The Government of the Kingdom of Lesotho

Technology Needs Assessment for Technologies in the Energy and Agriculture Forestry and other Land Use (AFOLU) Mitigation Component

Barrier Analysis and Enabling Framework for Climate Technologies

Final Draft

Ministry of Environment and Forestry

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Barrier Analysis and Enabling Framework for Climate Technologies in the Energy and AFOLU Sectors - Mitigation

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Foreword

Climate variability and change present significant challenges to sustainable development in Lesotho. Over the past few decades, the country has experienced an increase in the severity of climate-related hazards such as droughts, floods, heavy snowfall, and extreme temperatures. These challenges have a profound impact on the well-being, security and sustainable livelihoods of the population, leading to higher levels of poverty and increased strain on social services. To address these threats, the National Climate Change Policy 2017 – 2027 (NCCP) was developed to guide the integration of climate change management into development planning and implementation at all levels. Despite being a minor contributor to global greenhouse gas (GHG) emissions, Lesotho is one of the countries most severely affected by climate change. The country has made a commitment to adopting policies and measures to reduce its carbon footprint and enhance its resilience to the adverse impacts of climate change. This commitment aligns with the development priorities outlined in the second National Strategic Development Plan (NSDP II) for 2023-2028, and the revised Nationally Determined Contribution (NDC) 2024 commitments under the 2015 Paris Agreement.

Lesotho has aligned its national priorities with regional and international commitments. These commitments include the 2030 Agenda for Sustainable Development, Agenda 2063, and the SADC Regional Indicative Strategic Development Plan (RISDP). This integration is supported by the National Strategic Development Plan (NSDP II). Through NSDP II, Lesotho acknowledges the interconnected and inseparable nature of Sustainable Development Goals (SDGs) and is dedicated to addressing the three dimensions of sustainable development: economic, social, and environmental.

Urgent climate action is crucial for Lesotho to achieve its development goals. However, slow technological mobilization, limited knowledge transfer, and financial constraints hinder progress in addressing key drivers of climate vulnerability. The Technology Needs Assessment (TNA) process is essential in identifying the technological needs for transformative climate adaptation and mitigation initiatives at the national and sub-national levels.

The development of the Barrier Analysis and Enabling Framework (BAEF) report for Lesotho followed international best practices and methodologies, with stakeholder participation and feedback playing a crucial role in ensuring that all considerations, including gender, are taken into account. It is hoped that the BAEF report will support the country in mitigating the effects of climate change through the enhancement of climate technologies.

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Acronyms and Abbreviations

AFOLU	Agriculture, Forestry, and Other Land Use
AR4	Fourth Assessment Report of the IPCC
BAU	Business as Usual
BOS	Bureau of Statistics
CBOs	Community Based Organizations
CFLs	Compact Fluorescent Lamps
CO_2	Carbon dioxide
CO_2e	CO_2-equivalent
CSOs	Civil Society Organizations
DoAR	Department of Agricultural Research
DoC	Department of Crops
DoE	Department of Energy
DOE	Department of Environment
DOF	Department of Forestry
DoSWC	Department of Soil and Water Conservation
DWA	Department of Water Affairs
EF	Emission factor
GHG	Greenhouse Gas
GoL	Government of Lesotho
GWP	Global Warming Potential
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LDCs	Least Developed Countries
LED	Light-Emitting Diode
LMS	Lesotho Meteorological Services
LPG	Liquefied Petroleum Gas
LVAC	Lesotho Vulnerability Assessment Committee
M	Maloti (local currency) pegged to the South African rand on a 1:1 basis
MACC	Marginal Abatement Cost Curve
MCA	Multi Criteria Analysis
MDGs	Millennium Development Goals
MoEF	Ministry of Environment and Forestry
$MtCO_2e$	Million tonnes of carbon dioxide equivalent

NAMA	National Appropriate Mitigation Actions
NAPA	National Adaptation Programme of Action
NCCC	National Climate Change Committee
NCCP	National Climate Change Policy 2017 – 2027
NDC	Nationally Determined Contributions
NEP	National Energy Policy 2015 – 2025
NSDP	National Strategic Development Plan
PPP	Public Private Partnership
SDGs	Sustainable Development Goals
SNC	Second National Communication
Solar PVs	Solar Photovoltaic technology
tCO_2e	Tonnes of CO_2 equivalent
TNA	Technology Needs Assessment
TNC	Third National Communication
TAPs	Technology Action Plans
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNEP CCC	UN Environment Programme (UNEP)'s Copenhagen Climate Center
USD	United States of America Dollar

Glossary of Terms[1]

Greenhouse Gases	Gases within the Earth's atmosphere, principally water vapour, carbon dioxide, methane, nitrous oxide and ozone, the increasing concentrations of which are raising the Earth's average temperature and causing a range of other adverse climate and weather effects.
Low Carbon	Technology, including transport, that emits minimal carbon dioxide into the atmosphere or, in the case of 'zero carbon', emits no carbon dioxide at all.
Mitigation	An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks (IPCC, 2007a; glossary).
Technologies for Mitigation and Adaptation	All technologies that can be applied in the process of minimizing greenhouse gas emissions and adapting to climatic variability and climate change, respectively.
Technology Needs and Needs Assessment	A set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties other than developed country Parties, and other developed Parties not included in Annex II, particularly developing country Parties. They involve different stakeholders in a consultative process and identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity building.
Technology Transfer	The exchange of knowledge, hardware and associated software, money and goods among stakeholders, which leads to the spreading of technology for adaptation or mitigation. The term encompasses both diffusion of technologies and technological cooperation across and within countries.

[1] Adopted from the Technology Needs Assessment for Climate Change & Technologies for Climate Mitigation (Transport Sector) (UNEP, 2011).

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Executive Summary

The Barrier Analysis and Enabling Framework (BAEF) is the second step in the Technology Needs Assessment (TNA) process, following TNA Report I, which identified and prioritized climate change mitigation technologies in Lesotho's Energy and Agriculture, Forestry and Other Land Use (AFOLU) sectors. This report identifies the critical barriers that could hinder the acquisition, deployment, and diffusion of the prioritized technologies, and outlines measures to overcome these barriers. Additionally, it provides an enabling framework for successfully implementing these technologies.

The BAEF process utilized a participatory and consultative approach to ensure thorough and pertinent results. It also made use of institutional arrangements for the TNA, including a National Coordinator, Project Steering Committee, and Adaptation and Mitigation working groups.

This report defines a barrier as "*a reason why a target is adversely affected, including any failed or missing countermeasures that could or should have prevented the undesired effect(s)*" (Nygaard and Hansen, 2015). The barriers examined included economic and non-economic factors such as institutional capacity, human resources, socio-cultural propensities, environmental concerns, and information and awareness. The Barrier Analysis was used as a rapid assessment tool to identify causes hindering the achievement of the desired effect.

The energy balance of Lesotho is characterized by a huge dependence on biomass in rural areas, that is mainly used for cooking and space heating. According to the 2017 Household Energy Consumption Survey, approximately 62% of households used biomass in the summer and 65% in the winter. Fuel wood is the most commonly used biomass, followed by animal dung and shrubs (Bureau of Statistics, 2017a). The overwhelming reliance of rural households on biomass fuels places tremendous pressure on the forest resource and contributes to environmental degradation and health issues from indoor pollution. Furthermore, access to electricity in Lesotho is low, with only 50.38% of the population connected, despite recent considerable growth. This figure drops to under 40% in rural areas, hindering socio-economic development, particularly in education, health, and economic sectors (ESMAP, 2023).

In the light of this context and following a consultative process, the initial stage of the Technology Needs Assessment (TNA) identified the following three technologies as priorities for climate mitigation in the Energy sector, in line with Lesotho's recently revised draft NDC 2023. This prioritization was determined through a multi-criteria analysis (MCA) undertaken in initial step of the TNA process.

1) **Clean and Efficient Cookstoves,**
2) **Energy-Efficient Lighting and Appliances, and**
3) **Energy Efficiency and Conservation in Buildings (Residential, Institutional and Commercial)**

Although the ranking is done on a national level, the choice of technology would be based on location, as specific areas may offer better benefits for certain technologies.

However, during the barrier analysis and enabling framework, in consultation with key stakeholders, the National TNA Project Steering Committee, it was determined that there is insufficient information in the national context to thoroughly analyse ***Energy Efficiency and Conservation in Buildings*** technology. It was also acknowledged that this technology currently faces insurmountable barriers in the country. Additionally, it was noted that there are some commonalities between ***Energy Efficiency***

and Conservation in Buildings and ***Energy-Efficient Lighting and Appliances***, which could be integrated into the latter.

Therefore, stakeholders decided to include **Solar PV Minigrids** as the priority technology to analyse barriers that prevent its wide-scale transfer and diffusion. This decision was arrived at on the understanding that, despite being a mature technology with several government initiatives, solar PV minigrids still faces numerous challenges in Lesotho, unlike the ***Energy Efficiency and Conservation in Buildings*** technology that has not yet been implemented in the country. Additionally, stakeholders acknowledged that Lesotho does not have sufficient domestic generation capacity to meet peak demand and relies on imports to bridge the supply gap. They also noted that the electricity supply gap is likely to increase as the Government electrifies the population and exploits new diamond mines and manufacturing sectors, further weakening Lesotho's security of supply. Initially, during the technology identification and prioritization step, stakeholders had ranked solar PV minigrid as the sixth priority technology.

It is important to emphasise that there was a consensus to exclude the 4th and 5th ranked technologies, **Solar Water Heater (Residential)** and **Waste to Energy (WtE)** Technologies, from the analysis. The AFOLU sector contributes significantly to the national economy and livelihoods. Livelihoods of approximately 80% of the population in Lesotho depend on subsistence agriculture and 75% of the total national land is suitable for agricultural production especially livestock. However, the topography and geographic location of the country makes it vulnerable to soil erosion, land degradation, high climate variability and poor crop production. Highlands represent two-thirds of the country's land and can primarily support livestock production. The remaining fraction of land is classified as Lowlands that accommodate majority of the 2.2 million human population and croplands. Technologies used in the AFOLU sector are outdated traditional techniques that result in low yields, poor farm and land management practices. Agriculture's contribution to national gross domestic product (GDP) dropped from 80% in the 1960s to the current average of 5%. Despite these challenges, agriculture is a pillar of rural livelihoods in the country.

For the AFOLU sector, BAEF assessment was done for two technologies, which are **Small-scale biogas and homestead vegetable production in a mixed (crop and livestock) agricultural system** and **Carbon sequestration through agroforestry systems** of the prioritized list of the TNA. Barrier analysis for the second priority (**Promotion of conservation agriculture (minimum tillage, mulching, retaining of crop residues)**) in the AFOLU sector (i.e., **Promotion of conservation agriculture (minimum tillage, mulching, retaining of crop residues))** was not done. It was discovered that both adaptation and mitigation TNA reports identified conservation agriculture as a priority and it was therefore recommended that BAEF for this priority be done in either of the two analysis. Since adaptation is considered more important for Lesotho (due to its vulnerability to climate change), it was decided that BAEF analysis for this priority be conducted under adaptation document. The implementation of these technologies can reduce bottlenecks that currently hinder sustainable effective agriculture in the country.

The prioritized technologies in the AFOLU sector are not completely new to the country. There are isolated and not so well documented units of biogas digester technologies that are connected to dry toilets and kitchen facilities in various mass institutions and households in the country. Agroforestry systems are currently promoted in the country to achieve multiple benefits that include increasing forest and overall land cover in the country, improving food security through production of fruits and vegetables, and addressing climate change mitigation by growing carbon sinks.

The barrier analysis process has three main objectives:

1) Identifying barriers that hinder the acquisition, transfer, and diffusion of technologies, including failed measures that could have sustained diffusion.
2) Understanding the nature of individual barriers and any relationships among them to determine critical barriers and those that are easier to remove.
3) Identifying potential measures to address the critical barriers that have been identified.

The methodology for this process involved a comprehensive review of key policy papers, sectoral reports, and relevant literature by the TNA lead mitigation consultant. This review was complemented by interviews with experts, project developers and key stakeholders. The process was further enhanced by the use of Logical Problem Analysis (LPA) and the problem and objective tree tool to identify and analyse the barriers for each technology, and determine appropriate measures to overcome them. As a result, the identified barriers were categorized into two main groups: economic and financial barriers, and non-economic and financial barriers. The non-economic and financial barriers were further examined and broken down into sub-categories in consultation with stakeholders.

The report includes problem trees for prioritized technologies, showing the main problem and causal-effect relationships (refer to Annex I). It also includes **market maps** for these technologies, showing market actors, enabling framework, and inputs/support services (refer to Annex I). These were developed during the Barrier Analysis and Enabling Framework (BAEF) stakeholders' consultations. The list of stakeholders consulted in identifying barriers and developing the enabling framework is provided (refer to Annex II).

The final section of this report examines the links between the common barriers encountered by the three prioritized technologies in the energy sector and the proposed enabling frameworks for overcoming these barriers. There are numerous parallels in the barriers and measures identified across the technologies. Stakeholders have identified the prioritization of strengthening national institutions through policy definition and the appointment of leading institutions within the government. Likewise, financing and training issues are seen as crucial for the effective adoption of the various technologies.

Below are the barriers that impede the diffusion of the three prioritized technologies and the proposed enabling framework. These barriers are presented at two levels: first, the common barriers and then the technology-specific ones. The responsible entities and parties for implementing the enabling framework are also included.

Common barriers and proposed enabling framework for prioritized technologies in the Energy and AFOLU sectors.

Barrier category	All three prioritized technologies faced common barriers	Identified Enabling Measures	Responsibility
Financial barriers	High upfront costs and insufficient access to financial resources	• Funding is essential throughout the supply chain, and any delays or lack of funding can disrupt the entire process. There are various crucial investment requirements for manufacturers of low-carbon technologies, including capital expenditures for machinery, facilities, logistics, and more.	Ministry of Finance and Development Planning; Ministry of Energy; Ministry of Environment and Forestry; Revenue Services Lesotho; Ministry of Agriculture, Food Security and Nutrition

		• Consumer financing can have a significant impact on the willingness to pay for and adoption of low-carbon technologies. It is crucial to find creative ways to incorporate financing choices into both new and established low-carbon programs. • Develop appropriate subsidies or grants to reduce the initial cost and support public-private partnerships and grant-based funding to lower capital risk • Develop innovative financing schemes such as revolving funds; design strategies to reduce investment costs for renewable energy technology projects for developers and investors by offering direct subsidies, tax breaks, feed-in tariff systems, green certificate schemes. Seek international support for climate financing	
	Lack of Affordable Financing Strategy	• Encourage the utilization of electricity for income-generating activities. • Improve partnerships with local microfinance institutions to provide potential investors and users with affordable loans to finance all the technologies. • Capitalize the Energy Fund and make it operational to provide financial support, capital subsidies, and production-based subsidies to investors, suppliers, dealers and consumers. • Improve public private partnerships to increase participation of private sector investments.	Ministry of Finance and Development Planning; Ministry of Energy; Ministry of Environment and Forestry; Microfinance institutions; Private actors
	Limited capacity and willingness to pay for technologies by end-users	• Develop financial models that consider both affordability and willingness to pay. • Facilitate bulk Purchasing and Distribution • Limited demand for productive activities in rural areas	Ministry of Finance and Development Planning; Ministry of Environment and Forestry; Civil Society Organizations; private Actors

	Economic Risk Perception	• Awareness to private sector and communities. • Facilitate the development of distribution infrastructure networks.	Ministry of Environment and Forestry; Civil Society Organizations,
Social, Cultural and Behavioral Barriers	Awareness and Perception Social cultural preferences / biases; low women participation in the sector	• Consistent information, Technology awareness and education programme targeted at different stakeholders • Encourage the active participation of women in the management, development, operations, installations, engineering, procurement, construction, maintenance, and repair of renewable energy technologies by offering incentives. • Implement policies to ensure gender inclusiveness in the energy sector • Engage in thorough stakeholder consultations before, during, and after the development of Res, and maintain ongoing engagement with stakeholders after the projects are completed.	Ministry of Environment and Forestry; Civil Society Organizations s; Ministry of Gender, Youth and Social Development
Technical Barriers	• Insufficiently trained local technical expertise to install, operate and maintain renewable energy projects • Limited skilled personnel and relevant training to develop the necessary skills	• Establish training and accreditation centres to provide training and accreditation for human resource in the renewable energy sector • Establish quality assurance standards, and set up Renewable Energy demonstration sites in communities • Create a technology transfer initiative to boost the demand for productive use; establish a trained workforce to install, operate, and maintain renewable energy technologies.	Ministry of Environment and Forestry; Ministry of Energy; Technical and Vocational Education and Training; Universities
Information and Awareness	• Insufficient and limited sharing of information about technologies among stakeholders at the local and national levels • Lack of awareness by population on the link between climate change and technology	• Intensify dissemination of adequate information, public education and awareness campaigns through a variety of channels including print, electronic and social media. Additionally, organise seminars, workshops, conferences and other events	Ministry of Environment Forestry; Ministry of Energy; Technical and Vocational Education and Training; Ministry of Education and Training; Ministry

		to continue educating the public. • Enhance local capabilities and involvement of the community to enhance positive socio-economic effects and raise awareness about the advantages of renewable energy among consumers. • Capacitate co-operatives and farmer associations	of Small Business Development, Co-operatives and Marketing; Renewable Energy Associations; Farmer Associations
Institutional and Regulatory Barriers	• Insufficient legal, regulatory and institutional framework; • Absence of renewable energy policy, strategy and action plan • Lack of differential tariffs to encourage the use of highly efficient and renewable energy technologies • Inadequate regulations for importing new renewable energy and energy efficient technologies • Lack of reforms of land tenure system	• Develop and establish clear and appropriate regulatory guidelines for renewable energy projects, off-grid and minigrids systems, energy efficient lighting and appliances to ensure their efficient and effective functioning. • Promote institutional strengthening and the development of codes and standards, as well as the establishment of an institutional framework to enforce them. • Enhance the private sector's capacity for self-regulation through relevant industry associations. • Establish an official coordination channel between the line ministries • Create Public Private Partnership to foster collaboration between key stakeholders and the market • Reform land management and ownership	Ministry of Environment and Forestry; Ministry of Energy; Ministry of Local Government, Chieftainship, Home Affairs and Police; Ministry of Law and Justice; Ministry of Agriculture, Food Security and Nutrition

The market in Lesotho typically adopts technology from outside sources, making it a technology taker influenced by external market factors. The cost of technology on the international market is a significant external factor. Additionally, the small size of the Lesotho market results in a lack of economies of scale, creating barriers for most of the technologies being considered. To overcome these barriers, a coordinated and unified strategy is necessary. This strategy should consider the connections between the various barriers and how addressing one barrier can help overcome others. Implementing measures such as financial incentives, awareness campaigns, regulatory reforms, capacity building initiatives, gender inclusion strategies, and quality assurance mechanisms will be crucial to encourage the uptake of priority technologies in Lesotho.

Chapter 1: Energy Sector

After identifying and prioritizing technologies through country-led participatory processes that can contribute to Lesotho's mitigation goals while aligning with national sustainable development goals and priorities, this section focuses on identifying barriers that hinder the acquisition, deployment, and diffusion of these prioritized technologies. It also aims to specify activities and enabling frameworks to facilitate the transfer, adoption, and diffusion of these selected technologies in Lesotho. The identified technologies must align with the country's priorities, which include poverty alleviation, job creation, and social and economic development.

The breakdown of energy consumption in Lesotho by different sources is depicted in **Figure 1(a, b)** for the reference year 2017 (United Nations, 2019). **Figure 1(a)** shows to the total energy consumption from all economic sectors (manufacturing, construction, mining, transport, agriculture, commerce, public institutions and households). It is evident that electricity accounts for only 5% of the total energy consumption in Lesotho, whereas the main contributors to the energy balance are coal (*essentially used by manufacturing and mining sectors*), oil (*all oil-derived fuels and products as gasoline, LPG, paraffin, etc*.) and biomass (*fuelwood, shrubs, crop waste and animal dung*). **Figure 1(b)** illustrates to energy consumed by households only, also in this case electricity accounts just for a little part of energy consumption, while the energy balance is by far dominated by biomass, essentially used for heating and cooking (*along with charcoal and LPG*), whereas paraffin and candles overall represent the main energy sources for lighting (Bureau of Statistics, 2017b).

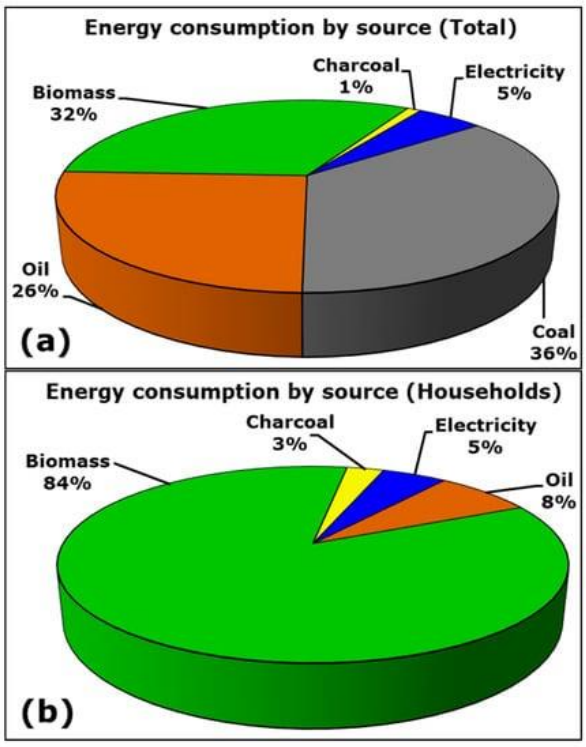

Figure 1: Distribution of energy consumption by source in Lesotho in 2017: (a) total consumption; (b) consumption for households' needs only (United Nations, 2020).

The majority of the population in Lesotho is lives in rural area and has limited access to the electricity grid. Consequently, they depend on traditional biomass for basic household energy needs, which leads to environmental degradation and exposure to household air pollution. Lesotho has a low overall electricity access rate of approximately 50% of the population. This figure drops to under 40% in rural areas, compared to 80% in urban areas, hindering socioeconomic development, particularly in education, health and rural economic sectors. Firewood is a very important source of energy in Lesotho. Despite the increase in electrification rates and the introduction of Lifeline tariffs (LEWA, 2018), many rural households continue to use fuelwood for thermal purposes, especially cooking and heating, due to various reasons, with income poverty being a significant factor. Additionally, fuelwood is widely used in both formal and informal urban and peri-urban areas, even though it may not be the primary energy source (Shackleton *et al.*, 2022). Firewood is also utilized in micro and medium enterprises involved in the sale of food, among other activities.

Lesotho's primary sources of electricity are the hydropower stations, 'Muela and Mants'onyane, which produce approximately 72 MW and 2 MW respectively and the Ramarothole Solar Power plant, which produces about 30 MWp. Lesotho's electricity supply has been steadily increasing over the past few decades, rising from around 200 GWh per year in 1990 to 900 GWh per year (UN, 2023b), with an average load of 100 MW and a peak load of 190–200 MW (Bureau of Statistics, 2023). However, the production is not sufficient to meet the ever-growing internal demand, and Lesotho compensates for the deficit by importing electricity from ESKOM (South Africa) and EDM (Electricidade de Moçambique) within the Southern African Power Pool (SAPP).

The Increasing demand for electricity in Lesotho is driven by a growing population with access to electricity, which has risen from 4% in 2000 to 47% in 2018, according to World Bank data. Additionally, other developmental activities with high electricity usage are contributing to this trend. The electricity deficit is expected to continue growing in the near future due to projected population growth, ongoing or planned electrification projects, and the expansion of the mining and other sectors. **Table 1** provides an overview of the energy applications in Lesotho and their respective sources.

Table 1: Overview of energy applications and their respective energy resources in Lesotho.

Sector	Application	Energy Resource Options
Residential	Lighting	Electricity, paraffin, LPG, candles and solar PV
	Cooking	Electricity, LPG, wood fuel, paraffin and coal
	Water heating	Electricity, wood fuel, paraffin, coal and solar
	Space heating/cooling	Electricity, wood fuel, paraffin, coal and LPG
	Refrigeration	Electricity and LPG
	Water pumping	Electricity, wind and solar and human (hand pumps)
Transport	Vehicle motive power	Diesel and petrol
Industry	Motive Power	Electricity
	Lighting	Electricity
	Refrigeration	Electricity
	Process heat	Coal, Heavy Furnace Oil (HFO), LPG and wood residue
	Cooking	Electricity, coal, paraffin, wood fuel and LPG
Commercial	Lighting	Electricity
	Water heating	Electricity and paraffin
	Air Conditioning	Electricity
Agriculture	Water Pumping	Electricity and solar

According to Lesotho's 4th National Greenhouse Gas Inventory 2011 – 2017, the country's emissions from the energy sector were 2 583.6 Gg CO_2e in 2011, and steadily increased to 2 861.2 Gg CO_2e by 2017. The residential sub-sector, particularly the burning of biomass (wood, shrubs, dung and crop residues), **was the largest contributor to Lesotho's energy sector emissions accounting for 1 900.86**

Gg CO_2e, or over 66% of all energy emissions. This high number can be attributed to the heavy reliance on fossil fuels and traditional fuels for basic household activities such as cooking, lighting, and water heating.

Addressing the challenges in the energy sector is essential to improve access to modern energy services and reduce the negative impacts on the climate, environment, and health caused by current energy practices. Investing in clean and renewable energy sources is a significant factor in driving economic growth in Lesotho's NSDP II. Energy also plays a role in enhancing the ability to adapt to and withstand the effects of climate change. Communities with access to energy, especially electricity through grid connection or mini-grids, can use it for income-generating activities to improve their livelihoods.

Meeting the energy shortfall is crucial for Lesotho's economic growth and its efforts to raise levels of human development. Investments in clean and efficient energy technologies will help reverse the trends in deforestation and soil erosion and enable society to heat homes and cook using cleaner, more efficient technologies. Adoption of green technologies will help rebuild Lesotho's natural capital, particularly benefiting poor populations whose livelihoods and food security depend on nature.

The energy sector in Lesotho has been recognized as a key area for technical support as part of the Technology Needs Assessment (TNA) project, primarily because it is the sector with the highest greenhouse gas (GHG) emissions. Using Multi-Criteria Analysis (MCA) tools in a participatory stakeholder process, the top three prioritized technologies for the energy sector have been identified and are listed in **Table 2**.

