupled with security concerns, makes it difficult to attract foreign investment. Projects like BURN Manufacturing's initiative in Somalia, which helps families transition to more fuel-efficient biomass stoves, are crucial but remain limited in scale due to these challenges. Although these projects have demonstrated significant positive impacts, scaling them up requires overcoming the barriers of economic instability and limited investment (Ecologi website).

1.3.2.2 Non-Financial Barriers

Apart from the economic and financial impediments, non-financial barriers also substantially hinder the widespread adoption of clean and efficient cookstoves in Somalia. These barriers can be broadly classified into categories of social-cultural, technical, and institutional-regulatory barriers.

1. Social-Cultural Barriers:

Inadequate Public Awareness and Knowledge: In Somalia, inadequate public awareness and knowledge pose significant barriers to the adoption of clean and efficient cookstoves. This barrier is related to limited information on the importance to clean cookstoves and related

cultural perception amongst the population as elaborated in Annex I- Problem tree for cookstoves. The country, grappling with various socio-economic and security related challenges, finds itself in a situation where burning non-renewable biomass remains a prevalent cooking method for the majority of households. This traditional cookstoves, largely due to low efficiency, contributes significantly to deforestation and greenhouse gas emissions. The negative effects extend beyond environmental degradation, compromising respiratory health and contributing to indoor air pollution.

Efforts like those by Ecologi to support cleaner cookstoves, such as BURN's JIKOKOA, are making strides in addressing these issues. These stoves, known for their fuel efficiency, are instrumental in reducing charcoal consumption by a significant margin, thereby preventing further deforestation and cutting indoor air pollution. The transition to these new cookstoves has reportedly led to improvements in health outcomes and financial savings for Somali families. However, despite these advancements and the potential benefits of cleaner cookstoves, a significant challenge remains in effectively disseminating information and educating the public about these benefits (Ecologi website, Smartest energy website).

Many Somali households are not fully aware of the health, economic, and environmental benefits associated with using clean and efficient cookstoves. The long-term savings, reduced pollution, and health advantages is not understood by many Somalis. Additionally, the new technologies for cooking is perceived as complex and challenging to use compared to traditional cooking methods.

Cultural Preferences: Traditional cooking methods and food tastes are deeply rooted in Somali culture. Many women are reluctant to change their cooking practices due to perceived differences in food taste or cooking experience with clean and efficient cookstoves. Many believe that the efficient cookstoves may only work in small family setting and the traditionally stoves are important for large households, typically of Somalis, and for events, hence see no need for the change. Others consider traditional stoves, often made from locally available materials, more durable or easy to repair compared to modern cookstoves which might require specific parts or expertise.

2. Technical Barriers:

Lack of Skills and Technical Know-How: The introduction and deployment of clean and efficient cookstoves in Somalia, like in many Africa countries, face a significant barrier in the form of a skills gap and limited technical know-how. This not only pertains to the end-users but also affects the entire value chain, from manufacturers to distributors. Many consumers and even suppliers lack the necessary skills and technical knowledge to install, use, and maintain clean and efficient cookstoves. This barrier can lead to a lack of trust in the technology and lower adoption rates. The production and maintenance of clean and efficient cookstoves require specific technical skills. This challenge is exacerbated by the absence of sufficient training centers and structured programs to equip the local Somali population, especially women, with the necessary skills to operate, maintain, and advocate for these advanced cooking solutions. This barrier has resulted in limited manufacturing and distribution network and resulted limited access to the energy efficient cookstoves at local levels as shown in Annex I -problem tree for efficient cookstoves.

Additionally, a lack of local Research and Development (R&D) capacity hinders the development of contextually relevant and innovative solutions. The lack of skills and technical expertise hamper the widespread adoption and sustainable use of clean cookstoves. Moreover, a lack of local expertise can lead to over-reliance on external entities, limiting the growth of a self-sustaining market ecosystem around clean and efficient cooking in Somalia.

Performance and Quality Concerns: Many consumers are concerned with quality of some of the clean cookstoves in the market as there is no nationally recognized standards and with many imported into the country. This is also quality concerns in relation to locally produced cookstoves. Additionally, with increasing demand for efficient cookstoves, the market is at risk of being flooded with products of varying quality. This situation is particularly concerning as many cookstoves are imported, and there's a fear that Somalia could become a dumping ground for low-quality, non-performing cookstoves, often imported from neighboring countries like Kenya.

The reliance on an external market and the limited local production capacities for clean cookstoves in Somalia represents a significant barrier for the technology's broader adoption and long-term sustainability. Dependence on imports does not guarantee the durability or suitability of the products for local conditions, as imported cookstoves may not align with the specific needs and preferences of the Somali population. Moreover, the minimal or small-scale manufacturing capabilities in the country hinder the development of a self-sustaining market that caters to local demands and ensures the availability of quality, durable products.

3. Institutional-Regulatory Barriers:

Inadequate Policy Support: In Somalia, the inadequate policy support for clean and efficient cookstoves is a significant barrier to their widespread adoption as shown in the problem tree Annex I. This issue stems from a lack of a comprehensive and supportive policy framework that facilitate the introduction and use of these technologies. While improved cookstoves have the potential to offer substantial benefits in terms of health, environmental impact, and social welfare, particularly for women who are traditionally involved in wood gathering, the absence of robust policy support limits the realization of these benefits.

The World Bank recognizes the importance of clean cooking and has been increasing its financing in this sector, emphasizing the need for political commitment, investments, and innovation centered on the needs of end-users. The establishment of the Clean Cooking Fund (CCF) by the World Bank, with a funding target of US\$500 million, aims to catalyze significant public and private investments to help millions of people gain access to clean cooking. This initiative is part of a broader effort to address the multisectoral development challenge of clean cooking access by catalyzing action through political prioritization, financing, knowledge creation, and partnerships.

Despite these efforts, the transition to clean and efficient cookstoves in Somalia and other LDC countries requires a concerted effort to improve the overall ecosystem. This includes not only increasing financial support but also ensuring that there is a supportive policy environment that encourages the adoption of these technologies. Addressing these policy

barriers is crucial for making clean cooking interventions more effective, lifesaving, and contributing to sustainable development (World Bank, 2018)

Weak Institutional Capacity:

In Somalia, like in many other developing or least-developed countries, inadequate institutional frameworks present a significant barrier to the development and uptake of efficient cookstoves and renewable energy technologies. This barrier is largely due to low institutional capacity and inadequate regulatory and investment frameworks, which are essential for creating an enabling environment for the development, uptake, and technology transfer at scale.

Weak institutional structures and lack of coordination among different stakeholders hinder the effective promotion, distribution, and adoption of clean and efficient cookstoves (Ecologi website). Additionally, there is no clear institutional mandate for efficient cookstoves at the federal level as well as at Federal Member states. This ambiguity in mandate results in lack of targeted interventions to support deployment of clean cookstoves at scale.

Moreover, the lack of attention to research and development (R&D) by the government, coupled with insufficient facilities and infrastructures for cookstoves, exacerbates these challenges.

The barriers to adoption of the clean and efficient cook stoves have been used to develop a problem tree diagram provided as annex I to this report.

1.3.3 identified Measures to Address Barriers

Clean cookstoves represent a transformative solution to indoor air pollution, gender inequality and contribute to climate goals. As discussed above, the barriers to this technology impede its widespread deployment in the country. To unlock the full potential of clean cookstoves and drive their acceptance and integration into households, it is essential to implement a set of enabling measures. These measures encompass financial incentives, awareness campaigns, policy support, and technological innovations, all aimed at overcoming the barriers that have hindered progress in the clean cookstoves technology in Somalia. These measures also form part of the solution tree for the barriers identified as highlighted in the diagram Annex II to this report. Below is a highlight of these enabling measures:

i) Addressing Economic and Financial Barriers:

Subsidies and Grants: This is a core measure to addressing the financial barriers related to the cookstoves and for realization of the preliminary targets for cookstoves as shown in Annex III market map for clean and efficient cookstoves. The government and international organizations should provide subsidies or grants to reduce the initial cost of clean and efficient cookstoves for consumers. There is need to establish a strong collaboration framework between the Federal Government, Federal Member States, and international organizations to ensure coordination in policymaking, fund mobilization, and implementation. Subsidies could be provided through direct price reductions, rebates, or

vouchers for clean and efficient cookstoves while grants could be provided to non-profit organizations or community cooperatives to purchase cookstoves in bulk and distribute them to targeted households and public institutions. A detailed economic analysis to assess the most effective subsidy for Somalia. However, considering the fact that a large proportion of the Somali population lives below the poverty line, direct price reductions or vouchers for clean cookstoves might be more effective in ensuring that the most vulnerable households can afford these technologies. This approach can directly alleviate the financial burden on families, making it a preferred option for immediate impact. Additionally, direct grants to local NGOs and CBOs for bulk purchases might be more cost-effective in terms of distribution and administration, especially if these organizations already have established networks and understand the community's needs.

In assessing the size of subsidy, stakeholders have indicated that affordable price for the Somali population is US\$10. Given the retail price of \$50 per clean cookstove and considering the economic realities of the target population, a subsidy model has been designed where the consumer's contribution is set at the affordable \$10 per unit. This arrangement necessitates a subsidy of \$40 per cookstove to bridge the gap between the market price and the consumer's capacity to pay. For a target distribution of 5 million clean cookstoves, this translates to a total subsidy requirement of \$200 million.

To ensure the sustainability of this initiative, a revolving fund could also complement the subsidy. An assumption is made of 80% repayment rate of the affordable price, which amounts to an expected recovery of \$8 per cookstove, or \$40 million in total for the 5 million units. Taking into account the operational costs estimated at 10% of the total subsidy (\$20 million), the initial capital required for the revolving fund is calculated to be \$180 million. This fund is intended not only to finance the upfront subsidy but also to reinvest the recovered costs into future distributions of clean cookstoves, thereby perpetuating the cycle of affordability and accessibility.

Microfinance and Innovative Financing Mechanisms: Partnering with local microfinance institutions could provide local producers and users with affordable loans to produce and purchase cookstoves. Pay-as-you-go models can also be explored for their viability. This would require engaging, strengthening and building partnerships with local microfinance institutions such as MicroDahab, Salam Somali Bank, Dara Salam Bank, Premier Bank, Kaah International and Amal Bank to develop innovative financing including, appropriate loan products that are tailored to the needs and repayment capabilities of potential cookstove producers and users. For example, this measure could build on the work of organizations like Kaah International Microfinance Services (KIMS) are making strides in providing Sharia-compliant microfinance services to micro and small enterprise (MSE) clients. KIMS's efforts, particularly in offering value-chain financing and innovative group loan products, demonstrate the potential of microfinance in enhancing economic and social development. By providing financial literacy and business skills training, KIMS ensures that the financing it provides translates into tangible benefits for communities, such as job creation, income increase, and improved living standards (Innovest advisory, 2022). This holistic approach to microfinance can be instrumental in supporting the deployment of clean cookstoves by ensuring that financial products are tailored to meet the needs of the communities, encouraging strong repayment cultures, and enhancing the overall impact of financial interventions. Such efforts should be

strengthened and upscaled with other microfinance institutions to support largely deployment in the country.

Bulk Purchasing and Distribution: Non-profit organizations or cooperatives could buy cookstoves in bulk to reduce the per-unit cost and ensure their wide distribution. The government could identify local NGOs that have strong community presence and have experience and willingness to participate in the bulk purchasing and distribution of cookstoves. For sustainable deployment of the technology there is a need to establish distribution centres across the country. Fund raising for such an initiative through a variety of mechanisms including grants, donations, social business models, or collaborations with government and international organizations.

International Cooperation: Collaborating with international partners can provide access to funding, technologies, and expertise, facilitating the wide adoption of clean and efficient cookstoves in Somalia. This can help either develop programmes and projects implemented to support the deployment of the technology and/or coordinate the development of key concepts for submission to multilateral funding opportunities.. Such notable international partners include the World Bank Group, Global Alliance for cookstoves, World vision, UNDP, bilateral partners among others. For example Work Bank in collaboration with the Global Alliance for Clean Cookstoves, has implemented a project that committed significant resources to support clean cooking for households (World Bank, 2018). Other key partners include; Burn Manufacturing, Ecologi among others to support local production.

2. Tackling Social-Cultural Barriers:

Awareness and Education Campaigns: Conducting campaigns to educate the public about the benefits of clean and efficient cookstoves can help overcome resistance to new technology and motivate change. A key element to achieving this, is carrying out consistent, direct sensitization initiatives that highlight the economic, social, and environmental benefits of adopting these technologies. Public awareness and acceptance are instrumental in accelerating the widespread diffusion and adoption of efficient cookstoves - a crucial factor in reaching climate change mitigation goals. Such initiatives need to be comprehensive, culturally sensitive, and accessible to ensure widespread understanding and acceptance. For these sensitization efforts to be successful, they must resonate with the public and foster their support. This can be achieved through carefully targeted campaigns that reach out to different societal demographics using various platforms. These could include televised programmes, radio broadcasts, public gatherings, and digital media platforms, among others. Awareness and campaigns on cookstoves is a key input to the realisation of sustainable market as shown in Annex III which elaborates the market map for the technology.

Community Participation and Women Empowerment: Involve communities, particularly women, in the decision-making process, as they are the primary users of cookstoves. Their input can lead to better acceptance and design of the cookstoves. This can be done through organizing community especially women engagement sessions, involving them in decision-making processes related to the choice of cookstove models, their distribution mechanisms, pricing and maintenance, providing training and capacity building to them as well as feedback mechanisms.

3. Overcoming Technical Barriers:

- a. **Capacity Building:** Capacity building is a pivotal component in the successful implementation and sustainability of clean cookstove initiatives in Somalia. Investing in training and skill development at the local level not only addresses the technical aspects of clean cookstove deployment but also stimulates the local economy and creates job opportunities, particularly for the youth, who constitute a significant portion of the population.

Specific strategies include:

- Establish comprehensive training programs for local artisans especially for youth and women. These programs should cover technical skills, safety standards, business management, and customer service.
 - Collaborate with local educational institutions to integrate clean cookstove technology into their curricula, ensuring a steady pipeline of skilled professionals in the sector. Example of such institutions include Somali Renewable Energy Association (SOMREA), Benadir University (BU, Puntland State University (PSU) among others.
- b. **Quality Assurance:** Quality assurance is key to ensuring that clean and efficient cookstoves meet the required performance and durability standards, ultimately building consumer trust in these technologies. The Federal Government of Somalia, preferably in collaboration with technical experts, should establish a set of clear and rigorous quality standards for clean and efficient cookstoves. These standards could encompass factors like emissions, fuel efficiency, safety, durability, and usability. Manufacturers, importers, and distributors of cookstoves should be trained on these quality standards and a system established for testing cookstoves against these quality standards. This could involve setting up testing labs in Somalia or partnering with international testing facilities. Consumers should be educated about the quality standards and the importance of buying certified cookstoves through awareness campaigns, product labels, and consumer guides.
- c. **Research and Innovation:** There is need for targeted investment in research and development efforts to enhance the durability, efficiency, and functionality of the cookstoves. The government's role both at Federal and FMSs levels in fostering an environment conducive to research and development is pivotal for achieving advancements in cookstove technology that meet the unique demands and conditions of the local population. This could be realized by:
- Allocating a portion of the government's budget and seek financial support from international development partners to fund research and development projects focused on clean cookstoves technology in Somalia.
 - Partnering with universities and research institutions, both within and outside Somalia, to conduct studies on cookstove technology.
 - Implementing pilot projects to field-test innovative cookstove models under real-life conditions including further adjustments to meet the expectations of the local population.
 - Encouraging partnerships between the government, private sector, and research institutions to pool resources, expertise, and networks. Such

collaborations can accelerate the development and commercialization of innovative cookstove technologies.

4. Addressing Institutional-Regulatory Barriers:

- a. **Policy Support:** The federal government of Somalia should develop and implement policy and legislative framework that encourage the production, distribution, and use of clean and efficient cookstoves thus stimulate market growth. This might include tax benefits for producers or importers, emissions standards that favour clean cookstoves, and regulations to phase out traditional stoves. As shown in Annex III, the market map for cookstoves, key enabling policies required include cookstoves policy(both at Federal and FMSs levels) and cookstoves standards.
- b. **Institutional strengthening:** To address institutional challenges, there's need for institutional strengthening to support the promotion and adoption of efficient cookstoves. Institutions at all levels - national, FMSs, districts and local - should be equipped with the resources, capacity, and knowledge to promote the benefits of clean and efficient cookstoves. It is essential that collaborative efforts between governmental agencies, NGOs, and private sector stakeholders be established to coordinate the implementation and adoption of cookstoves across the country.

The effective implementation of these measures will require a coordinated and sustained effort from various stakeholders, including the government, private sector, NGOs, communities, and international partners.

Measures to overcome the barriers to the uptake of clean and efficient cookstoves have been used to prepare solution tree as shown in Annex II and further developed into a market map shown in the diagram named Annex III to this report.

1.4 Analysis of barrier analysis and favourable measures for Portable solar lighting devices

1.4.1 General Description of Portable solar lighting devices for Somalia

Portable solar lighting devices are versatile, mobile light sources powered by solar energy. These devices are designed to provide an environmentally friendly, cost-effective, and safe lighting solution, particularly in off-grid or energy-scarce locations such as many regions in Somalia. Some specific features of Portable Solar Lighting Devices include: Solar Panel, battery storage and LED lights. Solar panels for lanterns are generally placed during the day on the roofs of shelters, or next to shelters to allow for an ample charge during night hours.

The devices are particularly well-suited to Somalia's context, where off-grid solar solutions can cater to the needs of a largely mobile population and offer a viable alternative to expensive and environmentally detrimental diesel-powered mini-grids. Portable lighting devices offer numerous benefits and contributing to improving lives, especially in rural and off-grid areas. These devices provide a reliable and sustainable source of lighting, improving safety, enhancing education, and supporting economic activities.

In rural villages in Somaliland, for instance, the installation of solar streetlights has significantly improved safety and social life. Residents, who previously faced dangers from wildlife and had limited social interactions after sunset, now enjoy enhanced security and community gatherings at night. The introduction of solar lighting has reduced incidents of wildlife attacks and road accidents, promoting a safer and more vibrant community life (Radio ergo, 2021).

In the education sector, solar lamps are making a meaningful impact by empowering girls' education. World Vision International's initiative to provide solar lamps to displaced women and girls in Baidoa and Wajid districts is a testament to this. These solar lamps enable students to continue their studies and homework during dark hours, offering a brighter future and aspirations for careers such as nursing. The provision of solar lighting is not just about illumination; it represents safety, education, and empowerment, contributing significantly to preventing gender-based violence and supporting economic activities within the camps (World Vision, 2019).

While these initiatives mark significant progress, the full potential of solar lighting in Somalia is yet to be realized. As of now, a large portion of the Somali population still relies on kerosene lamps, or biomass for lighting, all of which have environmental and health hazards. While stakeholders considered this is an immediate and priority technology for Somalia's context, there are some inherent challenges and barriers associated with the technology. Ensuring widespread access to these technologies requires continued efforts in investment, innovation, and collaboration with international partners and local communities.



Example of portable Lighting device

1.4.2 Identified barriers for portable lighting devices.

In Somalia, the introduction and adoption of portable solar lighting devices have the potential to catalyze transformative change across various sectors, from enhancing educational opportunities to improving security in rural villages and IDPs. However, the path to realizing this potential is hindered by barriers that need careful examination and strategic intervention. These barriers were identified through comprehensive literature review of energy sector and related reports, consultations with various stakeholders including Ministry of Energy and Water, Ministry of Environment and Climate Change, Federal Member states representatives and NGOs working in Somalia. By identifying and understanding these barriers, targeted strategies can be developed to overcome them and promote the adoption of portable solar lighting devices.

