THE GOVERNMENT OF THE REPUBLIC OF MALAWI

BARRIER ANALYSIS AND ENABLING FRAMEWORK FOR CLIMATE TECHNOLOGIES IN THE ENERGY AND FORESTRY SECTORS - MITIGATION

Ministry of Forestry and Natural Resources

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BARRIER ANALYSIS AND ENABLING FRAMEWORK REPORT FOR CLIMATE CHANGE MITIGATION TECHNOLOGIES IN THE ENERGY AND FORESTRY SECTORS

National Consultant:
Dr. Suzgo Kaunda Energy and Forestry Sectors

National TNA Coordinator (Team Leader):
Mr. Christopher Manda

TNA Global Project Coordinator:
Dr. Sara Laerke Meltofte Traerup UNEP DTU Partnership

TNA Regional Expert Reviewers:
Dr. Debbie Sparks University of Cape Town, South Africa
Dr. Jiska De Groot University of Cape Town, South Africa

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DISCLAIMER

FOREWORD

Malawi is a party of the United Nations Framework Convention on Climate Change (UNFCCC). In 2017, the country ratified the Paris Accord, which is the first ever universal, legally binding global climate change agreement which sets out ambitious targets for climate change mitigation, adaptation, transparency and role of different stakeholders in addressing climate change. In tandem with the UNFCCC and Paris Agreement, the Government of Malawi has prioritised climate change both in its vision, Malawi vision 2063 and in its medium-term development agenda, Malawi Growth and Development Strategy III, as a deterrent, and opportunity to achieve an inclusive wealth, resilient and reliant nation. The Nation further highlights climate technologies as a vehicle and an enabler to achieve development vision and agenda

The Ministry of Forestry and Natural Resources (MoFNR) through Environmental Affairs Department, has frequently reported UN Climate Change Convention on efforts the country is undertaking to contribute to the global efforts of mitigating climate change and building resilience of the communities to the effects and hazards exacerbated by climate change. Climate technologies among other climate change initiatives, offer an opportunity and innovate ways to reduce greenhouse gas (GHGs) emissions and enhance resilient nations and communities.

My Ministry with support from the Global Environment Facility (GEF) is implementing a Technology Needs Assessment (TNA) Project. Through a participatory and gender inclusive, Malawi has prioritised climate technologies, identified their barriers and developed an enabling framework with measures to enhance their adoption and diffusion. The technologies are anticipated to contribute to national climate change management efforts and strides towards implementation of the Paris Agreement.

The Government of Malawi, through My Ministry, is committed to support the development, upscaling and diffusion of climate technologies. It is my sincere hope that the stakeholders will coordinate and utilise the knowledge presented in these TNA reports to inform our efforts as we strive to reduce GHG emissions and enhance resilient societies.

Nancy G. Tembo, M.P.
Minister of Forestry and Natural Resources

PREFACE

Malawi is among the countries that have and continues to experience climate related shocks. These shocks have exerted pressure on the development of the country and increased the vulnerability of the communities and ecosystems.

The Government of Malawi, through the National Climate Change Management Policy (NCCMP) of 2016, sets out an ambitious strategy to tackle climate change and its impacts. The Policy also provides an enabling framework for a pragmatic and coordinated approach to resilience building and mitigating greenhouse gases and climate shocks.

Climate technologies play an important role towards resilient building of the communities and enhancing Malawi's development agenda. The Government of Malawi through the Malawi Vision 2063 and its medium-term development plan, Malawi Growth and Development Strategy III, underscores climate technologies as foundations for development gains. Being fully aware of the prioritised technologies in the adaptation and mitigation sectors under Technology Needs Assessment (TNA) Reports, the Barrier Analysis and Enabling Framework (BAEF) report provides decision makers, national planners and stakeholders with barriers, measures and enablers for enhancing the development, transfer, diffusion and uptake of climate technologies.