Table 2: Top three prioritized technologies in the Energy Sector and their categories

No	Prioritized Technology for Energy Sector	Category
1	Clean and Efficient Cooking Technologies	Consumer Goods
2	Energy-Efficient Lighting and Appliances	Consumer Goods
3	Energy Efficiency and Conservation in Buildings	Capital and Consumer Goods

While this ranking is nationwide, it is important to note that the actual technology selection would be location-based, as certain parts of the country may provide greater advantages to particular technologies. However, during the barrier analysis and enabling framework process, in consultation with key stakeholders, the National TNA Project Steering Committee, it was determined that there is insufficient information in the national context to thoroughly analyse **Energy Efficiency and Conservation in Buildings** technology. It was also recognized that this technology currently faces insurmountable economic and non-economic barriers in the country. Furthermore, it was observed that there are some commonalities between **Energy Efficiency and Conservation in Buildings** and **Energy-Efficient Lighting and Appliance**s, which could be integrated into the latter.

Therefore, stakeholders decided to include **solar PV minigrids** as the priority technology to analyse barriers that prevent its wide-scale transfer and diffusion. This decision was arrived at on the understanding that, despite being a mature technology in most Sub-Saharan African countries, substantial interest and initiatives from the private sector and Government in developing utility-scale solar PV, **solar PV minigrids** still face numerous challenges, unlike the **Energy Efficiency and Conservation in Buildings** technology that is not yet tried in the country. Additionally, stakeholders recognized that Lesotho does not have sufficient domestic generation capacity to meet peak demand and currently relies on imports to bridge the electricity supply gap. They also noted that the electricity supply gap is likely to increase as the Government electrifies the population and exploits new diamond mines and industries, further weakening Lesotho's security of supply.

During the initial technology identification and prioritization step, stakeholders had ranked Solar PV Minigrid as the sixth priority technology. It is important to note that there was a consensus to exclude the 4th and 5th ranked technologies, **Solar Water Heater (Residential)** and **Waste to Energy (WtE)** Technologies, from the analysis. This decision was based on the following observations:

Solar Water Heaters (Residential) technology was not considered due to the lack of piped water systems in rural and peri-urban areas where the technology is primarily intended. Many people in these areas do not have running potable water at their homes and rely on communal taps or water from boreholes. In addition, the cost of solar water heaters for rural populations was also a concern, as they are often too expensive for the majority of rural residents. Furthermore, the installation of solar panels on rooftops can be challenging for many roofing structures in these areas, as they were not originally designed to accommodate such devices.

Stakeholders have noted that **Waste-to-Energy (WtE)** technology, also known as **Energy-from-Waste** (EfW), has not been implemented in the country, as well as in many Sub-Saharan African countries. They strongly believe that the current focus should be on reducing overall waste rather than dealing with excess refuse. They are concerned about the expansion of solid waste incineration and fear that it may discourage the development of recycling facilities. Additionally, they believe that the large financial investment in WtE technology does not promote waste reduction, reuse, or recycling. Stakeholders also express concern that the volumes of waste collected in Lesotho's municipalities may be too small to sustain a WtE incineration plant, and they call for further studies on the feasibility of WtE technology. Finally, stakeholders agree that it is more environmentally responsible to invest in processes that align with the **Waste Management Hierarchy**[2], such as a material recovery facility (MRF), which would reduce waste and generate recycled raw materials. They view investment in large-scale waste incineration as a commitment to one of the least desirable alternatives.

Stakeholders agreed to focus on analysing the barriers to the adoption of technologies in the energy sector, considering their immediate importance for climate change mitigation and national development objectives as outlined in the Updated Nationally Determined Contributions (2024) and National Strategic Development Plan II (2022/23 – 2027/28). Thus, the barrier analysis and proposed enabling framework for the Energy Sector will aim to promote the use of **Energy Efficient Cookstoves**, **Solar PV Minigrids systems** and **Energy-Efficient Lighting and Appliances** to reduce greenhouse gas emissions and energy consumption in the residential sector, as well as enhance energy efficiency, increase energy savings and improve socioeconomics.

Recap on Prioritized Technologies for Barrier Analysis and Enabling Framework

Efficient Cooking Technologies are essential for achieving Sustainable Development Goal 7, which focuses on clean and affordable energy, as they have positive impacts on the environment, productivity and public health. In Lesotho, these cookstoves are a transformative technology that addresses the country's reliance on traditional biomass for cooking, reduces environmental damage, health risks, and gender disparities, and mitigates the climate change effects associated with traditional biomass cooking methods. Leading brands in Lesotho, such as SAVE80 and Africa Clean Energy (ACE) One, significantly reduce woody biomass usage, leading to prevention of deforestation, reduction of indoor air pollution, and conservation of resources for rural families and small-scale food entrepreneurs. Adoption of these clean and efficient stoves can also substantially decrease household emissions. The

[2] https://en.wikipedia.org/wiki/Waste_hierarchy

updated draft NDC aims to increase access and adoption of clean and efficient cookstoves to 11.55% penetration, resulting in at least 30 800 cookstoves. While the technology offers a promising alternative to traditional cooking, there are barriers that require necessary enabling frameworks for its deployment.

In rural areas of Lesotho, cooking meals is the main activity that consumes a lot of energy. Most people use firewood and the traditional 3-stone fire method for cooking. Introducing and using clean cooking technology in households could help advance at least five Sustainable Development Goals (SDGs): 3. Good Health and Well-Being; 5. Gender equality; 7. Affordable and Clean Energy; 13. Climate Action; 15. Life on Land. These technologies also have social benefits, especially for women and children who are affected by the use of biomass. Clean and Efficient Cooking Technologies offer an immediate solution and have the potential to reduce health issues caused by indoor pollution from paraffin and biomass cooking, while also helping to reduce greenhouse gas emissions.

Energy-Efficient Lighting and Appliances (Residential and Commercial): The residential sector in Lesotho is responsible for a significant and growing portion of energy and electricity consumption, leading to increased emissions into the atmosphere. This surge in residential energy demand is straining the country's finances and infrastructure. Despite some progress in improving energy efficiency of major domestic appliances and lighting equipment, the addition of new and larger appliances is offsetting these gains. The rapid expansion of ICT and consumer electronics has further increased power demand in the domestic sector, along with the desire for more comfort and larger dwellings. This has not only led to more CO_2 emissions but also put a greater strain on the electricity network, resulting in blackouts and other supply issues. By enhancing the energy efficiency of domestic appliances and lighting, Lesotho can maintain current comfort levels without the need for significant investments in energy and electricity infrastructure, and more importantly, without causing irreversible harm to the environment. Improving energy efficiency in this area offers significant potential for cost-effective solutions for both users and society as a whole.

Lesotho is facing a significant challenge in securing a stable electricity supply, as the demand continues to rise in a supply-constrained environment. Promoting efficient electricity use is crucial for ensuring energy security, which is essential for achieving economic and human development goals as well as the globally agreed SDGs. The use of efficient lighting and appliances will lead to substantial savings in electricity costs. Encouraging consumers to use efficient technologies may require diverse and creative ways of communicating the long-term benefits. Implementing energy efficiency initiatives can yield significant GHG mitigation dividends and are relatively easy to implement, which is crucial for Lesotho's efforts to address its electricity supply challenges and promote sustainable development.

Energy efficiency is often referred to as the "*first fuel"* in clean energy transitions because it offers fast and cost-effective ways to reduce CO_2 emissions, while also reducing energy costs and enhancing energy security. In the Net Zero Emissions by 2050 Scenario, energy efficiency is the most significant measure for reducing energy demand.

Solar PV Minigrids: Mini-grids are small-scale electricity systems that provide power to a localized group of customers independently from the national grid. In remote rural areas with low population density and a large distance to the national grid, solar PV mini-grids are the most cost-effective solution to provide affordable and sustainable energy. These mini-grids can provide uninterrupted renewable electricity to underserved villages and communities in Lesotho, helping to close the energy access gap by 2030 and offer a lower greenhouse gas emission alternative to diesel-fueled systems and kerosene-based appliances, supporting climate action efforts. Minigrids serve remote communities that are not economical to connect to large grids due to their isolation, but they have a sufficient density and diversity of end users so that it makes sense to connect them together rather than supply them all with stand-alone systems.

All three prioritized technologies are considered consumer goods, which are part of the broader category of market goods. Consumer goods technologies are widely distributed in mass markets with extensive supply chains and a large customer base, including households, businesses, and institutions. These goods are specifically purchased by private consumers. The market characteristics of these technologies include:

- A large number of potential consumers
- Interaction with existing markets, requiring distribution, maintenance, and installer networks in the supply chain
- Complex supply chains with multiple actors, including producers, assemblers, importers, wholesalers, retailers, and end consumers
- Potential barriers at every step of the supply chain
- Demand influenced by consumer awareness, preferences, and commercial marketing efforts

This report will start with preliminary targets for technology transfer and diffusion. Then the barriers for the selected technologies and the possible measures to overcome these barriers are identified and analyzed.

1.1 Preliminary targets for technology transfer and diffusion

General Targets

The transfer and diffusion of climate change mitigation technologies in Lesotho are guided by targets identified by the government in several key documents, including the Lesotho Sustainable Energy for All Country Action Agenda (DoE, 2018), the Electrification Master Plan (2018 – 2038) (AETS Consortium, 2018), National Strategic Development Plan II (2022/23 – 2027/28) (Lesotho, 2018), Lesotho Climate Change Policy and Implementation Strategy (MEM, 2017), Lesotho Energy Policy 2015 – 2025 (IEA, 2015), Lesotho's 3rd National Communication (LMS, 2021a) and Lesotho's 1st Biennial Update Report (LMS, 2021b). However, there is some disagreement on specific targets between different documents.

Additionally, Lesotho has mainstreamed the regional and international commitments into its national priorities. These include the 2030 Agenda for Sustainable Development, Agenda 2063, and the SADC Regional Indicative Strategic Development Plan (RISDP). This commitment is facilitated through the National Strategic Development Plan (NSDP II). As a result, the SDG 7–- *ensure access to affordable, reliable, sustainable and modern energy for all*, and SDG 13 - *take urgent action to combat climate change and its impacts*, are relevant.

The key SDG targets for technology transfer and diffusion are shown in below.

Table 3: SDG targets relevant to technology transfer and diffusion in Lesotho

SDG #	Relevant targets to technology transfer and diffusion
7	By 2030, increase substantially the share of renewable energy in the global (Lesotho) energy mix
	By 2030, double the global (Lesotho) rate of improvement in energy efficiency
	By 2030, access to affordable, reliable and modern energy services
13	Improve education, awareness-raising and human and institutional capacity on climate mitigation, [adaptation, impact reduction and early warning].

In the revised NDC, Lesotho specifically commits to unconditionally reduce its GHG emissions in the energy sector by 4.2% (166 $ktCO_2e$) by 2030. Additionally, Lesotho commits to a further reduction of

25.8% (1 017 $ktCO_2e$) by 2030 conditional to timely and adequate international support in the form of finance, investment, technology development and transfer, and capacity building to cover the full cost of implementing the proposed additional mitigation actions. This brings the total emission reduction to 30.1% (1 183 $ktCO_2e$) below BAU by 2030. The strategic objective is to reduce greenhouse gas emissions by scaling up the adoption of energy-efficient cooking technologies, promoting renewable energy sources and improving energy efficiency.

National Energy Policy 2015 – 2025 *policy provides for government to facilitate provision of reliable, stable and equitable electricity services to consumers towards achieving universal access by 2030. The policy does not indicate actual targets per technology but gives planned interventions for each of the three (3) prioritized technologies as thus:*

Specific Targets

The relevant specific targets for technology transfer and diffusion are:

Solar PV Minigrids and Electricity Access

Table 4: Estimated number of Institutions, Households and Commercial Establishments (AETS Consortium, 2018)

Attribute	Total	Electrified	Un-electrified
Households	537 457	~50%	~50%
Businesses (small shops)	10 750	4 300	6 450
Schools	1 452	787	665
Health Facilities	294	230	64
Principal Chief's Offices	22	7	15
Local Courts	33	29	4
Community Council Offices	47	14	33
Other Government Offices	77	16	61
Agricultural Resource Centres	22	8	14
Police Stations	60	41	19
Post Offices	47	40	7
Hostels and Barracks	131	109	22
Guest Houses and Hotels	285	258	27
Churches	1 965	504	940

Table 5: Preliminary targets for the Solar PV Minigrids technology transfer and diffusion

Preliminary targets for Solar PV minigrid	
Target	**30 Identified Potential Mini-Grid Sites:** Installation of around 30 solar PV mini-grids in rural communities with an average capacity of 150 kWp[3] each, which translates to approximately 4.5 MW capacity over a period of 20 year.
Required Investment	The assumption is that three mini-grids are installed every two years and total of 30 minigrids would be installed over 20 years. **Capital costs: USD 3.4 Million** Additional costs: Operations and maintenance, replacement costs and institutions strengthening - **USD 1.2 million** (1.5%) of capital costs per year over a period of 25 years. **Key Assumptions:**

[3] The typical system size assumed for the mini-grid is 150kWp based on the information obtained from different reports such as the 2001 Access Study, the 2007 NEMP and the 2016 UNDP SE4All Project Document.

	• Cost per kWp: USD 1,748[4] Investments will be made in 6 years.
Economic benefits	• Attracting investments into the country. • Job creation for importers, distributors and retailers. • Reduced energy costs. • Income generation and economic growth • Energy independence of local communities
Environmental benefits	• Household Reduction GHG emissions of 10 000 tCO_2e **Assumptions[5]:** The average open fire will emit 1.9 $kgCO_2$ for every kilogram of wood burnt, and an extra 0.07 kg of black carbon (soot). This equates to an average of 28.5 $kgCO_2$ emitted by a single household per day (*calculated at 15 kg of wood per day with an average of 4 people per household*). Reduced air pollution due to replacement of paraffin and diesel
Expected lifetime	The lifetime of solar PV is 25 years (average of 8 sunshine hours per day) The project will be implemented for the next 6 years

Private entities are increasingly interested in building more solar PV power plants to contribute to the national grid, in addition to the planned 4.5 MW. This could lead to an increase in electricity generation, potentially exceeding the country's current consumption. However, there is a growing demand for electricity in the Southern Africa Power Pool. If the country can commit early enough, it would be able to supply the excess electricity to the SAPP. The private sector has also expressed interest in installing large solar PV plants for both local and regional markets. Funding for this investment has already been secured from local financial institutions.

Using the GACMO model, an estimate was made for connecting 134 332 rural and peri-urban households to Solar PV Minigrids. Using Solar PV Minigrids for electricity for lighting, basic cooking, and water heating would result in an estimated CO_2 emissions of 188 $ktCO_2e$ per annum.

- **Energy Policy Statement 10 (*Electricity Connections*): The government aims to ensure more connections and utilization of electricity by end-users.**
- **Energy Policy Statement 4 (*Renewable Energies*): Government will improve access to renewable energy services and technologies.**
- The government's ambitious goal is to achieve 75% electricity access by 2030 using a mix of grid and off-grid solutions. **The Electrification Master Plan (2018) (Off-Grid Time Plan)** details a strategy to connect around 10 663 households to modern off-grid energy solutions and 379 units to mini-grids annually, beginning in 2018 (EMP, 2018).
- The Government of Lesotho, with funding from UNDP/GEF and the World Bank, is currently working on two projects to accelerate sustainable energy development in the country. The first project, "*Development of Cornerstone Public Policies and Institutional Capacities to accelerate Sustainable Energy for All (SE4All) Progress in Lesotho*," aims to establish **10 operational minigrids by 2030** through a private sector model. Preconstruction work is currently underway at 10 sites, although progress is

[4] https://en.wikipedia.org/wiki/Cost_of_electricity_by_source
[5] https://www.sunfire.co.za/solar-cooking-better/

slow. The second project, "*Lesotho Renewable Energy and Energy Access Project (LREEAP),*" aims to establish an additional 20 mini-grids through Public-Private Partnership (PPP). Pre-feasibility and feasibility studies for all 20 sites have been completed, and the **development of minigrids at 10 sites is currently at the pre-tendering stage.**

- In 2021, the Lesotho Government enacted the Mini-Grid Regulations, 2021, which serves as the primary document governing the development of mini-grid electricity generation. These regulations apply to mini-grid plants with a capacity ranging from 0 - 100 kW to 5 MW in Lesotho. The regulations oversee all aspects of mini-grid development in the country.

The main goals of the Minigrid Regulations are to

- Encourage investment in minigrids in Lesotho,
- Streamline the process for private sector involvement in the mini-grid sector of the Lesotho electricity market,
- Expand access to electricity in areas of Lesotho that currently do not have access or are underserved, and
- Promote the use of small-scale renewables, particularly small hydro and solar energy sources.

Table 6: Preliminary targets - Energy Efficient Lighting and Appliances

<table>
<tr><th colspan="2">(a) Preliminary Targets for Light Emitting Diodes (LEDs) Lighting</th></tr>
<tr><td>Primary Target</td><td>50 000 Households; 2 000 Institutional; 4 000 Commercial
Over the course of 2 years, 50 000 LED bulbs will be installed in homes, institutions, and commercial establishments, replacing incandescent light bulbs and Compact Fluorescent Lamps (CFLs). This initiative assumes the installation of 2 LED bulbs per household, 4 LED bulbs per institution, and 3 LED bulbs per commercial establishment. Additionally, the LED bulbs will also serve as replacements for paraffin and candles.</td></tr>
<tr><td>Required Investment</td><td>Minimum of USD 500 000 for purchasing and distributing the bulbs.
Public awareness campaign USD 50 000
Total = USD 550 000</td></tr>
<tr><td>Economic benefits</td><td>• Attracting investments into the country
• Job creation for importers, distributors and retailers
• Reduce electricity imports from South Africa and Mozambique
• For a household, the benefits of using LED lights include longer lifespan of over 10 years and reduced electricity bills, resulting in more disposable income.</td></tr>
<tr><td>Environmental benefits</td><td>
<table>
<tr><th>Lighting Technology (800 Lumens)</th><th>Daily kWh Consumed (@8hr)</th><th>Annual kWh Consumed (@8hr/day)</th><th>CO_2 Produced (Coal Based Power Generation)</th></tr>
<tr><td>Incandescent (60 Watts)</td><td>0.48</td><td>175.2</td><td>152.42 Kg</td></tr>
<tr><td>Halogen (42 Watts)</td><td>0.34</td><td>124.1</td><td>107.96 Kg</td></tr>
<tr><td>CFL (14 Watts)</td><td>0.11</td><td>40.15</td><td>34.93 Kg</td></tr>
<tr><td>LED (9 Watts)</td><td>0.07</td><td>25.55</td><td>22.23 Kg</td></tr>
</table>
• Each LED light saves 91 gCO_2. It takes 11 LEDs to save 1 kgCO_2, and 11 000 LEDs to save 1 tCO_2.
</td></tr>
</table>

Expected lifetime	• LED lights can last up to 100 000 hours, reducing the need for frequent replacements (*based on 8 hrs use per day*) • The project will be implemented for the next 6 years

Furthermore, according to the GACMO model, it was estimated that 64 050 LED bulbs could be implemented to replace kerosene-based lighting, resulting in an estimated reduction of 16.21 $ktCO_2e$ in CO_2 emissions per year. The hourly consumption of kerosene, as reported in the CDM PoA project "PoA 7 489: Project to replace fossil fuel-based lighting with Solar LED lamps in Africa," is 0.077 litres per hour[6].

Presently, there are no exact statistics on how much energy consumption comes from lighting. This creates some difficulties in providing exact estimates on energy savings, particularly for the application of high efficiency lighting systems. However, the following are relevant strategies from the National Energy Policy.

- **Energy Policy Statement 5 (Energy Efficiency in Electricity): Government will promote energy efficient practices and equipment across all sectors of the economy**
    - Introduce a metering system and tariff structure that will support energy efficiency and demand side management.
    - Discourage the use of energy-intensive devices and encourage the adoption of energy efficient technologies.
    - Conduct awareness campaigns on prudent energy usage.
    - Implement energy efficiency programmes in buildings.
    - Introduce incentives to support energy efficiency programmes and initiatives.
    - Support applied research and development in energy efficiency programmes and initiatives.

Table 7: Preliminary targets - Clean and Efficient Cooking Technologies

(b) Preliminary Targets for efficient cookstoves	
Target	Distribution of efficient fuelwood stoves to 10 000 households across the country, including rural and urban households that currently use inefficient traditional biomass. 50% discount/subsidy on wonder-boxes (slow cooker) for 100 000 households
Required Investment	Capital cost A: USD 1.0 million (Cookstoves) Capital cost B: USD 2.5 million (Wonder-boxes) Accompanying stainless pots and cast-iron pots: USD 0.5 million Institutional Strengthening and operations and maintenance costs of USD 0.06 million (1.5%) of capital costs per year over a period of 25 years. **Repair and Maintenance start in 3rd year old stove usage** **Key Assumptions:** Cost of efficient cookstove varies according to design features and materials used. Currently, cost of stainless steel SAVE80 Cookstove is LSL 1 500 (USD 80) depending on the capacity (*with the average lifetime of 20 years the annualized capital cost would be highly reduced*). The accompanying stainless pot and cast-iron pot is selling at LSL 500 (USD 25) each. Wonder-box is sold for LSL 500 (USD 25) each and must be imported. Currently, cost of ACE One Stove is LSL 1 750 (USD 90) depending on the capacity, with free service and maintenance (*terms and conditions will apply*) for every ACE

[6] https://cdm.unfccc.int/ProgrammeOfActivities/poa_db/JQXPWAYMOF6TUSNVZB1EKD8IC3542R/view

	One. ACE One is also sold on a 12-15-month micro-loan (*customers use the energy savings achieved with the product to pay back the investment*).
Economic benefits	Job creation for those involved in the construction of the cook stoves, suppliers of raw materials and tools; and providers of after sales services. Where the manufacturing and back-up services are local, there are jobs generated. Increased establishment of businesses engaged in efficient cook stoves construction. Fuel savings are both the most achievable and the most tangible benefit of clean and improved cooking solutions. Savings on cooking fuel by households (*An average household of 4 typically spends **LSL 514 per month on average in off-grid areas for cooking and heating***)
Environmental benefits	• Reduced deforestation given that households use less firewood for more cooking. • **10 000 Efficient Cookstoves**: *Reduced GHG emissions of 33 812 tO_2e per annum* • 50% Subsidy of 100 000 slow-cookers (wonder-boxes): *Reduced GHG emissions of 66 600 tCO_2e per annum* • Total = 100 413 tCO_2e per annum
Expected lifetime	8 - 10 years

Furthermore, current methods suggest that environmentally friendly and effective stoves have the potential to reduce carbon dioxide emissions by 1-3 tonnes per stove annually, with 1-2 tonnes being the typical amount. By applying the GACMO model, it was projected that the deployment of 30 800 efficient cookstoves in both urban and rural regions of Lesotho could lead to an annual reduction of approximately 83.16 $ktCO_2e$ (USAID, 2017).

- **Policy Statement 3 (Bioenergy):** ***Government will ensure sustainable supply of bioenergy resources.***
    - *Reduce pressure on biomass energy resources through fuel substitution and application of energy efficient cookstoves;*
- Lesotho's revised draft NDC 2023 aims to enhance access to clean and efficient cookstoves by distributing 30 800 improved cookstoves between 2025 and 2030. Currently, there is no accurate data on the total number of efficient wood stoves in use or the types of stoves used by the population. Therefore, the NDC's preliminary target will be used as a more realistic estimate. It is expected that this number will increase in the future as barriers to adoption are eliminated.
- Lesotho's specific NAMA on **"Scaling up Dissemination of Efficient Cookers", *with the slogan*** "*No one's life should be limited by how they cook*" aims to distribute efficient fuel wood stoves to 10 000 households nationwide by 2030, including both rural and urban households that currently use inefficient traditional biomass. The initiative also aims to provide a 50% subsidy towards the purchase of Industrial Quality Expanded Polypropylene (EPP) slow-cookers (commonly known as Wonder-box) for 100 000 households, with an anticipated GHG emissions reduction of about 100 413 tCO_2e per annum. The Efficient Stoves NAMA serves as a platform to coordinate and define current and future initiatives for efficient stoves in Lesotho. One of the major challenges facing the "Scaling up the Dissemination of Efficient Cookers" NAMA will be the creation of synergies between multiple initiatives and coordinating actors and various efficient stoves programs. To address this challenge, the proposal is to establish a National Forum that will facilitate coordination among different participants in the NAMA. The NAMA also considers the implementation of a capacity transfer program, as well as the

construction and distribution of efficient wood stoves from different suppliers. Additionally, the NAMA aims to define financing mechanisms to support its objectives.

In order for the country to achieve these preliminary targets of transferring and diffusing technologies in the energy sector, it is imperative for key stakeholders such as **Lesotho Electricity and Water Authority** (**LEWA**), Ministry of Energy, Lesotho Electricity Company (LEC), Ministry of Finance and Development Planning (MFDP), Ministry of Gender, non-governmental organizations (NGOs), and civil society to be actively involved and play an enhanced role in the successful implementation of these technologies. Other important players in the energy sector include consumers, builders, installers, architects, technicians, renewable energy experts, consultants, donor partners, independent power producers (IPPs), financial institutions, suppliers and dealers of relevant equipment, women advocacy groups, local government administration, youth and community leaders.

1.2 Barrier analysis and possible enabling measures Efficient Cookstoves

The barrier analysis and enabling framework process followed the TNA guidebook "Overcoming Barriers to the Transfer and Diffusion of Climate Technologies," which provided instructions on assessing the barriers to identified technologies in the countries concerned and on addressing and overcoming these barriers through various measures (Nygaard & Hansen, 2015).

To begin, the TNA lead mitigation consultant conducted a desk study of key policy papers, reports, and other relevant documents to determine why the three identified technologies were not widely used in the country and why there was limited investment from both the private and public sectors. The desk study was supplemented by interviews with experts and key stakeholders.

The increasing use of fuelwood by households in Lesotho for energy and income is putting significant strain on the surrounding forests and woodlands, leading to deforestation and negative climate impacts. This issue is exacerbated by the lack of regulated access to forest areas and inadequate management and coordination between local and traditional governance. While fuelwood is an important part of rural Basotho life, there is a lack of awareness about the consequences of its consumption. Additionally, deforestation is forcing households to travel farther to gather the fuelwood they require.