1.4.2.1 Economic and Financial Barriers

1. **High Initial Costs:** The upfront costs of portable solar lighting devices, including the purchase and installation, can be high compared to traditional lighting sources like kerosene lamps and open fires is a key barrier for the technology as shown in Annex IV, the problem tree for portable solar lighting devices. Even though these devices can provide long-term benefits, the upfront expense can be prohibitive for many potential users, especially in economically disadvantaged areas in rural areas. The current price range for these devices, ranges between USD 20-35(on average the price is US\$ 30) might seem affordable from a global perspective. However, for individuals in lower-income communities, this amount can represent a significant portion of their monthly or even yearly income.
2. **Limited Access to Affordable Financing:** Limited access to affordable financing is a significant barrier to the adoption of portable solar lighting devices in Somalia. Despite the recognized need for sustainable and clean energy solutions, the unstable political, social, and economic landscape in Somalia has led to high perceived levels of risk in the market. This perception has resulted in off-grid solar sector players facing substantially

higher interest rates compared to their counterparts in neighboring countries like Kenya. The cost of financing is thus a major hurdle, inhibiting the ability of companies to meet the growing demand for affordable, clean energy, particularly in underserved rural markets.

3. High Maintenance and Replacement Parts costs: The high cost of maintenance and replacement parts for solar lighting devices in Somalia presents a key barrier to their adoption and sustainability. While portable solar lighting devices typically have low maintenance costs compared to fossil fuel-based lighting, the costs of replacing batteries or other parts presents significant challenge to communities. The maintenance costs of portable solar lighting devices can vary based on the type of device, usage, and local conditions. However, generally, portable solar lights are designed to be low maintenance. The main components that may require maintenance or replacement over time include the solar panel, battery, and light-emitting diodes (LEDs). Local users who are mainly unskilled pastoral population lack the funds needed for unexpected repair or replacement costs. Additionally, such skills are not locally available at the local levels.

4. Limited Economic Incentives for Suppliers and Retailers: The distribution of portable solar lighting devices in Somalia often involves high logistics and operational costs including with the security and poor infrastructure challenges, and these does not be sufficiently offset by the potential profit margins, particularly when consumers' purchasing power is low. This, in turn, limits the availability and affordability of solar lanterns and similar products for consumers, particularly in remote or rural areas. Additionally, it hinders the growth of a robust market ecosystem that could drive innovation, competition, and further cost reductions in this technology. Furthermore, Somalia's economic volatility and limited economic growth affects both the demand for and supply of portable solar lighting devices. This affects consumers' confidence and affects their willingness to invest in relatively new technologies.

1.3.2.1 Non-Financial Barriers

Beyond financial challenges, portable solar lighting devices face a series of non-economic barriers that limit their broad adoption across Somalia. These challenges are multifaceted, encompassing social-cultural, technical, and institutional-regulatory aspects.

1. Social-Cultural Barriers:

- **Inadequate Awareness:** Many potential users are not fully aware of the benefits of portable solar lighting devices or how they operate. In many rural and remote areas of Somalia, access to information and exposure to modern technologies are limited. People may not have had the opportunity to learn about the existence and advantages of portable solar lighting devices. This lack of knowledge can inhibit their willingness to switch from traditional lighting sources.
- **Cultural Habits and Perceptions:** Somali households have long been accustomed to using traditional light sources such as kerosene lamps and open fires especially among pastoralists to guard their livestock against predators. Changing these cultural habits can be challenging. Additionally, there are some perceptions that solar lighting devices are a

luxury or are not as effective as traditional sources. Some believe that the device are not durable to withstand extreme climatic conditions such as flooding and heat.

- **Gender Roles and Household Dynamics:** Traditional gender roles and divisions of labor within Somali households can impact the adoption of solar lighting devices. In some cases, decision-making regarding household purchases and technology adoption is primarily controlled by male family members. Women may be less empowered to introduce and advocate for new technologies, even if they are responsible for household tasks like cooking and caregiving that could benefit from improved lighting.

2. Technical Barriers:

- **Inadequate Technical Skills:** There might be a shortage of skilled technicians for the installation, maintenance, and repair of solar lighting devices. These devices are largely imported with limited technical skills among the local population especially in the remote areas. The lack of technical skills represents a significant technical barrier to the widespread adoption and effective use of portable solar lighting devices in Somalia. Many potential users lack a basic understanding of how solar lighting devices work and how to operate and maintain them. Stakeholders noted that many communities worry about the ease of maintaining and repairing solar lighting devices. This lack of understanding can lead to inefficiencies, misuse, reduced device lifespan and discourage many from use of the technology.

3. Institutional-Regulatory Barriers:

- **Weak Policy and Regulatory Support:** Somalia lack of robust energy policy and regulations at the National and Federal Member states levels to promote solar technologies. The draft Energy policy, 2019 while acknowledging the challenge of lighting technologies especially for rural communities, doesn't recommend policy interventions to support the widespread adoption of these technologies. On the other hand, the institutional structures at the Federal Government level are weak characterized by limited capacity, few staff, lack of financial resources and weak coordination thus limiting the ability of the government to effectively provide enabling environment for the deployment of the technology. The situation is similar for many of the FMSs who lack regulatory and institutional frameworks to support the adoption of the technology. Additionally, the absence of quality standards and inadequate incentives for solar businesses remain barriers.
- **Poor Infrastructure:** Somalia's weak infrastructure, particularly in rural and off-grid areas, limit the distribution of solar lighting devices and restrict access to these technologies. The poor condition of roads and transportation networks can impede the distribution of solar lighting devices to remote and underserved communities. Additionally, users struggle to find suitable charging facilities for their solar lighting devices, hindering their ability to keep the devices powered. Furthermore, the lack of local service centers or skilled technicians presents a significant challenge.
- **Quality and Performance Concerns:** The availability of solar lighting devices in the markets vary widely in terms of quality and durability. Some lower-quality products don't meet performance expectations of the communities, such as poor light output and such inconsistent performance leads to some user dissatisfaction and skepticism about the

technology's reliability. This is related to the weak regulatory and institutional frameworks as the country has no standards and enforcement mechanism to ensure quality imports as shown in the problem tree provided in Annex IV to this report.

The barriers to adoption of the Portable solar lighting devices have been used to develop a problem tree diagram with clear causal relationship provided as annex IV.

1.4.3 Identified Measures to overcome the barriers.

In pursuit of sustainable development and contributing to climate mitigation goals of Somalia, the adoption of clean energy technologies, such as portable solar lighting devices, holds immense potential. However, the successful deployment of these technologies faces a series of challenges, including financial, cultural, technical, and infrastructural barriers. To unlock the full potential of this technology, it is imperative to implement enabling measures that address these barriers comprehensively. These measures were identified through extensive research of publications and consultations with key stakeholders in the sector. This section outlines enabling measures designed to overcome these barriers, ensuring that portable solar lighting devices become a catalyst for sustainable development in Somalia.

1.4.3.1 Economic and financial measures

The successful adoption of portable solar lighting devices in Somalia requires a range of economic and financial measures to address affordability, accessibility, and sustainability challenges. These measures can play a pivotal role in overcoming financial barriers and ensure widespread access to this technology for the majority of the unserved and poor population.

Subsidies and Grants: Financial barriers can be reduced by providing subsidies or grants to lower the cost of portable solar lighting devices especially for the majority of the population who are poor and in the rural areas as shown in Annex V, the solution tree for the technology. The Somali Federal Government and Federal Member States, with the assistance of international organizations, can set up funds to help offset these costs for consumers. This includes implementation of targeted subsidies or financial incentives to make portable solar lighting devices more affordable for low-income households. This could involve government programs that provide direct subsidies or tax incentives to manufacturers and distributors to reduce the retail price for consumers.

During the stakeholders' consultations, it was indicated considering the high levels of poverty among the majority rural population, most people could afford the devices at US\$ 5 to US\$ 10 depending on the location and specific situations in the local context. Noting the current cost per device as US\$30, the target being 5M portable solar lighting devices distributed, the subsidy required would be cost of the device (US\$ 30) minus the affordable price/contribution by population, which is on average US\$ 7, which is US\$ 23 per device. The total subsidy required is US\$ 115million. Additionally, a revolving fund for portable solar lighting devices could provide a sustainable financing mechanism by recycling the funds from recovered costs of the subsidized devices. In calculating the size of the revolving of fund, assuming 80% repayment rate on the \$7 contribution and 10% operational costs, the size of the fund will be total subsidy minus expected recovery plus operational costs which is about US\$ 98.5million.

Microfinancing and innovative financing models: This involves facilitating access to microfinance institutions and establish flexible payment plans for purchasing solar devices. For example, by spreading the cost of the devices over time, more households can afford solar lighting without a significant upfront expense. This should be done in strict compliance with the Islam sharia requirements especially with regards to interests which if not considered might lead to failure. Local institutions like MicroDahab, Salam Somali Bank, Premier Bank, and Amal Bank could be suitable partners for the implementation of this measure. This measure could also promote Innovative financing models such as Pay as you go (PAYG) financing models that allow users to pay for solar devices in installments through mobile payment systems, which is widely in use. This approach aligns with the payment behavior of many Somali households and enhances affordability.

Bulk Purchasing and Group Discounts: The Federal government of Somalia working with international development partners could initiate a programme for bulk purchasing and distributing for some targeted vulnerable groups such as IDPs. This could involve negotiating bulk purchasing agreements with manufacturers and distributors to secure group discounts for communities or organizations. This can drive down the cost of solar devices and make them more accessible.

Public-Private Partnerships: Somalia has vibrant private sector that play an important role in the development of the country. However, not many of the Somali private sector are engaged in business related to portable solar lighting devices. There is need for strengthen partnerships between the government, private sector, and non-profit organizations to facilitate the distribution and adoption of solar lighting devices. Such partnerships can leverage the strengths of each sector, resulting in wider reach, greater investment, and better service for consumers.

1.4.3.2 Non- Financial measures

b) Awareness Campaigns:

As with clean and efficient cookstoves, it is crucial to educate the population on the benefits of portable solar lighting devices. Campaigns should focus on the cost savings, environmental benefits, and improved quality of life these devices provide. In Somalia, this can be done through community meetings, radio and television broadcasts, social media, and religious or cultural gatherings. This also involves providing training to local stakeholders, including community leaders, educators, and outreach workers, on the cultural aspects and values associated with solar lighting. This training should emphasize the alignment of solar technology with local customs and traditions, highlighting its compatibility with Somali culture. Community-based educational sessions and workshops should be organized to raise awareness about the benefits and usage of solar lighting devices. These sessions should be interactive, engaging, and conducted in local languages to ensure understanding and retention.

c) Addressing the technical barriers

Training and capacity building: Offer training sessions on the proper use and maintenance of the solar lighting devices to extend their lifespan. In Somalia, these could be conducted at community centers, schools, or during distribution events. It is important to set up local service centers in all the districts or at least at every FMSs equipped with skilled technicians who can provide repair and maintenance services for solar devices. These centers should be strategically located to serve communities effectively and provide services for training of trainers (TOTs) especially for the youth. This can reduce import costs, create jobs, and promote the availability of affordable, locally produced devices. Providing well-illustrated and easy-to-understand user manuals/flyers in local languages. These manuals should include step-by-step instructions and graphics for setup, operation, and maintenance of the solar devices.

Quality Standards and Certification: The establishment of quality standards and a certification system for portable solar lighting devices will help ensure that the products are reliable and durable. The process could mirror the one suggested for clean and efficient cookstoves above, involving setting the standards, training stakeholders, testing and certification of products, monitoring and enforcement, and consumer awareness.

d) Policy and regulatory support

Policy Support: The Federal Government of Somalia should develop and implement clear and comprehensive renewable energy policies that prioritize the promotion of portable solar lighting technology. These policies should outline specific targets, incentives, and support. The policy could support subsidy programs that reduce the cost of solar lighting devices for end-users, making them more affordable. Subsidies can be funded through international development assistance. Additionally, there is need to put in place portable solar devices standards that promote imports and manufacturing of quality technologies. The policy and regulatory frameworks are key for the effective market ecosystem for the technology as shown in Annex VI -market map for the technology.

Institutional strengthening – Institutional strengthening is a vital component of Somalia's efforts to promote the adoption of the technology as shown in both the Annex V – solution tree and Annex VI-the market map for the technology. Building robust and capable institutions at both the national and FMSs levels is essential to effectively manage, regulate, and support the renewable energy sector. This process involves enhancing the technical expertise and administrative capacity of government agencies responsible for energy regulation and oversight. It also involves creating a specialized regulatory body or authority responsible for overseeing and regulating the renewable energy sector, including portable solar lighting. Strengthening institutions facilitates efficient market regulation, quality control, and policy implementation. Moreover, this fosters an environment where clear standards and consumer protection mechanisms are enforced, ultimately instilling confidence in the technology among users and industry stakeholders. Through institutional strengthening, Somalia can better navigate the complexities of the renewable energy landscape, foster innovation, and drive the sustainable deployment of the technology, contributing to broader energy access goals and the country's sustainable development.

Supply Chain Strengthening: Strengthening the supply chain for portable solar lighting devices in Somalia is crucial to ensure that this technology is accessible, especially in remote/rural areas. An efficient supply chain can significantly reduce costs and delivery times, making the technology more affordable and readily available to the population. This involves a comprehensive and coordinated approach, engaging various actors and investing in critical areas of the supply chain. The key supply chains components include:

- Local Manufacturing- Encourage local production of solar lighting devices or parts thereof to reduce import costs and stimulate the local economy. Investment in local manufacturing facilities can also create job opportunities.
- Facilitate bulk procurement strategies to negotiate better prices for solar lighting devices, especially when dealing with international suppliers.
- Partnerships with Local Distributors -Collaborate with local businesses and entrepreneurs for the distribution of solar lighting devices. Local distributors are more familiar with the terrain and can navigate the logistical challenges in remote areas more effectively.
- Training for Local Distributors- Provide training on inventory management, customer relations, and basic technical knowledge of solar lighting devices to ensure that distributors are well-equipped to handle the products and engage with customers effectively.
- Sales Services- Establish local service centers for maintenance and repair of solar lighting devices, ensuring longevity and reliability of the products. This also contributes to building trust among consumers.

This would require financial support through subsidies/grants and credit facilities or microfinancing options as elaborated above for distributors and consumers to alleviate the upfront cost burden, making solar lighting devices more accessible to a broader population segment. Key actors involved in supply chain strengthening include Government, both Federal and FMSs, local manufacturers and distributors, International and Local NGOs as well as community Organizations. This measure is crucial in contributing to the wider adoption of this technology.

Identified measures to overcome the barriers to the uptake of portable solar lighting devices have been developed into a solution tree shown in diagram annex V and further developed into market map named as Annex VI to this report.

1.5 Analysis of the barriers and favourable measures for decentralized Solar PVs

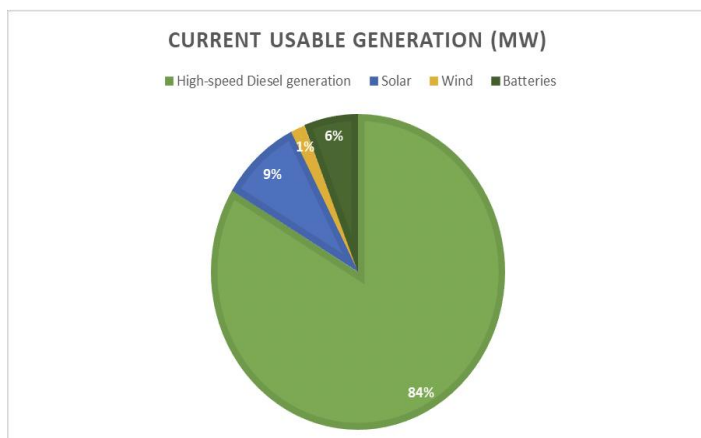
1.5.1 General Description of decentralized Solar PVs in Somalia

Solar Photovoltaic (PV) systems, often referred to simply as solar PV, are innovative technology solutions that harness the power of sunlight to generate electricity. These systems are designed to convert sunlight directly into usable electrical energy through the photovoltaic effect, a process where sunlight interacts with semiconductor materials in solar cells to produce a flow of electrons, generating an electric current. The generated current is then gathered through wiring and can be either utilized immediately or stored in a connected battery as part of the photovoltaic system. Contrary to the misconception that solar cells exclusively function in bright sunlight, they can generate electricity even on cloudy days, although their power production is diminished compared to sunny conditions.

Some key features of decentralized Solar PV Systems include Solar Panels, inverters and battery storage. Decentralized Solar PV systems can be deployed for a wide range of applications, from small-scale residential installations to large utility-scale solar farms. They are commonly used to generate electricity for homes, businesses, schools, and industrial facilities. In remote areas or off-grid locations, solar PV systems are employed to provide power where traditional electrical infrastructure is absent.

According to Somalia Power Master Plan (FGS, 20218) the current electricity generation mix in Somalia with 84% from diesel generation, with solar accounting for only 9% of the power as shown in the figure below. However, there is also significant interest in, Pico photovoltaic (PV) systems and Small Home Solar (SHS) PV electricity systems for residential lighting in both urban and remote areas.

Figure 1: Energy mix in Somalia



FGS, 2018(PMP): Current Energy Generation

The solar PV products market in Somalia is largely import-driven, with a growing network of local distributors and dealers facilitating access to these technologies. Continued support from the government, international donors, and private sector investments is crucial to further expand the reach of solar PV systems, especially in off-grid and underserved communities. Comprehensive data collection and market analysis would be beneficial to gain

a more accurate understanding of the penetration rate and the dynamics of the solar PV sector in Somalia.



Image: cotrim/Pixabay

<https://somalisolar.com>

Examples of decentralized Solar PV options in Somalia

Significance of decentralized Solar PVs in the Somali Context

Decentralized Solar PVs present an opportunity for Somalia to address its energy access challenges and to transition towards more sustainable and resilient energy systems. Key reasons for promoting Solar PVs in Somalia include:

- **High Solar Potential:** Somalia experiences abundant sunlight throughout the year, which can be harnessed for electricity generation.
- **Energy Access:** Many parts of Somalia, particularly rural areas, lack access to the national electricity grid. Decentralized Solar PV systems can provide a viable solution for electrifying these off-grid regions.
- **Resilience and Independence:** Solar PV systems, especially decentralized ones, can increase the resilience of the energy system against disruptions and reduce reliance on imported fossil fuels.
- **Sustainability:** Solar PV systems generate clean, renewable energy, helping to reduce greenhouse gas emissions and combat climate change.

There is significant potential to use the abundant solar energy resources and indeed it is already being exploited. According to Abdullahi et al 2023 the installed photovoltaic capacity was found to be 41 MW and contributed 11.9% of the total electricity generation. Banadir Electric Company (BECO) is Somalia's most prominent electricity provider, mainly covering Mogadishu (80%), the airport (100%), and Halane zone, Hirshabele, Jubaland, and Southwest.

The implementation of decentralized Solar PVs in Somalia faces a series of economic and financial challenges, which hinder their widespread adoption and deployment. These barriers

were identified through comprehensive literature review of related sector reports and consultations with various stakeholders including Ministry of Energy and Water, Ministry of Environment and Climate Change, Federal Member states representatives and NGOs working in Somalia.

1.5.2 Barriers for decentralized Solar PVs

1.5.2.1 Financial and Economic barriers

High Initial Costs:

As described in the problem tree in Annex VII to this report, in Somalia, the major barrier to the wider adoption of decentralized solar PVs systems is the high upfront cost of these systems. Solar PV systems require substantial initial investment for the purchase and installation of equipment. The high upfront investment required for purchasing solar panels, inverters, batteries, and other system components. Stakeholders indicated that the cost varies depending on various factors, including the system's size, components, location, and installation complexity. It is estimated that on average a small-scale residential solar PV system, typically designed to meet the electricity needs of a single household in an urban setting, can range in cost from approximately \$3,000 to \$5,000 for basic installations. These systems usually include solar panels, inverters, mounting structures, and wiring. While many appreciate the long-term viability of investing in Solar PVs, they however find it difficult to cover these initial costs, which can discourage them from transitioning to solar energy.