The process for developing the BAEF report for Malawi in the adaptation (water and agriculture sectors) theme was guided by international good practices and methodologies. Stakeholder participation and feedback have been key in the process to ensure all considerations are incorporated including gender. It is my sincere hope that the BAEF report will support the country to adapt to the effects of climate change through enhancement of the contribution of climate technologies.

Yanira M. Ntupanyama, PhD
Principal Secretary for Forestry and Natural Resources

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ABBREVIATIONS AND ACRONYMS

BAEF	Barrier Analysis and Enabling Framework
BARREM	Barrier Removal to Renewable Energy in Malawi
BERL	Bio Energy Resources Limited (Malawi)
CAMA	Consumer Association of Malawi
CO_2 eq	Carbon dioxide equivalent
ESCOM	Electricity Supply Corporation of Malawi
EthCo	Ethanol Company (of Malawi) Limited
FFVs	Flexible fuel vehicles
FiT	Feed in Tariff
GHG	Greenhouse gas
GoM	Government of Malawi
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPPs	Independent Power Producer
JCED	Jesuit Centre for Ecology and Development
kW	kilo Watts
LPG	Liquefied Petroleum Gas
MBS	Malawi Bureau of Standards
MCC	Millennium Challenge Corporation
MERA	Malawi Energy Regulatory Authority
MGDS	Malawi Growth and Development Strategy
NAMAs	Nationally Appropriate Mitigations Actions
NGO	Non-governmental organization
PERFORM	Protecting Ecosystems & Restoring Forests in Malawi
REDD+	Reducing Emissions from Deforestation and forest Degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks
REIAMA	Renewable Energy Industry Association of Malawi
RETs	Renewable Energy Technologies
SEA4All	Sustainable Energy for All
Solar PV	Solar Photovoltaic
TNA	Technology Needs Assessment
UNDP	United Nations Development Programme
UNEP-DTU Partnership	United Nations Environment Programme - Technical University of Denmark Partnership
USD	United States Dollar

EXECUTIVE SUMMARY

This report presents barrier analysis and enabling framework for identified climate change mitigation technologies in energy and forestry sectors of Malawi. The report is part of the project: Technology Needs Assessment for Malawi. The barrier identification and analysis process was guided by the TNA guidebook for countries conducting a Technology Needs Assessment (TNA) and Action Plan. The process of barrier identification and analysis was consultative one, involving stakeholders ranging from academics (Lilongwe University of Agriculture and Natural Resources, University of Malawi, Chitedze Agricultural Research Station, and Mzuzu University), policy makers (Department of Energy Affairs, Department of Forestry, and Environmental Affairs Department), national standard and certification body (Malawi Bureau of Standards), National Commission on Science and Technology, Forestry Research Institute of Malawi (FRIM) and industry (Electricity Generation Company and various Independent Power Producers). Barriers that prevent wide-scale transfer and diffusion of the prioritized climate technologies were initially identified and compiled by the consultant through document review and expert consultation. A stakeholder consultative workshop was then organized for stakeholders to select important barriers and analyze them. The workshop provided further opportunity to solicit further barriers from stakeholders that were not captured b the consultant. The analysis of the barriers and the corresponding measures to address them were aided by use of problem tree/solution tree and market mapping. The workshop also discussed and agreed on the enabling frameworks for transfer and diffusion of technologies in the energy and forestry sectors

Top four prioritised technologies for the energy sector that underwent barrier analysis are: liquefied petroleum gas for cooking and heating services, biofuel as transport fuel, biomass gasification, and solar PV min-grid. In the technology identification and prioritization step, stakeholders rated solar PV minigrid as the fifth and wave energy technology harnessing energy from Lake Malawi (Lake Malawi hydrokinetic electric power) rated forth, in the order of being a priority technology. However, during the barrier analysis, stakeholders decided to include solar PV minigrids as the priority technology to analyze barriers that prevents its wide-scale transfer and diffusion. This was arrived at on the understanding that solar PV minigrid, despite being a mature technology, faces a lot of challenges in Malawi, unlike the hydrokinetic technology that is not yet tried in the country. Further, stakeholders decided to analyse barriers for the four technologies in the energy sector, basing in the importance for the technologies to climate change mitigation and national development. In the Forestry Sector, the prioritized top three climate technologies are: forest and landscape restoration; efficient use of forest products; and urban forestry. The results of the barrier analysis and enabling framework are presented in Tables A1-1 to A1-4:

Table A1-1: Identified barriers, measures and enabling environment for LPG for cooking and heating

Barrier	Identified Enabling Measures	Enabling Domain

Weak LPG distribution mechanism	Put in place and improve on available LPG supply and distribution infrastructure to consuming points	Availability of infrastructure to support wide scale LPG access by consumers in Malawi
	Establish energy kiosks in towns and important trading centres in rural towns and peri-urban areas to ensure increased availability of LPG close to consuming points	Availability of energy kiosks in towns and important trading centres in rural towns and peri-urban areas stocking LPG cylinders and other accessories
	Incentivize retailers to stock LPG components and systems for cooking and other thermal services (e.g stove, valves, piping).	Availability of retailers involved in trade of LPG components and systems for cooking and other thermal services
LPG market is still in its infancy stage	Incentivize the private sector to invest in energy business like LPG supply and services	Robust participation of private sector in LPG supply and provision of services
	Develop a deliberate marketing strategy to attract investors in the LPG supply and services	Availability of favorable marketing strategy to attract investors
	Conduct awareness campaigns on LPG as an alternative fuel to create an increased demand for it	Availability of market for LPG
	Develop LPG specific standards and regulatory framework to protect the LPG business actors and consumers against unscrupulous elements in the business	Availability of standards and regulatory framework for LPG as cooking fuel and other thermal services. Among others, the standards should be on LPG as cooking fuel, on LPG stoves and accessories, regulation framework on supply and distribution of LPG
Limitation in development of sustainable business models	Conduct training on how to develop viable business concerning clean energy, such as clean cooking using LPG. The business models could be pay as you go, and the LPG cylinder recirculation model.	Availability of viable businesses in clean off-grid energy services such as LPG for cooking
Low investment cost of the baseline technologies compared to LPG cooking system	Provide financial support e.g through reduction of import duty on components of LPG cooking system	Availability of financial incentives for promotion of LPG for cooking, like subsidies on fuel and tax reduction on import of it LPG for cooking system components
	Explore additional uses (e.g used in gas barbecue grills, gas lighting, and indoor heating**)** that could come alongside LPG system for cooking. This would reduces payback time of the investment	Increased usage of LPG for cooking and other applications
Low willingness to pay for LPG cooking system	Conduct extensive awareness campaigns for LPG as cooking technology, focusing on benefits of LPG as a cooking fuel. The awareness should also be directed at explaining on why the consumers must switch to LPG cooking and pay for a high initial investment.	Increased level of awareness of LPG as an alternative fuel for cooking and other thermal services
Limited affordability for LPG cooking system	Reduce investment and operational costs through reduction in importation duties (e.g on cylinders and stoves) and through application of targeted subsidies on retail price of LPG	Availability of incentives to promote LPG for cooking like subsidies on LGP retail price and reduction or exemption of import duty on LPG cooking equipment like stoves and other LPG cooking accessories
	Increase access to financing options such as bank loans and credits from micro-financing organizations	Presence of institutions to offer financing options like loans and credits to consumers and investor in clean energy such as LPG for cooking