1.2.1 General Description of Efficient Cookstoves

Efficient stoves, also known as "improved stoves", have been specifically designed to address several environmental and health concerns. These stoves aim to reduce deforestation, lower greenhouse gas emissions from wood consumption and burning, and improve the overall quality of life for people by reducing health risks and the time spent collecting firewood. Various types of efficient stoves have been developed, each tailored to meet specific objectives and taking into consideration the cultural traditions of the communities that use them. The most common designs have improved combustion chambers that reduce fuel usage and harmful emissions by increasing combustion efficiency and transferring heat to the cooking device more effectively. These cookstoves can run on a variety of fuels, such as sustainably harvested wood, charcoal, and pellets, depending on the specific design.

The current focus on improved cook stoves (ICS) is on the multiple benefits they provide. These include improved health and time savings for households, preservation of forests and associated ecosystem services, reduction of emissions contributing to global climate change, and empowerment of women

and cost savings for consumers. Despite the numerous benefits of improved cook stove programs, progress in achieving widespread adoption and use has been slow.

Highly efficient cookstoves are not currently widely manufactured in Lesotho. However, there are two organizations and companies working to promote and implement them. The ACE One Ultra-Clean Biomass Cookstove, manufactured by African Clean Energy (ACE), and the SAVE80 Cookstoves, locally assembled by Solar Lights Ltd (Pty), are the most popular and highest efficiency cookstove available on the market.

The SAVE80 Cookstoves are made in Germany and then assembled in Lesotho by Solar Lights (Pty) Ltd. According to the manufacturer, each stove saves around 2 to 2.5 tCO_2 per year, which is more than the emissions produced by a mid-size car driven 10 000 kilometres per year[7,8]. The SAVE80 set reduce wood usage by 80% compared to open fire, leading to an 80% reduction in CO_2 emissions. The average CO_2 reduction per household (through daily use) for cooking and water boiling is approximately 2.8 tCO_2 annually. Over a 20-year lifespan, a SAVE80 Stove Cooking Set saves over 50 tCO_2.

Figure 2: SAVE80 Cookstove and Industrial Quality Expanded Polypropylene (EPP) slow-cooker (commonly known as Wonder-box)

ACE One Cookstoves, produced by African Clean Energy (ACE) in Lesotho (**Figure 3**), are clean cookstoves alternatives that can burn a wide range of solid biomass. The gasifier technology of ACE-1 allows for more complete fuel combustion, resulting in lower emissions and reduced fuel consumption compared to traditional stoves. Users can cook with 50-85% less fuel compared to traditional cookstoves, leading to significant cost savings, lest time spent gathering fuel, and helping to mitigate deforestation in Lesotho. The ACE-1 burns biomass fuels without producing smoke, reducing CO_2 and fine particulate matter (PM2.5) emissions by up to 95% compared to an open fire. Conservatively calculated, one ACE1 clean cooking stove reduces **10 tCO_2 over 8 years.** These health benefits, along with fuel and time savings, help reduce gender inequalities, improve lives, and preserve forests.

[7] https://www.atmosfair.de/en/climate-protection-projects/energy_efficiency/lesotho/
[8] https://cdm.unfccc.int/Projects/DB/RWTUV1323354971.78/view?cp=2

Figure 3: ACE One Cookstove and biomass fuel cut into pieces that can fit into the chamber

The Government of Lesotho, through its research and development centre, Appropriate Technologies Services (ATS), is also working on developing affordable and efficient cook stoves that can also be used for space heating. ATS is also focused on developing other energy-efficient household technologies, such as solar fruit and vegetable driers, commercial-scale solar box cookers, and solar hot water collectors.

In summary, the implementation of improved cookstoves offers several benefits, including:

- Reduced demand for biomass, leading to a decrease in deforestation associated with firewood consumption.
- Improved air quality is achieved through the reduction of emissions of soot particles (black carbon) and smoke.
- Reduction in GHG emissions (CO_2, CH_4 and N_2O), as well as s decrease in respiratory diseases.
- Reduction in fuel needs associated with firewood collection.
- Creation of new jobs opportunities in the production, sales, marketing and distribution of efficient stoves.

1.2.2 Identification of Barriers for Efficient Cookstoves

Identifying barriers entails recognizing the obstacles that impede the transfer and spread of technology. This includes pinpointing the most significant barriers and identifying the easiest barriers to eliminate. The process also involves identifying any unsuccessful or absent measures that could have supported the diffusion of the technology. To initiate the process, the TNA national mitigation consultant conducted a comprehensive review of policy papers, energy sector reports, feasibility studies, and other pertinent documents to identify the primary reasons for the limited implementation of the technology and the lack of significant investments in clean and efficient cookstoves projects by both the private and public sectors.

This was followed by a series of technical working sessions and interviews with experts and key stakeholders from various governmental agencies, ministries, civil society, and the private sector to ensure a successful process.

During the stakeholder consultation, **Market Mapping** was carried out to help choose barriers and measures. The market maps for different mitigation technologies can be found in Annex I. Additionally, the **Logical Framework Approach**, using the problem and objective tree tool, was employed to analyze the barriers for each technology and to propose measures to address them. The identified barriers were categorized into **Economic and Financial** barriers, as well as **Non-economic and**

Financial barriers. The Non-economic and Financial barriers category was further examined and broken down into subcategories in collaboration with stakeholders.

The starter problem is **low adoption of clean and efficient cookstoves in communities**.

The main barriers:

- High upfront costs of improved stoves
- Social culture and behavioural
- Poor market infrastructure
- Inadequate information
- Absence of a robust and updated national policy and regulatory framework

The root-cause of some barriers is the low affordability of the device for consumers, consumer preferences, social biases and traditions, a lack of a coordinated marketing strategy, and insufficient information and awareness about improved stoves and their accessibility.

Table 8: Summary of the decomposition of identified barriers to the transfer and diffusion of improved cookstoves in Lesotho.

Summary of the decomposition of identified barriers to the transfer and diffusion of improved cookstoves in Lesotho.		
Category	**Barrier**	**Elements contributing to barrier**
Economic and Financial	High upfront costs of Improved stoves	Most end users cannot afford to purchase improved cooking stoves because they are much more expensive than traditional stoves.
Social, culture and behavioral	Social, culture and behavioral biases	Social and cultural norms and biases influence the preference for traditional stoves due to their lower cost, as well as consumer habits and traditions.
Market failure/imperfection	Poor market infrastructure for marketing of improved stoves	Lack of a coordinated marketing program to develop an awareness and information campaign.
Information and awareness	Inadequate information on improved stoves	Lack of market information on improved stoves due to limited awareness of their availability and usage. There is also a lack of awareness about the health impacts of using traditional stoves, such as respiratory diseases and eye irritation.
Institutional-Regulatory Barriers (*Policy, legal and regulatory*)	Lack of Policy Support: no targeted and comprehensive wood biomass policy; weak Institutional Capacity	The absence of a comprehensive national strategy focused on improved stoves and biomass energy.

1.2.2.1 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 Lesotho. These barriers occur at various levels, affecting both the supply and demand sides of the market. **Improved cookstoves are considered expensive and unaffordable by the majority of rural population. Most households need assistance in financing for stoves while manufacturers want more creative payment options, which would enhance affordability and improve repayment.**

Table 9: Economic and financial barriers and their description for clean and efficient cookstoves.

Barriers	Barrier Description
High upfront costs of improved stoves and Absence of Subsidies	• The high initial up-front capital cost is one of the most significant barriers hampering the widespread diffusion of improved cookstoves in Lesotho, making affordability a major barrier for many consumers in poor peri-urban and rural communities, as well as for manufacturers. • The price of a traditional cast iron 3-legged black pot ranges from LSL 250 (USD 20) to LSL 2 000 (USD 130) depending on its size and capacity. The cost of an efficient cook stove varies based on its design features and the materials used. The SAVE80 Stove can cost up to LSL 1 200 (USD 80) depending on its capacity, while the ACE One Stove can cost up to LSL 1 750 (USD 117). **This is a significant investment and without financing, it is not affordable for the majority of poor rural people in a country** where estimates for 2022 suggest that 32.4% of the population is still living below the USD 2.15 poverty line[9]. Most rural areas in Lesotho consist of very poor population with low ability and willingness to pay for the connection and operation fees. • Improved cookstoves in Lesotho primarily target rural and peri-urban households that are not connected to the national grid and do not have a sustainable or reliable source of electricity. These household have limited saving potential, and often do not have access to financial services, such as loans from banks to acquire improved cookstoves. • Many of the rural population in Lesotho are unable to afford Improved Cookstoves without subsidies from NGOs, bilateral and multilateral donor agencies. Additionally, most consumers do not have access to affordable financing options to cover the initial cost of the stove. Default and delinquency rates are often high for the rural poor, who have limited disposable income for energy expenses. ○ *The government offers incentives to encourage rural households to use electricity through pro-poor electricity tariffs in the fight against poverty. However, these incentives and subsidies are not available for Improved Cookstove projects, which is a significant barrier to their adoption in the country*. Shifting these incentives and subsidies from electricity to Improved Cookstove projects could help to accelerate their growth and adoption in Lesotho.
Limited access to finance and long term capital	Banks and other financial institutions are anticipated to have a vital role in the spread and advancement of Improved Cookstoves technology in the country. The Improved Cookstoves supplier/dealer lacks the necessary working capital to provide credit to the end-user and relies on banks to bridge this gap. However, these commercial banks and other financial institutions are reluctant to provide long-term loan facilities to the low-income population in rural areas due to concerns about credit risk, lack of collateral, and the uncertain legal status of the market segment for Improved Cookstoves.
Limited Return on Investment for Manufacturers and Distributors:	The high costs of production and distribution, combined with the large rural areas and low consumer purchasing power, are hindering the profitability of clean and efficient cookstove businesses in the country. This is discouraging potential manufacturers and distributors. The private sector believes that the local market is already saturated with low-priced, traditional stoves, leaving little space for efficient models. Additionally, the absence of established supply chains for clean cookstoves is leading to higher costs and inefficiencies, reducing the availability and accessibility of these stoves in the market, especially in rural areas.
Economic Risk Perception	Consumers frequently perceive clean and efficient cookstoves as risky investments due to uncertainties about their performance, durability, and maintenance costs. To tackle this issue, it is essential to implement targeted campaigns and raise public awareness about the potential cost savings for

[9] https://www.worldbank.org/en/country/lesotho/overview

	consumers and the profitability of businesses involved in clean and efficient cookstoves.

1.2.2.2 Non-Financial Barriers

Aside from economic and financial obstacles, there are also non-monetary barriers that are greatly impeding the widespread use of clean and efficient cookstoves in Lesotho. These barriers can be categorized as social-cultural, technical, and institutional-regulatory.

Social, culture and behavioral Social-Cultural Barriers:

- **Awareness and Perception**: The lack of awareness and traditional perceptions are major barriers to the widespread adoption of clean and efficient cookstoves in Lesotho. Many potential consumers in poor peri-urban and rural communities are not fully informed about the health, economic, and environmental benefits of using clean and efficient cookstoves. They do not grasp the long-term savings, reduced pollution, and health advantages. Improved Cookstove technologies are viewed as complicated and difficult to use compared to traditional cooking methods. Furthermore, many do not realize that fuel savings can be a source of income.
- **Cultural Preferences**: Traditional cooking methods and food flavours are ingrained in Lesotho culture. Some women are hesitant to alter their cooking techniques because they believe there is a difference in taste or cooking experience when using clean and efficient cookstoves. They feel that efficient cookstoves are only suitable for small families, while traditional stoves are necessary for larger households and events, and therefore see no reason to make a change. Others view traditional stoves, as more durable and easier to repair compared to modern cookstoves, which may require specific parts or expertise.
- **Mistrust of technology due to bad experiences:** Often, technology adoption is not thoroughly researched, resulting in a focus on distributing cookstoves without adequate follow-up on their maintenance. When cookstoves malfunction and are not promptly repaired, it creates a negative perception of the system. This negative perception spreads among users, causing them to reject the technology when recommending it to others. Furthermore, damaged or improperly installed cookstoves are frequently sold or kept as decorations, causing users to revert to traditional cookers.

Technical Barriers:

- **Lack of Skills and Technical Know-How:** Introducing and deploying clean and efficient cookstoves in Lesotho, as in many African countries, faces a significant barrier due to a skills gap and limited technical know-how. This affects not only end-users but also the entire value chain, from manufacturers to distributors. Many consumers and suppliers lack the necessary skills and technical knowledge to install, use, and maintain clean and efficient cookstoves, leading to a lack of trust in the technology and lower adoption rates. The production and maintenance of these cookstoves require specific technical skills, and there is a lack of sustained programs to equip locals with the necessary skills. Additionally, a lack of local Research and Development capacity hinders the development of contextually relevant and innovative solutions. The lack of skills and technical expertise hampers the widespread adoption and sustainable use of clean cookstoves, leading to over-reliance on external entities and limiting the growth of a self-sustaining market ecosystem around clean and efficient cooking in Lesotho.

- **Performance and Quality Concerns:** Consumers are worried about the quality of clean cookstoves in the market due to the lack of nationally recognized standards. Clear standards and designs tailored to local markets are needed to prevent the country from becoming a dumping ground for low-quality, non-performing cookstoves.

Institutional-Regulatory Barriers:

- **Lack of Policy Support:** Lesotho has implemented policies that support the deployment of renewable energy technologies, such as the **National Energy Policy 2015 – 2025, National Climate Change Policy and Implementation Strategy 2017**, Updated NDC 2024 and the **National Strategic Development Plan (NSDP II), 2023 - 2028**. However, the country lacks specific policies or incentives to encourage the widespread adoption of clean and efficient cookstoves. The current energy policy prioritizes petroleum and electricity over other sources of energy.
- **Weak Institutional Capacity:** The existing institutional setup is not sufficient to support the sustainable development of biomass energy and clean cookstoves. Ineffective institutional structures, lack of coordination among stakeholders and government agencies, and the absence of a dedicated agency for promoting biomass energy all hinder the effective promotion, distribution, and adoption of clean and efficient cookstoves. Additionally, there is no clear institutional mandate for efficient cookstoves, resulting in a lack of targeted interventions to support their widespread deployment.
- **Absence of a comprehensive inventory of experiences hinders access to information and data**: Without a specific coordinating institution for project initiatives, there is no centralized repository for information on all ongoing projects, making it inaccessible to the public. Consequently, valuable experience is often duplicated or lost.

1.2.3 Identified Measures

Efficient cookstoves have been used in Lesotho for a while, but most of the efforts to promote and distribute this technology are funded by donors. Despite their potential to address indoor air pollution, gender inequality, and climate goals, they have not been widely adopted.[10] To fully realise their benefits and integrate them into households, it is necessary to implement financial incentives, awareness campaigns, policy support, and technological innovations in Lesotho. The barriers and measures to overcome them were identified through a review of energy sector reports, meetings with Ministry of Energy officials, conversations with dealers, and stakeholder discussions. The logical problem analysis, with inputs from expert groups, and results are shown in Annex I.

1.2.3.1 Economic and Financial Measures: Clean and Efficient Cookstoves

Favourable financing and fiscal policy

In order to establish an appropriate financing and fiscal policy to enable increased demand and uptake of the efficient cook stoves, there is need for Government to:

[10] https://www.wame2030.org/project/996/

- Introduce innovative financing methods, such as targeted subsidies (which would only be available to specific vulnerable groups), to promote the use of renewable energy technologies like efficient cook stoves. It is important that these subsidies are transparent and publicly disclosed. For instance, the Government of Lesotho could subsidize interest rates to enable financing institutions to provide more affordable loans to contractors and households purchasing efficient cook stoves. This would help alleviate affordability issues for households and financing challenges for stove manufacturers. Lower interest rates would incentivise contractors to take out loans, enabling them to build more efficient cook stoves while waiting for customer payments.
- Create affordable financing solutions, such as customised revolving funds, tailored to local needs and traditions to support the growth of renewable energy technologies. This will encourage contractors to access funds and repay them as consumers make their payments.
- Establish a Renewable Energy Fund under the Ministry of Energy to address funding challenges faced by players in the renewable energy sector, such as those involved in the Improved Cookstoves business. This fund could lower interest rates on loans and provide incentives to early adopters of the technology.

Bulk Purchase and Distribution: Non-profit organizations or cooperatives could buy cookstoves in large quantities to reduce the cost per unit and ensure widespread distribution. The government could identify local NGOs with strong community presence and willingness to participate in bulk purchasing and distribution. To ensure the sustainable implementation of the technology, distribution centres need to be established nationwide, with funding raised through grants, donations, social business models, or collaborations with government and international organizations.

International Cooperation: Collaborating with international partners can help Lesotho access funding, technologies, and expertise to promote the widespread use of clean and efficient cookstoves. This collaboration can also assist in developing and implementing programs and projects to support the technology deployment, as well as coordinating the development of key concepts for submission to multilateral funding opportunities.

Promote the market for technology rather than relying solely on donations. To increase the perceived value of the technology, it is important to create a cost for the user, even if it is subsidized. Additionally, the technology should not be limited to a select group of people but should be accessible to anyone who wants to acquire it. This means that different models should be available on the market and their sale should be controlled and governed by a promotion policy.

1.2.3.2 Non-Financial Measures

Overcoming Social-Cultural Barriers:

- **Awareness and Education Campaigns: Educating** the public about the benefits of clean and efficient cookstoves can help overcome resistance to new technology and motivate change. ***Currently, awareness campaigns focus more on the potential economic benefits of reducing the amount of firewood than on the health implications for everyone in the household and the damage to the environment***. To achieve this, consistent, direct sensitization initiatives are needed to highlight the economic, social, and environmental benefits of adopting these technologies. This can be done through carefully targeted campaigns that reach out to different societal demographics using various platforms such as televised programmes, radio broadcasts, public gatherings, and digital media platforms.

- **Creating a platform for public access to studies produced by different institutions, CSOs and NGOs for technology development**. The platform could be created online and available to anyone wishing to obtain information on projects and research related to efficient cookstoves, whether for academic or commercial purposes.
- **Encourage Community Participation and Gender Inclusivity.** 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 achieved through organizing community engagement sessions that specifically target women and involve them in decision-making processes related to the choice of cookstove models, distribution mechanisms, pricing, and maintenance. Additionally, providing training and capacity building to women, and implementing feedback mechanisms, can further enhance their involvement in the process. Furthermore, implementing programs that support entrepreneurship, for both men and women, utilizing improved cookstoves as a means of work can also be beneficial.
- **Foster stakeholder participation during planning of RE projects and activities:** Government, project developers and promoters should foster community participation in renewable energy projects and strive to promote knowledge of and greater acceptance by the public of prospective renewable energy projects that are appropriate for their locations. This involvement should start at an early stage in the planning process. These developments should take into account the socioeconomic set up of the concerned community, including the needs of the poor. The development of the renewable energy resources should lead to employment creation and poverty alleviation.

Overcoming Technical Barriers:

- **Capacity Gaps**: Local level training and capacity development are essential to boost the local economy and promote widespread adoption of technology. Providing training to local artisans and engineers by qualified personnel from relevant training institutions and other national experts in the design, manufacture, and repair of clean and efficient cookstoves can help address technical challenges and create local job opportunities, particularly for the youth, who make up the majority of the population.
- **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 Government, 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 Lesotho 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.
- **Perform statistical analysis specifically targeting the utilization of fuelwood within households.** Accurate data collection is crucial for identifying the individuals who have adopted the technology and the actual decrease in fuelwood consumption following the installation of the cooker in order to develop country-specific strategies.

- **Provide technical support throughout the entire process of implementing efficient cookstoves**. As part of the country's policies and strategies, there should be a designated individual responsible for overseeing the distribution of improved cookstoves by organizations or companies, ensuring proper installation, functionality, and maintenance.
- **Establish a complaints mechanism**. Such a mechanism would provide a means for users to report faults with their stoves and receive technical support to rectify them. In addition, if they only had questions about the operation that they did not ask during the socialisation or control visits, users could use the already established consultation system.

Addressing Institutional and Regulatory Barriers:

Policy Support:

- The Government of Lesotho should develop and implement a policy and legislative framework that encourages the production, distribution, and use of clean and efficient cookstoves thus stimulating market growth. This might include tax benefits for producers or importers, emissions standards that favour clean cookstoves, and regulations to phase out traditional stoves.
- There is a need for a comprehensive national policy and strategy that enables the creation of and access to quality services at each link of the value chain that promote the adoption of fuelwood, and thus reduce fuelwood consumption and improve the health of families, especially women and children.

Institutional strengthening:

- To address institutional challenges, there is a need for institutional strengthening by the government to support the promotion and adoption of efficient cookstoves. Institutions at all levels (national, 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.
- Lesotho requires a specialized institution to address biomass energy issues. The majority of Basotho voters and taxpayers rely on biomass energy, so it is a reasonable expectation to have a dedicated institution for this purpose. This institution could be housed within the Ministry of Natural Resources, Rural Development, or Environment. Its primary goal should be to increase the productivity and sustainability of biomass energy in order to improve the income and living standards of citizens**.**
- **Publicise the Energy Act**: As the Energy Act is expected to come into operation this year (2024), it will be necessary to publicise it through different media, and to directly inform the companies and organisations that are working on renewable energy and energy efficient technologies.

The successful implementation of these measures will require a collaborative and continuous effort from various stakeholders, including the government, private sector, NGOs, communities, and international partners. The measures outlined above, which are expected to increase the adoption of efficient cook stoves, have been used to create a market map, as detailed in Annex I.

1.3 Barrier Analysis and Possible Enabling Measures: Solar PV Minigrids

1.3.1 General Description: Solar PV Minigrids

Solar PV mini-grids technologies are a promising solution to meet the energy needs of urban and rural poor communities in Lesotho that are far from the national grid. They have the potential to stimulate socio-economic development and improve living standards in these deprived areas. Solar minigrids generate electricity centrally and distribute it to households and small businesses within a specific area. According to the World Bank, "*minigrids are electric power generation and distribution systems that provide electricity to just a few customers in a remote settlement or bring power to hundreds of thousands of customers in a town or city*" (ESMAP, 2019). Solar PV minigrids consist of a solar PV array for generating electricity, a battery bank for electricity storage (in some business models), a power conditioning unit with charge controllers, inverters, AC/DC distribution boards, and necessary cabling, and a local low-tension power distribution network.

The PV energy system can be categorized into three main groups: grid-connected system without storage facility, grid-connected system with storage facility (such as a battery), and off-grid PV system (primarily with a battery). In areas that are isolated or remote and do not have access to the grid, the off-grid PV system with storage facility may be the only feasible option for providing electricity to the people in those areas.

Mini-grids will play a significant role in achieving the ambitious goal of the Government of Lesotho to increase rural electricity access to 75% by 2030, as outlined in the Electrification Master Plan (Off-Grid Master Plan). The plan aims to electrify approximately 10 600 households with off-grid energy solutions and 300 households with mini-grids annually, starting in 2018 (EMP 2018). Minigrids have the potential to help Lesotho achieve SDG7 by 2030 in a cost-effective manner. While a few isolated solar PV mini-grid systems have been installed in remote communities in Lesotho through private and international initiatives, this technology is still in its early stages in the country. The Department of Energy has identified several pilot projects to kick-start the deployment of solar PV mini-grid systems.

Lesotho established the Lesotho Electricity and Water Authority (LEWA) Energy Regulatory Authority (LEWA) to oversee regulatory requirements for electricity, including solar PV electricity generation. According to LEWA, grid-connected systems must obtain a license or permit to export to the grid, as well as the necessary metering equipment installed by a professional to accurately measure the level of export for compensation. Larger installations obviously require appropriate planning permissions that would be necessary for any moderate to large infrastructure project.

1.3.2 Identification of Barriers: Solar PV Minigrids

In order to identify the main barriers to the transfer and diffusion of solar PV minigrids in Lesotho, the following process was followed:

- Reviewing relevant policy papers and important documents:
- Conducting field visits to two solar minigrid sites - *The **purpose** of **these visits** was to observe **differences** in **entrepreneurial activities**, household **income,** and electricity access before and after minigrid **installation** in the **village,** as well as to identify potential barriers to the **current minigrids in order to** address these barriers for future minigrid implementation projects.*

- Reviewing Minigrid Pre-Feasibility and Feasibility Studies:
- Consulting with developers (IPPs), experts and key stakeholders.
- Seeking guidance from the TNA guidebook.
- Utilising a market mapping tool for consumer goods and capital goods.

Market mapping was used in the assessment process to understand the marketing aspects of Solar PV Minigrid Technology, as well as key to identify key players and barriers. It was important to identify the chain and relationships between all players in order to pinpoint barriers that hinder the diffusion of the targeted technology. Mapping the actors involved in the market chain, from consumers to importers or producers of the product, was a crucial step in establishing the flow of actions between them. The key barriers were categorized under economic, financial, and non-financial barriers.

To identify the main starter barriers, Logical Problem Analysis was utilized (Annex I) as a tool in the analysis. After conducting a comprehensive and detailed barrier analysis involving key players in the sector (Annex 2) and desktop work, the main initial problem was identified as "***Low utilization of Solar PV Minigrids***". This method was also used to pinpoint the root cause of the barriers, with all problems/barriers arranged around an initial problem. All identified problems were organized in a hierarchy of cause-effect relations, with the initial problem at the centre and the direct causes below it and direct effects above. The problem tree includes screened barriers, which were broken down in close consultation with the stakeholders. Annex I displays a problem tree for the technologies indicating causes and effects.

1.3.2.1 Economic and Financial Barriers

Table 6 shows the economic and financial barriers to transfer and diffusion of Solar PV Minigrids electrification, technology in Lesotho.