According to World Bank 2021, the Somali Business Catalytic Fund (SBCF) has made efforts to attract private capital for financing solar energy solutions in Somalia. However, the overall electrification rate in Somalia, at 35.3%, still lags behind the East African average and the Sub-Saharan Africa average. The high initial costs of solar systems, along with liquidity challenges faced by businesses, especially in the wake of the COVID-19 pandemic, contribute to the slow uptake of solar energy solution.

Limited Access to Affordable Financing: This challenge of high upfront costs is compounded by the lack of suitable financing mechanisms to support the development and promotion of solar energy solutions as highlighted in the problem tree for decentralized Solar PVs. In Somalia, the difficulty in accessing finance for solar energy projects presents significant challenges, particularly for suppliers operating with a business model that involves extending credit. This model places the initial capital financing burden on the supplier, increasing the overall capital requirement as the deployment rate increases. The reliance on credit sales can leave companies with substantial cash deficits. Additionally, financial institutions in Somalia often impose high-interest rates, making credit expensive and unsustainable for most companies. As a result, companies are forced to resort to cash-based transactions, which severely limit sales potential.

The situation is further exacerbated by the lack of developed track records among local operators, hindering their ability to secure financing from local banks. The stringent requirements for collateral, which local players typically cannot meet, pose another

significant barrier. The readiness of local entrepreneurs for investment is also a concern, as they often lack the necessary materials and understanding of the language used in impact investing, making it challenging for them to effectively communicate their narratives for impact and growth to potential investors.

The situation is clearly described by a study conducted in Somalia by Abdullahi S, Saad M et al 2023 that confirms the high initial costs, unfamiliarity, and lack of energy awareness significantly hinder the utilization of solar energy, despite the country's abundant solar potential due to its equatorial location.

Cost of Maintenance and Replacement Parts: In Somalia, the cost of maintenance and replacement parts for solar PV systems presents a significant barrier to the widespread adoption of solar energy. This challenge is due to several factors: a) Lack of Qualified Personnel and Technical Skills: One of the biggest challenges in the development of the solar energy sector in Somalia is the shortage of qualified personnel and technical skills. This deficiency is emphasized by the absence of skills and qualification measurement infrastructure, leading to low quality of labor. Development partners such as United Nations Development Programme (UNDP) in Somalia has identified this issue and is seeking to address it through training programs. b) Maintenance and Operational Challenges: The operation and maintenance (O&M) of solar PV systems are critical for ensuring their reliability and efficiency. Maintenance is essential for retaining the functional and design stature of solar PV installations. Effective O&M capabilities are crucial for the prolonged and cost-effective operation of these systems. However, the lack of local expertise and resources in Somalia for such maintenance can result in higher costs and reduced system performance ((Keisang K, Badar & Samikanu 2021).

The combination of these factors makes the cost of maintenance and replacement parts for solar PVs a significant economic barrier in Somalia, hindering the country's ability to fully harness its solar energy potential.

Economic Instability

In Somalia, economic instability and ongoing security concerns create a climate of uncertainty that significantly impacts the financing and development of decentralized solar PV projects. These challenges contribute to deterring both domestic and foreign investments, thereby limiting the availability of funds for expanding renewable energy infrastructure.

Ongoing security issues, particularly in the southern regions of Somalia, pose significant operational risks for solar PV installations. Al-Shabaab's presence and activities in these areas disrupt the installation and maintenance of solar systems. The fear of attacks deters technicians from servicing the systems, leading to limited deployment and maintenance of solar PVs. The government military operation against al-Shabaab has weaknesses that could undermine the campaign, as al-Shabaab remains entrenched, adding to the security challenges (Vanda B 2023).

Additionally, Somalia's economic environment is characterized by political instability and ambiguous business regulations, making it a challenging landscape for investors. This situation is further complicated by the country's past three decades of tumultuous events, which have led to hesitancy among global investors to engage in the Somali energy sector (Abdishakur A, 2022).

1.5.2.2 Non-Financial Barriers

Apart from financial challenges, the adoption and implementation of Solar PVs in Somalia face numerous non-economic barriers that include awareness, technical and institutional-regulatory barriers.

Lack of Awareness and Understanding:

In Somalia, the lack of awareness and understanding of decentralized solar PV technology significantly hinders its widespread adoption. Many individuals, communities, and businesses remain unfamiliar with the benefits and functionalities of solar PV systems. This includes limited knowledge about how solar panels generate electricity from sunlight, their potential for cost savings, and their positive environmental impact. Additionally, misconceptions and misinformation about solar PV technology persist, further impeding its acceptance and adoption.

The utilization of solar energy in Somalia is constrained by a general unfamiliarity and lack of awareness about solar energy. Despite the country's abundant solar potential due to its equatorial location, the access to electricity remains limited, impeding economic growth and sustainable development. The lack of infrastructure and high initial costs also contribute to the limited use of solar energy (Abdullahi S et al 2023).

Some efforts have been made to create awareness and demonstrate the potential of solar energy in Somalia by for instance, the United Nations Development Program (UNDP) and other development partners in Somalia.

Despite these efforts, the need for continued education and training in solar PV technology is evident. To bridge the knowledge gap, it is crucial to invest in awareness-raising campaigns, educational programs, and training initiatives. This will not only improve understanding and acceptance of solar PV systems but also support the development of local technical capacity in renewable energy.

Limited Technical Capacity

The advancement of renewable energy (RE) technologies in Somalia encounters a significant challenge stemming from a shortage of technical expertise compounded by challenging security conditions that restrict access to high-quality technical support. Somalia's energy sector faces a dearth of qualified professionals with the requisite technical skills to effectively plan, implement, and maintain RE-based power technologies. As confirmed a study by ILO 2016 Somalia lacks important technical skills to enable the deployment of renewable energy. Within Somalia, the energy sector faces a significant shortage of qualified personnel, with the lowest proportion of skilled workforce among various industries. This shortage is particularly

pronounced in primary industries, where 41% of the workforce is employed. In contrast, only 5% of professionals, 10% of skilled workers in agriculture, forestry, and fisheries, and 9% of craft and related industry workers are engaged in the energy sector (Abdullahi S et al 2023). This disparity highlights the critical need for capacity-building and skills development initiatives to bolster the country's energy workforce and support the growth of the renewable energy sector particularly for Solar PVs. This shortage hampers the development and growth of the renewable energy sector.

There is no dedicated national-level or sub-national training institutions providing consistent capacity-building support in the field of renewable energy, including solar photovoltaics (PV). This gap presents a significant challenge in nurturing the technical skills and expertise necessary for the advancement and maintenance of renewable energy infrastructures within the country. However, it is important to recognize that there have been a few ad hoc training initiatives and programs, for short durations, which have been implemented in partnership with local universities and international organizations. These are limited and have not had significant impact.

Quality Assurance and Performance:

In Somalia, the issue of quality assurance and performance of solar PV technologies is a significant barrier that affects the costs and the overall sustainable adoption and growth of renewable energy in the country as highlighted in problem tree in diagram VII.

The country has no national quality assurance institution dedicated to overseeing the quality and performance standards of solar PV technologies. This lack of a regulatory framework contributes to the influx of low-quality solar products in the market, which can lead to performance and durability issues. The presence of low-quality solar products in the market can result in performance and durability issues. These products might not meet the necessary standards for efficiency and longevity, which can damage the reputation of solar PV technologies in Somalia. The unreliability of these products can discourage potential users from adopting solar energy solutions, thus hindering the growth of the renewable energy sector (Abdullahi S et al 2023).

Institutional-Regulatory Barriers:

Policy and Regulatory challenges:

In Somalia, policy and regulatory challenges significantly impact the solar PV sector. These challenges are rooted in a complex socio-political environment, characterized by security concerns, political instability, and ambiguous business regulations. In the recent years, Somalia has put in place several policies to support the deployment of Renewable energy including Solar PVs. These include the National Development Plan 2020, Somalia Power Master plan, Environment Policy among others. However, the lack of a robust regulatory framework, including an energy policy and legislation that promotes the use of solar energy, hinders the growth of the Solar PV market. The power sector in Somalia has largely been managed by the private sector due to limited government functionality, leading to innovations and self-investments in renewable energy, including solar PV. However, this has

resulted in decentralized and sometimes inefficient systems. The absence of a robust regulatory framework and clear policy guidelines further exacerbates these issues, contributing to high electricity losses and reliance on expensive, imported diesel for power generation. The average price per kilowatt of electricity is significantly higher than neighboring countries, underscoring the need for improved regulatory mechanisms and policy reforms to foster a more efficient and sustainable solar energy sector in Somalia (abdishakur A, 2022)

Poor Infrastructure and Supply Chains:

The supply chain for solar technologies in Somalia is underdeveloped, making it difficult to acquire and install quality solar systems efficiently. The limited availability of solar batteries and other essential components hampers the expansion and sustainability of solar energy solutions. Additionally, the limited infrastructure in Somalia, particularly in remote areas, poses logistical challenges in transporting and installing Solar PV systems.

These infrastructure and supply chain deficiencies highlight the need for targeted investment and policy interventions to strengthen the solar PV sector in Somalia. Addressing these challenges is essential for harnessing the country's solar energy potential and improving its energy access(World Bank 2021).

The barriers to adoption of the decentralized Solar PVs have been used to develop a problem tree diagram provided as annex VII to this report.

1.5.3 Measures for Addressing Barriers to Solar PVs in Somalia

Addressing barriers to the adoption of photovoltaic solar energy (PV) systems in Somalia requires a multifaceted approach, tailored to the unique geographical, social, and economic context of the country. The process for identifying the measures entailed review of relevant policy documents including the national development plans and energy sector policies and plans, stakeholders' analysis and consultations and validation.

1.5.3.1 Economic and Financial measures

Regulatory Policies and Incentives:

Policy development for solar PVs in Somalia is imperative to unlock the full potential of renewable energy in the country and enhance energy access. To harness the abundant solar resources and expedite the transition toward a sustainable energy landscape, Somalia needs to adopt comprehensive renewable energy policies and regulations that prioritize decentralized solar PV technology. These policies should outline clear objectives, targets, plans and incentives for the deployment of solar PV systems, ensuring a conducive environment for investors, businesses, and individuals. The country will need a national plan for decentralized solar systems to enhance energy access and promote sustainable development(Abdullahi S et al, 2023). The policy development should be coupled with effective implementation mechanisms and work collaboratively with other actors to enact, enforce, and monitor implementation policies rigorously.

Institutional support

Institutional strengthening is vital for promoting deployment of solar PVs in Somalia. One key step is the establishment of a dedicated Renewable Energy Agency (REA) tasked with

facilitating, regulating, and promoting the development of solar PV projects across the country. The REA would serve as a centralized authority responsible for policy formulation, regulatory oversight, and coordination of renewable energy initiatives. To strengthen the REA's effectiveness, investing in the training and capacity building of its staff is essential. This includes providing specialized training programs for regulatory experts, technicians, engineers, and policymakers, equipping them with the necessary skills and knowledge on solar PV technology, market dynamics, and regulatory frameworks. Additionally, the REA can play a pivotal role in fostering collaboration with international partners, attracting investment, and facilitating technology transfer to advance the solar PV sector.

Public-Private Partnerships (PPPs): Already Somalia private sector plays a key role in the country's energy sector, the Federal government should encourage PPPs can facilitate greater investment and expertise in solar energy infrastructure. These partnerships can also work toward developing decentralized off-grid systems to cater to remote areas. PPPs should involve local communities in planning and implementation of projects, ensuring that the benefits of solar PV initiatives are shared with the people living in proximity to the projects. PPPs should include capacity-building, where international private companies train local personnel, transfer technical knowledge, and build workforce skills in solar PV technology, maintenance, and operation.

1.5.3.2 Non- Financial measures

Capacity Building and Training:

The government train local technicians in the installation, maintenance, and repair of solar PV systems. Vocational training centers or programs especially for the youth in partnership with international organizations could be initiated for this purpose. The government will need to establish vocational schools and enhance existing secondary schools to address the shortage of qualified personnel, particularly in the technology sector, in the country. The government of Somalia should develop a strategy to improve the soft skills of young graduates and address the shortage of qualified personnel. The capacity build should include training and awareness campaigns that can help potential solar adopters understand available financing mechanisms.

Access to Finance: Develop collaborations with financial institutions, international donors, and microfinance institutions to provide loans or grants for decentralized solar PV systems. Innovative financing mechanisms like crowd-funding, green bonds, and risk guarantees can also be explored.

Establishing financial institutions that offer affordable loans and credit facilities specifically tailored for solar PV projects can help individuals and businesses overcome the initial investment hurdle. These financial products should have competitive interest rates and flexible repayment terms. The government should design and implement microfinance schemes or community-based financing models can make solar PV systems accessible to low-income households and remote communities.

Introducing dedicated solar financing programs that provide targeted financial support for solar PV installations can drive adoption. These programs can be designed to address specific

market segments, such as residential, commercial, or rural electrification. Engaging with international donors and organizations can secure funding for solar PV projects. International support can include grants, concessional loans, and technical assistance to promote solar energy development.

Awareness Campaigns: Awareness campaigns are a pivotal measure to overcome barriers hindering the adoption of solar PV technology in Somalia. Given the limited awareness and understanding of solar PVs among the Somali population, well-designed awareness initiatives can play a transformative role in fostering increased deployment. The awareness campaigns can educate individuals, businesses, and communities about the benefits of solar PV technology. These campaigns can explain how solar panels convert sunlight into electricity, reducing reliance on costly and environmentally harmful energy sources such as charcoal and wood. By highlighting the potential for substantial cost savings over the long term and the positive environmental impact of solar PVs, awareness campaigns empower consumers to make informed decisions regarding their energy choices. The campaigns can dispel misconceptions and address misinformation about solar PV technology. By providing accurate information on topics such as system affordability, the reliability of solar installations, and the availability of financing options, awareness campaigns can mitigate skepticism and uncertainty that may deter potential solar adopters. Additionally, these initiatives can showcase successful solar PV projects in Somalia, serving as real-life examples of the technology's effectiveness and impact. These campaigns could be run through local media, community meetings, and educational institutions.

Research and Development (R&D): The Federal Government of Somalia should encourage Research and Development (R&D) on solar PV technology as a critical measure to overcome barriers and drive the advancement of solar energy in Somalia. This involves systematic research and innovation in solar PV systems, materials, and applications to enhance their efficiency, affordability, and suitability for the local context. R&D can lead to the development of more efficient and cost-effective solar PV systems tailored to Somalia's unique environmental conditions. This includes improving the performance of solar panels in areas with high temperatures and dust, as well as enhancing energy storage solutions to ensure a stable power supply. Research can focus on locally sourced materials and manufacturing processes, reducing the reliance on imported components and lowering the overall cost of solar PV installations. This can include exploring the use of locally available materials for solar panel production and establishing domestic manufacturing capabilities.

Additionally, this should take account of people's expectations in terms of purchasing power and the delivery of services. R&D should contribute to the development of innovative financing mechanisms for solar PV projects, such as pay-as-you-go (PAYG) models and crowd-funding platforms, making solar energy more accessible to a broader range of consumers.

Measures to overcome the barriers to the uptake of Solar PVs have been developed into a solution tree provided as Annex VIII and market map is provided as annex XI to this report.

1.6 Linkages of the identified barriers for the technologies in the energy sector

In examining the barriers to the adoption of clean and efficient cookstoves, portable solar lighting devices, and decentralized solar PVs in Somalia's energy sector, several common challenges or linkages emerge:

Financial Barriers: Across all three technologies, financial barriers are a major hindrance. This includes the high upfront costs of the technologies, limited access to finance for consumers, and lack of favorable investment conditions for manufacturers and distributors.

Lack of Awareness and Understanding: Misconceptions about the technologies, lack of awareness about their benefits, and low understanding of their operation and maintenance are common barriers. This lack of knowledge affects both the demand and supply sides of these technologies.

Regulatory and Policy Challenges: The lack of supportive policies and regulatory frameworks hinder the growth and penetration of these technologies. This includes inadequate incentives for production or importation, unclear or absent regulations regarding quality and safety, and lack of policies to facilitate access to finance.

Technical Capacity and Skills: For all three technologies, the lack of skilled technicians for installation, maintenance, and repair is a significant barrier. This shortage of skills affects the reliability of the technologies and scaled up deployment in many areas.

Cultural and Social Factors: Cultural and social factors can also inhibit the adoption of these technologies. This may include cooking habits that are hard to change, reluctance to switch to new technologies, and gender-related issues that affect the decision-making process in households.

Quality and Performance Concerns: Concerns about the quality, durability, and performance of these technologies can also act as a barrier. These concerns may stem from past experiences with low-quality products or from the absence of clear and enforced quality standards.

1.7 Linkages of measures to overcome the barriers

To overcome the identified barriers and facilitate the adoption of clean and efficient cookstoves, portable solar lighting devices, and decentralized solar PVs in Somalia's energy sector, an enabling framework comprising of a combination of measures, policies, strategies, and responsible institutions is required. The following table represents a suggested enabling framework:

Barriers	Measures	Responsible institutions
Financial Barriers	<ul style="list-style-type: none"> • Develop financial schemes like subsidies, grants, and innovative financing mechanisms. • Enact distinctive legislative frameworks that prioritize renewable energy sources • Create financial models that are aligned with local needs, such as revolving fund schemes, which could allow more sustainable funding for energy technologies. • Donor agencies to consider providing adequate funds on concessionary terms to government and private institutions • Develop and submit relevant funding proposals to multilateral funding options e.g. GCF, World bank etc 	<p>Ministry of Finance to work with Ministry of Energy on fiscal incentives and legal frameworks</p> <p>Microfinance institutions – provide necessary support financial packages</p> <p>International donors – to support implementation.</p>
Inadequate Awareness and Understanding	<ul style="list-style-type: none"> • Launch nationwide sensitization campaigns on the economic, social, and environmental benefits of energy-efficient technologies. • 	<p>Ministry of Energy- to lead the programme</p> <p>Media houses- to support</p>
Regulatory and Policy Challenge	<ul style="list-style-type: none"> • Develop and implement supportive policies and regulatory frameworks, including tax incentives and quality standards. 	Ministry of Energy to lead and coordinate with others
Technical Capacity and Skills	<ul style="list-style-type: none"> • Initiate capacity-building programs, vocational training, and education curriculums to develop local technical skills. 	Ministry of Education, Vocational training institutions to lead
Cultural and Social Factors	<ul style="list-style-type: none"> • Promote community participation and women empowerment in decision-making processes related to energy-efficient technologies. 	<p>Ministry of Women and Human Rights – coordinate & track progress</p> <p>Local community leaders & NGOs- to facilitate & support implementation</p>
Quality and Performance Concerns	<ul style="list-style-type: none"> • Establish and enforce quality standards and certifications for energy-efficient technologies. • Strengthen the capacity of the private sector for self-regulation under the relevant umbrella associations 	Ministry of Energy to take lead

Table 9: Enabling framework for the Energy sector technologies

The successful implementation of this enabling framework will require strong cooperation and coordination among the responsible institutions. It will also be critical to ensure transparency, accountability, and ongoing monitoring and evaluation of the measures taken to gauge their effectiveness and make necessary adjustments. This enabling framework aims to create a conducive environment for the widespread adoption of priority technologies, thereby advancing Somalia's energy sector's climate change mitigation efforts.

CHAPTER 2: FORESTRY SECTOR

2.1 Forestry Sector Context in Somalia

Somalia's forestry sector plays a crucial role in the country's economy and ecological balance, yet it is characterized by complex challenges and untapped potential. The country's arid climate, coupled with socio-political factors, has significant implications for forest management and conservation efforts.

As of 2021, Somalia's forest cover represented a mere 9.4% of the country's total land area, as reported by the World Bank data. This stark reduction is evident when compared to historical data; in the 1980s, the forest cover in Somalia constituted a significant 62% of the nation's total land mass. However, the continuous degradation, particularly post the civil wars of the 1990s, have drastically reduced this cover. Between 2001 and 2021, Somalia experienced a significant reduction in tree cover, losing approximately 429,000 hectares. This equates to a decrease in tree cover of about 4.9% over this two-decade period. In terms of environmental impact, the loss of this magnitude of tree cover corresponds to the emission of approximately 840,000 tons of carbon dioxide equivalents, contributing to the country's overall greenhouse gas emissions (World Bank Blogs 2022).