Social issues and cultural practices and perceptions that work against promotion of LPG cooking technology. The social issues includes negative perception on LPG safety, where as cultural practices includes those on control of monetary resources in a household by a man	Conduct extensive LPG awareness campaigns in order for the technology to be accepted by the masses, focusing on benefits of the LPG cooking and its safety.	Increased level awareness of LPG an alternative fuel for cooking
	Mainstream gender and cultural issues in clean energy projects such as LPG for cooking	LPG for cooking initiatives are well accepted an supported by society
Limitations in technical skills and knowledge in LPG cooking system	Establish and enhance capacity of technical training institutions on designing, operating and maintaining LPG cooking technology	Availability of well staffed and equipped technology development and manufacturing institutions on clean cooking
	Establish a centre of excellence in clean cooking in Malawi to spearhead research and development on alternative cooking systems such as LPG for cooking	Availability of research and training institutions on clean cooking such as those using LPG fuel
	Establish an organization to certify technical experts involved in installation and maintenance of LPG cooking systems	Availability of a certification body on installation and maintenance of LPG cooking systems
Presence of cooking fuel stacking, which works to the disadvantage of LPG for cooking	Carryout awareness programmes, making use of promotional LPG systems to make LPG a significant fuel (fuel of choice) in the fuel stack	Increased level of awareness and acceptability of LPG technology for cooking
Absence of LPG specific policy and strategy in relation to using the fuel for cooking	Come up with policy and its corresponding strategy on LPG distribution and its use as a cooking fuel in Malawi	Availability of policy and strategy on LPG as a cooking fuel
Limitation in LPG regulations, standards, and their enforcements	Develop regulations specific to LPG supply, distribution and consumption in the country	Availability of regulations on LPG consumption
	Regulate and certify LPG technical personnel and companies that install and maintain LPG cooking systems.	Availability of a certification body on installation and maintenance of LPG cooking systems
	Develop standards on LPG as a fuel and LPG cooking system components (e.g cylinders, stoves)	Availability of standards on LPG as a fuel and on cooking system components
Limitation in information on LPG cooking system	Conduct of national awareness programmes, focusing on the following, among others: 1. benefits of cooking with LPG 2. educating the public on LPG usage 3. addressing safety concerns 4. viable business models	Availability of institutions and programmes (e.g awareness) to support promotion of LPG as a cooking fuel in Malawi

Table A1-2: Identified barriers, measures and enabling environment for biofuel as transportation fuel

Barrier	**Identified Enabling Measures**	**Enabling Domain**

Biofuel (fuel grade ethanol) is not competitive with petroleum (e.g petrol) based on pump price per unit energy	Revise pump price of biofuel used for transport (automotive) taking into account the energy content of the fuel	Availability of regulation on pricing of biofuels that include pricing taking into account energy content of the fuel
Limitations in financial incentives for biofuels	Put in place fiscal incentives to promote wide scale production of biofuel like fuel grade ethanol compared to petroleum (petrol and diesel) including import duty exemption, subsidies and guaranteed market for all technical and economic proven biofuels in Malawi.	Availability of incentives to promote biofuels as automotive fuel like subsidies on biofuels and reduction or exemption of import duty on components of biofuels production systems
	Expand fuel stabilization fund to also benefit biofuel production companies	Availability of financial support to investors in biofuel production
High investment cost of flex-fuel - vehicles and accessories	Reduce import duty for flexible fuel vehicles (FFVs) and its accessories to reduce the investment cost	Availability of incentives to reduce cost of FFVs
Absence of retail market for biofuel	Establish infrastructure that support retailing of biofuel in Malawi.	Availability of biofuel retail infrastructure
Limitation in policy, standards and regulation	Develop a biofuel policy in harmony with other key sectors like agriculture and forestry	Availability of biofuel policy that is in harmony of other policies in key sectors like agriculture and forestry
	Revise and develop new standards and regulations pertaining to production, distribution and use of biofuels as automotive (transport) fuel	Availability of standards and regulation on biofuel as transportation fuel
Limitation in knowledge and technical skills in biofuel as fuel for transportation	Enhance capacity in research and development in biofuel production and refinery	Availability of well capacitated research and development institutions
	Revise curricula/ syllabi on biofuels for higher education institutions to enhance knowledge acquisition as transportation fuel	Availability of education and training institutions to support promotion of biofuel as transportation fuel
	Establish practical research and training programmes in universities and vocational training institutions.	Availability of well capacitated research and development institutions
Limited availability of raw materials for production of biofuels in Malawi	Encourage current companies (Presscane and EthCo) to invest in expanding the production capacity for biofuels	Vibrant private sector involvement in biofuel production
	Identify new investors in the biofuel sector to add extra biofuel production capacity for the country	Vibrant private sector involvement in biofuel production
	Improve feed stock supply infrastructure (such as road connectivity) to biofuel production points so that access to feedstock is available	Availability of feedstock supply support infrastructure
Limited infrastructure to support biofuel as transportation fuel	put in place infrastructure to support increased production and use of biofuels	Availability of biofuel support infrastructure
Limited institutional support for biofuel as transportation fuel	Enhance institutional support for biofuels in the country	Availability of institutions to support promotion of biofuels in Malawi