Table 10: Economic and financial barriers and their description for Solar PV Minigrid electrification in Lesotho

Barrier Category	Barriers	Barrier Description
Economic & Financial	High initial investment cost	Although a great reduction in prices has been achieved during the last few years, solar powered technologies still face a challenge in their high initial cost. High initial up-front capital cost of solar product and batteries and the unwillingness of local commercial banks to fund such investment are the main economic barriers that hinder the widespread deployment of solar PV minigrid systems in Lesotho. All solar PV mini-grid components and spare parts are imported into the country. According to the International Renewable Energy Agency, "installed solar PV mini-grid costs for systems below 40 kW, range from USD 6 000 to USD 13 000 per kW" (IRENA, 2021). Simple payback periods for solar PV minigrids can be relatively long, between 3 and 7 years, depending on the generation capacity and number of customers. These long payback periods make it hard for developers to mobilize commercial financing. Currently, most of the country's investments in mini-grids are donor-funded. Consequently, the limited private sector participation in the project development stage of solar PV mini-grid technology has an adverse effect on its long- term sustainability.
	Limited demand for productive	Rural minigrid operators sell electricity to customers who often have little income and limited ability to pay. Power demand from these customers can be limited and unpredictable as many

	activities in rural areas	rely on agriculture for income. Varying weather conditions, seasonality and crop yields all directly impact the ability of these customers to pay their bills. The power demand in rural areas is relatively low and unstable, which makes it difficult for operators to recover costs. The lack of productive-use customers, who could generate revenue with the electricity generated during the day, brings economic pressure to the continuity of the system. Lesotho's agriculture-based economy offers numerous opportunities for creating value-added agricultural products. However, there is currently limited use of productive energy in the country
	Inadequacy of subsidy programs; Low ability to pay for the electricity from solar mini-grid	The absence of subsidies and financial incentives to foster the solar PV mini-grid technology to mature commercial status is another barrier to its successful diffusion in the country. In general, most rural communities have relatively low levels of incomes and the affordability for electricity without subsidies is much low. This low level of affordability is further exacerbated by the fact that the consumer cost of electricity from minigrids in most southern and eastern African countries is higher than tariffs for the national grids, which are generally cross subsidized and not cost-reflective (EEP Africa, 2018). In most of the rural areas of Lesotho, there are few households that can connect to a minigrid, which has the investment cost. This makes it difficult to recover the cost of investment and minigrid developers resort to grants and for subsidies, in order to bring down the cost of energy (tariff) to a level that is affordable to customers. The national electrification targets outlined in the 2018 Electrification Master Plan cannot be met without subsidies for solar mini-grid projects, due to their high capital costs.
	Limited access to finance and long term capital	Local commercial banks and other financial institutions are reluctant to finance solar mini-grid projects based on perceived high risk and a low rate of return. The majority of rural minigrids range from just 10 to 100 kW. Private financiers tend to favour larger deals that allow them to amortize transaction-related costs over larger volumes of capital. Owing to the inability of investors to secure long tenor capital financing from commercial banks and other financial institutions, several promising solar PV mini-grid projects in parts of the country remote from the national grid have suffered setbacks. In addition, local expertise in coming up with bankable business proposals for financing solar PV minigrids projects is lacking. This explains why the majority of the current IPPs in solar minigrid are international enterprises. Donor guarantee programs that provide a substitute for collateral to solar system operators are rarely given to local players, in favour of the larger multinationals.
	Low ability and willingness to pay	The cost of electricity from utility-scale solar PV mini-grids is generally higher than the cost of national grids, particularly for customers in isolated rural communities. In these rural areas the consumers' ability and willingness to pay for the power becomes a major barrier for investors and operators of these minigrids because the average purchasing power of the consumer is very low. Most rural areas in Lesotho consist of very poor population with low ability and willingness to pay for the connection and operation fees. Default and delinquency rates tend to be quite high for rural poor with little disposal income for energy.

	Small Market size	Small market potential, low consumer demand density, limited or difficult access to international markets.

1.3.2.2 Non-Financial Barriers

The stakeholders agreed that, despite the initial costs associated with the installation of solar PV minigrids, the policy, regulatory and legal framework is one of the most critical non-financial barriers preventing the uptake of Solar PV systems. Additionally, the stakeholders also concluded that the current tariff structure contributes significantly to the poor diffusion rate for PV systems. The following section provides the key non-financial and economic barriers to the transfer and diffusion Solar PV Mini-grid Systems in Lesotho as shown in **Table 11.**

Table 11: Non-financial and economic barriers and their description for Solar PV Mini-grid System

Barrier Category	Barriers	Barrier Description
Technical	Limited number of local skilled labour to install and maintain the systems	There is a general limitation among local experts in conducting technology and feasibility assessments, as well as in building, operating and managing solar mini-grids. This is linked to the current Lesotho tertiary education system, technical training is primarily offered at on technical courses is pitched at Bachelors levels, which have very little practical or hands-on training. Vocational training programmes show promise, but have not been effective so far due to the lack of experienced professional trainers. This creates a gap in the industry for skilled manpower to maintain engineering based systems like solar PV minigrids. The available technical training institutions at the technician's level must have curricula that respond to the dynamic needs of the renewable energy industry like solar PV mini-grids. This is critical now because it appears that solar PV electricity production is the most preferred technology for the IPPs.
Information & Awareness	Inadequate and limited information sharing	The majority of Basotho still have little information concerning the potential social, economic and environmental benefits of the solar powered technologies. The public awareness of solar mini-grid is just for electricity generation to use for home appliances as a benefit of the system. People are not aware of the system's capabilities to use other than household consumption
Cultural, Social & Gender	Absence of inclusive gender participation in Solar PV Minigrids projects	There are limited initiatives that focus on training and supporting women and vulnerable people in the renewable energy sector in the country. The absence of inclusive gender participation especially in rural areas is a barrier to the deployment of the technology, as women benefit more than men from access to clean energy. Stakeholders also suggested that the presence of certain local customs, practices and social norms are further obstacles to the deployment of SMG in the region.
Policy Legal, Regulatory and Institutional framework	Inadequate legal, regulatory and institutional framework (*renewable energy policy, strategy and action plan*)	There is low institutional capacity and inadequate regulatory and investment frameworks to provide the enabling environment for RE development, uptake and transfer of technology on a larger scale. There are also uncoordinated stakeholder activities among those who promote the technology, which leads to duplication of initiatives.

	Time-consuming Approval Process of Independent Power Producers' applications	There is significant delay in the processing of IPP applications. The time it takes for potential IPPs to obtain concessions, licenses and environmental approvals can be several months. This is especially true for acquiring generation and distribution licenses, which has caused delays in solar PV project development
	Absence of robust, updated renewable energy policy and regulatory framework	Lesotho lacks an adequate renewable energy policy with a clear strategy and action plan for each line ministry. This results in delaying and restricting progress not only in solar minigrid projects but also in renewable energy project development and commercialization. Therefore, having a renewable energy policy, strategy, and action plans in the country can lead to moving forward the country's renewable energy sector in a sustainable manner and to attract both local and international investors to invest in the renewable energy sector. A renewable energy policy and its action plan can be a guideline for the country to implement renewable energy projects and commercialization.
	Existence of low quality systems	Lesotho suffers from influx of cheap and low quality solar PV components that erodes confidence in the technology, all of which are imported into the country. The main challenge is enforcement of standards, exacerbated by corruption and system abuse. This affects the operation and life-span of solar PV minigrids in terms of access to genuine spare parts.

1.3.3 Identified Measures

While Lesotho's solar PV market has great development potential, there are still significant barriers, both structural and fundamental, that need to be overcome before this potential demand can be translated into effective demand. To overcome these barriers and accelerate the transfer and diffusion of solar PV minigrids in most off-grid parts of Lesotho, the government needs to introduce favourable policies at its different levels. These policy frameworks are essential for the Government of Lesotho to apply, extend, and assess its policies and succeeding actions, including legislation, enforcement, and decision-making. This will effectively address major renewable energy concerns that are captured in the policy framework and others which are not. The following efficient measures and policies are thereby suggested, in order to accelerate uptake of solar PV minigrids in Lesotho. These are further analysed in the market map (Annex I). These economic, financial and non-financial measures were identified through stakeholder consultation, desk review of energy sectoral reports, field visits, and interviews with project developers in the field, the enabling measures thus identified are listed below.

1.3.3.1 Economic and Financial Measures

In order to establish an appropriate financing and fiscal policy to attract more investments and enable RETs such as solar PV minigrids systems to penetrate different markets, there is need for Government to consider implementing measures shown in **Table 12**.

Table 12: Measures to overcome economic and financial barriers of Solar PV Minigrid System

Barrier type	Barriers	Measures identified to overcome the barriers
Economic & Financial	High investment cost	Implement innovative financing mechanisms, including targeted subsidies to stimulate the market penetration of renewable energy technologies. Where subsidies are provided, they should be determined in a transparent

		manner and published. For example, the government can subsidize interest rates to enable financing institutions to provide cheaper and more affordable loans to importers of solar PV system components and other players in the business value chain. This will help overcome the barrier of expensive capital resulting from high interest rates charged by financing institutions. Reduced interest rates will attract importers to secure loans, increasing their capital to import more solar PV system components. This, in turn, will reduce the cost of solar PV systems and make them more accessible to users. Subsidies on interest rates will also help overcome the barrier of difficulty in accessing finances by suppliers enabling them to sell solar system components at lower prices and is expected to increase demand and uptake for solar PV systems.
		Introduce specific policies that favour renewable energy such as preferential tax treatment and tax exemptions. For example, the government could exempt all solar PV system components from taxes which would lower the capital costs for importers purchasing and bringing the components into the country. This would help overcome the major barrier of high prices for the systems.
		Implement innovative risk mitigation mechanisms and credit enhancement instruments, to provide comfort to lenders. Credit enhancement is a strategy for improving the credit risk profile of a business, usually to obtain better terms for repaying debt. The strategy reduces the credit risk and default risk of the company's debt, making it eligible for a lower interest rate. For example, the government can provide Partial Risk Guarantees to facilitate Financial Institutions on lending for Renewable Energy projects/ programmes. These guarantees reduce the real or perceived risks faced by primary lenders and financial intermediaries. *It is further recommended that the Department of Energy carry out a comprehensive impact assessment aimed at understanding the political, economic, social and environmental impact of the waiver of customs duties for quality-tested solar PV mini-grid systems.*
	Low affordability of consumers to pay for the electricity	To address the barrier of low ability and willingness to pay, there is a need to provide capacity building that will help solar PV mini-grid installers and investors better assess the creditworthiness of their customers and incorporate it into financial models. This could also help solar electric companies determine where to focus their efforts The provision of duty exemptions for solar PV mini- grid equipment and accessories by the government can substantially lower the retail price and lead to improved affordability.
	Limited commercial use of the generated solar PV electricity	Promote solar energy for productive use such that users gain income from the solar systems. This will contribute to overcoming the barrier of low disposable income. It will also help users to earn income that will be used to pay for services.
		Provide grant funding to support agricultural activities especially for rural farmers. Development of the agricultural sector will enable rural communities to engage in commercial farming, leading to increased incomes among the population and overcoming the barrier of low disposable income. With enough food and money to cater for education and health needs, people will be able to include clean energy in their budgets.
		The Government and other stakeholders should create programmes to train people on how to start an economic venture taking advantage of access to electricity.
	Limited financing mechanism for solar minigrids	Develop the carbon financing market. The government can secure funding to offer subsidies to reduce interest rates and grants to the different players in the renewable energy sector, as RE technologies directly contribute to the reduction of GHG emissions and would be collectively eligible for green financing. Carbon credits can also be

		earned by the private sector players, which will help in financing their businesses and reducing the need for loans.
		In order to address the barrier of limited access to finance and long-term capital, it is recommended that the government capitalize the Energy Fund and make it operational to provide long term financial support, capital subsidies, production-based subsidies to investors, suppliers, dealers and consumers of off-grid solar PV system targeted at remote areas without access to electricity. The government should be supported by international development partners and donors by offering concessionary loans or grants to extend solar PV minigrids to isolated and remote areas in the country.

1.3.3.2 Non-Financial Measures

The identified measures to remove economic and financial barriers are presented in **Table 13.**

Table 13: Measures to overcome non-financial and economic barriers of Solar PV Minigrid System

Identified Barriers' category	Measures identified to overcome the barriers
Technical	To overcome the barrier of inadequate local technical expertise, the government needs to institute capacity-building initiatives to train both males and females in the areas of construction, installation, operation and maintenance of solar PV projects. This includes the development of manufacturing capabilities for solar PV components and spare parts, as well as the training of a critical mass of scientists, engineers, economists etc. for research and development.
	There is a need for the country's higher learning institutions to establish and enhance research and development centres in renewable energy technologies, where issues of designing, installing and maintaining the mini-grid solar PV systems could be addressed. Furthermore, the institutes of higher learning should revise curriculums to make the practical element of renewable energy technologies prominent. Additionally, there should be a platform where institutes of higher learning and industry can work together in the training of renewable energy technicians. Develop a technology transfer program to increase productive use demand. Create a regulatory framework to enable grid interconnection systems.
Information & Awareness	In order to address the inadequate and limited information sharing barrier, there is a need for the government to disseminate adequate and sufficient information on the availability, advantages and opportunities of solar PV energy resources to the general public in order to raise public awareness and generate activities in the RE market. This initiative is crucial for building public trust and embracing solar PV mini-grid technologies in rural communities without access to modern electricity. Providing information to selected stakeholder groups such as private investors will help leverage the financial capital required to fund solar PV mini-grid projects.
	Training the media and equipping them with relevant knowledge and information about the renewable energy sector is a step in the right direction. This is because the media plays a key role in disseminating information to the public. If the media has access to the right information about the renewable energy sector, they can raise awareness among the public about the benefits of transitioning from climate-harming technologies to clean energy solutions like solar. The media will be able to report effectively about the sector and promote the use of RE technologies in Lesotho. It is also important for RE training to start in schools by integrating the basics of RE into the school

	curriculum and running awareness programmes for youth in and out of school.
Cultural, Social & Gender	To address the absence of inclusive gender participation in Solar PV Minigrids projects in the country, there is a need for the government to provide equal opportunities for women to work in the renewable energy sector. Moreover, special focus on gender inclusion to enhance the well-being of women and children is needed in the renewable energy sector. Women should be empowered to participate more actively in decision-making in the renewable energy sector and to contribute to areas such as operations and management of solar PV mini-grid installations, engineering, procurement and construction, maintenance and repair works. The impact of rural electrification programs on women is well-documented, with its benefits ranging from time savings, employment and education, to safety and maternal health. It is important to greatly consider gender in all rural electrification programs and in all phases of planning and implementation.
Legal, Regulatory and Institutional framework	The government needs to strengthen various regulatory agencies so that they can enforce compliance with respect to the quality of solar mini-grid equipment and spare parts imported into the country. The Department of Energy needs to be empowered to enforce safety standards, minimum technical standards for mini-grids, as well as licensing or certification procedures for solar PV mini-grid installers, and other professionals to ensure that firms active in the sector have the required technical skills and are insured
	Introduction of relevant provisions in funding agreements, technical assistance programs and consultancy services contracts that impose contractors' commitments and obligations to transfer skills and knowledge to local personnel.
	The development of a renewable energy policy with a clear strategy and a proper action plan is essential.
	Proper coordination of stakeholders engaged in and supporting solar energy initiatives is necessary to avoid duplication of programs and initiatives.
Stakeholder Participation	Government, development partners, importers, distributors and suppliers should foster community participation in renewable energy projects and initiatives and strive to promote knowledge of and greater acceptance by the public of prospective renewable energy solutions that are appropriate for their locations. This involvement should start at an early stage in the planning process. These developments should take into account the socioeconomic setup of the concerned community, including the needs of the poor. The development of renewable energy resources should lead to employment creation and poverty alleviation. This will create a sense of ownership in the public and will increase acceptance and uptake of the renewable energy solutions.
Time consuming approval process for Independent Power Producers' applications	The Government should introduce an initiative to streamline the IPP application process, reducing the time it takes to make a decision on applications.

The above identified measures have been used to develop a market map for solar PV minigrids systems, see Annex 1.

1.4 Barrier Analysis and Possible Enabling Measures: Energy-Efficient Lighting and Appliances

Improving energy efficiency is the cheapest, fastest and most environmentally benign option to meet a significant portion of the Lesotho's energy needs. Energy efficiency measures for buildings, appliances and equipment can reduce the need for investment in energy infrastructure, lower energy bills, boost competitiveness and enhance consumer welfare. Numerous energy efficiency measures are already cost-effective, and they will pay for themselves over their lifetime through reduced energy costs. Energy efficiency options are generally characterised as having technical and cost barriers that are secondary to other barriers, such as lack of public acceptance, financing, information, education or appropriate incentives.

The main energy efficiency options that will have a significant energy reduction usage and are relatively easy to implement are LED lights, automatic lighting controls and energy efficient appliances. Low-energy halogen lamps, fluorescent-tube lights in combination with electronically controlled systems for dimming, and automatic shut-off are also readily available.

The government's push to increase access to electricity in Lesotho is expected to result in a continued rise in the use of appliances and equipment. However, the use of inefficient appliances could lead to higher electricity demand, which can be mitigated by improving the efficiency of the appliances and equipment used in the country. This would also help reduce greenhouse gas emissions and contribute to the achievement of the NDC targets. The main obstacles to achieving this goal are the lack of institutional capacity and regulatory frameworks. Additionally, a financial mechanism needs to be established to facilitate the deployment of energy-efficient appliances and equipment.

Lesotho has started to promote energy-efficient lighting and is currently working on finalizing the Regional Compliance Framework for Energy Efficient Lighting and Appliances in the SADC and EAC Regions. This framework will support the implementation of regionally harmonized energy efficiency standards for lighting products and appliances. Awareness-raising campaigns on energy efficiency have been conducted through media and educational programs, but there is a need for a robust quality control and enforcement system to prevent low-performance bulbs from entering the market. It is also necessary to establish international testing standards and a lighting laboratory, as well as create an enforcement system.

1.4.1 General Description: Energy-Efficient Lighting and Appliances

High-efficiency lighting systems are a cost-effective way to save energy and reduce electricity demand. They also create job opportunities and contribute to a secure energy supply. Transitioning to these new technologies can lead to substantial energy savings and lower greenhouse gas emissions. Some of these technologies and practices require no initial investment and can improve reading and working conditions while reducing light pollution.

There are various types of light bulbs available, including incandescent, halogen, fluorescent, metal halide, high pressure sodium, and LED. LED technology is becoming more affordable and offers unique benefits such as long life, energy efficiency, and resistance to breakage and vibration.

The use of high-efficiency lighting systems aligns with Lesotho's development priorities, reducing energy costs, contributing to energy supply security, and supporting a more environmentally friendly energy supply. While the initial cost of LED bulbs may be high, the long-term savings outweigh this cost. Consumer awareness activities may be necessary to help people understand this trend.

Overall, high-efficiency lighting systems offer numerous benefits for Lesotho, including reducing household energy bills, creating job opportunities, improving indoor comfort, and contributing to energy security and environmental sustainability.

1.4.2 Identification of Barriers: Energy-Efficient Lighting and Appliances

The process began with a thorough review of policy papers and relevant documents in order to understand why the technology is not widely used and why there has been limited investment from both the private and public sectors. Following this, stakeholders were engaged through interviews to gather their input. The Logical Problem Analysis (LPA) tool was utilized to analyze the situation. LPA tools aid in systematically and logically analyzing problems and integrating all aspects of the problem.

To begin the barrier analysis process, we conducted a thorough review of policy papers and relevant documents to understand why the technology is not widely used and why there has been limited investment from both the private and public sectors. Following this, we engaged with stakeholders through interviews and questionnaires to gather their input.

Barriers related to high-efficiency lighting systems were identified in four categories:

- economic and financial barriers;
- policy and regulatory barriers;
- environmental barriers; and
- Capacity-building and information barriers.

The overall process of identifying barriers includes the following steps:

- Conducting a desk study and literature review
- Utilizing a market mapping tool
- Conducting key informant interviews
- Collecting users' perspectives
- Performing logical problem analysis
- Seeking guidance from the TNA guidebook
- Engaging in stakeholder consultations

The draft report was shared with the Energy Sector Working Group as a final step, following stakeholder consultations. The purpose was to review the report and collect any additional information.

The primary barriers to the widespread use of energy-efficient appliances are a lack of awareness of the cost benefits and the absence of a clear institutional framework for implementation. These barriers can be categorized as economic, financial, and non-financial.

Table 14: Decomposition of Identified barriers to deployment of Energy-Efficient Lighting and Appliances

Category	Barrier Dimension	Main Barriers
Economic and financial barriers	Cost	• High initial cost compared to other lamps, mainly due to taxes and import duties.

		• High cost for retrofitting existing lighting systems, especially changing over from fluorescents to LEDs • Lack of financial support • Lack of economic feasible data
Non-financial barriers	Policy, legal and regulatory	• Lack of a legal, regulatory and enforcement framework for lighting and efficient appliances • Lack of appropriate regulations, allowing the import of highly inefficient appliances • Lack of standards/energy codes to promote energy-efficient technologies in buildings • Lack of differential tariffs to encourage use of highly efficient and renewable energy technologies
	Institutional and organizational capacity	• Limited coordination capacity of existing organizations
	Technical	• Lack of (minimum) performance standard and labelling • Lack of quality control and assurance
	Information and awareness regarding Energy Efficiency	• Limited market information and awareness, • Limited awareness of the financial or qualitative benefits arising from energy efficiency measures, influenced by resistance to change and interest due to relatively lower electricity tariffs. • Lack of knowledge and understanding among consumers about energy consumption and energy efficiency improvement opportunities for appliances, making energy efficiency a non-top-of-mind factor in their purchase decisions • Uncertainty about the market demand for high-efficiency models, making suppliers reluctant to tie up financial resources in more costly appliances, resulting in consumer reluctance to stock energy-efficient models
	Social and culture	• Inability to anticipate potential benefits due to low household income • Resistance to change and lack of a culture of saving due to relatively lower electricity tariffs

Energy efficiency is crucial for ensuring both financial stability and energy security, especially as the demand for energy and clean energy alternatives increases. Essentially, energy efficiency involves using less energy to provide the same level of service (such as using less electricity to power a building). This not only reduces the financial costs of energy, but also minimizes the negative impacts of energy production and consumption.

It is crucial for the Government to prioritize the finalization of the Draft Energy Efficiency Builders Manual (2023) and the implementation of the Regional Compliance Framework for Energy Efficient Lighting and Appliances in the SADC and EAC Regions (2021) without delay. This will serve as a clear demonstration of the government's dedication to energy efficiency for stakeholders and the public. Once the Regional Compliance Framework is in place, the Government should collaborate closely with relevant stakeholders to create secondary legislation and regulations across various sectors. Furthermore, the Government should consider providing incentives to support energy efficiency programs and activities. Establishing a dedicated agency to develop and implement national and sectoral energy efficiency policies and programs is also essential.

1.4.2.1 Economic and Financial Barriers

A number of barriers exist that block the widespread introduction of more energy-efficient appliances (not only in the residential and buildings sectors, but also in other sectors).

High cost of capital barriers

In Lesotho, high-energy efficient products are typically more expensive than regular products. This is due to factors such as the absence of local manufacturing, a small market size, and import taxes. Currently, there are no tax exemptions for importing energy-efficient appliances and equipment under the current customs tax and tariff laws. As a result, these appliances are subject to import duties and taxes when they are brought into the country and when they are sold.

Lack of financial support

The proposed technology focuses on market-driven products, as energy-efficient lighting appliances are considered consumer goods, unlike renewable energy projects and large energy efficiency projects. Additionally, people are unable to access hire purchase or credit schemes for these appliances, unlike for other electric appliances such as refrigerators, TVs, and washing machines. Therefore, homeowners need to purchase these appliances with their own funds.

Lack of economic feasible data

High efficiency lighting, in particular LED technology is becoming increasingly popular in urban areas of Lesotho, but there is a lack of data on its economic feasibility. This technology is more expensive than CFL and incandescent bulbs, and not easily accessible for households. As a result, people generally view it as financially unfeasible and are reluctant to invest in this technology.

Low financial incentives

Consumers are not interested in implementing energy efficient technology such as energy efficient lights because of relatively lower electricity tariffs. Due to the very low tariff for electricity consumption, consumers have no incentive or willingness to replace current incandescent lamps with more energy efficient lamps.

1.4.2.2 Non-Financial Barriers

Lack of legal, regulatory and enforcement framework for lighting

Even though Lesotho has a draft of the Energy Efficiency Builders Manual (2022), there is still a gap in terms of energy-efficient lighting systems. This is one of the fundamental barriers to effectively implementing this proposed technology in the country. Without a legal and regulatory framework, there are no compliance guidelines to ensure the sustainability of the technology. For example, inferior quality lighting products, such as low-quality, uncertified, and substandard products, could enter the country because there are no entry requirements in place as part of a legal and regulatory framework. Moreover, the country could face difficulty in controlling and preventing the entry of low-efficiency products due to the lack of legal enforcement.

Currently, there is no regulation in place to ensure the quality of LED light bulbs being imported in the country, which could undermine consumer confidence in the technology. Additionally, the absence of a policy to prohibit the import or phase out of low-efficiency light bulbs is hindering the widespread adoption of LED bulbs.

Low institutional and organizational capacity

The relevant institutions and agencies have a weak institutional basis due to limited technical capacity and poor coordination of activities. For example, the energy efficiency and conservation division of the Department of National Housing (under the Ministry of Local Government, Chieftainship, Home Affairs and Police) and the Department of Energy (under the Ministry of Energy) lack coordination due to limited human and technical resources. This limited coordination capacity is a barrier to the diffusion of technology.

Technical barriers

Lack of (minimum) energy performance standard and labelling

Most Energy-Efficient Lighting and Appliances lack standardization and labelling in Lesotho. The country does not have its own standard for electric appliances, which could result in the importation of lower efficiency products without a benchmark to follow. There is also a lack of quality control for imported energy-efficient lighting and appliances, with some not meeting international quality requirements.

As a result, importers are unable to meet the country's efficiency level, leading to low-quality products in the market. This means that consumers may not realize the potential benefits of energy-efficient lighting and appliances when making purchasing decisions.

Lack of quality control and assurance

The issue of quality is directly linked to the lack of quality control systems in the country. This means that there are no checks in place to verify the quality and performance stated in product manuals. For example, LED lamps claim to have a lifetime of 10 000 hours (although this may vary depending on the brand and quality), and the price is based on this and its rated luminous flux. However, in practice, this claim cannot be verified in the country. According to the market map, there are no testing centers in the country to test the quality of LED products. As a result, low-quality products are imported into the country because they are cheaper than higher quality products.

Information, awareness and lack of knowledge about eco-innovative products such as LEDs

In Lesotho, many people, especially those in rural areas, struggle to access the latest information on technology due to a lack of availability in the public domain. Information about technology is primarily found in supermarkets and on websites owned by electrical appliance companies, making it difficult for rural residents to stay updated.

Additionally, there is no integrated information system for the energy sector in Lesotho. While the Lesotho Bureau of Statistics publishes Energy Statistics annually, the information is limited to financial, technical, and economic indicators. This publication does not provide information about energy-efficient technology for consumers. As a result, there is a lack of access to information about energy-efficient technology for consumers in Lesotho. This issue is further illustrated in the problem tree and causal relation for the transfer and diffusion of efficient lighting technology, as shown in Annex I.

Consumers have limited knowledge and information about the eco-innovative benefits of LED light bulbs, which hinders the widespread adoption of these products. Typically, consumers opt for fluorescent and incandescent bulbs because of their lower cost and familiarity. The decision not to switch to LED lighting is often based on a narrow comparison of the initial cost of the bulbs, rather than considering the overall return on investment in the technology.