As of 2016, the forest cover was reduced to 10%, a significant decrease from the 12% observed in 2000. It is estimated that about 1.03% of the forest is lost in the country annually, which is double the average rate of forest lost in Africa. Between the years 2000 to 2019, approximately 23 % of forest cover was lost, an equivalent of a loss of 1,058ha per year (Medium.com). The reduction in forest cover has had an adverse impact on the availability of fodder for livestock and the integrity of wildlife habitats, thereby impacting the productivity of these sectors in Somalia.

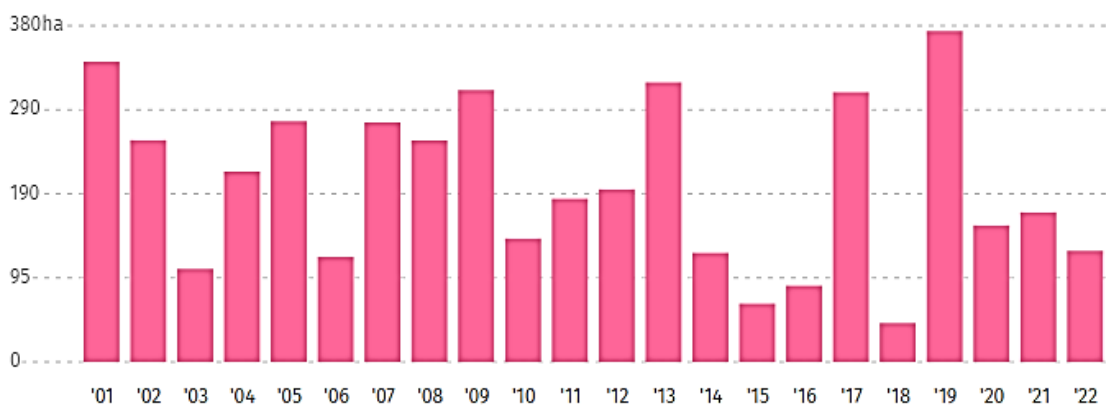
Statistics from the 2020 FAO report highlight that the annual deforestation rate in Somalia is approximately 1.5%, primarily driven by charcoal production, agricultural expansion, and the unregulated harvesting of wood for fuel. The report estimates that between 2010 and 2020, Somalia lost an average of 100,000 hectares of forest per year, signifying a significant threat to the ecological balance and biodiversity of the region.

Between 2001 and 2022, Somalia experienced a significant depletion of its tree cover, with a loss of 4.41 thousand hectares (kha), marking a 5.1% reduction in tree cover from levels in 2000. This loss not only altered the landscape but also had substantial environmental repercussions, leading to the emission of 962 kilotons (kt) of carbon dioxide equivalent (CO₂e), exacerbating the global challenge of climate change. During this period, the majority of tree cover loss in Somalia was concentrated in just two regions, which together accounted for 81% of the total loss. Notably, Jubbada Dhexe emerged as the region with the most significant decline, witnessing a loss of 2.10 kha of tree cover. This figure starkly contrasts

with the national average loss, which stood at 490 hectares, underscoring the acute environmental challenges faced by Jubbada Dhexe in terms of forest resource depletion. (globalforestry.org).

Figure 2: **Tree cover loss in Somalia**

From **2001 to 2022, Somalia** lost **4.41 kha** of tree cover, equivalent to a **5.1%** decrease in tree cover since **2000**, and **962 kt** of CO₂e emissions.



Source: Global Forest watch (2022)

Despite these challenges, the forestry sector holds immense potential for contributing to Somalia's economic development and environmental sustainability. The FAO 2020 report underscores the importance of non-timber forest products (NTFPs), such as gums and resins, which are prevalent in Somalia's woodlands. These resources, if harnessed sustainably, can provide crucial income for rural communities and play a role in the global market for organic and natural products. Forests act as carbon sinks, and their conservation and restoration can significantly contribute to Somalia's efforts in reducing greenhouse gas emissions and contribute to the achievement of Somalia NDC 2021. Additionally, the restoration of degraded forest lands is identified as a key strategy for enhancing resilience against climate-related impacts such as droughts and floods.

The National Development Plan (FGS, 2020), Initial National Communication (FGS, 2018), and Somalia's updated NDC(FGS,2021) underscore the importance of afforestation and reforestation, agroforestry, and land degradation reduction. These are not only seen as key avenues for addressing climate change but also as mitigation strategies against natural disasters. These measures also aim to restore food security, enhance resilience, and enhance economic growth.

Afforestation and reforestation activities aim to restore degraded forest landscapes by establishing tree nurseries, producing tree seedlings, and planting these seedlings. These actions intend to restore forests to their original status, thereby enhancing their productivity

and biodiversity. The establishment of tree plantations through afforestation can significantly contribute to carbon sequestration.

2.2 Preliminary Targets for the technologies

The technologies prioritised through the phase 1 of the Technology Needs Assessment (TNA) are:

- a) Afforestation and reforestation programme
- b) Agroforestry

These priority technologies fit into the category of publicly provided goods due to their wide-reaching and non-exclusive benefits. Agroforestry, while it has elements of privately managed systems, also contributes significantly to public welfare and ecosystem services, aligning it with both publicly provided goods and other non-market goods, depending on the specific context and the scale of implementation.

2.2.1 Preliminary target for Afforestation and reforestation programme

The NDC target is to achieve a 5% increase in Somalia's forest and tree cover by 2030, which equates to establishing approximately 117,000 hectares of forests per year. Various stakeholders, including government departments, non-governmental organizations, community-based organizations, international donors, and local communities, would play pivotal roles in the successful implementation of this programme. The program will also include initiatives like awareness-raising, consultation and demonstration, capacity building, the development, testing, and application of compensation and benefits-sharing mechanisms, measuring, monitoring, and reporting, and research activities. These efforts are projected to reduce up to 16.0 MtCO₂eq by 2030.

Target	<ul style="list-style-type: none"> • 5% increase in Somalia's forest and tree cover by 2030 • Establish approximately 117,000 hectares of forests per year
Required Investment	<ul style="list-style-type: none"> • US\$385 million per annum over a 10-year period • US \$5 million for community engagement, capacity building, policy strengthening
Economic benefits	<ul style="list-style-type: none"> • Job creation in planting and maintenance • Increased revenue from forest products (timber, non-timber products) • Improved livelihoods due to enhanced ecosystem services
Environmental/climate benefits	<ul style="list-style-type: none"> • Reduce up to 16.0 MtCO₂eq by 2030 • Enhanced biodiversity • Improved soil quality and water conservation
Expected lifetime	<ul style="list-style-type: none"> • Initial Phase (1-2 years): Planning, community engagement, securing funding • Implementation Phase (3-10 years): Active planting, monitoring, and maintenance

	<ul style="list-style-type: none"> • Post-implementation Phase (10-15 years): Continued maintenance, monitoring of forest growth, and impact assessment
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2.2.2 Preliminary target for Agroforestry

Given the lack of substantial data on the current presence of agroforestry systems, the NDC target is to transition 5% of the fertile land into agroforestry systems. This equates to a tangible overarching target of 400,000 hectares, planned to be converted over a decade (2021-2030). By establishing agroforestry on 400,000 hectares from 2020 through 2030, we can anticipate a decrease in CO₂ equivalent emissions from 0.14 MT in 2020 to 3.8 MT by 2030. This reduction would comprise a considerable portion of the total emissions from the agricultural sector.

Target	<ul style="list-style-type: none"> • Convert 5% percent of fertile land to agroforestry systems • Implementing agroforestry across 400,000 ha between 2020 and 2030
Required Investment	<ul style="list-style-type: none"> • US\$385 million per annum over a 10-year period
Economic benefits	<ul style="list-style-type: none"> • Increased agricultural productivity – improved soil fertility and increased yields resulting in enhanced farmers income • Job opportunities in rural areas • Enhanced land value due to increased productivity
Environmental/climate benefits	<ul style="list-style-type: none"> • Reduce up to 3.8MtCO₂eq by 2030 • Enhanced biodiversity • Improved soil quality and water conservation • Reduced dependency on use of fertilisers and pesticides
Expected lifetime	<ul style="list-style-type: none"> • Initial Phase (1-2 years): Planning, community awareness, securing funding • Implementation Phase (3-10 years): Active planting, monitoring, and maintenance • Post-implementation Phase (10+years): Continued expansion and sustained benefits

2.3 Analysis of the barriers and favourable measures for Afforestation and Reforestation Programme in Somalia

The implementation of afforestation and reforestation programme in Somalia is hindered by a myriad of barriers that include financial and non-financial ones. The Technology Needs Assessment (TNA) process involved key steps in the identifying barriers and measures, which include: Review of existing research, reports, and case studies related to afforestation and reforestation projects, both within Somalia and in Africa and consultation of stakeholders including local communities, government agencies, NGOs, and experts in forestry and land

management to gather insights and diverse perspectives on the challenges faced. The identified barriers and enabling measures were presented to stakeholders at a validation workshop.

2.3.1 General description of the technology

In the context of Somalia's pressing need for environmental restoration and climate change mitigation, afforestation and reforestation programmes take centre stage. These initiatives form an integral part of the country's strategy to enhance its resilience to climate change, restore ecological balance, and promote sustainable economic growth.

The primary objectives of the afforestation and reforestation programme in Somalia are to increase the country's forest cover, enhance carbon sequestration capabilities, reduce land degradation, and create sustainable livelihood options for communities.

The Afforestation and reforestation technology uses conventional forest planting techniques such as plant planning, plant selecting, land preparation, fertilizer application, irrigation, protection and other associated technologies, such as creating new species, tissue culture, seeding to afforest new areas and reforest previously deforested areas.

As per the FAO's 2020 Global Forest Resources Assessment, Somalia has experienced a significant decline in its forest cover over the past decades. The country lost approximately 4.41 thousand hectares of tree cover from 2001 to 2022, which is indicative of the urgent need for reforestation and afforestation efforts. The report also highlights that afforestation and reforestation activities can significantly contribute to carbon sequestration. The potential of these activities to mitigate climate change is considerable, with the Somalia NDC 2021 indicating that such initiatives could reduce up to 16.0 MtCO₂eq by 2030 if implemented effectively across the country.

As part of implementation of the programme, the Federal Government of Somalia in 2022 launched the National Regreening Initiative which aims to plant 10 million trees in Somalia(medium.com)



Somalia President HE Hassan Sh Mohamud launching the Somalia Regreening Initiative in 2022

2.3.2 Identified barriers to afforestation and reforestation.

2.3.2.1 Financial and Economic barriers

Limited Funding: The scarcity of funding represents a significant barrier to advancing afforestation and reforestation initiatives in Somalia. Given the country's economic situation, where resources are stretched thin and many competing priorities exist, allocating public funds for forestry projects is a challenge. Currently, the Federal Government of Somalia does not directly fund development projects as the limited finances support the recurrent expenditure particularly staffing. According to FGS 2022 report, under the Local Government Fund, compensation of employees accounted for 35.50% of total expenditure followed by purchase of goods and services at 19.23%, transfers at 15.21%, social benefits at 25.83%, capital at 1.80%, interest on debt at 1.74% and subsidies at 0.70%. No specific allocation for the forestry sector report in the expenditure report. With limited governmental budget, these initiatives often depend on external financing for implementation under Donor Project Fund. At the international level, although there is increasing recognition of the importance of afforestation and reforestation for climate change mitigation, the availability of funding is inconsistent and unpredictable. Furthermore, accessing to international funds with complex procedures and fulfilling stringent criteria, poses challenges to local actors and institutions who lack the necessary capacities or resources. Additionally, there is very limited private investment in forestry projects in Somalia due to perceived high risks associated with the unstable political climate, lack of clear regulations and incentives for investment in the forestry sector, and insufficient awareness of the potential profitability of sustainable forestry ventures among investors. For example, stakeholders have pointed out that potential investors often overlook the forestry sector due to a lack of success stories and visible models of profitable sustainable forestry enterprises, leading to a preference for more traditional and

perceived lower-risk investments.

High Costs: The high expenses associated with afforestation and reforestation projects present a significant impediment to their implementation in Somalia. These costs cover various stages of project execution, from initial land preparation and acquisition of seedlings, logistics, planting and subsequent maintenance to protective measures to guard young trees against livestock, pests, and harsh weather conditions. The purchase of high-quality seedlings suitable for Somalia's climate conditions involves major expense that majority poor cannot afford. Additionally, the need for continuous care and protection of the newly planted trees – from threats such as drought and water scarcity, overgrazing and pests– adds to the ongoing costs. Given these cost barriers, large-scale afforestation and reforestation initiatives in Somalia necessitate significant investment. Stakeholders have indicated that the overall cost for the first year per hectare for afforestation or reforestation projects could range from approximately \$850- \$1500 depending on the location and further expenses required for maintenance and monitoring. Without substantial financial support from the government, international donors, or the private sector, implementation of these initiatives may be difficult.

Lack of alternative livelihoods and poverty- In Somalia, the forestry sector faces significant challenges due to poverty and the lack of alternative livelihood options for local communities. As many residents rely on forest resources for their basic needs, including fuel, shelter, and income, the continuous extraction and overexploitation of these resources further deplete the already fragile ecosystems. The absence of sustainable alternatives forces many to resort to activities like charcoal production and illegal logging, exacerbating deforestation and land degradation.

2.3.2.2 Non-financial Barriers:

Land Tenure Issues: In Somalia, land ownership and tenure is complex, and disputes are common. It is estimated that about 46 to 56 percent of the country's land area is permanent pasture, while 20 percent is classified as forest and 13 percent is suitable for cultivation (UN Habitat, 2006). The pastoral rangelands remain commons areas, where claims on water and grazing areas are seen as very communal and are possessed by clans and not by individuals. Without clear land rights and security of tenure, local communities and investors are reluctant to engage in long-term activities like afforestation and reforestation.

Inadequate public Awareness: Inadequate awareness and understanding among local communities regarding the benefits of afforestation and reforestation, both in terms of climate change mitigation and local livelihood improvements. The global benefits are not clear or relevant to the daily lives of local individuals, particularly with the majority poor grappling with immediate survival needs. Additionally, the local benefits of afforestation and reforestation eg. provision of shade and shelter, improvement of local micro-climates, prevention of soil erosion, and provision of non-timber forest products are also not be fully

recognized. Moreover, the lack of awareness also extends to the understanding of sustainable forest management practices. Without proper knowledge, local communities engage in practices such as charcoal production that degrade forests and undermine afforestation and reforestation efforts.

Climate change Challenges: Somalia's harsh climatic conditions, including prolonged periods of drought and high temperatures, hinder the survival and growth of newly planted trees. Drought, in particular, poses a severe threat to reforestation and afforestation activities. Extended periods without sufficient rainfall lead to water scarcity, limiting the availability of the essential water resources needed for trees to grow and survive. Additionally, the high temperatures experienced in Somalia can contribute to increased evaporation rates, further exacerbating water scarcity issues. Extreme heat also causes heat stress in trees, impacting their health and growth rates, and in severe cases, leading to tree mortality. This would require use of specific drought resilient seedling species that might not be available to the local communities.

Ineffective policy and regulatory framework – Somalia has also put in place several relevant policies and strategies to support the forestry sector, including: the National Environment Policy (2020), the Updated Nationally Determined Contribution (2021) the National Voluntary Land Degradation Neutrality Targets (2020), and the draft National Energy Policy (2018), draft National Charcoal Policy. However, overall, capacity for environmental governance and natural resources management in Somalia remains generally limited, and, at best, can only be described as fragmented (EU Interactive Country Fiches site.) The country has no forest management regulations, an absence of forest certification and no forest management agency. The country also lacks environmental or forestry legislation to enforce the implementation of the policies. Most FMSs have no forestry policy or legislation.

Weak Institutional Framework: The forestry mandate is under the newly established Ministry of environment and climate change which has limited technical and institutional capacities to implement and enforce forestry policies. The absence of a robust institutional framework for forest management hinders the implementation and success of afforestation and reforestation programmes. Additionally, the authorities have limited knowledge, skills, and capacity to effectively implement and enforce afforestation and reforestation programmes.

Security Concerns: Security concerns and conflicts especially in the Southern part of the country pose significant obstacles to afforestation and reforestation efforts in Somalia. Ongoing conflicts in various regions of the country create unstable conditions, making it difficult to plan, coordinate, and execute large-scale forestry projects. Such volatile conditions create logistical challenges, as project organizers may face difficulties in transporting necessary resources, such as seedlings, equipment, and personnel, to the designated planting sites. The threat of violence also makes it difficult for external entities, including international organizations and donors, engage in or supporting afforestation and reforestation activities

in the affected regions. The insecurity can also put the safety of project participants at risk. Forestry initiatives often require the physical presence of individuals in the field, exposing them to potential dangers if they are working in conflict-prone areas. Conflicts often disrupt community structures and relationships, leading to mistrust and apprehension, which can undermine collaborative efforts and engagement of local communities.

The barriers to adoption of afforestation and reforestation have been used to develop a problem tree diagram included as annex I to this report.

2.3.3 Identified measures to overcome barriers

To overcome the barriers associated with afforestation and reforestation in Somalia, a multi-pronged approach involving policy, financial, and community-driven measures can be adopted. Below is a detailed analysis of the key measures to be implemented to overcome to identified barriers. These measures were identified through review of existing literature in Somalia and other countries in Similar context including reports and policies and through stakeholders consultation in the TNA Process.

2.3.3.1 Financial and economic measures:

Financial measures are vital to overcoming the barriers to afforestation and reforestation in Somalia. Below are potential measures at how these can be implemented:

- **Mobilize Domestic Resources:** The Federal Government of Somalia, along with Federal Member States, can earmark and allocate a specific portion of their budget towards afforestation and reforestation initiatives. All Ministries should have a clear targets that mainstream afforestation and reforestation initiatives. This should be cascaded to FMSs. This would signal the importance placed on these efforts at the national level and pave the way for increased investments.
- **International Funding:** Collaborate with international organizations, development banks, and foreign governments to secure funding for afforestation and reforestation programs. The overall required investment for the technology is estimated at about US\$ 385million per annum. This could be in the form of grants, concessional loans, or technical assistance. Additionally, Somalia could leverage climate finance mechanisms such as the Green Climate Fund, Least Developed Countries Fund, Adaptation Fund among others.
- **Public-Private Partnerships (PPP):** Public-Private Partnerships (PPP) present a strategic approach to enhancing forest conservation and development in Somalia, especially considering the current limitations in private sector investment. By leveraging PPPs, the government can actively collaborate with private entities, aligning mutual interests and resources towards afforestation and reforestation projects. The government could establish a structured framework that clearly defines the roles, risks, and responsibilities of both public and private partners. This framework should include transparent regulatory guidelines, performance metrics, and a conflict resolution mechanism to foster a stable partnership environment. On the other hand, corporations could sponsor tree planting

projects as part of their corporate social responsibility (CSR) programs or to offset their carbon emissions.

- **Innovative Financing Mechanisms:** Explore the use of innovative financing tools such as green bonds, social impact bonds, or crowdfunding to generate funds for tree planting activities. Another potential option could be to partner with local microfinance institutions to offer low-interest loans to individuals, communities, or small enterprises for initiating afforestation or reforestation activities. This can enable them to bear the initial costs associated with tree planting, such as procuring seedlings and preparing land.
- **Payments for Ecosystem Services (PES):** Implement PES schemes that provide financial incentives to landowners and local communities to maintain and enhance forest cover. These payments can serve as a source of income for the communities, thereby offsetting opportunity costs associated with land use change.
- **Carbon Financing:** Carbon financing emerges as a compelling measure for promoting afforestation and reforestation in Somalia, offering a pathway to monetize the carbon sequestration potential of forestry projects. Forestry projects in Somalia can generate carbon credit. Each credit typically represents one tonne of CO₂ either sequestered from the atmosphere or emissions avoided. These credits can then be sold on carbon markets through compliance or voluntary markets and provide a financial incentive for the country to invest in forest conservation and development. To realise this objective, there is need for concerted effort in capacity building of public and private sector and development of support policy frameworks.

2.3.3.2 Non- Financial measures

Policy and Legal Framework Development: The government should develop and implement comprehensive forestry laws and regulations at both the federal and member state levels to regulate the sector. These legislations should define clear roles, responsibilities, and enforcement mechanisms for the management and protection of forests, and promote sustainable forestry practices. The development of these policies should involve all relevant stakeholders, including local communities, to ensure their buy-in and commitment. Implementation of existing policies in particular National Charcoal policy should also be given priority. There is need to create a new authority to manage the country's forest reserves should be established, with representations in all the Federal Member States (FMS)(EU Interactive country Fisches site).

Public Awareness and Education: Public awareness campaigns about the impacts of deforestation and the importance and benefits of afforestation and reforestation need to be conducted. These campaigns could use various channels, such as TV, radio, community meetings, school curriculums, and social media, to reach different demographics. Emphasizing the long-term economic, environmental, and social benefits of tree planting, including its role in climate change mitigation and adaptation, and linking it with livelihood improvement opportunities, can help change public perception and encourage active community participation in forestry activities. Engaging popular Somali artists, musicians, and

writers to produce content that raises awareness on the importance of forests can have significant impact.

Capacity Building and Technical Assistance: Training programs should be provided to communities, local organizations, and relevant government agencies on sustainable forestry practices, project management, and monitoring and evaluation. This would enhance their capacity to plan, implement, and oversee afforestation and reforestation initiatives. In addition, technical support be provided to improve the survival rate of newly planted trees, such as introducing drought-resistant tree species, providing guidance on optimal planting times and techniques, and promoting the use of locally appropriate agroforestry systems. There is need to provide forestry extension training to both state and non-state actors to enhance capacities.

Security Measures: In areas with ongoing conflicts, close coordination with security forces and local leaders is necessary to ensure the safety of project personnel and the successful implementation of tree planting activities. In addition, engaging local communities can enhance local initiatives thus limiting logistical arrangements affected by the security challenges. In the medium and longer term, promoting peace and stability in these regions is crucial.

Addressing Opportunity Costs and supporting alternative livelihoods: Strategies should be developed to make afforestation and reforestation economically attractive for communities. This involves supporting the development of forest-based enterprises, promoting agroforestry systems that allow for simultaneous cultivation of crops or rearing of livestock, and facilitating access to markets for forest products. At the policy level, providing incentives such as tax benefits or land tenure rights to individuals or communities engaging in tree planting could be considered. Efforts should be made to divert pressure from the forests and and to provide the communities with environment friendly alternative livelihood sources such as bee keeping, and value addition of agriculture and livestock production.

Establish community watering infrastructure - Establishing community watering infrastructure, especially focusing on water harvesting and storage, is a pivotal measure to enhance afforestation and reforestation efforts in Somalia. Given the country's arid and semi-arid climate, ensuring consistent water availability becomes crucial for the survival and growth of planted trees. By introducing water harvesting techniques, communities can capture and store rainwater during the brief rainy seasons, ensuring a steady supply throughout the drier months. Additionally, boreholes and dams could be developed to support this initiative. This not only facilitates tree growth but also promotes community involvement, as they witness the direct benefits of having a sustainable water source. Moreover, such infrastructure can serve dual purposes by providing water for agricultural practices, thereby enhancing food security and offering an alternative livelihood, reducing the pressures on existing forest resources.

Measures to overcome the barriers to the uptake of afforestation and reafforestation have been developed into a market map in annex I of this report.

2.4 Analysis of the barriers and favourable measures for Agroforestry

2.4.1 General description of Agroforestry in Somalia

Agroforestry in Somalia represents a blend of agricultural and forestry practices that involve the intentional integration of trees with crops and/or livestock on the same land. This practice is particularly well-suited to the Somali environment, which is predominantly arid and semi-arid, making sustainable land management practices crucial for the livelihoods of its population, the majority of whom are dependent on agriculture and livestock.

Small farmers in Somalia rely on their land for a variety of products, including food, fodder, and wood for various uses. Agroforestry can significantly enhance the productivity of their land by improving soil protection and offering a variety of useful products, thus increasing yields of certain crops. Larger farmers, with more capital, can invest in more extensive agroforestry systems like shelterbelts, leveraging their resources for greater agricultural output and environmental protection. The integration of nitrogen-fixing tree species such as *Leucaena leucocephala*, known for its rapid growth and adaptability, can enhance soil fertility and thus crop productivity. Intercropping with legumes is another strategy that can increase soil nitrogen levels, leading to increased crop yields and reduced input costs.

The deployment of agroforestry in Somalia is at a nascent stage but holds great potential. Traditional farming practices have historically dominated the landscape, but with increasing awareness of sustainable practices and the benefits of integrated land use, there is a growing interest in adopting agroforestry techniques. However, the widespread adoption is still hindered by several challenges including lack of knowledge, resources, and policy support. Despite these challenges, initiatives like the Regreening Africa Project in Puntland, implemented by the World Agroforestry Centre in partnership with World Vision Somalia, demonstrate the potential of agroforestry to promote sustainable land management and enhance economic opportunities through strengthened tree-based value chains.

In efforts to combat climate change and promote sustainable livelihoods, organizations like the Nomadic Assistance for Peace and Development (NAPAD), in partnership with Terre des Hommes and with funding from the Federal Ministry for Economic Cooperation and Development (BMZ), have implemented agroforestry programs in regions like Qurdubey Village. These programs aim to support agropastoralist communities by offering training in tree nursery management and agroforestry techniques, thus enhancing household nutrition, income diversification, and resilience against climate impacts (Nomadic assistance for Peace & Development website).

The success of agroforestry in Somalia hinges on comprehensive strategies that address the diverse climatic zones of the country. Understanding the rainfall patterns and temperature ranges is essential for determining suitable agroforestry practices for different regions. This knowledge is crucial for the

design and implementation of agroforestry systems that are in harmony with the local environment and capable of contributing to both climate change mitigation and the socio-economic development of the communities(world agroforestry website).

By embracing agroforestry, Somalia can transform its agricultural landscape into a more productive, sustainable, and resilient system, capable of withstanding the challenges posed by climate change and land degradation. The combined efforts of local communities, government, and international partners are key to unlocking the full potential of agroforestry in Somalia.



Agroforestry initiative in Puntland

2.4.2 Identified barriers for Agroforestry.

2.4.2.1 Financial or economic barriers

Lack of Access to Credit: Implementing agroforestry demands an initial financial and temporal commitment, yet its long-term returns often surpass those of annual crops (Sharma et al., 2016). Numerous poor farmers, who stand to gain from agroforestry, face challenges in mobilising the necessary resources for such extended investments due to limited capital and financial safety nets. Stakeholders estimate that the initial set up cost could range US\$ 500- \$1000 per ha depending on the local conditions (excluding irrigation systems) and also annual maintenance of about US\$ 500 is required. This falls within the average figure by World Agroforestry policy brief of US\$1470 per ha (Verchot L, Swallow B & Noordwijk, 2008)

Moreover, their ability to secure credit is typically constrained. This disparity is even more pronounced for women, who, lacking land ownership for collateral, receive less than 10% of available credit in developing nations (World Bank, 2013). Small-scale farmers in Somalia often have limited access to formal banking institutions, restricting their ability to obtain loans for investing in agroforestry. When farmers receive loans, they often come with short repayment plans which is not appropriate for long-term investments such as agroforestry. Many financial institutions including microfinance lack specific credit provisions for agroforestry, offering them only for agriculture.

High Initial Investment: The initial costs associated with adopting agroforestry— including the purchase of diverse tree species, land preparation, and management— can be a significant financial burden for many Somali farmers. This includes high initial labour costs especially for pruning and incorporation of trees. Stakeholders have indicated that the cost could range between US\$ 500- US\$1000 depending on the location. The use of family labour is important in smallholder farmers, the additional labour requirements for trees planting without immediate results or profits is a challenge for poor small holder farmers who would want immediate source of income for livelihoods. The other costs associated with conservation agriculture with trees are the cost of herbicides. Herbicides are expensive, hard to find locally and require specialized equipment to apply (Mwase et al 2015). The challenge of water scarcity is also a problem which can present additional cost to many farmers in Somalia.

Lack of incentives: In Somalia, one of the significant barriers to the widespread adoption of agroforestry practices is the lack of incentives. While the potential environmental and long-term economic benefits of agroforestry are clear, many farmers are hesitant to transition from traditional agricultural methods due to the immediate costs and perceived risks associated with change. For example the transaction costs are significant for such schemes and monitoring complex making implementation together with smallholder farmers far from trivial (Vi-agroforestry, 2018). The absence of financial incentives such as grants and subsidies, tax incentives, payment for ecosystem services among others, technical support, or market mechanisms that reward sustainable land management practices further exacerbates the situation. Moreover, the benefits of agroforestry, such as enhanced biodiversity, improved soil health, and carbon sequestration, are often realized at a community or regional level, rather than directly benefiting the individual farmer. As a result, without tangible and immediate incentives, farmers in Somalia might be reluctant to invest in and commit to agroforestry, hindering its broader implementation and the realization of its potential benefits for the country.

Limited Market Access and Weak Value Chains: Limited access to markets and weak value chains for agroforestry products hinder the profitability of agroforestry. Additionally, when small scale farmers adopt agroforestry practices, the production is often diversified, and farmers often start to produce relatively low volumes of some products. This implies challenges in terms of high transaction costs. The relative transaction cost when selling a product decrease with the volume of this product, e.g. the time it takes to reach the market

is the same regardless of the volume you are bringing. This risks lowering the profit for many agroforestry products unless producer groups are formed for joint activities on value addition and marketing of larger quantities (VI-Agroforestry, 2018). Farmers need access to markets where they can sell their diverse agroforestry products at fair prices. Establishing cooperatives or farmer organizations could help farmers pool their resources, access better markets, and negotiate better prices for their products.

2.4.2.2 Non-economic barriers

Lack of Knowledge and Skills: Farmers in Somalia lack the necessary knowledge and skills to successfully implement agroforestry systems. This includes understanding how to manage diverse tree species, knowing which species are best suited to their specific conditions, and techniques for integrating trees into their farming systems without compromising crop yields. The lack of proper extension services to farmers on the importance of agroforestry is a barrier. Additionally, the paradigm of separation between agriculture and forestry has also resulted in a generally low level of knowledge of agroforestry among stakeholders involved in land use management (Vi-Agroforestry, 2018)

Climate change impacts and water scarcity: Somalia is highly vulnerable to climate change impacts. Climate change impacts and water scarcity pose significant barriers to agroforestry in Somalia, a country inherently vulnerable due to its arid and semi-arid climatic conditions. Research indicates that the increasing variability in rainfall patterns, coupled with extreme weather events, exacerbates water scarcity, directly impeding agroforestry practices that are reliant on consistent water availability. As a result, the survival and growth of trees and crops are jeopardized, undermining the potential benefits of agroforestry systems, such as soil conservation, microclimate regulation, and carbon sequestration.

Policy and Institutional Barriers: Agroforestry generates significant public environmental services such as biodiversity, watershed protection, and carbon sequestration for which market failures exist. Without government involvement in providing enabling policy and greater incentives, the level of adoption will be very minimal (Mwase et al, 2015). While policies for agriculture and forestry exist in Somalia, however, they lack measures to promote agroforestry in the country. Agroforestry is said to belong to both sectors, but in reality, it belongs to none, there is little work has been done so far to harmonize with other policies and no governmental body takes on the lead for implementation (Mwase et al, 2015). This absence of a strategic policy framework hinders the country's ability to adopt a. Additionally, on a FMSs level, individual member states within Somalia are also lack policies that promote agroforestry. This absence of a policy framework on both the national and sub-national levels present a significant challenge to adoption of agroforestry in Somalia.

Land Tenure and Ownership Issues: Land ownership and tenure rights are often complicated in Somalia, with overlapping traditional, religious, and statutory laws. These complexities can

deter investment in long-term initiatives like agroforestry. This problem is more pronounced among poor farmers with women facing particular challenges (Vi- Agroforestry, 2018). Typically, informal land rights might permit farmers to claim crop ownership, but not the trees. This disparity is especially stark for women, whose land rights are generally far less secure than their male counterparts. Farmers might not even possess rights to the trees on their property or their yields or their products. Such tree protective policy measures date back to the colonial era and are of course barriers for agroforestry implementation (FAO, 2013).

Gender Disparities: In many rural communities in Somalia, women play a significant role in farming but may have limited access to resources and decision-making power. This can limit their ability to adopt and benefit from agroforestry. Women receive less extension services than men and face more challenges in acquiring knowledge from information systems. As women in general are tasked with taking care of the household, they have fewer opportunities to take part in off-farm extension workshops. Most of the extension workers are also men and, in many African societies, and communities, socio-cultural barriers prevent women from engaging with them (Vi- Agroforestry, 2018). Training and capacity building programmes to farmer through NGOs in the country often addressing farmers with higher educational levels, preventing many women from acquiring the information they have the right to, as they in general have a lower educational level than men.

Conflict and Security Issues: In regions of Somalia where conflict and insecurity persist, farmers are unwilling or unable to invest in agroforestry. The risks associated with conflict can make it difficult to maintain and protect agroforestry systems, and insecurity can disrupt access to seedlings and markets and other necessary resources for agroforestry.

Lack of Research and Data: There may be a lack of research and data on the most effective agroforestry techniques and species for different regions and conditions in Somalia. This can make it difficult for farmers to make informed decisions about how to implement agroforestry.

Poor Infrastructure: Limited access to good roads, water sources, and other necessary infrastructure can make it difficult to establish and maintain agroforestry systems. For example, without reliable access to water, trees may not survive during dry periods.

The barriers to adoption of agroforestry practices have been used to develop a problem tree diagram provided as annex I

2.4.3 Identified measures to overcome the barriers.

2.4.3.1 Financial/economic measures

Subsidies and grants

Subsidies and grants can be provided by Federal government of Somalia and Federal member states, international organizations, and NGOs to encourage the adoption of agroforestry to address the barrier around upfront costs related to agroforestry. The Somali government (both at Federal and FMSs level, with support from international partners, can allocate funds specifically for the development of agroforestry. These subsidies might cover a part of the costs associated with establishing tree nurseries in villages, planting trees, purchasing necessary equipment, or building irrigation systems. Depending on the locations and the specific needs of the community to support agroforestry, the grant could vary. It is also important to ensure that the subsidies and grants are accessible to the intended beneficiaries, particularly smallholder farmers and marginalized communities. Building awareness about these opportunities, simplifying application processes, and providing assistance in meeting the requirements can help in maximizing the impact of subsidies and grants for agroforestry in Somalia.

Microfinance and Innovative Financing Mechanisms: Access to monetary resources could be improved by supporting innovative scalable financial models that address the long return on investment of many agroforestry practices (VI- agroforestry, 2018). Microfinance and innovative financing models offer alternative financial solutions to smallholder farmers and communities, particularly in regions like Somalia where traditional banking services may be limited or inaccessible. These models are designed to bridge the gap by providing the necessary capital for starting or expanding agroforestry and other sustainable agricultural practices. It's crucial to design these financial products/models in a way that is culturally appropriate and considers the local economic context to ensure their effectiveness and sustainability. Local microfinance institutions in Somalia can be engaged to provide Sharia-compliant microfinance products designed to support small-scale farmers and entrepreneurs, helping them to initiate and sustain agroforestry activities. Examples of such products to be explored include Murabaha (cost-plus financing), Mudarabah (profit-sharing), and Ijara (leasing) can be tailored to finance the upfront costs of starting or expanding agroforestry projects. For instance, an MFI could purchase necessary agroforestry inputs on behalf of the farmer (Murabaha) and sell them to the farmer at a mark-up, payable over time. Utilizing mobile banking platforms can make financial services more accessible, especially in remote areas. Digital platforms can facilitate loan applications, disbursements, repayments, and the distribution of information about agroforestry and financial management. Offering training programs alongside financial products can help farmers maximize the benefits of the products. This could include education on Sharia-compliant financial principles, sustainable agroforestry practices, market access, and business management skills. The cost of this measure could vary depending on types and scales of products offered.

Carbon Financing:

Carbon finance in the context of supporting agroforestry in Somalia involves monetizing the carbon sequestration and storage capabilities of agroforestry systems by engaging in carbon trading markets. This approach provides financial incentives to landowners and farmers to maintain and expand their agroforestry practices, contributing to climate change mitigation. Agroforestry practices capture and store atmospheric carbon dioxide in biomass and soil. The carbon sequestered can be quantified and converted into carbon credits. One carbon credit typically represents one ton of carbon dioxide either removed from the atmosphere or reduced in emissions. Farmers and communities in Somalia can sell these carbon credits on international carbon markets, providing a financial return on their sustainable land management practices. This process is often facilitated by global initiatives like the United Nations' REDD+ (Reducing Emissions from Deforestation and Forest Degradation) program or voluntary carbon markets. Such examples of initiative include the Kasigau Corridor REDD+ Project in Kenya which has been recognized for its substantial contributions to community development and conservation efforts (Bernard F et al 2014).

Strengthen the value chains for agroforestry- To strengthen adoption of agroforestry, it's vital to establish new value chains, particularly for products linked to indigenous trees, which can significantly benefit women, especially when focusing on locally processed goods. Addressing gender roles is crucial since larger markets often favour men (Vi-agroforestry, 2018). These value chains can connect the poor rural population to the expanding urban middle class, potentially by guaranteeing minimum prices for specific products. While targeting global markets offers lucrative prospects, it poses risks for smallholder farmers with limited adaptability to market fluctuations. Local markets might offer them more flexibility and easier entry (FAO 2015). Collaborating with the private sector can harness their resources for more extensive supply chains, but quality control becomes paramount. Other aspects of the value chain include establishing community seedling centres to facilitate provision of high quality and native seedlings at local levels.

2.4.3.2 Non-financial measures

Strengthening Policy and Regulatory Frameworks: A robust regulatory framework that supports the practice of agroforestry is essential. This could involve developing new policies on agroforestry and updating existing agriculture and forestry policies to incentivize agroforestry, protect the rights of farmers, and ensure the sustainable use of resources. Somalia's Federal and Federal Member States' governments would need to take the lead in this, with possible support from international organizations and NGOs in terms of policy drafting and consultation processes. Appropriate coordination between ministries and other institutions is necessary to promote agroforestry as it is not in a specific ministry.

Capacity Building and Extension Services: In Somalia, the effective implementation and management of agroforestry systems necessitate a comprehensive approach to capacity building and extension services. These services aim to equip farmers, local communities, government officials, and practitioners with the requisite skills and knowledge, thereby enhancing the sustainability and productivity of agroforestry initiatives. An elaborate strategy should encompass formal training sessions, the establishment of model farms, and the utilization of technology, all while ensuring inclusivity and addressing gender-specific needs:

- Develop comprehensive training programs that combine classroom-based learning with practical, on-field experience. This should involve technical training on agroforestry practices, restoration techniques, and sustainable land management. Extension officers play a crucial role in delivering these services, providing continuous support and guidance to farmers.
- Leverage partnerships with agricultural institutes, international organizations (like World Agroforestry Centre), and local NGOs to design and implement these training programs. These partnerships can ensure that the programs are scientifically sound, culturally appropriate, and tailored to the specific needs of the Somali environment and its people.
- Establish model farms that demonstrate successful agroforestry practices. These farms serve as practical, real-world examples for local farmers and communities, showcasing the benefits and techniques of agroforestry.
- Use these model farms as hubs for learning and innovation, where farmers can participate in workshops, see the tangible results of agroforestry practices, and share their experiences and knowledge with peers.
- Complement traditional extension services with modern technology. This could include mobile applications for knowledge sharing, online platforms for training modules, and forums for community engagement.
- Recognize and actively involve women, who play a significant role in agriculture and food production in Somalia. Ensure that training programs and extension services are accessible to women and cater to their specific needs.