Social and cultural factors

Recent estimates show that poverty continues to be a significant issue in Lesotho. In 2020, 31.2% of the population lived below the international poverty line of USD 1.90/person/day, and this figure increased to 53.1% when the lower-middle-income-country threshold of USD 3.20 per day was used. This is relatively high for a lower middle-income country.

Moreover, more than 65% of the population resides in rural areas, and only 52% of households have access to grid electricity. The combination of the high poverty rate and low electricity access is limiting the market size of Lesotho. Additionally, some consumers prioritize the design of lamps and lighting systems over cost and energy efficiency. Many individuals are reluctant to invest in energy-efficient lighting and appliances due to their higher price, which can be up to 5 times higher than an incandescent bulb and 3 times higher than a fluorescent lamp. This is despite the benefits of energy-efficient options, such as lower energy bills, longer life spans, and better quality. Consequently, people are generally uninterested in purchasing more efficient electric appliances, believing that they are too expensive and not feasible given their household income.

1.4.3 Identified Measures

The TNA consultant initially identified ways to overcome obstacles and promote energy-efficient lighting and appliances through personal experiences, field visits, and interviews with project developers. These findings were further supported by reviewing existing literature in the country and other countries' experiences. The systematic problem analysis helped to move from identifying problems to finding solutions. The measures were then categorized and evaluated during stakeholder consultations. Additionally, additional feedback was sought from line ministries to provide further inputs before finalizing the measures.

All energy efficiency measures aim to achieve the same goal, which is to reduce the need to import energy. Therefore, a highly effective energy efficiency program would decrease energy imports, allowing for a reduction in energy imports from SAPP accordingly. The cost of implementing many energy efficiency measures is minimal. It is important to be aware of these measures and to have regulations in place that require their installation in both new and retrofit installations.

1.4.3.1 Economic and Financial Measures

High Cost of Capital (*Consider creating tax incentives for imports*)

In order to lower capital costs, the government should consider introducing tax incentives for energy-efficient lighting and appliances to encourage the adoption of technology by reducing or eliminating commercial taxes. These incentives can greatly offset the initial investment and offer long-term financial advantages. Tax incentives make energy-efficient appliances more affordable and accessible to a wider range of consumers. Additionally, these incentives promote job creation and support economic growth within the renewable energy sector.

Lack of financial support (*Create subsidy program for customers*)

There are two options to assist customers and importers in successfully introducing the proposed technology in the country. The first option is for the government to allocate a budget to distribute LEDs in targeted areas of the country. However, the sense of ownership of the products can diminish when people receive them for free. Additionally, people may be hesitant to purchase replacements with their

own money once the product is broken. Therefore, the program should be market-based. For example, the government could subsidize a portion of the product cost for customers, in cooperation with suppliers.

The second option is for the government to seek support from donor agencies to access funding or loans to promote this technology. This funding or loan could then be used to provide funds on concessionary terms (such as a low-interest rate loan) to the suppliers or companies distributing the proposed technology. Such funding should be channeled through either the government treasury or commercial banks.

The Ministry of Energy and the Ministry of Finance can provide a one-time 50% subsidy for an LED lighting program of approximately LSL 15 000 000.

Lack of economic feasible data (*Conduct economic and financial feasibility study and disseminate the study results to the public*)

It is recommended that the Department of Energy conduct an economic and financial feasibility study of the proposed technology. The results of this study should be made available to the public and decision-makers through dissemination. Competent national personnel should be responsible for conducting the study to ensure accurate results. The government could allocate a budget for the study or collaborate with international non-governmental organizations (INGOs) that have experience in promoting efficient lighting systems.

The government should prioritize organizing a knowledge base that compiles information on energy efficiency projects, including those financed by donors, and lessons learned. This will help the government develop a strategy and prioritize future donor financing for energy efficiency projects.

Based on similar campaigns of this magnitude and importance, it is estimated that this would take two years at a cost of LSL 1 500 000.

1.4.3.2 Non-Financial Measures

Lack of legal, regulatory and enforcement framework (*Develop Sufficient Legal, Regulatory and Enforcement Framework*)

The adoption of the Regional Compliance Framework for Energy Efficient Lighting and Appliances in the SADC and EAC Regions guidelines (2022) and the draft Energy Efficiency Builders Manual which was drafted by the Department of Housing in 2020 under the auspices of the Ministry of Local Government and Chieftainship Affairs is crucial for promoting the use of energy efficient lighting in residential and commercial buildings. To encourage energy efficiency in these sectors, a legal and regulatory framework for lighting should be developed and integrated into the Energy Policy Framework. This framework should include entry requirements for products, a registration scheme, and a verification program to test product parameters. Additionally, an enforcement framework should be established to ensure compliance with national legislation by importers and suppliers. This will help strengthen the legal and regulatory framework for energy efficiency.

The Government needs to complete the Energy Act quickly. Promulgating the Energy Act will show energy users and the public how important energy efficiency is. After the Energy Act is adopted, the

Government should work closely with relevant actors to develop secondary legislation and regulations in different sectors.

The global market is full of different brands of LED light bulbs, some of which are of low quality[11]. Therefore, consumers need to be protected from these inferior products through strategic policies and a screening process. One such policy could involve clearly defined performance standards for imported LED light bulbs, including minimum efficiency requirements, as well as an enforcement body to test and monitor compliance with these standards. Additionally, the policy should include a robust environmental management plan for the disposal of light bulbs, especially those containing toxic elements. Lastly, the policy should address the phase-out of low-efficiency light bulbs in order to promote the use of high-efficiency, low-energy light bulbs. This could involve investigating the phase-out of low-efficiency light bulbs such as incandescent bulbs. Feasibility studies and surveys should be used to inform the development of the policy and legislation to ensure widespread acceptance.

Limited coordination capacity in existing organizations (*Enhance coordination between line ministries*)

The initiative aims to enhance coordination among various government ministries to encourage the adoption of energy-efficient lighting and appliances in the country. This will entail collaborating with the Ministry of Energy and the Ministry of Finance and Development Planning to review existing tax policies and streamline the importation of technology. Furthermore, cooperation with the Department of Research and Innovation is essential for establishing a national standard and labeling system for lighting. However, current institutions and organizations have insufficient capacity to collaborate effectively on developing appropriate policies, laws, procedures, and technical specifications. The Ministry of Finance and Development Planning should also explore the possibility of implementing an environmental levy on the importation of incandescent light bulbs.

Lack of (*minimum*) standard and labelling (*Develop standard and labelling*)

Energy standards and labelling are crucial for ensuring that all electric appliances, including energy-efficient lighting, meet the minimum national energy efficiency standards. This helps to encourage consumers to carefully consider the advantages and disadvantages of different appliances and products before making a purchase. It is recommended that the government establish national minimum performance standards for energy-efficient lighting and appliances. Additionally, all labels should be written in both Sesotho and English to effectively communicate the benefits and drawbacks of a product to consumers. **The Ministry of Trade can provide funding of around LSL 500 000 for the development of minimum standards and labeling.**

Lack of quality control and assurance (*Establish a quality control system and establish a testing laboratory*)

In order to guarantee the quality of the products, it is essential to have a suitable testing mechanism in place. For instance, in order to assess the estimated rated luminous flux and lifetime of LEDs, a proper methodology is necessary to test LED samples under more rigorous conditions in order to determine the estimated rated luminous flux and the lifetime of the LED. Therefore, it is important to introduce a testing institution to conduct the testing and issue quality certification based on the test results. Stakeholders believe that it is imperative to offer this service in order to maintain control over the quality of LEDs.

[11] https://www.waveformlighting.com/home-residential/why-your-lighting-looks-bad-5-potential-reasons

The Ministry of Finance can provide funding of around LSL 10 000 000 for the establishment of a quality control system and a state-of-the-art testing laboratory facility.

Information and awareness barrier (*Promote public awareness about the benefit of energy-efficient lighting and appliances*)

LED technology is driven by the market, so it is important to raise public awareness about it. One way to do this is through a promotion campaign in busy areas like supermarkets and local markets. Using media such as radio, TV, and social networks can also be effective. Public events, like World Environment Day, can help spread information about LED technology. Materials like posters, pamphlets, and billboards can also be used to raise awareness. Working with private sectors can help promote LED products. During these efforts, it is important to provide information about the different types of LEDs available, use localized terms to make it easier for people to understand, and highlight the benefits of using LED technology, such as saving on energy bills and improving living conditions. Annex I outline translated problem to solution of efficient lighting and appliance technology.

Importers and the Electrical Division should educate their customers about the costs and advantages of the technology. It is important to understand that switching from filament or compact fluorescent light bulbs can lead to savings of 25% to 70% on energy consumption, which equates to approximately LSL 2.8 to LSL 8.5 per 40 W bulb per month, resulting in a payback period of 4 months.

The Ministry of Energy could fund this awareness campaign with approximately LSL 150 000. Based on similar campaigns, it is estimated that this would take two years. Furthermore, it would be beneficial to incorporate efficient technologies from other sectors, such as those the efficient cookstoves, into this campaign. This would help create a comprehensive understanding for the public of the capabilities of the various technologies.

Social and cultural factors (Conduct awareness raising)

In Lesotho, it is common for people to focus only on the initial price of a product rather than considering the benefits of using it. This is likely due to the high poverty rate and limited access to information. To address this issue, public awareness campaigns should be conducted. This barrier is similar to the limited market information and awareness barrier, so addressing it will require similar measures. In addition to awareness-raising programs, it is important to consider effective strategies for convincing users to adopt the technology in the long term.

This awareness raising campaign could be funded by the Ministry of Energy for approximately LSL 100 000.

- The focus of addressing this issue was on the Electrical Division of the Ministry of Public Works, which is responsible for certifying all local electrical installations. It is recommended to encourage engagement between this unit and electrical designers as an effective way to raise awareness of the benefits of energy-efficient fixtures in the building process, as demand is entirely client-driven. To address the general appliances used in homes and businesses, energy-efficient standards should be required from appliance importers and enforced at the ports of entry. Generally, appliances imported from North American, European, and South African markets conform to stringent energy efficiency standards. The problem arises when importation is done from countries without these standards. A system of an environmental levy with specific characteristics is also proposed to address this issue. All appliances below a particular efficiency rating should attract an additional levy based on estimated GHG emission targets.

1.5 Linkages of Barriers Identified for the Technologies in the Energy Sector

While the technologies differ in nature, a review of the barriers faced by the three prioritized energy sector technologies reveals common obstacles. During the barrier analysis, connections between the barriers of the prioritized technologies were identified to maximize synergies and optimize the effects of recommended measures. All three technologies are market goods, with efficient cook stoves and energy-efficient lighting and appliances being consumer goods, and solar mini-grids being capital goods. **Table 15** illustrates the linkages between the three technologies.

Table 15: Linkages of common barriers identified for three prioritized technologies in the energy sector

Common Barriers	Energy-Efficient Cookstoves	Solar PV Mini-grids	Energy Efficient Lighting and Appliances
Economic and Financial • High initial capital or investment cost. • Absence of adequate subsidies and financial incentives. • Limited access to finance and long-term capital. • Low ability and willingness to pay for technologies by end users. • High interest rate charge by banks and other financial institutions on loans for renewable energy projects.	✔	✔	✔
Weak legal, regulatory and institutional framework The absence of strong legal, regulatory and institutional framework have led to: • limited technical and operational standards, codes and guidelines to measure the performance of operators or service providers; • limited private sector investment; • importation of low quality products and spare parts; • Limited technical skills and capacity of local actors.	✔	✔	✔
Information and Awareness • Inadequate and limited information sharing about the technologies among stakeholders at the local and national level	✔	✔	✔
Technical • Inadequate trained local technical expertise to install, operate and maintain renewable energy projects.	✔	✔	✔
Cultural, Social and Gender • Absence of inclusive gender participation in renewable energy projects. • Absence of a well-developed and targeted engagement plan to engage with potential beneficiaries, leaders or other influential members in the targeted areas.	✔	✔	✔

The identification of common barriers for three prioritized technologies in the energy sector has revealed several linkages between the barriers. These linkages provide insights into the interconnected nature of the challenges faced by these technologies. By understanding these linkages, policymakers

and industry stakeholders can develop more effective strategies to overcome these barriers and accelerate the deployment of these technologies.

Some of the common linkages identified include:

Regulatory barriers: Many of the barriers identified for the prioritized technologies are related to regulatory issues, such as regulatory uncertainty. These regulatory barriers are often interconnected and can create significant challenges for technology deployment.

Financial barriers: Another common linkage is the presence of financial barriers, such as high upfront costs, lack of access to financing, and uncertainty around future revenue streams. These financial barriers are often linked to regulatory issues, as well as market and investment conditions.

Market barriers: Market barriers, such as lack of demand, competition from incumbent technologies, and market access issues, are also interconnected with regulatory and financial barriers. These market barriers can create significant challenges for technology deployment and adoption.

By understanding these linkages, policymakers and industry stakeholders can develop more holistic strategies to address the barriers faced by these technologies. This can include coordinated efforts to streamline regulatory processes, improve access to financing, and create supportive market conditions. Addressing these linkages can help to create a more enabling environment for the deployment of these technologies and accelerate the transition to a more sustainable energy future.

Furthermore, the importance of local Technical and Vocational Education and Training (TVET) in developing local capacities and fostering microenterprises is apparent across all technologies. Additionally, there is a need for a government institution to oversee and coordinate all project proposals aimed at addressing climate change. This coordinating body should be linked to or incorporated into the LMS, as all the technologies are designed to mitigate climate change.

1.6 Enabling Framework for Overcoming the Barriers: Energy Sector

In order to overcome the obstacles that have been identified and encourage the use of clean and efficient cookstoves, energy-efficient appliances, and solar minigrids in Lesotho's energy sector, it is essential to establish a comprehensive enabling framework. This framework should include a range of measures, policies, strategies, and accountable institutions **Table 16** provides an overview of the proposed enabling framework.

Table 16: Enabling Framework for the Prioritized Energy Sector Technologies

Type	Measures	Responsible Institutions / Entity
Economic and Financials	• Implement financial schemes such as subsidies, grants, and innovative financing mechanisms to support renewable energy projects. • Implement distinctive legislative frameworks that prioritize renewable energy sources. • Develop financial models tailored to local needs, such as revolving fund schemes to ensure sustainable funding for energy technologies. • Encourage Development Partners to offer sufficient funds on concessionary terms to government and private institutions.	Ministry of Finance and Development Planning; Ministry of Energy; Development Partners; Microfinance Institutions

	• Explore opportunities to access climate finance through multilateral funding options such as GCF, World Bank, etc. • Capitalize the Energy Fund and make it operational to provide financial support, capital subsidies, and production-based subsidies to investors, suppliers, dealers and consumers. The Energy Fund can (a) subsidize interest rates on RE loans, (b) provide low-cost funding to financial institutions to attract investors in the RE sector, and (c) cater for incentives to early adopters of the technologies in the communities • Offer tax breaks and holidays for private sector investment in renewable energy technologies	
Lack of Awareness and Understanding	• Initiate aggressive nationwide awareness campaigns highlighting the economic, social, and environmental advantages of energy-efficient technologies. • Enhance the dissemination of comprehensive information through various channels including print, electronic and social media. Additionally, conduct seminars, workshops and conferences to educate the public. • Boost local capacity and community involvement to maximise the positive socio-economic impact and promote awareness of the benefits of renewable energy among consumers.	Ministry of Energy, Ministry of Information, Communication, Technology and Innovation; Ministry of Education and Training; Media houses
Regulatory and Policy Challenges	• Develop and implement supportive policies and regulatory frameworks, including tax incentives and quality standards to promote growth and innovation. • Develop codes, standards and institutional framework to ensure compliance.	Ministry of Energy; Ministry of Trade, Industry and Business Development; Parliament
Technical Capacity and Skills	• Implement capacity-building programs, technical and vocational training, and educational curriculums to enhance local technical skills • Set up a scholarship program to incentivize the enrolment of women for gender mainstreaming	Ministry of Labor and Employment; Ministry of Education and Training; Technical and Vocational Education Training Institutions; NGOs
Cultural and Social Factors	• Encourage community involvement and empower women to participate in decision-making processes related to energy-efficient technologies. • Encourage and reward women's involvement in the management, development, operations, installations, engineering, procurement, construction, maintenance, and repair of renewable energy technologies through incentives. • Engage in thorough stakeholder consultations before, during, and after the development of renewable energy projects. This ongoing engagement is crucial for the successful implementation and continued success of these projects.	Ministry of Gender, Youth and Social Development; Civil Society organizations; Local Community Leaders
Quality and Performance Concerns	• 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; Ministry of Trade, Industry and Business Development (Standards and Quality Assurance)

Effective implementation of this framework will depend on close cooperation and coordination among relevant institutions. Transparency, accountability, and continuous monitoring and evaluation of the

measures taken will be crucial to assess their effectiveness and make any needed adjustments. The goal of this framework is to establish an environment that supports the widespread adoption of priority technologies, thus advancing Lesotho's efforts to mitigate climate change in the energy sector.

Chapter 2 Agriculture, Forestry and Other Land Use

2.1 Preliminary targets for technology transfer and diffusion

The AFOLU sector is the second highest source of GHG emissions in Lesotho after Energy. AFOLU was responsible for 2 417 Gg of CO_2e emissions in 2017 with land use change responsible for approximately 45% of the sector's total emissions. Soil carbon loss due to land degradation is the main source of emissions. Enteric fermentation is the second highest source of emissions in the sector.

This document is a continuation to the initial phase of the TNA which identified and prioritized mitigation technologies in the AFOLU sector. The AFOLU TNA I prioritized the following technologies:

Table 17: Ranked GHG mitigation technologies in the AFOLU as identified in the TNA I

Rank	Identified technologies
1	Small-scale biogas and homestead vegetable production in a mixed (crop and livestock) agricultural system
2	Promotion of conservation agriculture (minimum tillage, mulching, retaining of crop residues)
3	Carbon sequestration through agroforestry systems

The second technology (conservation agriculture) is also prioritized in the Adaptation TNA. Since adaptation is a primary focus for Lesotho in relation to responding to challenges associated with climate change, it was found appropriate to conduct a BAEF analysis in the Adaptation TNA document as its outcome will for large extend, apply even for mitigation side. As a result, this technology will not be discussed further in this report.

Table 18: Preliminary targets for small-scale biogas and homestead vegetable production in a mixed agricultural system

Prioritized technology	Preliminary target
Small-scale biogas and homestead vegetable production in a mixed (crop and livestock) agricultural system	To pilot biogas installations in farming households in Lesotho, fifty (50) emerging dairy farmers in the Lowlands can be identified. Dairy farming is a growing enterprise in the country with established commercial and governance structure, the National Dairy Board. Aim would be to develop medium sized biogas plant that can provide biogas enough to supply energy requirements for a household. The primary energy need is cooking. A biogas plant fed with about 26 kg of wet cow dung a day can produce 1 m^3 of biogas which is equivalent to 6 kWh (Nijaguna, 2002). A farming household needs 3 kWh about for cooking per day (Meyer et al., 2021). A biogas system has a potential to replace 33% of liquified petroleum gas (thus sustainably saving costs) and (Obileke et al., 2022). At current costs, five biogas plants for five farming households would require a total capital investment of not less than M100 000. The INDC identified promotion and use of biodigesters in livestock farms as a key mitigation activity with the following targets; Improve agricultural systems for both crops and livestock.

	Develop strategies for improved resource management. Gradual replacement of 100% of mineral fertilizers with organic fertilizers by 2030.
Carbon sequestration through agroforestry systems	Target a plantation of 1 000 ha of agroforestry systems that consists of forests and fodder grasses in five years in the lowlands of Lesotho. Studies (Khatri-Chhetri et al., 2022; Fatumah et al., 2023) estimate that trees in agroforestry systems have a potential to sequester between 0.50 $tCO_2e\ ha^{-1}\ year^{-1}$ and 17 $tCO_2e\ ha^{-1}\ year^{-1}$ depending on the tree species while grasses can capture up to 2 $tCO_2e\ ha^{-1}\ year^{-1}$ when they are about 1.5 years old. These carbon sequestration potentials can increase with growing biomass with age particularly of trees. Agroforestry systems achieve carbon storage by increasing biomass carbon stocks, stored both below and above the ground. In addition to acquiring land, it is estimated that a smallholder farmer may need to contribute USD 33 ha^{-1} excluding their own labour costs (MWE, 2017). Agroforestry systems have been shown to increase productivity of the land by improving soil organic carbon, soil fertility and soil water holding capacity.

Barriers that have potential to affect implementation and adoption of biogas technology, and carbon sequestration through agroforestry systems are summarized in the figure below. Barriers in the AFOLU sector are related and interlinked. They revolve around challenges of land tuner system where majority of farmers own not more than 1 hectare (ha) of land that is not registered and cannot therefore be used as a collateral. Land is also communal and difficult to manage. The sector needs to be transformed from its current subsistence nature to be commercial enterprises that can attract investments from private sector and funding from financial institutions. The country lacks capacity to develop its own technologies, making it vulnerable to market factors including costs of technologies and local suitability. The NSDP II and other sector plans have proposed several interventions which if effectively.

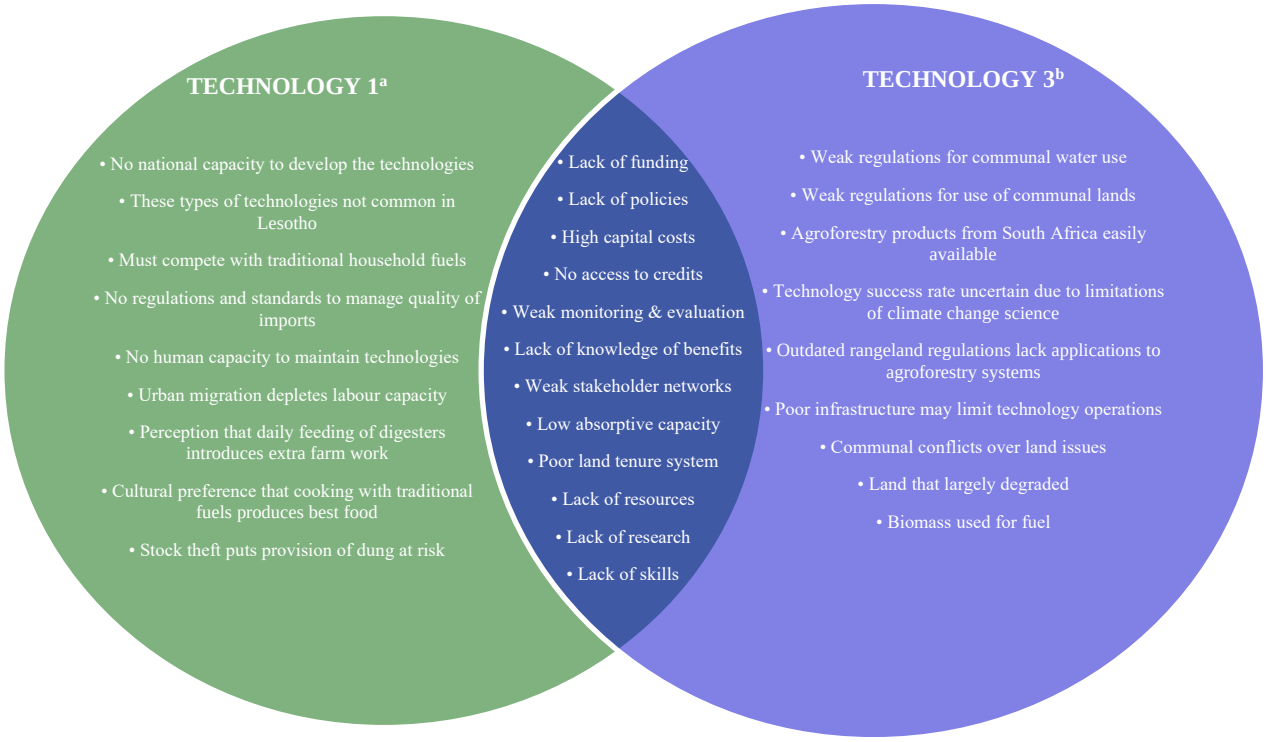

Figure 4: Summary of possible barriers that may affect implementation of mitigation technologies in the AFOLU sector in Lesotho

[a] Small-scale biogas and homestead vegetable production in a mixed (crop and livestock) agricultural system

[b] Carbon sequestration through agroforestry systems

2.2 Barrier analysis and possible enabling measures for small-scale biogas and homestead vegetable production a mixed (crop and livestock) agricultural system

Barriers to successful adoption of small-scale biogas and homestead vegetable production in a mixed agricultural system, and possible enabling measures are discussed in subsections 2.2.1 and 2.2.2.

Market map for this technology is presented in the appendix.

The Figure 5 below shows a summary of barriers that can affect implementation of biogas digester technologies by small-scale farmers in Lesotho, and possible measures that can promote adoption of the same.

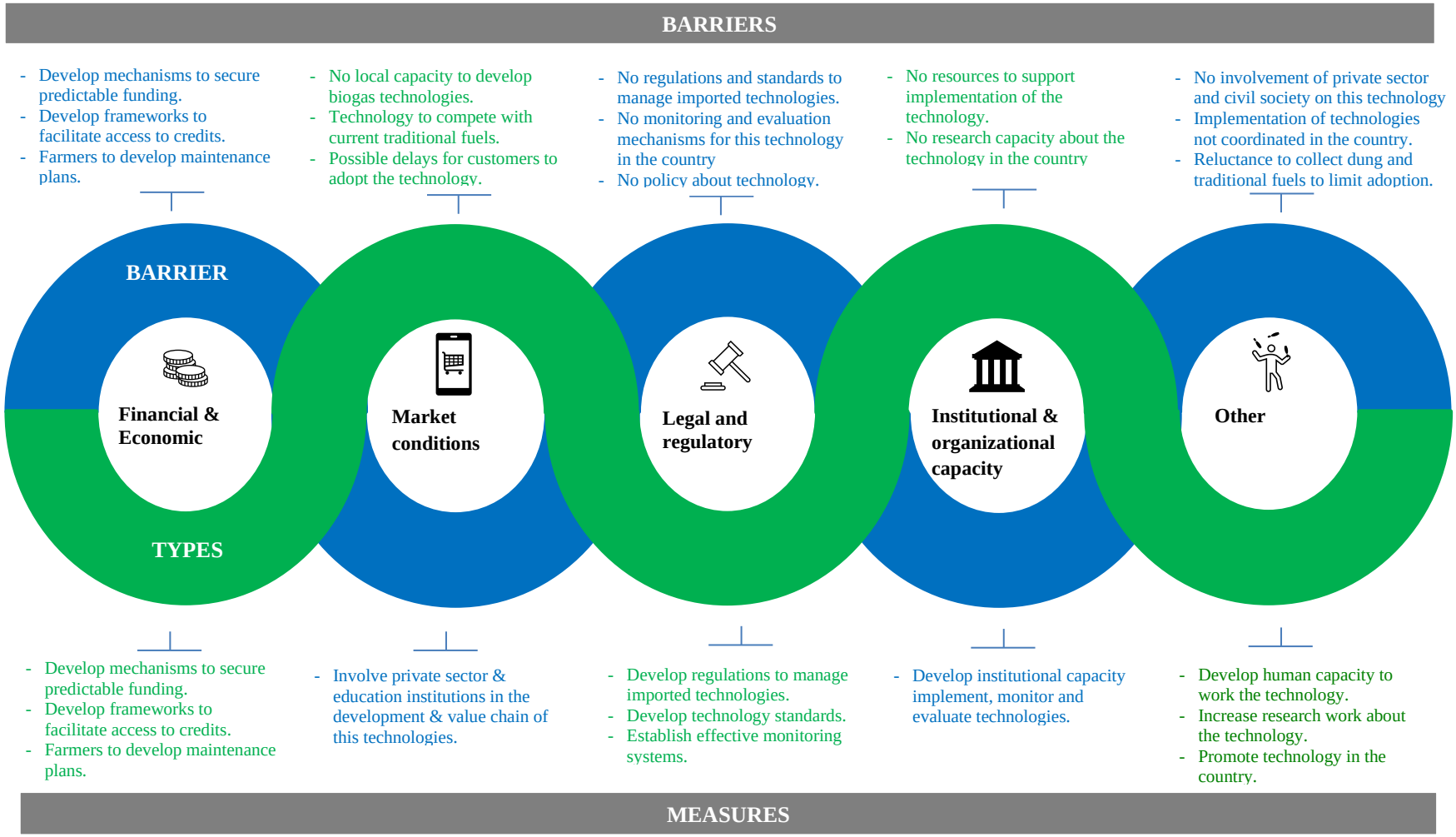

Figure 5: Summarized presentation of identified barriers and measures to increase adoption of small-scale biogas and homestead vegetable production in a mixed farming system

2.2.1 General description: Small-scale biogas and homestead vegetable production in a mixed (crop and livestock) agricultural system

Energy provision is an important need to societal development. Many governments are making plans to transition from old and unsustainable technologies to climate-friendly technologies. Biogas is one of the renewable energy sources that can provide a sustainable solution to increasing energy demand (Hasan et al., 2022). This technology can be easily adaptable to remote homesteads that may be hard to be connected to national grids farming households that may not afford other forms of sustainable energy sources.

Cattle production is the main source of GHG emissions from livestock. They produce methane from enteric fermentation and manure management. There is also nitrous oxide from manure latter. Cattle dung and urine deposited on rangelands and kraals are also sources of the GHGs.

In Lesotho, cattle are taken to the communal rangelands in the mornings and return for a sleep in the small encloser of kraals. The dung they leave in the kraals and the rangelands is dried and used as fuel source in the form of *lisu* (dried cow dung) by many households.

Methane that is produced from manure and agro-industrial waste management systems can be captured using anaerobic digestion technologies including small-scale digesters. Cattle dung can be used to produce biogas that can be used to supply clean energy at household levels. Cow dung contains CH_4 which has a greenhouse effect that is 25 times greater than that of CO_2. Biogas is produced under anaerobic conditions and contain CH_4.

Biogas contains 50-70% combustible CH_4, 20-40% CO_2 and other trace gases. When it is burned, CH_4 is reduced to CO_2 and water, reducing the impact of the greenhouse impact. Collected biogas can provide basic household energy requirements like cooking.

Construction of a biogas plant requires a capital cost (~ZAR 20 000) which many subsistence and small-scale farmers may not have (Meyer et al., 2021). In addition to not prioritizing biodigesters, financial institutions in Africa put high interest rates on loans of biogas technologies and limit access to affordable long-term finance (Clemens et al., 2018).

2.2.2 Identification of barriers: Small-scale biogas and homestead vegetable production in a mixed (crop and livestock) agricultural system

2.2.2.1 Economic and financial barriers

The following economic and financial barriers have a potential to affect adoption of biogas technologies in small-scale mixed farming systems in Lesotho. Main economic and financial barriers are the difficulties for the farmers to access credits from financial institutions and lack of public subsidies.

Table 19: Economic and financial barriers that can affect adoption of biogas systems in small-scale farming system in Lesotho

Barrier type	Barriers
Financial and economic	Difficult to get credits. Nearly all the farmers in the country practice subsistence farming with limited asset base. Although there are formal and informal financial service providers in Lesotho, the sector is small and has declined over time (Motsoari

	et al., 2015). For farmer to access loans from formal financial institutions they must satisfy stringent requirements and therefore many applications often fail. Informal financial services providers charge high interest rates that result in perpetual repayments of the loans and reduce margins of the farmers. Informal loans are common throughout the country particularly in the rural areas where people do not necessarily use formal financial settings. The absence of financial institution dedicated to supporting the agricultural sector after the closure of Lesotho Agricultural Development Bank in the 1990s has created a void and significant inaccessibility of financial support to farmers. The current financial institutions do not have products relevant to the agricultural sector. Many farmers do not have collateral to use to secure loans from financial institutions (including banks).
	Limited public funding. Public funding is insufficient. Failure to finance transactional and monitoring costs will compromise successful implementation of the technology. Low public financing on research and development lead to structural constraints in developing countries (UNEP-CCC and UNFCCC, 2022). Lesotho is a least developed country and is characterized by lack of resources and growing demands. Although agriculture is pillar of rural economy and livelihoods, the sector has been declining in its contribution to the national GDP. Fiscal support is low, inconsistent, and unpredictable. Government subsidies in the sector often reach beneficiary farmers late (i.e., support with inputs prior to onset of the season) and therefore become ineffective. Funding of forestry programs over the years has not produced the intended results. Combination of funding for afforestation and land rehabilitation programs throughout the country did not always hold because forests would sometimes be planted where environmental conditions (general climate, soil type etc) were not suitable. This applies to also agroforestry projects. The government through the Ministry of Agriculture and Food Security, has in the past years provided 30% subsidies and 100% bank guarantees to farmers under block farming. This arrangement has implanted to farmers a practice of non-payment of loans with the understanding that every support is a subsidy or farmers do a deliberate defaulting knowing the government will settle the loan (Motsoari et al., 2021). This practice is not sustainable and instils fear to formal financial service providers that farmers would generally default.
	Capital costs that include purchase of construction material, transportation of material and labour to install this technology are high for resource poor farmers. Biodigesters can either be prefabricated and bought to be installed, or they can be built with bricks and mortar. Capital costs of the latter may be slightly cheaper than those of the former. Procurement of equipment, labour and maintenance costs are usually high for resource poor farmers.

2.2.2.2 Non-financial barriers

Non-financial barriers that can affect adoption of biogas technologies are discussed in the table below. These barriers include lack of capacity for the country to manufacture prefabricated units, lack of institutional capacity, no mechanisms and regulations and standards to monitor the technology.

Table 20: Non-financial barriers that can affect adoption of biogas technologies in a small-scale mixed farming systems in Lesotho

Barrier type	Barriers
Market conditions	Lesotho does not have capacity to develop input materials required to install biogas digesters and thus depends heavily on imports of prefabricated units mainly from South Africa. These imports increase investments costs especially costs associated with transportation. There are no suppliers of auxiliary materials in the country and few in South Africa, a situation that monopolizes the supply and influences price inflation.
	Biogas digester technologies are not common in Lesotho. These technologies are not in the local market at the moment. As adoption rates of new technologies that are not

	known by consumers are low (Nabuurs et al., 2022), it can be anticipated that customers will take some time to adopt the technologies. It may take some time before the demand market for the technology to increase.
	Fossil fuels that are commonly used in the households (i.e., paraffin, LPG, wood) are generally subsidized by the government and cheap in Lesotho. They are also easily accessible in the market. Lower prices and ease of access of fossil fuels can make it difficult to make people change to this technology (Nevzorova and Kutcherov, 2019). Biogas technologies with their high capital costs and unavailability in the market can be a hindrance for their absorption especially if they will not be subsidized.
Legal and regulatory	Lack of regulations and standards on imported technologies can lead to substandard and poor technologies being brought into the country. Lack of monitoring systems that can detect and prevent entry of substandard technologies into the country. Ports of entry into the country are poorly resourced with equipment and protocols to identify substandard technologies that are imported into the country.
	Lack of policy certainty limits adoption rates in the country. Producers of technologies and the entire value chain prefer to have clear policies and support for the industry regarding future of taxes, incentives, and the extend of governmental support for programmes (Nevzorova and Kutcherov, 2019). There is no clear policy on biogas development in the country and this affects planning for sustained adoption of this technology in the country.
Network	Lack of participation of private sector and civil society. Few technologies that are implemented in the country are isolated and found in various institutions that particularly provide social services. These installations are largely funded by donor organizations. There is generally no working relationship between stakeholders to address issues around technology development in the country. Climate change activities in the country are isolated and lack coordination. There is no coordinated approach and network between stakeholders to adopt the biogas digester technologies in the country. There is limited learning between projects and activities. Success stories and challenges encountered during implementation of technologies are often not shared between stakeholders.
Institutional and organizational capacity	Implementation of technologies and programs need support from relevant institutions. These institutions, public or private, need to have resources to provide support. However, lack of organizational capacity in terms of resources (i.e., vehicles to move around) affect provision of support services that may be required from time to time. Biogas production may not be high on the government agenda. This leads to a lack of political support to capacitate institutions that need to provide support services.
	Research capacity of biogas technologies in the country is low. There is currently low research outputs on improved agricultural technologies due to lack of (1) funding and (2) little or no coordination between key research institutions in the country and these limitations decrease adoption rate of climate-smart agricultural technologies including biogas development (CIAT, 2018)
Human skills	Biodigesters experience frequent blockages and breakdowns especially when the technology is new, and installation and operation standards have not matured. Trained technicians to repair the breakages are hard to find. Moreover, local people who can be trained during installation may migrate to look for employment elsewhere. This has resulted in many biogas systems failing in many countries (REN21, 2018).
	Low agricultural labour productivity. Migration of young people from rural areas to the urban centres including to neighbouring South Africa, and high prevalence of diseases (i.e. HIV) make adoption of labour-intensive biogas digester systems in the country to be low. The regular average time spent on feedstock preparation and feeding bio-digesters is usually high that it can affect the time required to execute another regular agricultural practices (Sime, 2020).
Social, cultural and behavioral	Farmers are reluctant to collect dung and water to daily feed biodigesters. Farmers find collection of feedstock as additional work to them, especially when the feedstock is not within their immediate reach. Collection of dung can be viewed as degrading public status of the farmer or the employee. Collection of dung for fuel use is commonly done in the country when households have no other better fuel alternatives available to them.

	Traditional fuels may likely be preferred over biogas technologies. There is possibility that beneficiaries may complain that food for an example, cooked using these new technologies taste differently to what they are used to, or they take long to cook. In households where open fire is used for both cooking and space heating, biogas application with only cooking capability may cause rejections or reduced use by beneficiaries. This may particularly be true during winter season when space heating becomes important.
	Crop residues are used as animal feedstocks. Energy poverty and social conditions may limit change from this practice. These energy sources are also easily accessible and affordable.
	Poverty. High levels of poverty make it difficult for farmers and communities to afford or consider new technologies in the country (CIAT, 2018). This is particularly relevant when there is no external support provided to the customers.
Information and awareness	Lack of research and publicity about the biogas technology. Although this technology has been used in some settings in Lesotho (i.e., in dormitories), its efficiency, success rates and challenges are not documented. Scientific studies are important to carry out in the country because they will investigate local conditions that may affect biogas digesters.
	Education level of household heads is generally low in the country. Subsistence farmers have low levels of education and it may take time for them to comprehend and adopt new technologies. Education enhances individuals understanding and increases chances of adoption of new ideas and technologies (Uhunamure et al., 2019; Meyer et al., 2021).
Technical	Biogas systems operate in anaerobic conditions and their productivity rely on soil temperature. As a result, productivity of biogas plants biodigesters can be considerably reduced in winter when temperatures drop (Nape et al., 2019) in Lesotho. Temperatures in Lesotho drop significantly and may cause poor performance because of reduced rate of decomposition in the plant.
	Failure to sustain livestock keeping and water sources (World Bank, 2019). Livestock theft and water insecurity are common in Lesotho. Water is fetched from communal taps and is often not available during droughts. Livestock may be sold and their population reduced to address social and business needs of a farmer.
	Productivity of biogas digesters can also be affected by the type of input feedstock. Other factors such as retention time, rate of input to the digester, composition of feedstock etc. affect the efficiency of biogas production and play a substantial role in the final composition (energy content) of biogas (Nevzorova and Kutcherov, 2019).
	Water availability: Animal dung (or any organic substances used as inputs) are mixed with water before it is poured into the biogas digester plants. Water networks in rural Lesotho are not connected at a household level but water is obtained from communal water-taps. The national policy is for a water-tap to service households within 300 m from it. Communities collect water from communal water supply systems for basic human needs including for cooking, bathing and laundry. Many farmers consider collecting water to mix dung to feed biogas digesters an additional burden.

2.2.3 Identified measures

This subsection discusses measures that can be used to increase adoption of carbon sequestration through agroforestry technologies in Lesotho.

2.2.3.1 Economic and financial measures

The identified economic and financial measures to improve adoption of biogas digester technologies in small-scale mixed agriculture system in Lesotho are discussed below. Economic and financial measures that are identified include assisting farmers with funding capital investments and planning for operational as well as maintenance costs.

Table 21: Identified measures to increase adoption of agroforestry technologies in Lesotho

Barrier type	Measures	Responsibility
Financial and economic	Develop mechanisms to secure predictable donor funding and public support for capital costs.	Ministry of Finance and Development Planning
	Government need to develop frameworks or arrange credit facilities with financial institutions to support farmers afford capital costs.	Ministry of Finance and Development Planning; Ministry of Agriculture, Food Security and Nutrition
	Train farmers to make plans for maintenance costs. These costs can be budgeted for over time.	Ministry of Finance and Development Planning; Ministry of Information, Communication, Science Technology and Innovation; Ministry of Agriculture, Food Security and Nutrition
	Identify and promote cheaper construction options of biogas digesters. Construction of brick-and-mortar biogas digesters usually costs less than the prefabricated units because they remove many costs that are associated with supply chain and importations.	Ministry of Finance and Development Planning; Ministry of Information, Communication, Science Technology and Innovation; Ministry of Agriculture, Food Security and Nutrition

2.2.3.2 Non-financial measures

The table below presents possible measures that can be implemented to increase adoption of biogas digester technologies in small-scale mixed agriculture system in Lesotho.

Table 22: Non-financial measures that can affect adoption of biogas digesters in a mixed farming system in Lesotho

Barrier type	Measures	Responsibility
Legal and regulatory	Develop regulations that will administer and provide standards of imported biogas technologies to avoid substandard materials and technologies. Develop standards for technologies that may be developed in the country (i.e., brick and mortar biogas technologies) to ensure quality of the installations or constructions. Establish effective monitoring systems in the ports of entry to prevent entries of substandard technologies.	Ministry of Information, Communication, Science Technology and Innovation; Ministry of Agriculture, Food Security and Nutrition
Policy	Implement NCCP proposed measures; - Promotion of renewable energies including biogas technologies.	Ministry of Information, Communication, Science Technology and Innovation; Ministry of Agriculture, Food Security and Nutrition
Market	Increase involvement of private sector and technical training institutions in the development and marketing of technologies.	Ministry of Information, Communication, Science Technology and Innovation; Ministry of Agriculture, Food Security and Nutrition; Ministry of Trade, Industry and Business Development

Technical and technological	NSDP II proposes; - Promote efficient bio-energy resources and appliances, and renewable energy technology and services. - Promote renewable energy use in particular for rural, productive, and social uses. National Adaptation Plan of Action proposes; - Promote biogas energy use as a supplement to hydropower energy	Ministry of Information, Communication, Science Technology and Innovation; Ministry of Agriculture, Food Security and Nutrition
Research	National Energy Plan proposes; Promote research and development in the field of bioenergy and associated technologies for power generation, heat and fuel production. Implement the plan's proposal.	Ministry of Information, Communication, Science Technology and Innovation; Ministry of Agriculture, Food Security and Nutrition; Ministry of Education and Training
Institutional and organizational capacity	Develop capacity to monitor and evaluate, to capture data related to technology adoption rates, availability and access to inputs (CIAT, 2018). Current and future investments need to have data collection and analyses integrated within them to provide basis for policy decisions and planning in the country.	Ministry of Finance and Development Planning; Ministry of Information, Communication, Science Technology and Innovation; Ministry of Agriculture, Food Security and Nutrition; Ministry of Education and Training
Human capacity	Capacity building and technology transfer need to support endogenous African scientific and technological growth and must build on indigenous knowledge (Mutengwa et al., 2023).	Ministry of Finance and Development Planning; Ministry of Information, Communication, Science Technology and Innovation; Ministry of Agriculture, Food Security and Nutrition; Ministry of Education and Training

2.3 Barrier analysis and possible enabling measures for carbon sequestration through agroforestry systems

Barriers to successful adoption of small-scale biogas and homestead vegetable production in a mixed agricultural system technology, as well as possible enabling measures are discussed further in subsections 2.3.1 and 2.3.2.

There are no market maps developed for this technology as it does not require extensive market goods.

Identified barriers and possible measures that can improve adoption of carbon sequestration through agroforestry systems' technologies are summarized in the Figure 6 below.

The Figure 6 below presents a summary of identified barriers and possible measures that can enhance adoption of agroforestry technologies that can assist climate change mitigation in Lesotho.

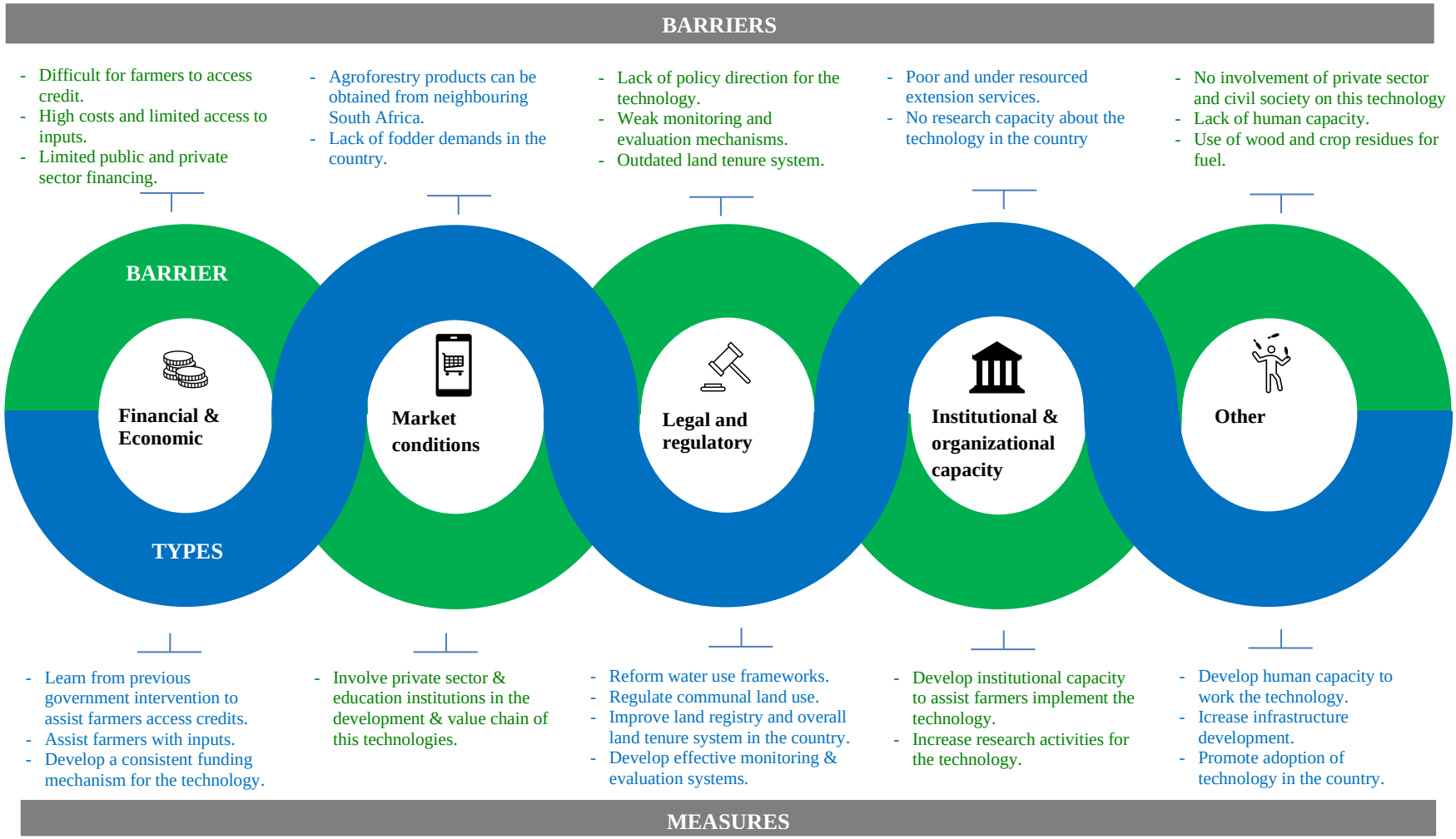

Figure 6: Summarized presentation of identified barriers and measures to increase adoption of carbon sequestration through agroforestry systems

2.3.1 General description of technology

Agroforestry combines production of trees with crops or grasses. As a result, agroforestry technologies combine afforestation and improvement of food security and nutrition. In addition to potential GHG mitigation benefits depending on operational management practices, this can also provide other social and ecosystem-related services. Regarding mitigation applications, agroforestry technologies aim to reduce GHG emissions through carbon sequestration by planted biomass, prevention of land degradation and organic improvement of soil health.

Agroclimatology of Lesotho is suitable for fruit trees production. Cold winter climate of the country can provide chilly environment for Mediterranean fruits. Land degradation, a challenge that has existed for a long time, provide a great opportunity for agroforestry applications that can be used to conserve soil. Although supplementation with irrigation may be necessary in some occasions, cold temperatures and several snow occurrences in winter are favourable for cultivation of Mediterranean fruit trees including grapes, apricots and citrus.

Plants remove carbon dioxide from the atmosphere through photosynthesis and keep it as both biomass above ground (leaves and stems) and below ground (roots). Soil organic matter consists of 50-58% carbon, loss of organic matter during conventional tillage results in a significant sources CO_2 emissions into the atmosphere (Sollen-Norrlin et al., 2020). Improvement of agroforestry assists by storing carbon in the terrestrial systems and prevents carbon loss through land degradation.

This technology can mitigate emissions by restoring degraded grazing lands by through a combination of intensive, extensive agroforestry (silvopastoral) livestock systems and planting of improved and nutritious forage trees. Agroforestry involves integration of forest (or tree) planting with other crops and grasses. Trees are planted at strategic points in the field to allow for production of crops together with them. Agroforestry enhances biomass production and therefore carbon sequestration. Trees in this system provide shading which reduces evapotranspiration, prevents soil erosion and increase nutrient cycling. They also protect crops from strong winds and storms. Crops grown can include fodder crops (pastures) for livestock. Since roots of trees extends to deeper soil levels, they avoid competition for resources with other crops and other trees which they are integrated with.

Agroforestry systems improves soil carbon content which improves overall soil fertility. As a result, crop and tree yields produced in agroforestry required 14–34% less land or fewer resources in terms of light, water, nutrients, compared to monoculture systems (Sollen-Norrlin et al., 2020).

2.3.2 Identification of barriers

Agroforestry systems cover a broad spectrum of technologies. These technologies vary from a combination of trees and crops (including horticulture) and tress and fodder grasses. Barriers that may affect these technologies may also vary accordingly.

2.3.2.1 Economic and financial barriers

Economic and financial barriers that affect adoption of agroforestry technologies in Lesotho are identified in the table below.

Table 23: Economic and financial barriers that can affect adoption of agroforestry systems in Lesotho

Barrier type	Barriers
Financial and economic	Difficult to get credits (World Bank Investment Plan). Nearly all the farmers in the country practice subsistence farming with limited asset base. Many farmers do not have collateral to use to secure loans from financial institutions (including banks).
	High costs and limited access to inputs (World Bank Investment Plan). Many farmers will not afford capital costs to start and manage agroforestry projects. Farmers often lack funds to buy inputs regularly due to high costs. These costs are market related and fluctuate from time to time which affect sustainable uptake of agroforestry technologies (IFAD, 2023). There is lack of subsidies from government towards agroforestry industries.
	Limited public and private funding. Farmers that currently undertake agroforestry systems lack funding support from both public and private investors. There are not consistent and predictable funding mechanisms for agro-forestry industries.

2.3.2.2 Non-financial barriers

The following non-financial barriers may affect successful implementation of agroforestry technologies in Lesotho. Main barriers are land tenure system that makes it difficult to increase scale of production, lack of institutional and human capacity to manage agroforestry systems, and use of crop residues as fodder or fuel at homes.

Table 24: Non-financial barriers that can affect adoption of agroforestry systems in small-scale farming system in Lesotho

Barrier type	Barriers
Market conditions	Horticulture products are easily obtained from South Africa. Agroforestry has an option to grow trees and horticulture. Demand to grow horticulture in Lesotho may be reduced since the market in Lesotho is currently being satisfied by imports from South Africa which has a mature horticulture industry. Agroforestry that involves trees and fodder grasses may be affected by lack of fodder demand. Fodder is usually used in commercial setups which is small in Lesotho. It is also not a common practice to grow or buy fodder in the country.
Legal and regulatory	Weak policy & programme analytical work. There is a lack of policy direction regarding agroforestry production in the country. Although this technology is proposed in several national plans and strategies (including NSDP II), it does not have its specific policy. Weak implementation of policies. Environmental challenges are exacerbated by lack of enforcement of plans and non-policy compliance (NSDP II).
	Weak monitoring & evaluation systems. There is a generic challenge of weak monitoring and evaluation of technologies in Lesotho. As a result, it will be difficult to identify progress or challenges associated with implementation of agroforestry technologies in the country.
	Outdated regulations currently in use in the country. Old national rangeland regulations may not adequately address new sustainable agroforestry management systems. These regulations may have been designed specifically for rangeland management and may not sufficiently cover agroforestry systems.
	Outdated land tenure and land use rights. Average farmer in the country owns a hectare of land for production and has insecure rights to access other land. This land is also not registered. Acquisition of land from other farmers is unregulated and puts investments at risk.
	Forestry rights are not sufficiently regulated and documented. There are weak governance systems and insecure forestry property rights in the country and this can limit access to benefits brought by forest management (i.e., carbon offset projects, Nabuurs et al., 2022).