Community Engagement and Awareness: The Government should conduct extensive awareness campaigns targeting local communities, stakeholders, and decision-makers to increase understanding of the importance of agroforestry. Engage with communities through workshops, seminars, community meetings, and educational programs to highlight the ecological, social, and economic benefits of restoration. Foster a sense of ownership and empowerment among local communities by involving them in the decision-making process and promoting their active participation in agroforestry activities.

Capacity Development of Local Institutions: There is need to strengthen the capacity of local institutions, including community-based organizations, non-profit organizations, and government agencies, to effectively plan and implement agroforestry. This involves providing

technical support, training in project management, financial planning, and organizational development. Empowering local institutions to take leadership roles in agroforestry efforts, fostering local ownership and sustainability.

Collaboration and farmers cooperatives: Cooperation among rural farmers is essential for scaling up agroforestry. Furthermore, having strong communities that facilitate knowledge dissemination between farmers can provide an environment in which farmers are encouraged to test innovations as they get some stability from being a part of a group. When supporting cooperatives and other farmer organisations, it is necessary to address gender roles and youth discrimination (Vi- Agroforestry, 2018). It is important foster collaboration among various stakeholders, including government agencies, non-governmental organizations, research institutions, local communities, and private sectors in Somalia. The government should establish multi-stakeholder platforms or working groups to facilitate information sharing, coordination of efforts, and collective decision-making. Promotion of partnerships that leverage the diverse expertise and resources of different stakeholders will ensure effective implementation of agroforestry activities.

Research and Knowledge Sharing: It is important to initiate and support research initiatives agroforestry techniques that are specifically suited to the Somali context can lead to more effective and efficient practices. Universities and research institutions could be key partners in this. This will encourage knowledge sharing and information exchange among researchers, practitioners, and local communities through platforms such as workshops, conferences, and publications. Promotion of the integration of traditional ecological knowledge with scientific research to inform agroforestry practices and enhance local community involvement. Investing in R&D could lead to the development of more cost-effective agroforestry techniques and species which are suitable for the Somali context.

Land Tenure Security: Strengthening land tenure rights is pivotal for promoting agroforestry. In this context, it's essential to champion women's rights, as they often possess minimal legal entitlements to land. Furthermore, legitimate land rights can enhance credit access since land typically serves as the primary collateral in rural locals (Vi- Agroforestry, 2018). The right to trees should be intertwined with land rights. Resolving issues around land ownership can incentivize farmers to invest in long-term practices like agroforestry. Government intervention is necessary to establish clear and fair land tenure systems for communities to be encouraged to implement agroforestry.

2.5 Linking the Barriers to forestry sector technologies

To provide a comprehensive understanding of the barriers in the forestry sector technologies, it is essential to identify the linkages between these barriers. The barriers identified in the forestry sector technologies, including afforestation and reforestation activities and agroforestry are interconnected and can influence one another. The following are the linkages between these barriers:

Limited Funding and access to finance: The financial barrier is a common challenge across all forestry sector technologies. Limited funding restricts the implementation of afforestation, reforestation and agroforestry projects. The lack of adequate funding affects the capacity to establish nurseries, procure seedlings, conduct monitoring activities, and provide training to communities. Insufficient funds can also hinder the enforcement of regulatory measures and the development of supportive policies. Communities and farmers experience challenges of accessing appropriate financing for agroforestry and afforestation activities.

Lack of Effective Policy and Regulatory Framework: The absence of a forestry policy and legislation not only hampers the regulation of forestry resources but also affects the implementation of afforestation, reforestation, agroforestry, and coastal/mangrove restoration initiatives. Without clear policies and regulations, it becomes challenging to address other barriers such as limited funding, lack of awareness, and inadequate capacity.

Institutional Challenges: Weak institutional frameworks and governance structures can impact the implementation of forestry sector technologies. This includes challenges related to coordination among government agencies, inadequate policies and regulations, and insufficient enforcement mechanisms. These institutional and governance barriers can have cascading effects on funding, capacity building, and awareness initiatives.

Inadequate Awareness and Understanding: Lack of public awareness and understanding about the benefits of forestry technologies, including afforestation, reforestation, agroforestry, and coastal/mangrove restoration, can hinder their adoption and implementation. This barrier affects the involvement and engagement of communities, government agencies, and other stakeholders, which in turn affects the allocation of funding, policy support, and overall implementation.

Capacity and Technical Expertise: Limited capacity and technical expertise in implementing forestry technologies can hinder their effective execution. This barrier includes the lack of knowledge and skills in tree planting, nursery management, species selection, sustainable land management practices, and monitoring techniques. Inadequate capacity affects the success of afforestation, reforestation and agroforestry projects and their long-term sustainability.

Climatic Change impacts: Somalia experiences extreme weather events, prolonged droughts, erratic rainfall, and elevated temperatures, which can affect establishment and survival of trees. This can hinder seed germination, reduce growth rates, and increase the susceptibility of trees to pests and diseases. Water scarcity and the competition for water between trees and crops and other uses present a significant in many regions in Somalia

By understanding the interlinkages between these barriers, it becomes evident that addressing one barrier can have positive spill-over effects on others. For example, the establishment of effective policies and regulatory frameworks can enhance funding

opportunities, increase awareness, and strengthen institutional capacities. Similarly, improving capacity and technical expertise can lead to better implementation, which in turn can increase awareness and stimulate funding. Taking a holistic approach to address these barriers will contribute to the successful implementation and scaling up of forestry sector technologies in Somalia.

2.6 Enabling environment to overcome barriers in the sector.

To establish a comprehensive understanding of the measures for addressing barriers in the forestry sector, it is crucial to identify the linkages between these measures. The measures identified for addressing barriers in the forestry sector, including afforestation and reforestation activities, agroforestry, and coastal/mangrove restoration, are interconnected and can reinforce one another. The following are the linkages between these measures:

Policy and Regulatory Framework Development: Developing effective policies and regulatory frameworks is a fundamental measure for overcoming barriers in the forestry sector. This measure can address barriers related to limited funding, lack of awareness, and inadequate capacity. Clear policies and regulations create an enabling environment for the implementation of afforestation, reforestation, agroforestry, and coastal/mangrove restoration initiatives. They can provide guidance on funding mechanisms, community engagement, sustainable practices, and the protection of forest resources

Capacity Building and Training Programs: Capacity building measures aim to enhance the knowledge and skills of stakeholders involved in forestry sector technologies. These measures are vital for overcoming barriers related to limited awareness, inadequate capacity, and insufficient technical expertise. By providing training programs on tree planting techniques, nursery management, sustainable land management practices, and monitoring methods, stakeholders can gain the necessary skills to implement and manage afforestation, reforestation, agroforestry, and coastal/mangrove restoration projects effectively.

Community Engagement and Awareness Campaigns: Engaging local communities and raising awareness about the benefits of forestry sector technologies are critical measures for overcoming barriers such as limited funding, inadequate awareness, and low community participation. By involving communities in decision-making processes, conducting awareness campaigns through various channels, and promoting the socio-economic benefits of these technologies, stakeholders can foster community ownership, mobilize support, and attract funding for the implementation of forestry initiatives.

Financial Support and Funding Mechanisms: Mobilizing adequate funding is a key measure for addressing financial barriers in the forestry sector. Establishing financial support mechanisms, such as grants, loans, subsidies, and public-private partnerships, can address barriers related to limited funding and high costs. These mechanisms can attract investments, provide financial incentives to stakeholders, and facilitate the implementation of

afforestation, reforestation and agroforestry projects.

Monitoring, Evaluation, and Adaptive Management: Implementing monitoring, evaluation, and adaptive management measures is essential for assessing the progress, effectiveness, and impact of forestry sector technologies. These measures address barriers related to inadequate capacity, limited awareness, and governance challenges. By monitoring the performance of projects, evaluating their outcomes, and using adaptive management approaches, stakeholders can learn from experiences, make necessary adjustments, and improve the implementation of forestry initiatives.

Provision of seedlings: To promote the practice of forestry and agroforestry, a focused measure on providing high-quality and climate resilient seedlings is imperative. Ensuring easy access to a diverse range of native and adaptive tree seedlings not only promotes biodiversity but also increases the chances of successful tree establishment and growth. Collaborative efforts between governmental agencies, CSOs, and community-based organizations can lead to the creation of community seed banks and nurseries, which can act as vital hubs for distributing seedlings to farmers and local communities. This measure would not only address the initial barrier of sourcing appropriate planting material but also promote local ownership and investment in sustainable land management practices. Furthermore, training sessions on the best planting and nurturing techniques can be organized to enhance the survival rate of these seedlings, ensuring long-term success in reforestation and agroforestry initiatives.

Partnerships and Collaborations: Collaborating with diverse stakeholders, including government agencies, non-governmental organizations, research institutions, and local communities, is a crucial measure for overcoming barriers in the forestry sector. Building partnerships fosters coordination, knowledge sharing, and resource mobilization. It strengthens the collective efforts to address barriers and promotes the effective implementation of afforestation, reforestation, agroforestry, and coastal/mangrove restoration initiatives.

By recognizing the interlinkages between these measures, stakeholders can adopt a comprehensive and integrated approach to address barriers in the forestry sector. Coordinated implementation of these measures will enhance the success, scalability, and sustainability of forestry sector technologies in Somalia.

Below is a summary of linked barriers and measures for adoption of afforestation and deforestation and agroforestry:

Barriers	Measures	Responsible institutions
Financial barriers <ul style="list-style-type: none"> Limited Access to Capital for the implementation substantial upfront investments Limited Financial Incentives Inadequate Access to Credit 	<ul style="list-style-type: none"> Introduce microfinance initiative tailored towards agroforestry & afforestation. Promote community-based agroforestry and afforestation initiatives. Offer training and capacity building on financial literacy to farmers and communities. Seek increased international financing for the sector including for capacity building, seedlings development. Increased domestic allocation for the sector Carbon financing 	<p>Ministry of Finance & MoECC to lead with fiscal policies & incentives</p> <p>Development partners- to provide grants & budgetary support NGOs – trainings & awareness private sector – carbon financing</p>
Non-financial barriers		
Inadequate Policy and Regulatory Framework	<ul style="list-style-type: none"> Review and align forestry and agriculture sectors policies with the view to strengthening them. Develop effective policies and regulatory frameworks at the FMSs Develop regulations and enforce for illegal logging, charcoal for export Institutional strengthening including staffing and training of policy makers Implement technology based monitoring 	<p>MoECC to lead on policy at Federal government level</p> <p>FMSs Ministries responsible for environment at FMSs level</p>
Lack of public awareness & education	<ul style="list-style-type: none"> Organize workshops, seminars, and training sessions for specific groups including women, youth Launch public awareness campaigns using TV, radio, newspapers, and public meetings, social media Strengthen collaboration with NGOs and CSOs on the awareness initiative Strengthen inclusive extension services Engage popular Somali artists, musicians, and writers to produce content that raises awareness. 	Government & NGOs could implement with support from development partners
Inadequate capacity on the implementation of afforestation and agroforestry	<ul style="list-style-type: none"> Develop youth-focused forestry programs to foster interest and cultivate future leaders in the sector. Allocate sufficient resources (financial, human, technical) to MoECC Establish platforms where different stakeholders, including government, private sector, communities, and NGOs, can collaborate and share knowledge. Collaborate with academic institutions and international organizations for joint research projects and knowledge exchange. 	<p>MoECC & FMSs ministries to lead for government level capacity strengthening</p> <p>Universities and academic institutions to provide trainings</p>
Limited access to quality seedlings and seedlings	<ul style="list-style-type: none"> Support the development of community-based nurseries to produce and supply quality seedlings tailored to the local environment in different districts in the 6 FMSs. 	MoECC to coordinate and closely work with development partners to support

	<ul style="list-style-type: none"> • Train local communities in proper seed collection techniques during the appropriate seasons. • Partner with research institutions and universities to identify tree species best suited for the local environment and climate. • Offer training programs for farmers, community members, and nursery operators on modern tree propagation techniques and seedling care. • Engage the private sector in seed and seedling production, offering incentives for companies to invest in high-quality tree production. • Partner with international forestry and conservation organizations for technical assistance, seed exchange programs, and knowledge sharing. 	NGOs and FMSs to facilitate on ground establishment of tree nurseries
Climate change impacts	<ul style="list-style-type: none"> • Support the development of community water infrastructures to secure reliable water supply • Promote water efficient technologies such as drip irrigation • Promote use of climate resilient seedlings 	Ministry of Water & Irrigation to coordinate together with MOECC

Table 10: Linked barriers and measures for the forestry sector technologies

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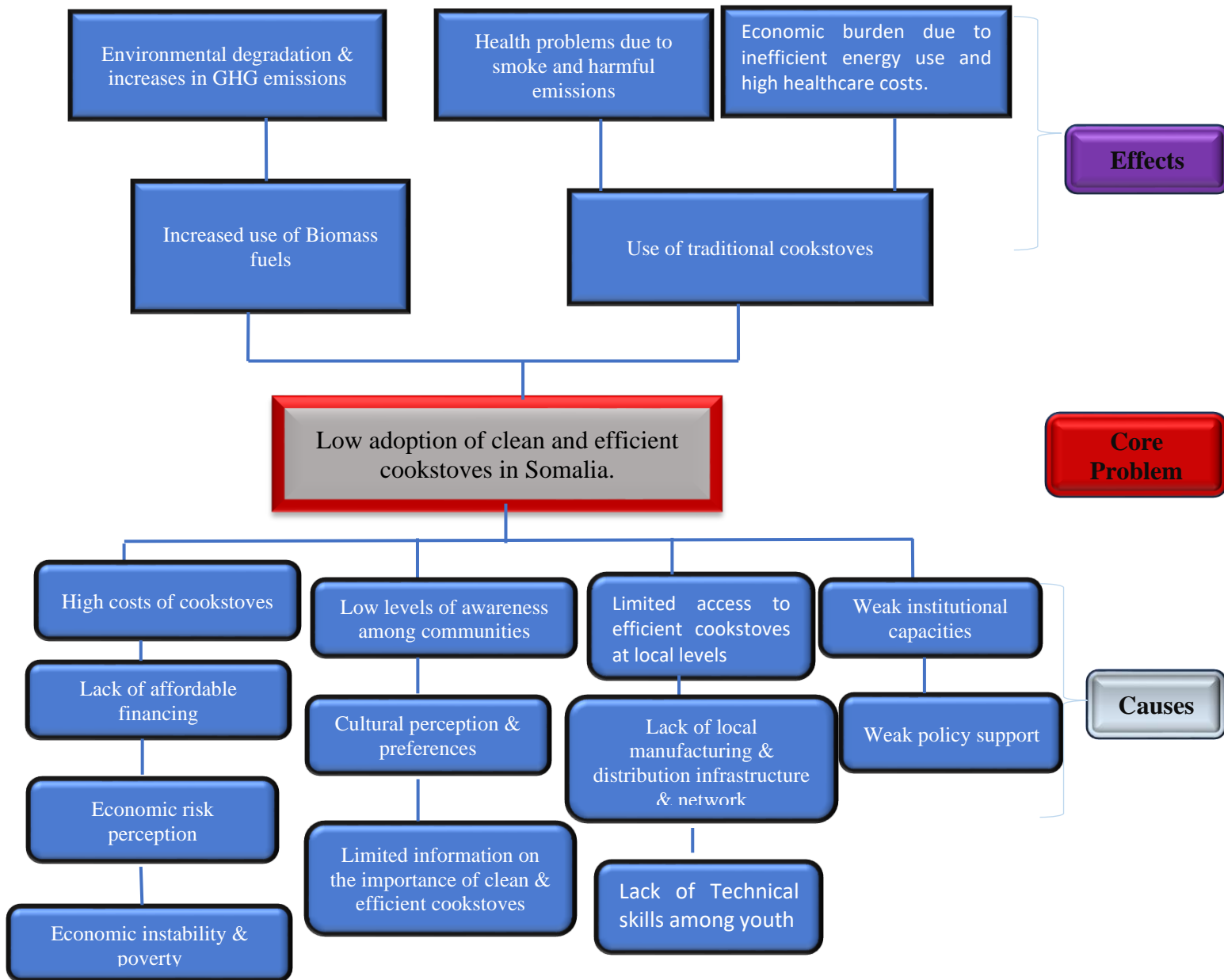
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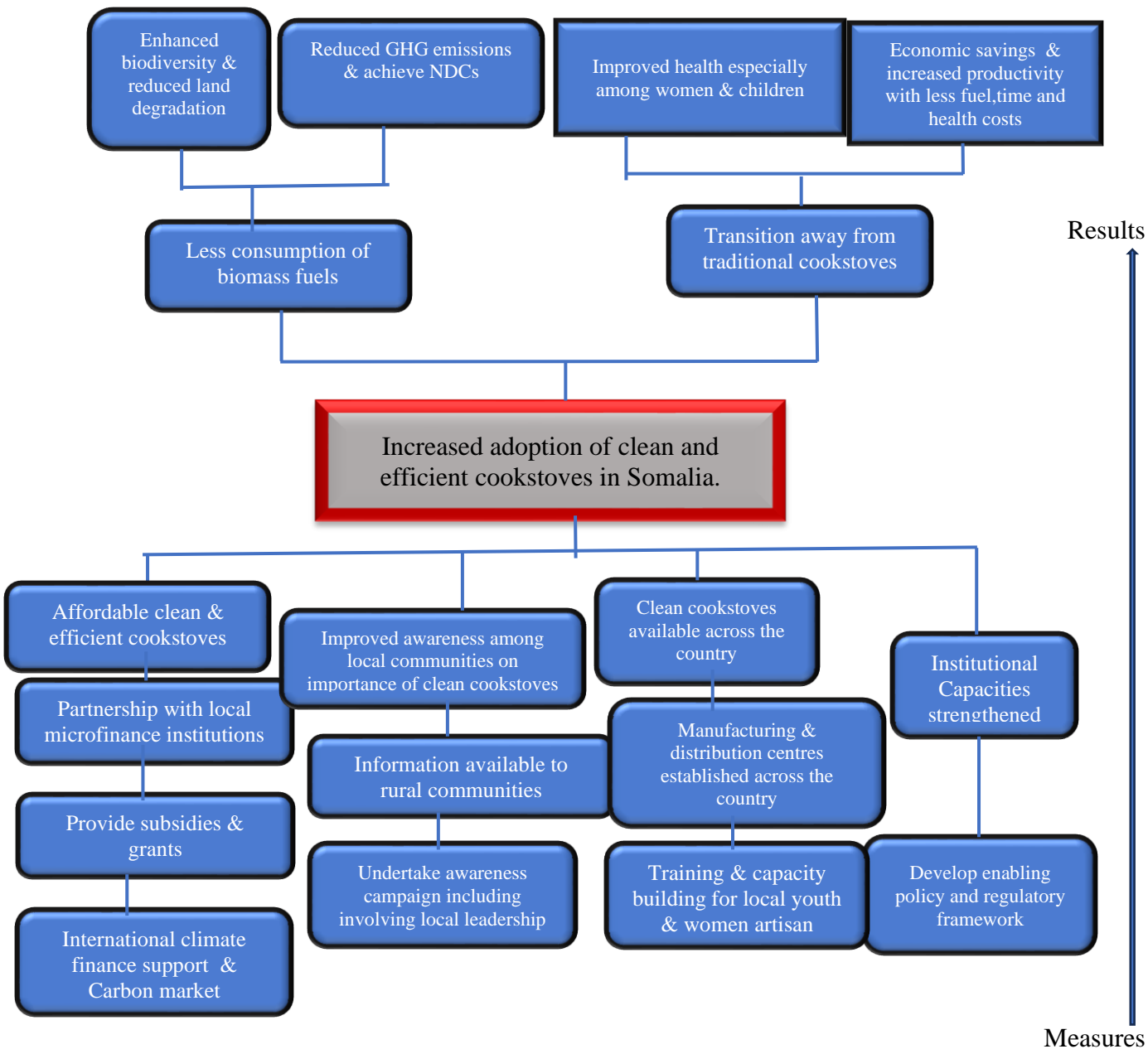
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ANNEXES

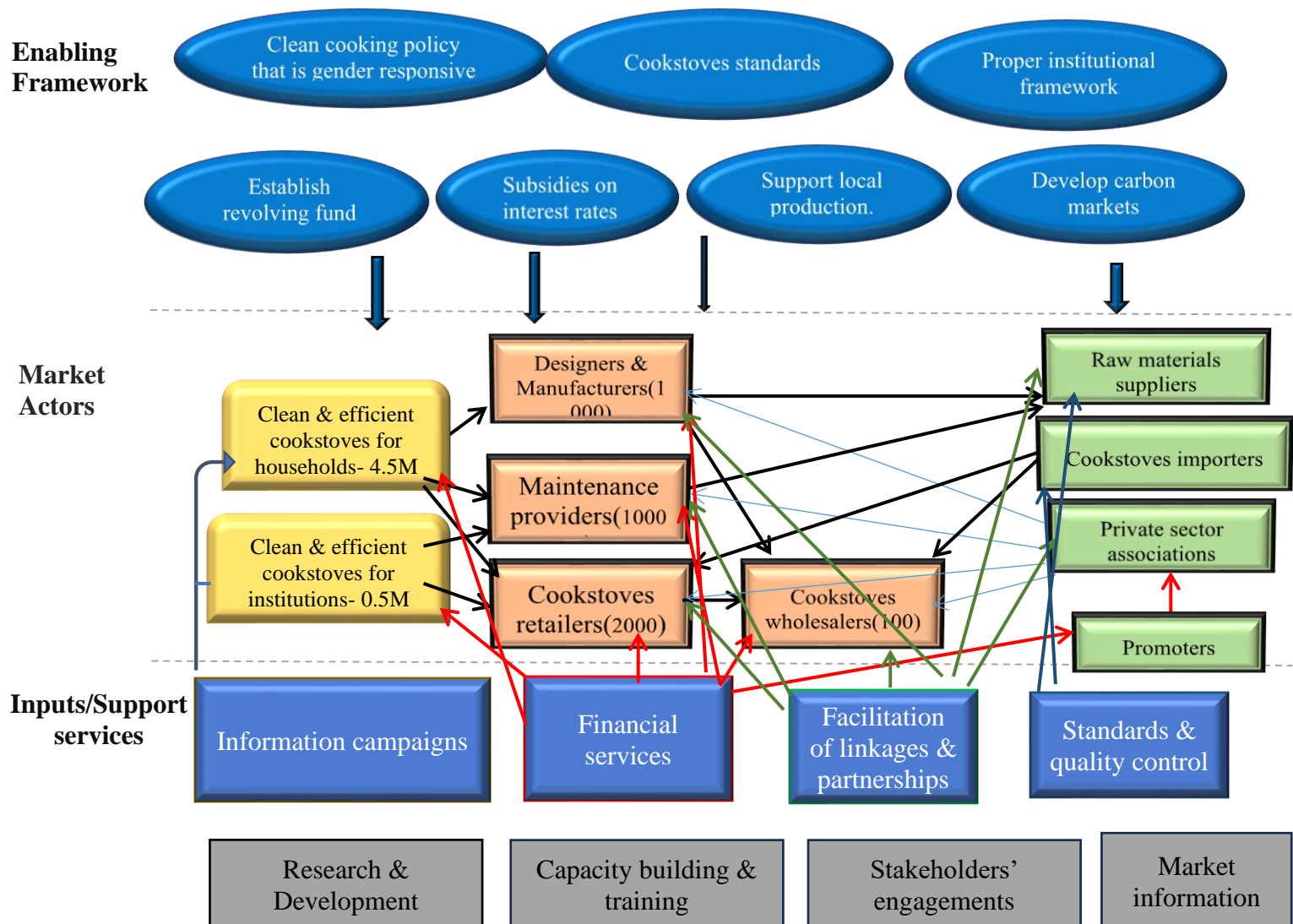
Annex I: Problem tree for clean and efficient cook stoves



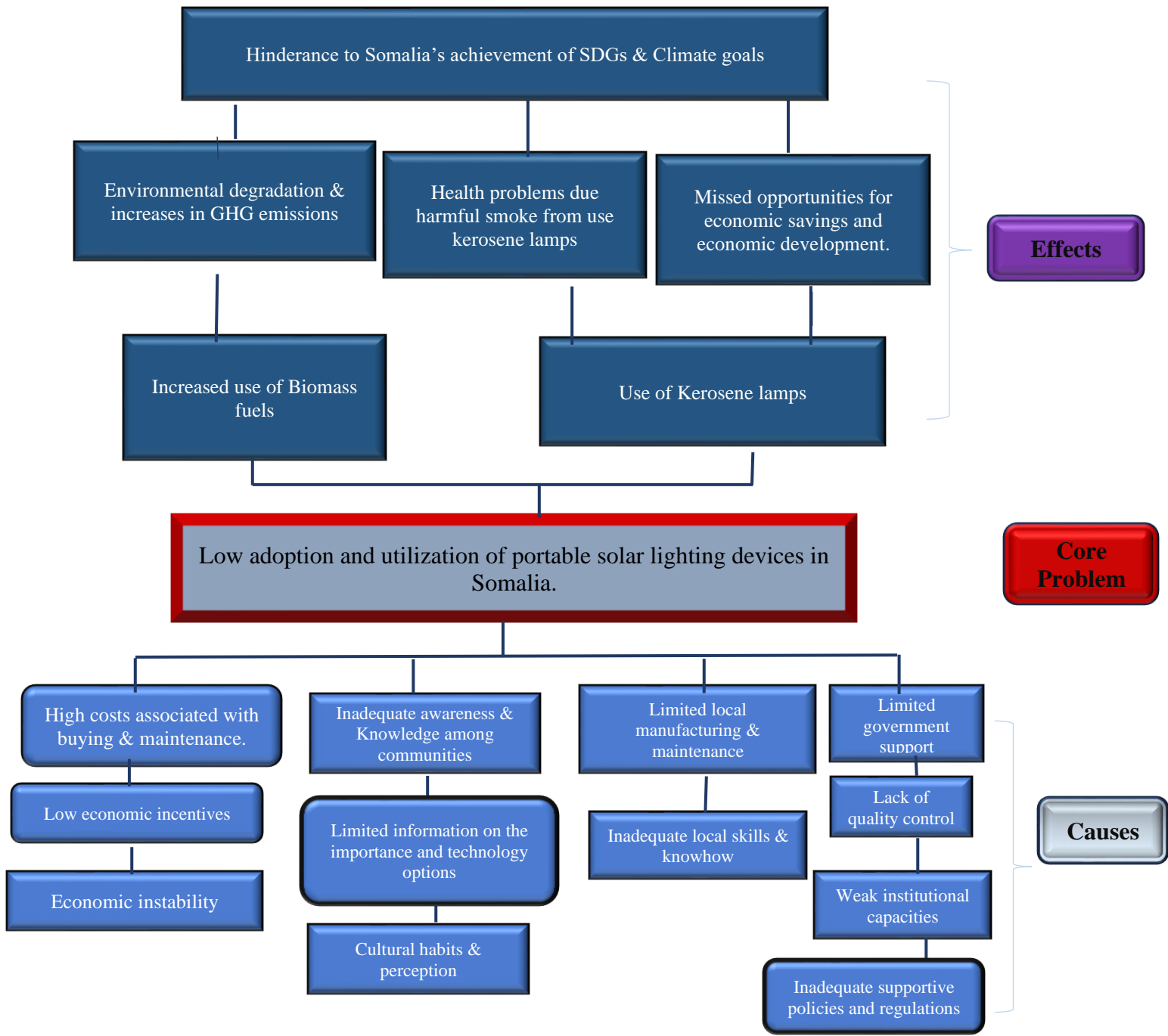
Annex II: Solution tree – Clean and efficient cookstoves



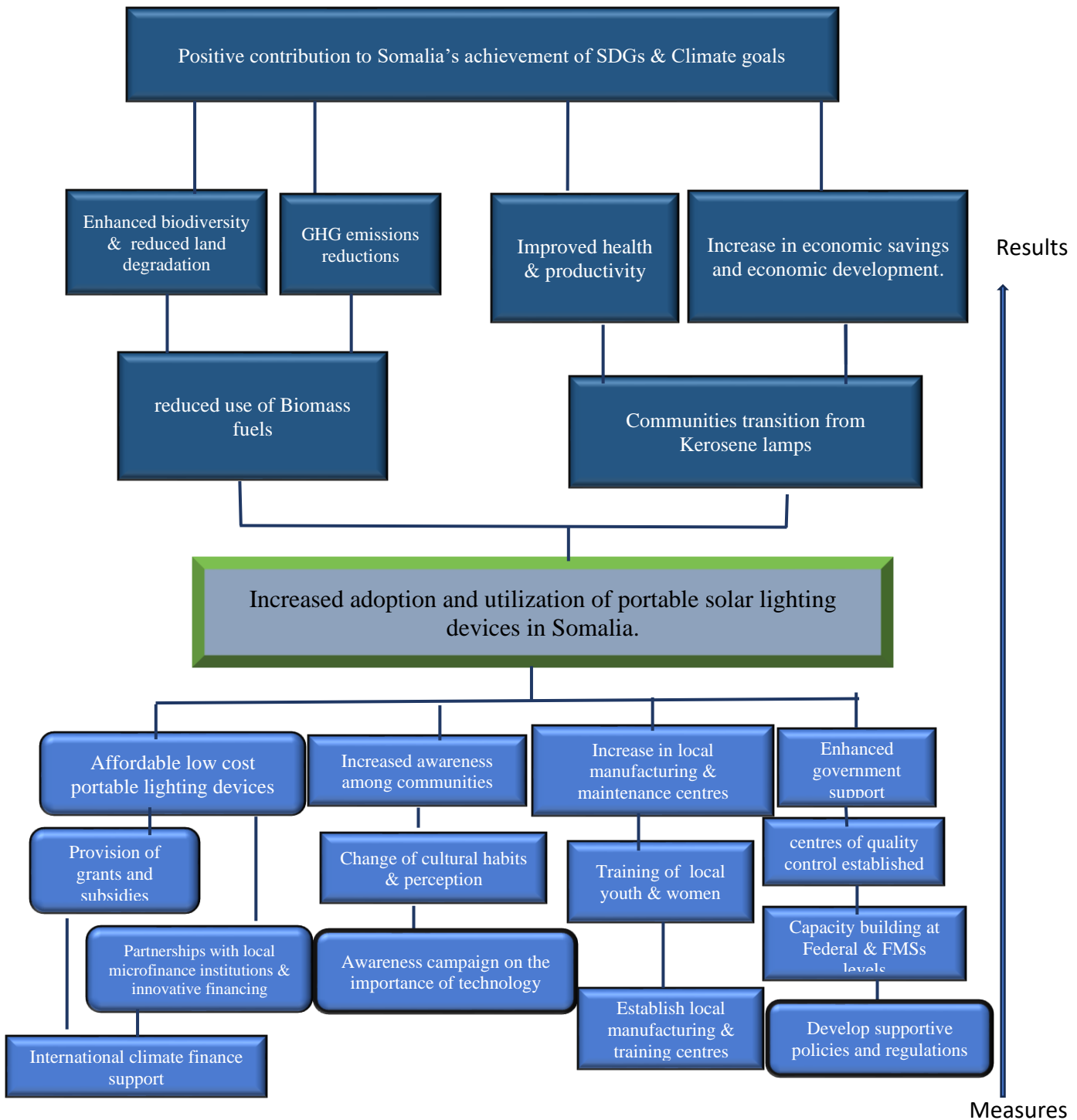
Annex III: Market map for Clean and efficient Cookstoves



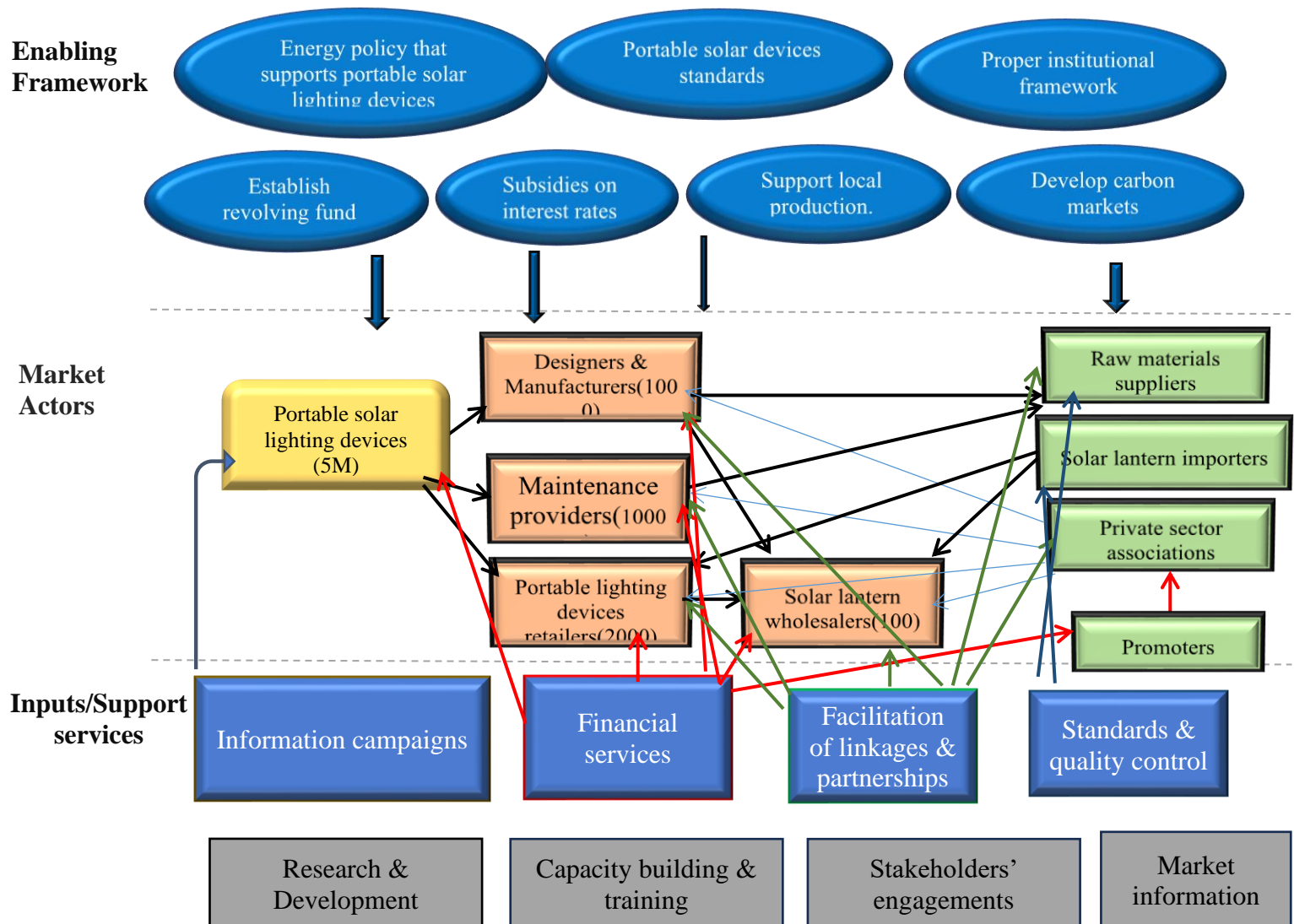
Annex IV: Problem tree for Portable solar lighting devices



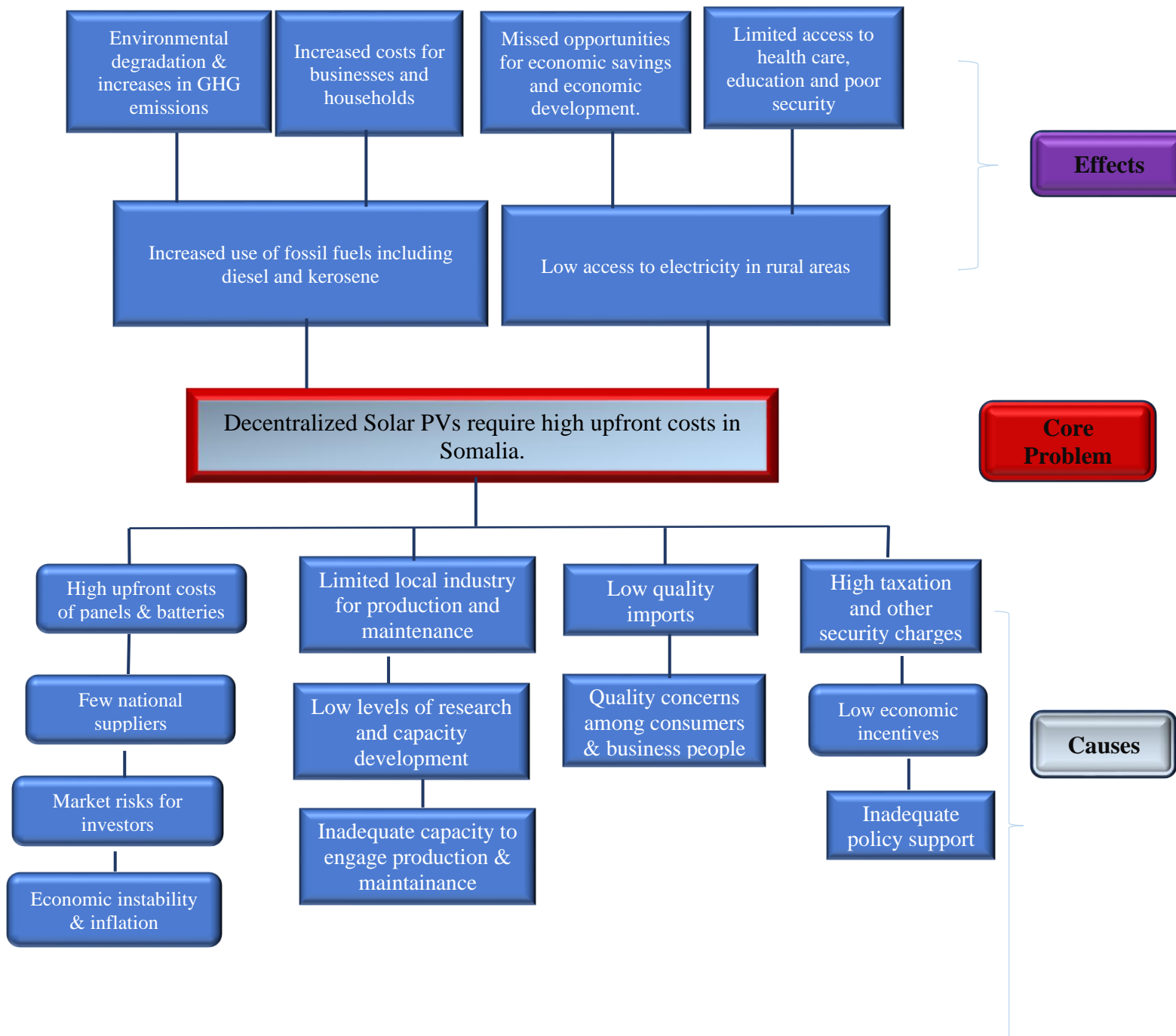
Annex V: Solution tree – Portable solar lighting devices