Network	Lack of participation of private sector, civil society and overall coordination. Climate change activities in the country are isolated and lack coordination. There is limited learning between projects.
Institutional and organizational capacity	Lack of research capacity. National and local institutions lack capacity (human & equipment) to monitor and evaluate carbon sequestration projects. Low research. Low research outputs on improved agricultural technologies due to lack of (1) funding and (2) no coordination between key research institutions in the country decreases adoption rate of climate-smart agricultural technologies.
	Failure of extension services in poor African countries limits the possibility to scale up innovations in agroforestry for improved land use systems (Mbow et al., 2014). Lack of resources for extension services can affect services that are required to assist implementation of agroforestry systems in the country.
Human skills	Limited human expertise due to constant brain drain. There is a large turnover of professional staff who get better opportunities outside the country, particularly South Africa. As a result, there is lack of research on agroforestry systems in the country due to lack of both human and institutional capabilities.
	Low agricultural labour productivity. Migration of young people from rural areas to the urban centres including to South Africa, and high prevalence of diseases (i.e. HIV) make adoption of labour-intensive climate-smart agricultural systems in the country to be low (CIAT, 2018)
Social, cultural and behavioural	Conflicts for land among farmers and officials about land management. There are frequent conflicts amongst users of communal land especially during drought seasons when resources become scarce. Agroforestry systems are likely to be targeted when there are social pressures around them.
	Crop residues are used as animal feedstocks and wood for fuel. Energy poverty and social conditions may limit change from this practice. Biomass that would be beneficial to the agroforestry ecosystem including growth of trees and grasses or crops, soil organic carbon, moisture conservation and increase in overall soil health will likely to be harvested for fuel or animal feeding.
	Poverty. High levels of poverty in the country will make it difficult for farmers and communities to afford or to consider new technologies in the country (CIAT, 2018). Poor households or farmers are likely not to be enthusiastic to engage in new technologies and methods of production.
Information and awareness	People are unaware of value of trees (National Forestry Policy, 2008). This will affect appetite of communities to appreciate agroforestry and their overall benefits.
	Lack of information sharing, documentation of lessons learned and experiences. Several climate-smart technologies are knowledge- intensive. Promoting their adoption requires well-designed, inclusive, and innovative knowledge management systems.
Technical	Droughts and lack of water are frequent occurrences in Lesotho. This can reduces potential irrigation and overall productivity of agricultural commodities including in agroforestry systems.
	Poor performance and no upscaling of previous technologies. Challenges faced by several irrigation schemes in the country in the past can reduce appetite in new investments (World Bank, 2016).
	Lack of inputs (World Bank CSA Report). There is lack of inputs and equipment in the country. Lesotho will have to depend on imported technologies. There is lack of inputs and equipment in the country. Lesotho will have to depend on imported technologies.
	Lesotho lacks empirical evidence of the impacts of various agroforestry technologies and strategies promoting these technologies (CIAT, 2018). No research on lessons learned about the technologies.
	Few farmers in the country have technical and commercial skills to produce marketable agroforestry products including fruits. This limits large scale production systems and overall scaling up of the technology.
Other	Remote areas are inaccessible due to poor infrastructure. Inaccessibility of where the agroforestry technologies are being implemented or located can affect services to them including maintenance, monitoring and evaluation as well as overall operations of the technologies.

	Shallow soils across the country could limit accessibility of land to be used, effectively reducing potential of the plantations. Shallow and degraded soils also reduce productivity of crops (FAO, 2011).
	Water security and overall state of local environment. Exotic species if not investigated sufficiently, may have unwanted consequences where they can affect existing resources like depletion of water resources or further degrading of the environment. This can affect immediate ecosystems, downstream demands (i.e., downstream water needs) and social benefits that would have otherwise been obtained.
	Shifting of climate patterns due to climate change. Uncertainty regarding suitability of technologies that are used currently and, in the future, make long term investments difficult (FAO, 2015). Agroforestry technologies face uncertainty of whether they will survive future climatic and other related or climate induced environmental conditions.

2.3.3 Identified measures

This section discusses possible measures that can be used to increase adoption of agroforestry systems and increase carbon sequestration in Lesotho.

2.3.3.1 Economic and financial measures

The following financial and economic measures are identified to address barriers that may affect successful implementation of agroforestry technology. Main measures include making access of funding to the farmers available as well as provision of subsidies.

Table 25: Measures identified to promote adoption of agroforestry technology in Lesotho

Barrier type	Measures	Responsibility
Financial and economic	The government has in recent past, arranged with commercial banks to assist farmers with credits. While this is an important step, modalities and effectiveness of the assistance may still be improved so that more farmers can be reached. The arrangement can be strengthened to transform subsistence farming into commercial farming.	Ministry of Finance and Development Planning; Ministry of Agriculture, Food Security and Nutrition
	For the subsistence nurseries to expand, they will need systematic support for inputs. This can be achieved through national programmes and projects with sustainable funding. These programmes will be important because this technology may need production of approved inputs at a large scale.	
	Systematic funding from both public and private investors is required. Funding may be important for school activities and other "environmental days" aimed at promoting and expanding agroforestry technologies. Private sector investments can be improved by government providing incentives and guidelines.	
	The NSDP II identifies the following measures: - Provide financial (public and otherwise) and technical support services to farmers. Develop frameworks that make it easier for farmers and communities to get access to finance for agroforestry technologies. - Explore and establish agri-insurance in collaboration with private sector. Develop	

	mechanisms and frameworks for private sector to provide insurance products for agroforestry technologies. - Finalize and operationalize collateral registry to allow use of land and other assets as collateral. - Develop capital market instruments for agriculture. Climate Smart Agriculture Investment Plan identifies this measure: Financing the modernization of land administration through digital land registry and titling, spatial data infrastructure development, and capacity building for land administration.	

2.3.3.2 Non-financial measures

The following non-financial measures are identified to address barriers that may affect successful implementation of agroforestry technology. The measures are summarized as follows: (1) Land tenure systems will need to be reformed in order to promote agroforestry systems in the country, and (2) capacity development at institutional and production levels will have to improve.

Table 26: Non-financial measures that can assist adoption of agroforestry technologies in Lesotho

Market conditions	Measures	Responsibility
Legal and regulatory	Reform laws, policies and regulations governing water use and land governance (Lesotho, undated). Agroforestry practices may need irrigation that will need to be optimally regulated.	Ministry of Law and Justice; Ministry of Natural Resources; Ministry of Agriculture, Food Security and Nutrition; Ministry of Environment and Forestry
	Regulate and manage diversified land use practices, including agroforestry systems. Develop and promote management practices that will operationalize agroforestry systems.	
	NSDP II proposes the following measure: Organize land titling. To have successful investments, land tenure system will need to be reformed and land registered. This will need legal frameworks to be reviewed and development of regulations.	
	There needs to be increased focus on monitoring and evaluation, capturing data related to technology adoption rates, availability and access to inputs (CIAT, 2018). Current and future investments need to have data collection and analyses integrated within them to provide basis for policy decisions and planning in the country.	
Policy	NCCP identified the following measure: Support agroforestry programmes that are initiated to conserve trees and crops. Existing and new programmes will need support of various forms including guiding policies for them to be successful.	Ministry of Agriculture, Food Security and Nutrition; Ministry of Environment and Forestry
Institutional and organizational capacity	Capacitate institutions with resources to assist farmers to adopt technologies. Government institutions and relevant civil society organizations need to be provided with resources to assist them to be able to reach out to farmers and locations where technologies are implemented.	Ministry of Finance and Development Planning; Ministry of Agriculture, Food Security and Nutrition
	Increase research activities associated with the technology. Research outputs assist to provide information regarding possible adoption mechanisms for the technology.	Ministry of Agriculture, Food Security and Nutrition; Ministry of Information, Communication,

		Science, Technology and Innovation
Human skills	Capacity building and technology transfer need to support endogenous African scientific and technological growth and must build on indigenous knowledge (Mutengwa et al., 2023).	Ministry of Agriculture, Food Security and Nutrition; Ministry of Information, Communication, Science, Technology and Innovation
Technical	High available water can make Lesotho an attractive investment destination for agroforestry technologies (CST report). Irrigation infrastructure can unlock many opportunities associated with this technology. Introduce agribusiness training in tertiary curriculum (Lesaane and Akinkunde, 2020). This training to focus on increasing entrepreneurship in the agroforestry industry.	Ministry of Agriculture, Food Security and Nutrition; Ministry of Information, Communication, Science, Technology and Innovation; Ministry of Education and Training
	NSDP II identifies the following measures: Strengthen national agriculture research. Agricultural research is needed to identify trees, fodder grasses and horticulture species that may be suitable to Lesotho environmental conditions and provide optimum results. Conduct land capability assessment and create online database of land parcels suitable for agroforestry production systems and responsible irrigation. Mechanize agricultural production. Large scale and commercial production systems require appropriate equipment. There is a need to assist farmers with suitable equipment and techniques of production. INDC proposes this measure: Implement conservation agriculture and agroforestry practices. Agroforestry maybe considered as a form of conservation agriculture. This approach may assist this technology to gain needed publicity and recognition by government institutions and private funders.	Ministry of Agriculture, Food Security and Nutrition; Ministry of Information, Communication, Science, Technology and Innovation; Ministry of Education and Training
Other	Long term planning in infrastructure development and agroforestry technologies becomes important. Strengthening local government capabilities can assist with improved governance and resource management.	Ministry of Finance and Development Planning; Ministry of Agriculture, Food Security and Nutrition

2.4 Linkages of the barriers identified

All the technologies that were identified in the Lesotho mitigation TNA in the AFOLU sector need agricultural land for them to be implemented. As a result, these technologies have several common barriers. They will both be affected by challenges brought by the land tenure system in the country. Land ownership limits diffusion and expansion of technologies in both crop and livestock systems. Small portions of unregistered land that are owned by the farmers in the country do not allow for the land to be used as a collateral. Farm size and land ownership have a positive relationship with the demand for credit, which suggests that a unit increase in farm size is likely to increase the demand of individuals for credit and that the bigger the farm size, the more likely it is that farmers would obtain loans (Motsoari et al., 2015).

Lack of funding from public resources and private sector is a common barrier that affects both technologies. Although the AFOLU sector is a key source of livelihoods to most people in Lesotho

especially the rural population, there is a lack of clear and consistent policy direction that guides funding in the sector.

Lesotho lacks capacity to mobilize and absorb external climate funding. Financial flows into the country have been inconsistent but on a declining trend over the years and the causal factor of this situation is the limited capacity to mobilize climate finance (AfDB, 2023).

There are several international funding opportunities which developing countries can approach to seek resources for their climate change mitigation activities. It is however, difficult for developing countries particularly the least developed countries because of lack of skills to develop fundable proposals. Although there can be good project ideas, their further development to reach competitive and fundable level requires systematic approach and knowledge of requirements of the funders. Technical skills to maneuver some of these processes may be lacking especially when there is no scientific data to support the proposal.

High poverty rate throughout the country suggests that there will be low local investments in the economy. Farmers will have limited capital and government funding overstretched but skewed towards social sectors. Rural poverty is associated with poor performance of the agriculture sector since the sector supports over two-thirds of population yet its contribution to the GDP is currently less than 20% and continues to decrease (CIAT, 2018).

Lack of technical capacity in the government institutions cuts across all the technologies. Tools of trade are always not sufficient and limits implementation of projects. Lack of capacity also affects monitoring and evaluation of projects. This insufficiency includes for an example, absence of vehicles to visit project sites and lack of equipment to conduct assessments. Land based technologies that need to be implemented in the remote rural areas across the country require frequent visits by officials and non-availability of resources can lower their optimum potential.

Successful implementation of technologies involves sharing of lessons learned from other locations and challenges experienced in the past. However, with lack of documentation and information sharing platforms, these lessons are hardly learned, mistakes are likely to repeat and good experiences not replicated. Technologies identified in the TNA have multiple overlaps and commonalities that can provide opportunities for integration. Similarly, the technologies do have common barriers which if not documented and shared, can have repeated impacts that could have been avoided.

These three technologies will largely be imported from South Africa or even abroad. This results in high costs for farmers who are largely located in rural areas of the country (Mutengwa et al., 2023). Large scale imports of the technologies will result in outflow of foreign currency and that may negatively affect economic conditions of the country.

2.5 Enabling framework for overcoming the barriers in the AFOLU sector

The effectiveness of mitigation technologies in the AFOLU sector will depend largely on barriers that will affect their adoption (Gerber et al., 2013). It is crucial that the identified barriers are addressed with appropriate measures. For the measures to be successful when they are implemented, it is important that bottom-up approaches are followed when they are identified and implemented. Extensive consultations with relevant stakeholders for each technology are increase acceptability, ownership and adoption of the technologies by the stakeholders.

Financial instruments, such as low interest loans and microfinance schemes, may be important tools that are needed to complement extension policies and support the adoption of new technologies and practices. These instruments are required when practices require upfront investments and their adoption is constrained by ineffective or missing capital markets and financial services, which is a common constraint to technology use in developing country contexts (Gerber et al., 2013).

This may include subsidies to support the adoption of more efficient technologies and practices that may not be profitable for all farmers. Mitigation subsidies can be designed to cover part (e.g. cost-sharing mechanisms) or all of the mitigation costs incurred by farmers. Subsidy instruments may stand alone (i.e. funded by government), or they may be supplied through offset schemes where these mechanisms exist (e.g. the Clean Development Mechanism and the Carbon Farming Initiative in Australia) (Gerber et al., 2013).

Significant additional research is needed to further assess the costs and benefits of mitigation practices, to help policymakers understand which policy options are better placed to incentivize their uptake (Gerber et al., 2013). Like many other African countries, Lesotho has a challenge of unavailability of impact data that assists to understand technologies, their development and transfer progress. Replicability and scalability of technologies are also difficult (UNEP-CCC and UNFCCC, 2022).

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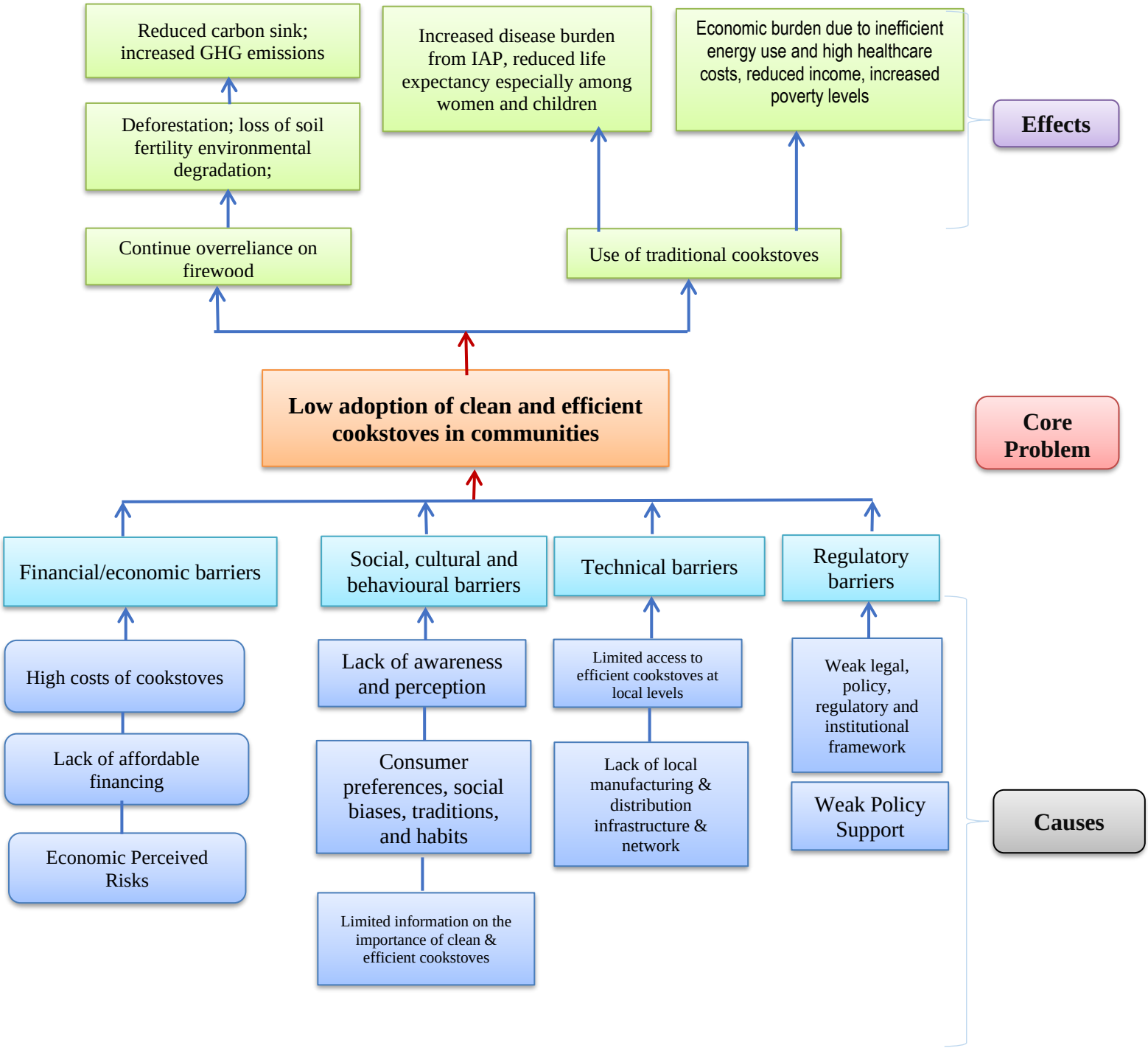
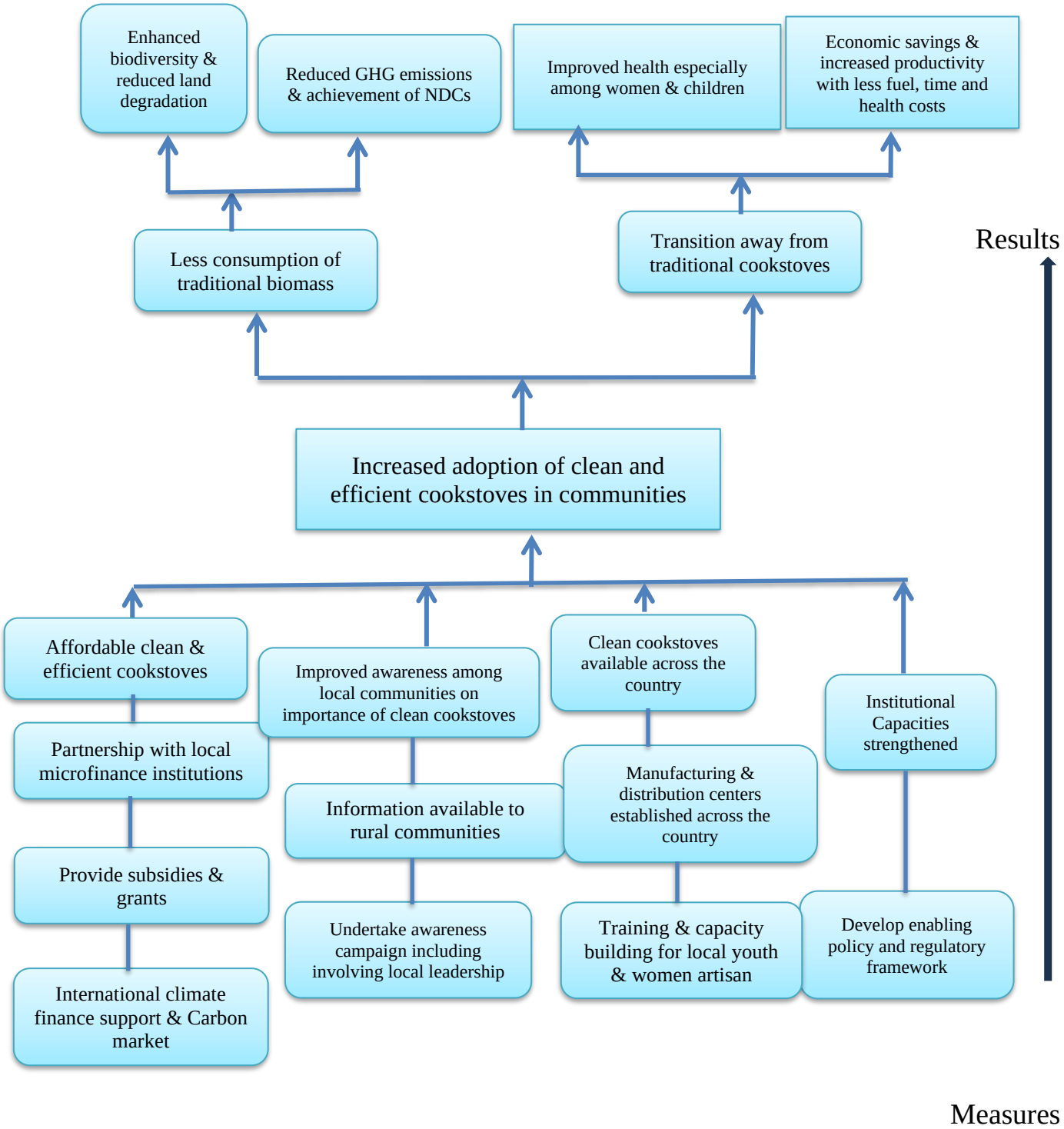
Annex I: Problem Trees, Solution Trees and Market Maps for Prioritised Technologies