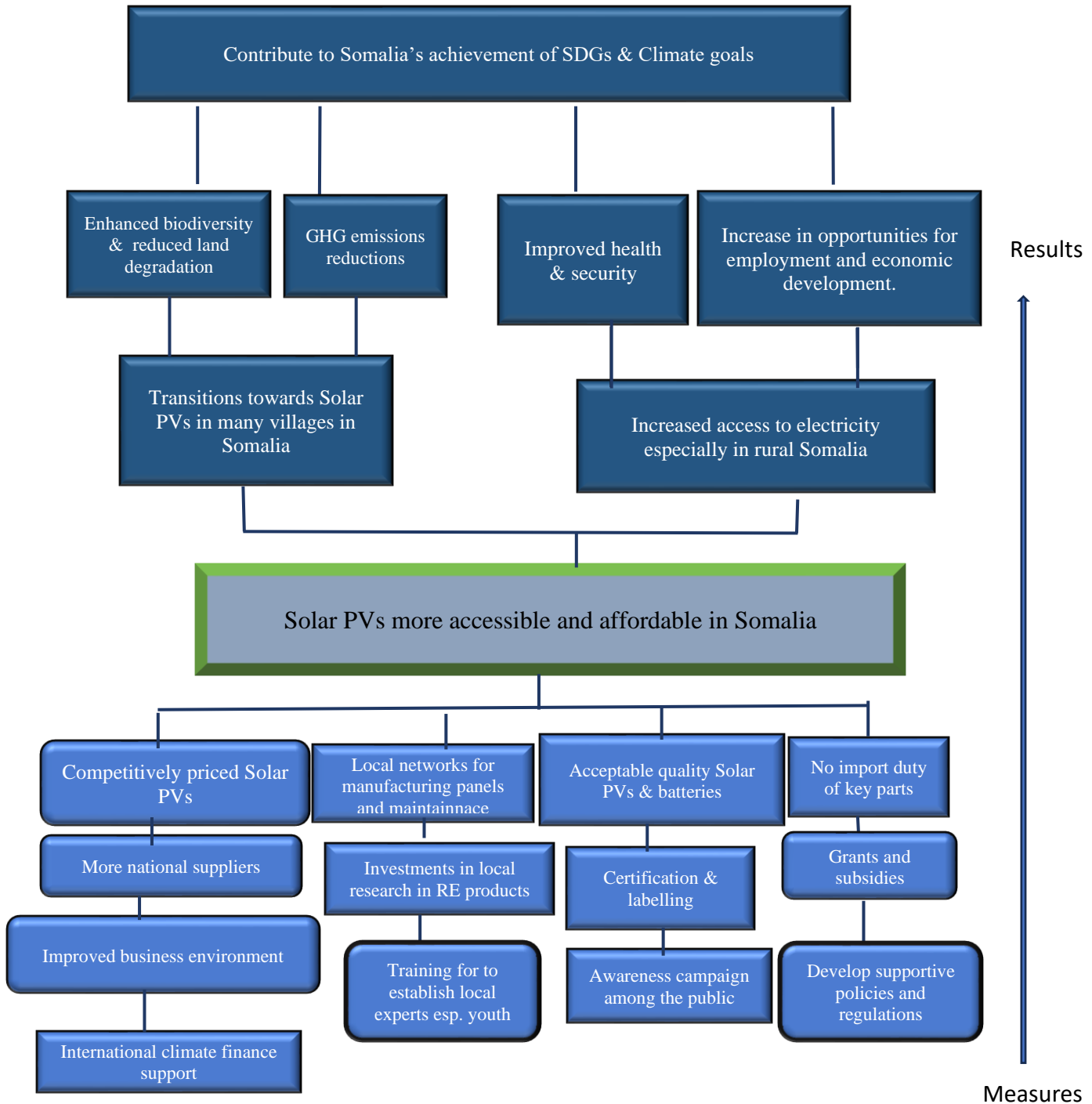
Annex VI: Market map for Portable solar lighting devices



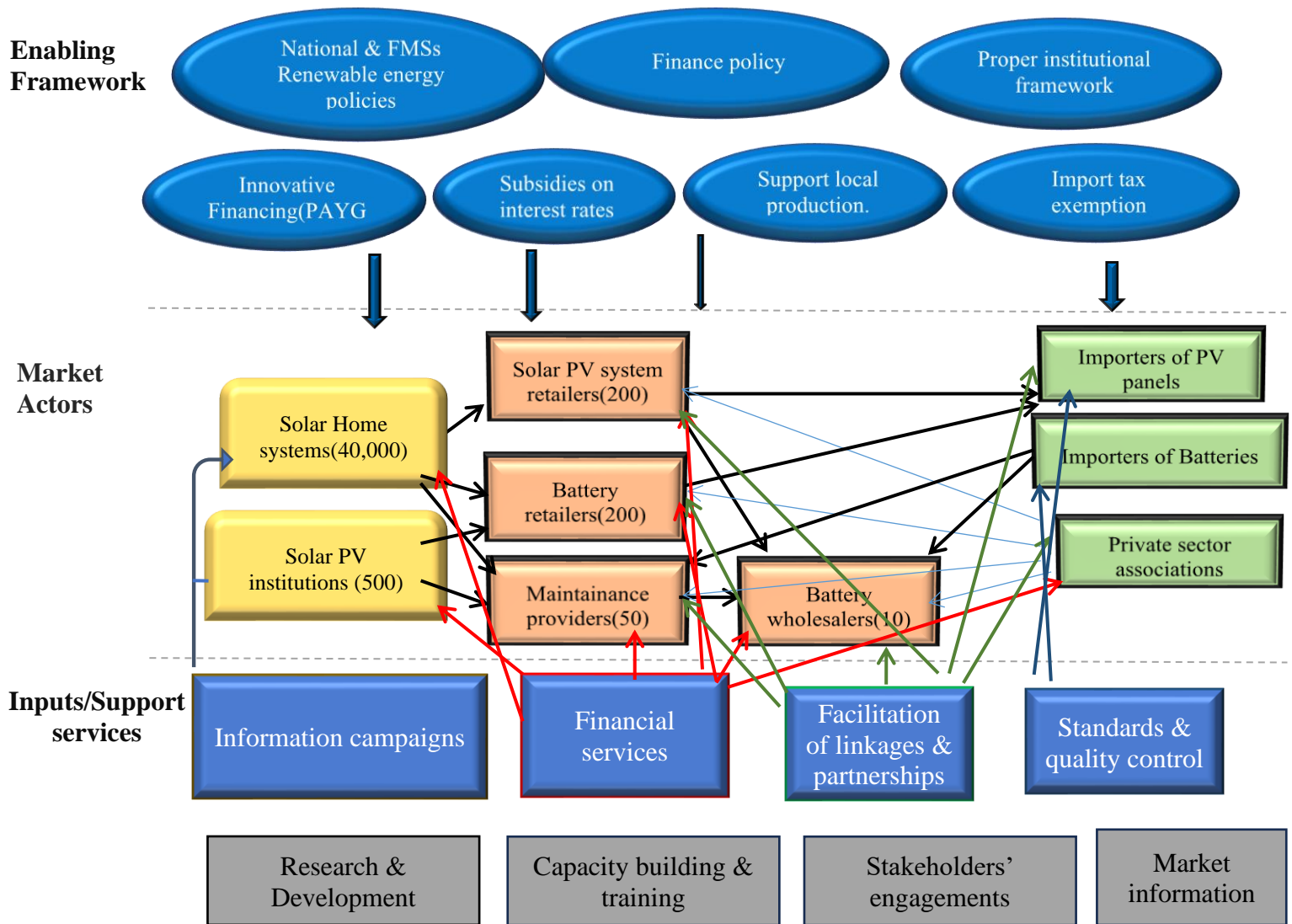
Annex VII: Problem tree for Solar PVs



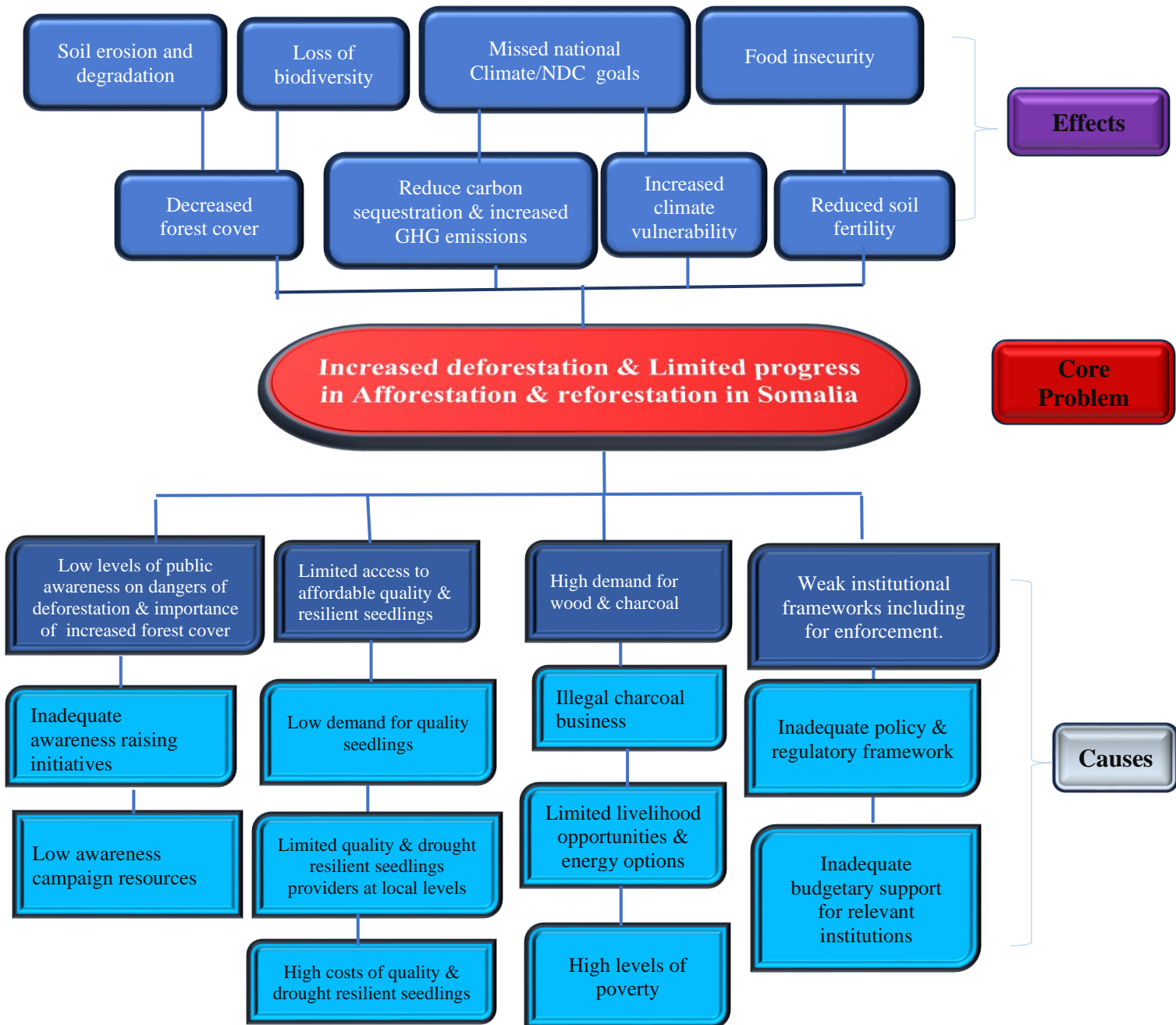
Annex VIII: Solution tree – Solar PVs



Annex IX: Market map for measures for Solar PVs



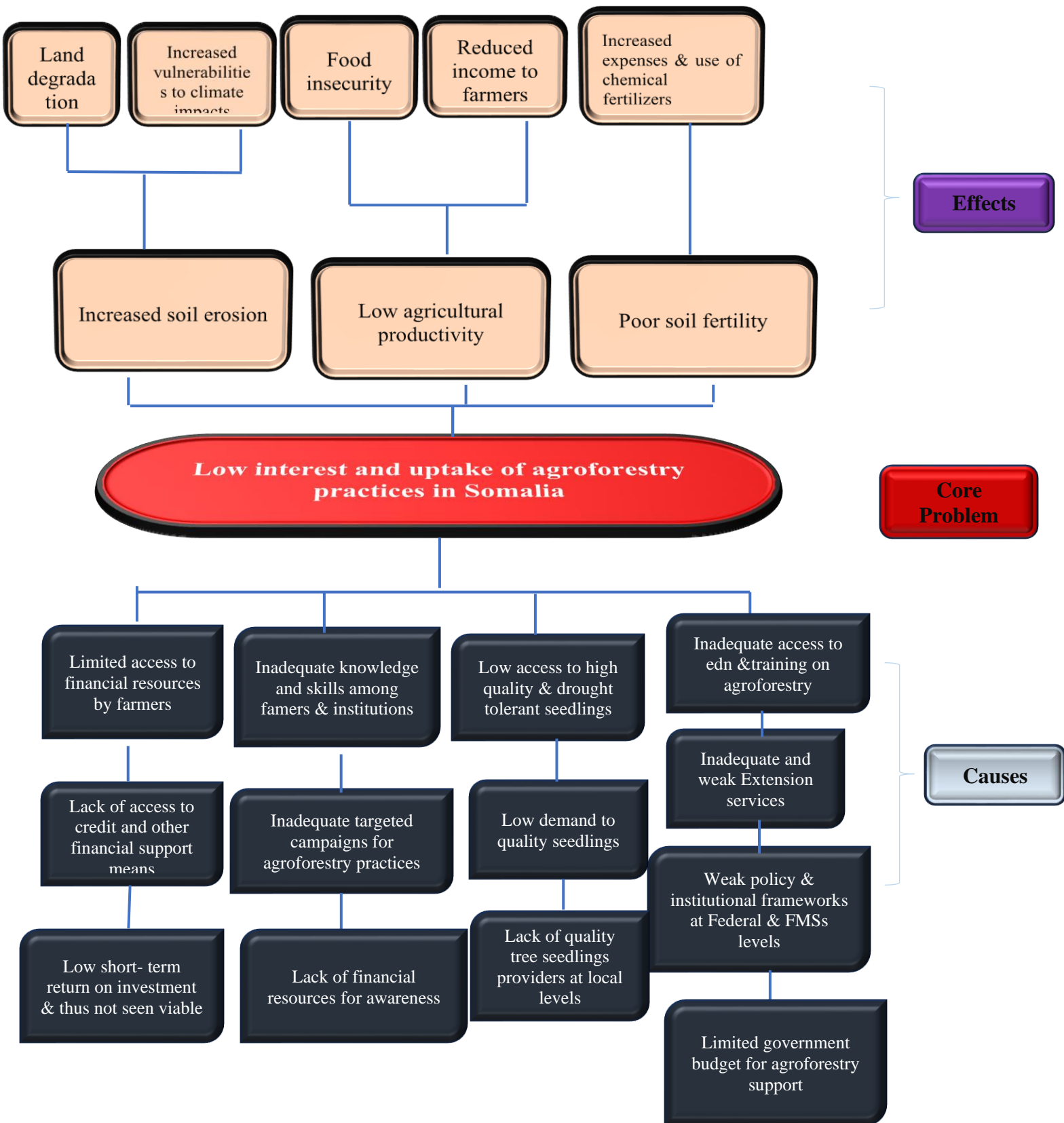
Annex X: Problem tree for afforestation and reforestation.



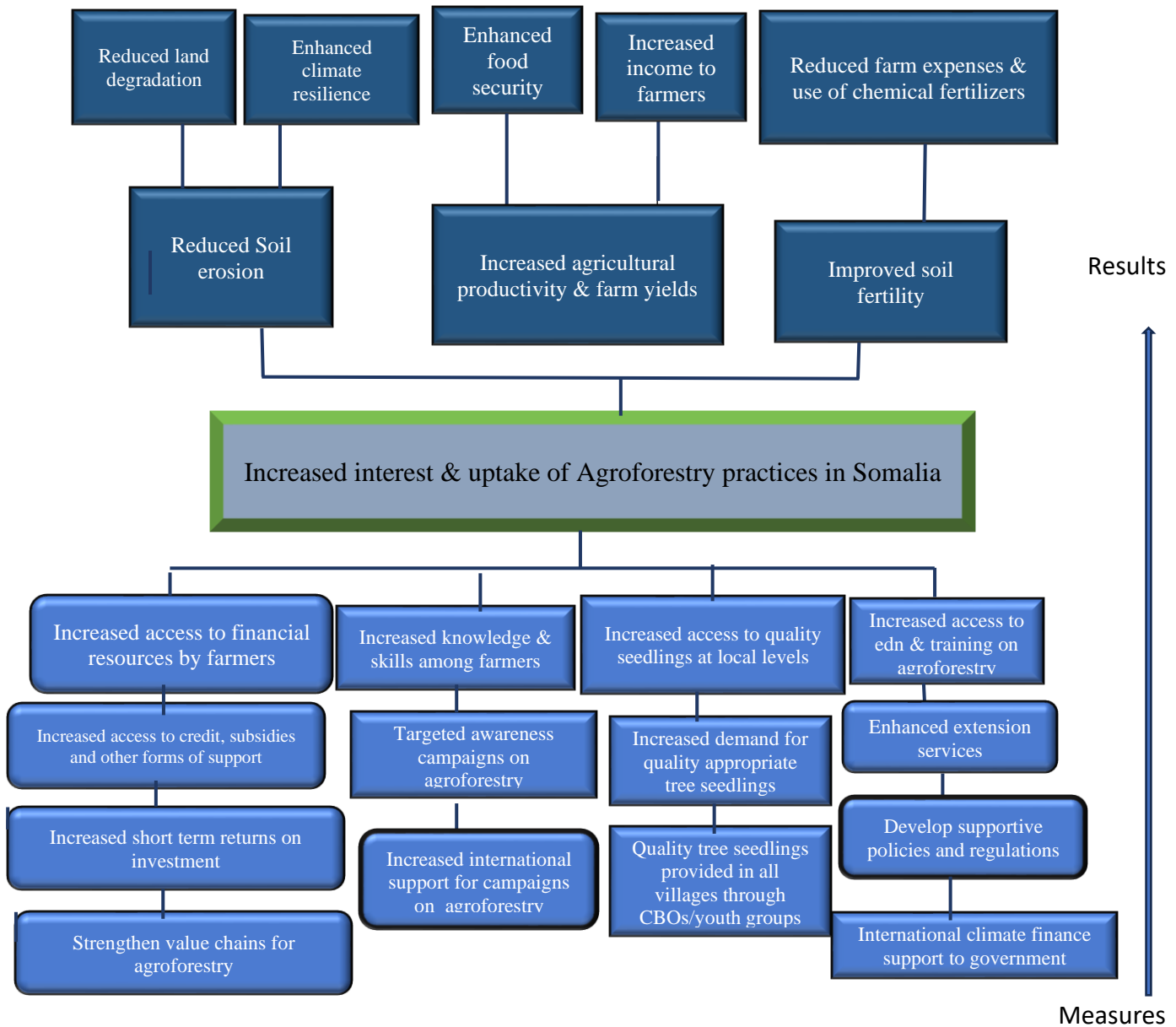
Annex XI: Solution tree – Afforestation and reforestation.



Annex XII: Problem tree for Agroforestry



Annex XIII: Solution tree – Agroforestry



Annex XIV: List of Stakeholders Consulted

S/N	Name	Institution	Email
1.	Ahmed Yusuf Ahmed	Ministry of Environment and Climate Change (MoECC) -Director General	dg@moecc.gov.so
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10.	Abdulahi Ahmed	Ministry of Agriculture and Irrigation	irrigationdept@moa.gov.so
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13.	Khadra Omer Hassan	Barwaaqo Voluntary Organisation (BVO)	Khadra.Hassan@bvo.org
14.	Abdiwali Mohamud	Dahabshiil Group South and Central Somalia, Business Development and Corporate Clients manager. (Private Sector)	
15.	Abdikani Sheikh Omar Hassan	Ministry of Women and Human Rights Development	
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20.	Omar Abdullahi	Private Sector	oaharab@gmail.com