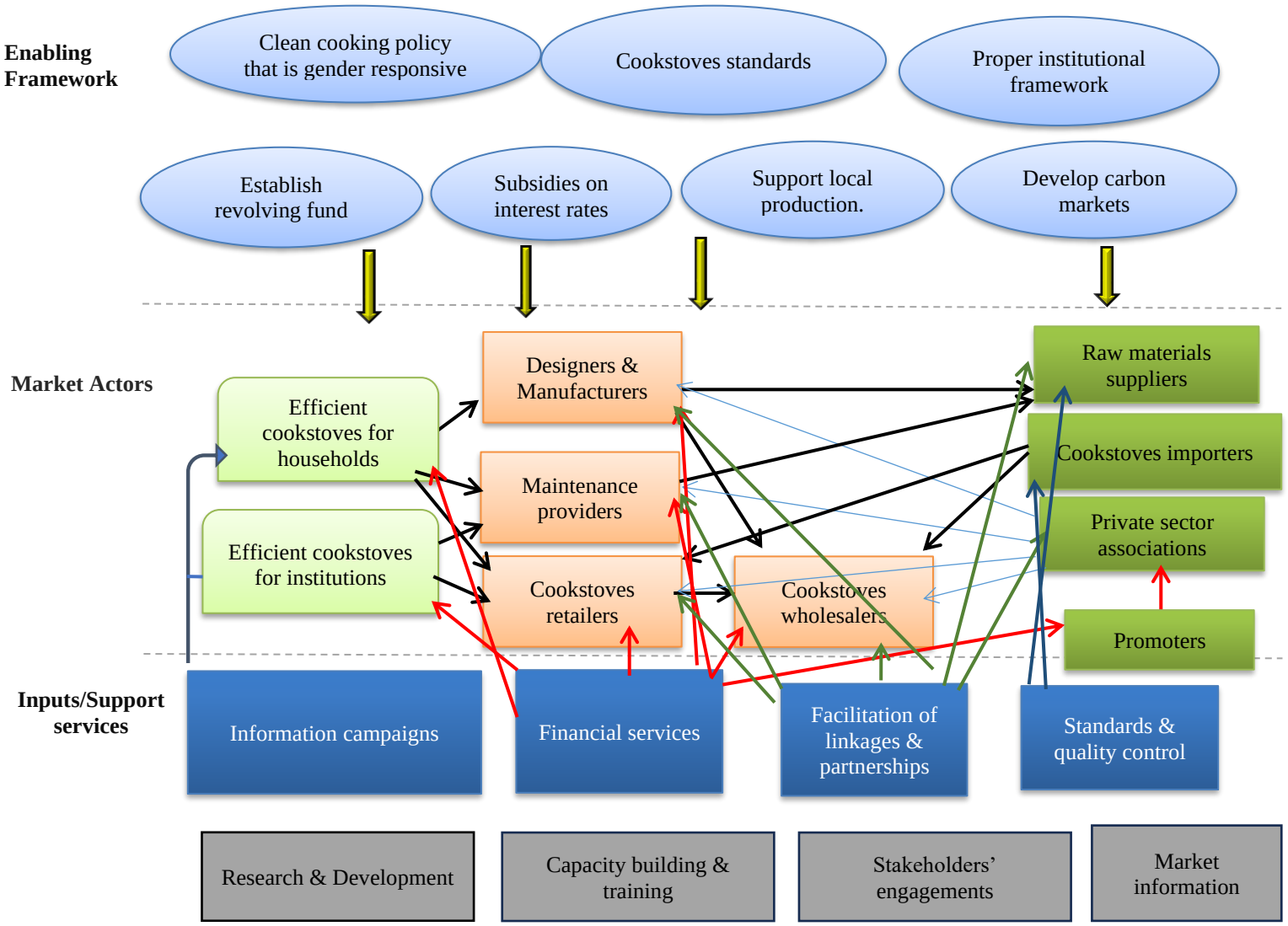
Problem Tree: Efficient Cookstoves



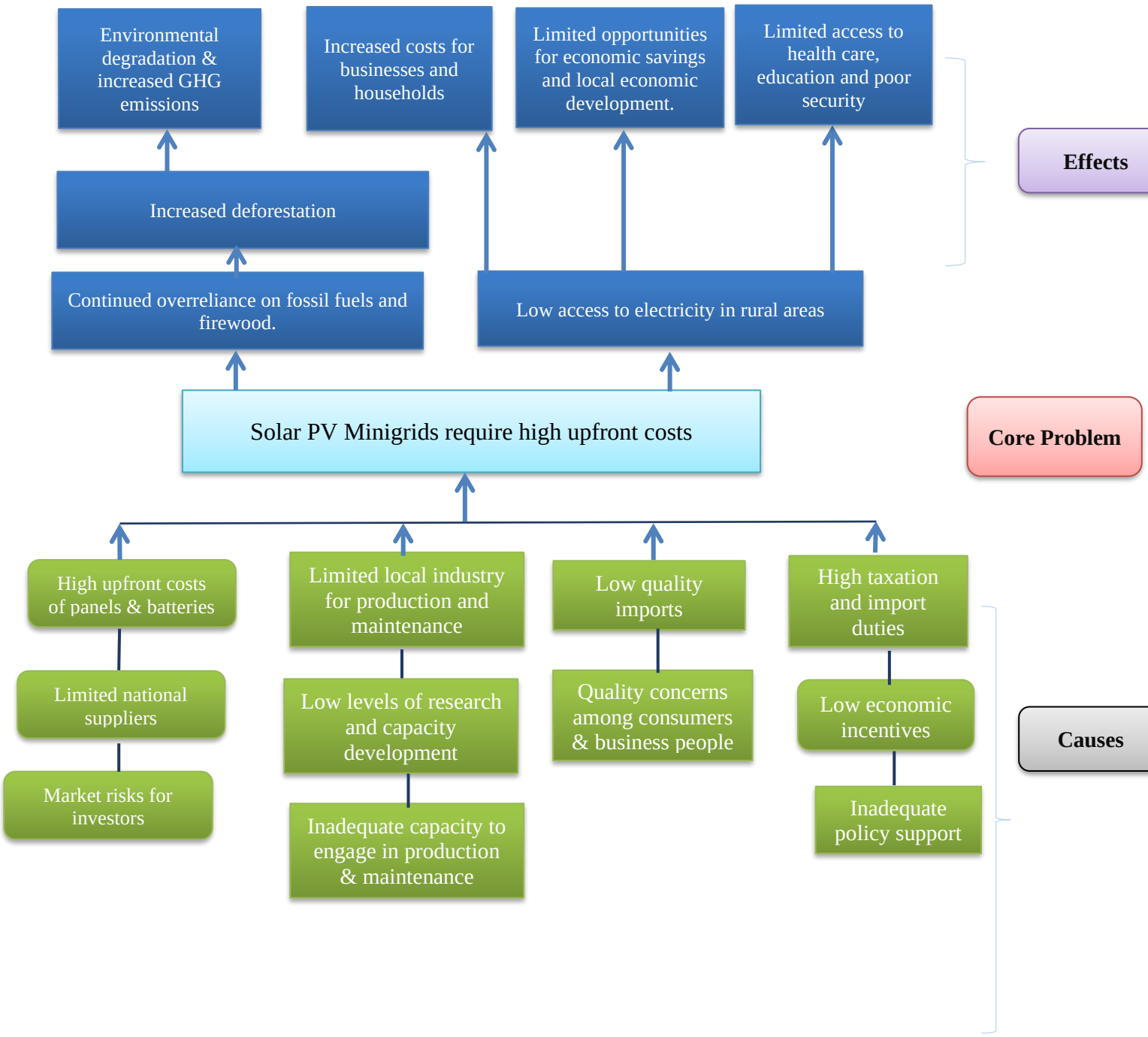
Solution Tree: Efficient Cookstoves



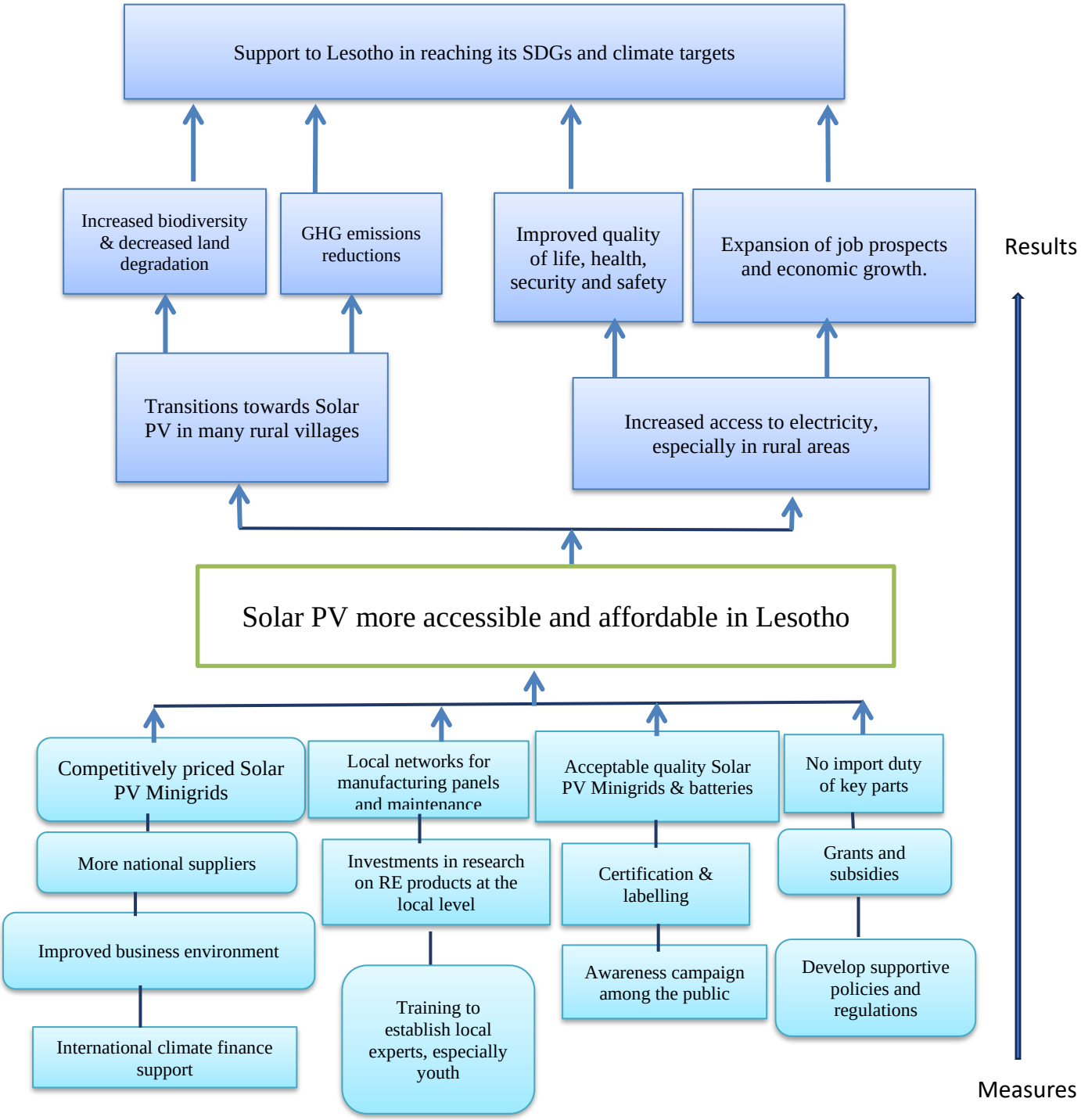
Market Map: Efficient Cookstoves



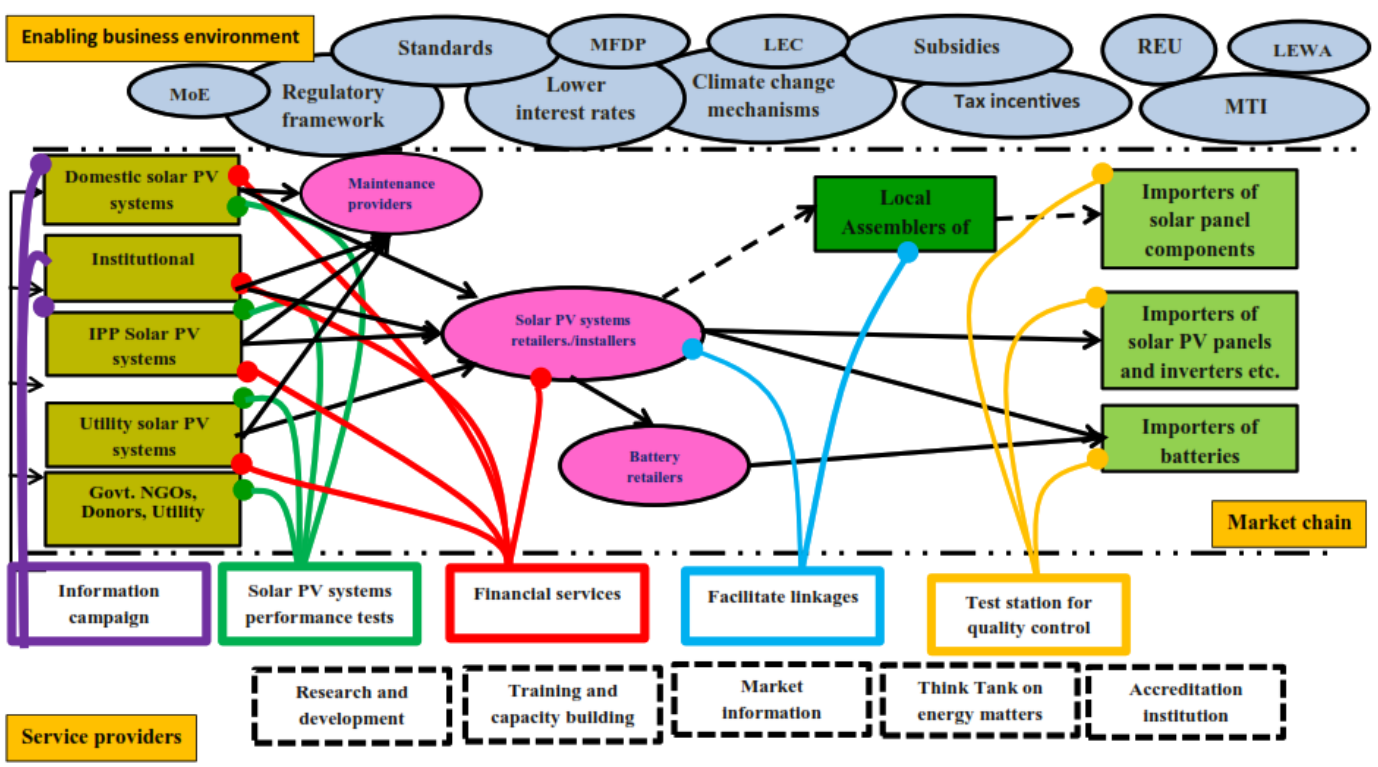
Problem Tree: Solar PV Minigrids



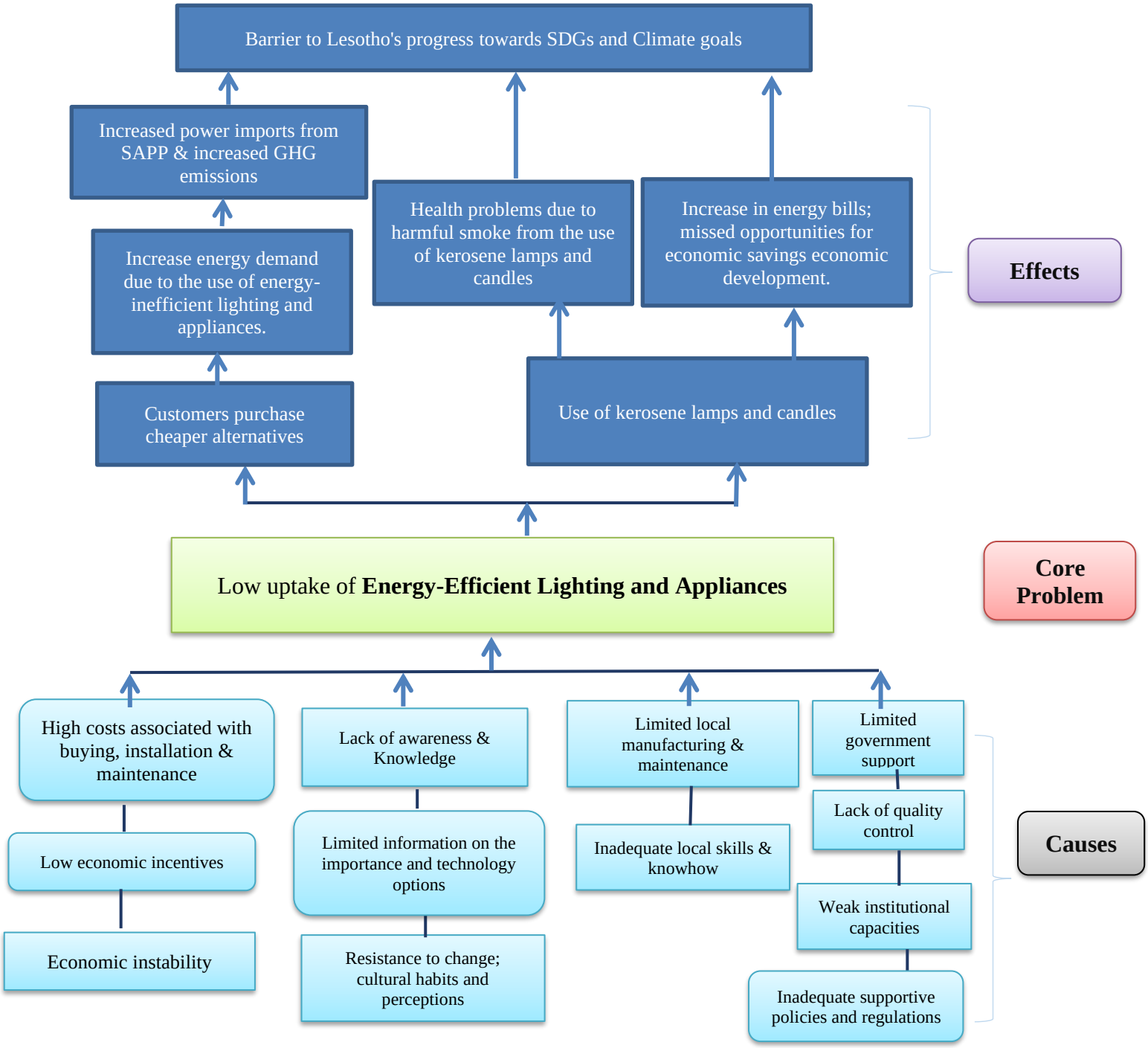
Solution Tree: Solar PV Minigrids



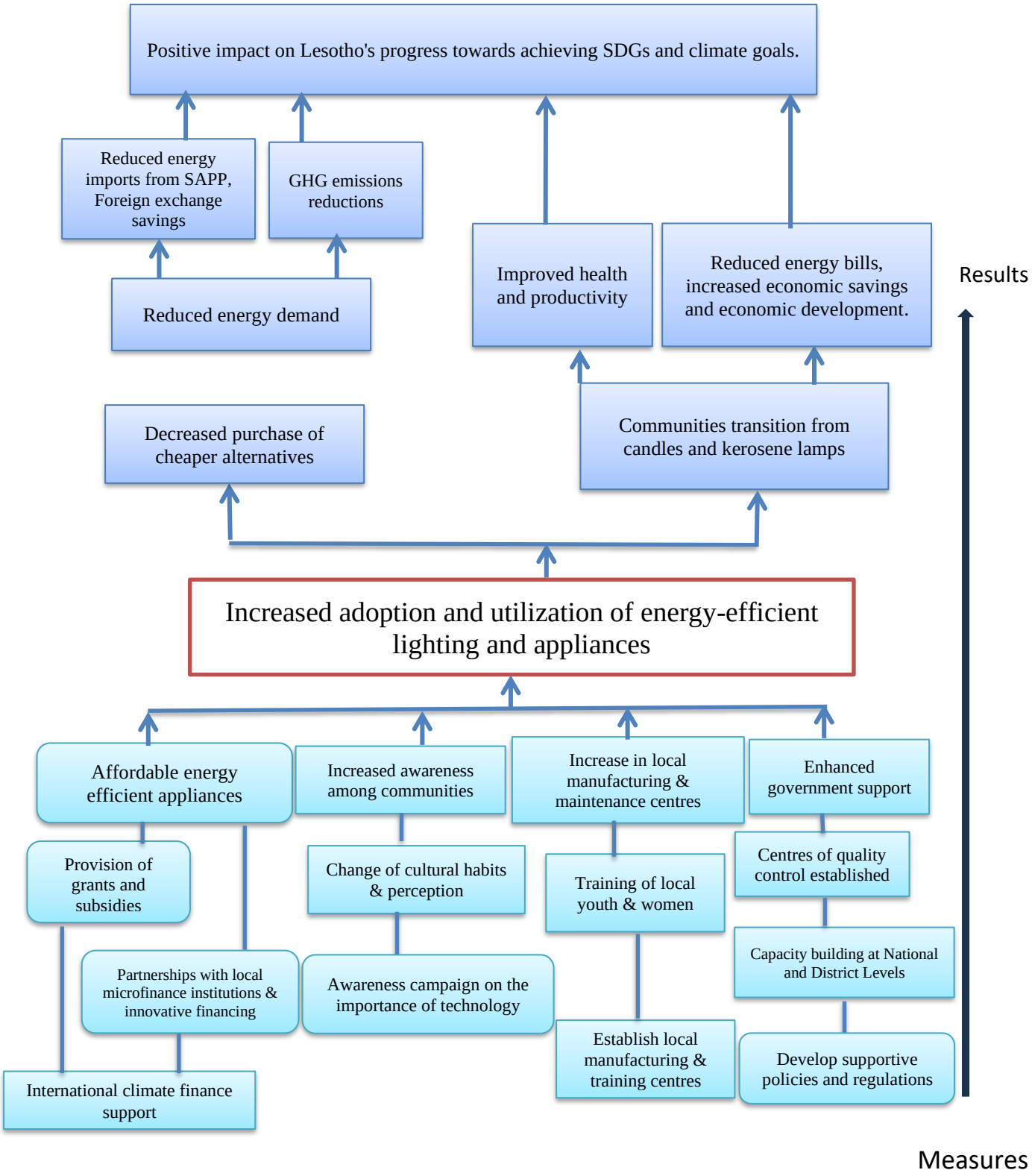
Market Map: Solar PV Minigrids



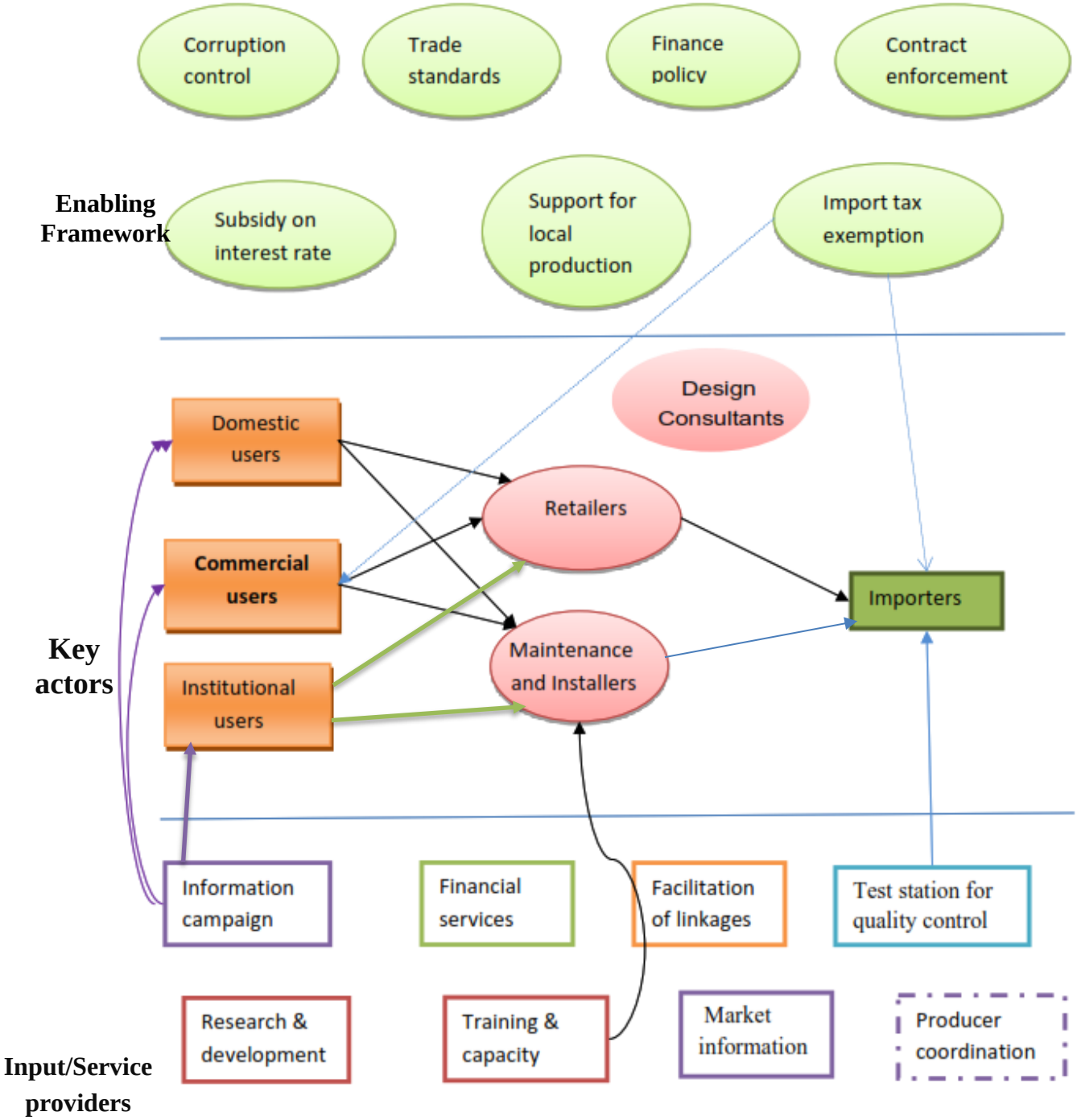
Problem Tree: Energy-Efficient Lighting and Appliances



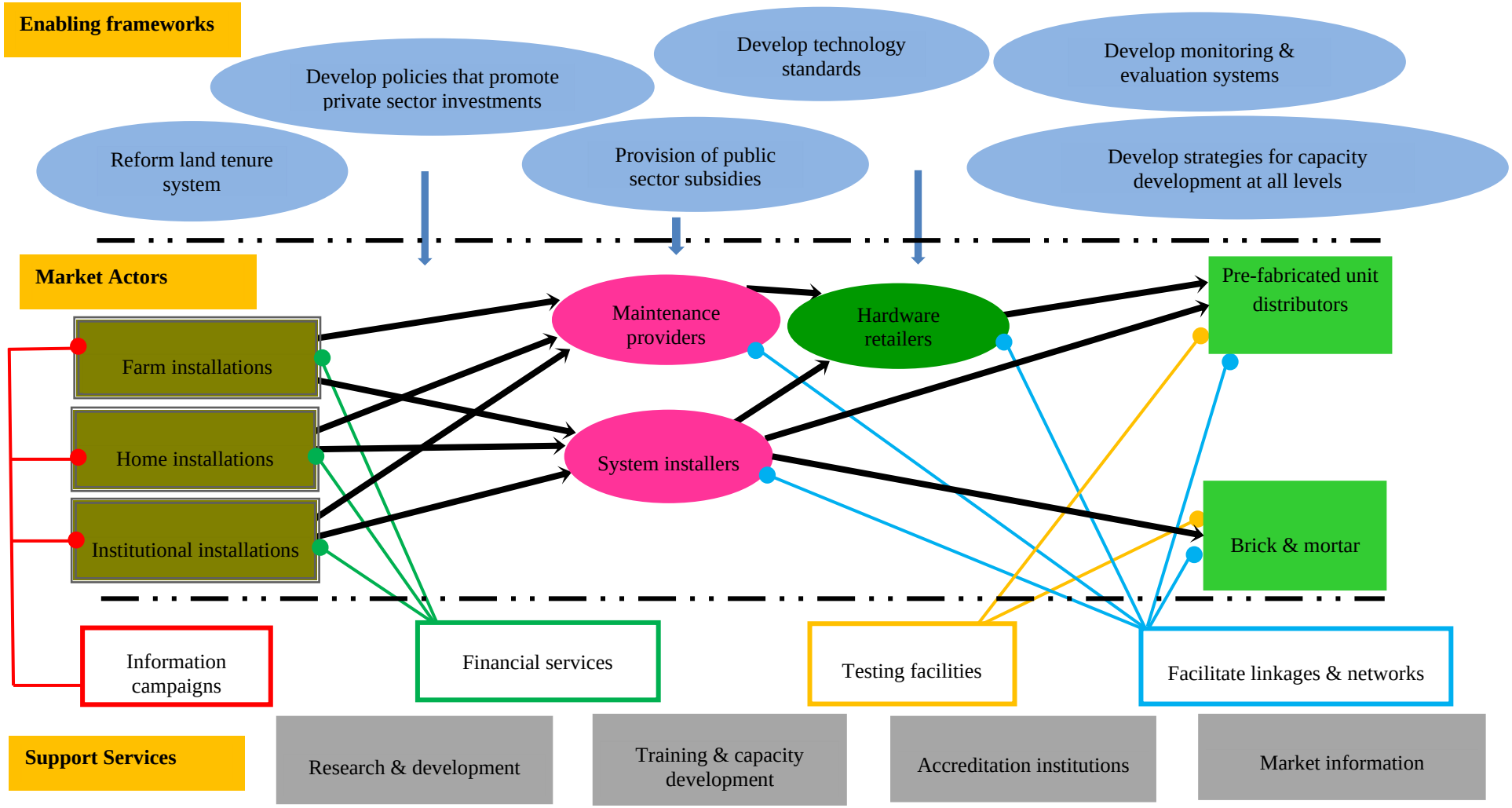
Solution Tree: Energy Efficient Lighting and Appliances



Market Map: Energy-Efficient Lighting and Appliances



Market Map: Market mapping: Small-scale biogas and homestead vegetable production in a mixed (crop and livestock) agricultural system



Annex II: List of Stakeholders Involved and Their Contacts

Name & Surname	Gender	Institution	Email
Kornel Ramaisa	M	MOFS-Crops Department	kornelramaisa@gmail.com
Mapoho Ramahloli	F	Ministry Of Water - Rural Water Supply	mapohoramahloli@gmail.com
Mphonyane Ntuba	M	Lesotho Red Cross Society	ntubamphonyane@gmail.com
Mojalefa Sello	M	Ministry Of Science And Technology - Department Of S&T	mojalefa.sello@gov.ls
Theletsa Mpholle	M	LMS - Climate Change	theletsampholle@gmail.com
Malerato Ngakane	F	LMS - Climate Change	maleraton2014@gmail.com
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