	Come-up with specific biofuel policy and strategy that compliments other development policies in Malawi	Availability of biofuel policy that is in harmony of other policies in key sectors like agriculture and forestry
	Create a platform where efforts and achievements concerning diffusion and dissemination of biofuel as automotive fuel is documented and coordinated	Availability of institutions and programmes to support promotion of biofuels in Malawi
Limited information and awareness of the biofuel as transportation fuel	Carryout biofuel awareness programme	Availability of institutions and programmes (e.g awareness) to support promotion of biofuels in Malawi

Table A1-3: Identified barriers, measures and enabling environment for biomass gasification plant

Barrier	**Identified Enabling Measures**	**Enabling Domain**
High initial investment on installation of biomass gasification plant	Introduce incentives such as tax reduction on importation of renewable energy components including those of biomass gasification technology	Availability of incentives such as reduction of import duties
Limitation in financing installation of biomass gasification plant	Come up with innovate financing options such creation of renewable energy fund, through which the funds to finance renewable energy venture (e.g biomass gasification) could be drawn, in form of revolving fund	Availability of financing mechanisms like loans
Lack of market conditions for successful commercialization of biomass gasification plant	Set up programmes to improve market conditions that are associated with biomass gasification technology	Availability of programmes to improves market conditions for gasification plants
Limitation in technical expertise and knowledge of biomass gasification plant	Training and capacity building institutions that are involved in research and development.	Availability of well capacitated research and development institutions
	Establish data collection system on renewable energy systems and their associated information (e.g feedstock) to collect information necessary for design and policy formulation	Availability of information collection and archiving system on biomass gasification plants in Malawi
Lack of institutions, laws and policies and strategies concerning biomass gasification plant	Establish of standards and regulatory statutes for the gas	Availability of standards and regulatory frame to promote biomass gasification plants
	should put in place institutions responsible for promotion of climate mitigation technologies that include biomass gasification technology	Availability of institutions that promote biomass gasification plants
	Strategy on promotion of gas from biomass gasification plants should be developed to support the gas-specific policy	Availability of policies and strategy to promote biomass gasification technology
Limited availability of feedstock for biomass gasification plant	Conduct training programmes on how to availability and supply of feedstock for the gasification so that the power system is able to produce gas or electricity during most times of the year as designed	Availability of feed stock for production of gas
Limitation in technology awareness of biomass gasification plant	Conduct awareness campaigns and installation of demonstrational plants	Availability of institutions and programmes (e.g awareness) to support promotion of biomass gasification plants in Malawi

Table A1-4: Identified barriers, measures and enabling environment for solar PV Minigrid

Barrier	Identified Enabling Measures	Enabling Domain
High investment cost for solar mini-grid	Apply incentives like reduction in import duties on solar mini-grid components imports.	Availability of incentives such as reduction of import duties
	Locally produce of some solar PV system components	Availability of local manufacturing units an assembly companies in Malawi for solar PV system
Low affordability of consumers to pay for the electricity	Increase affordability of consumers to pay for electricity generated by decentralized power systems like the solar minigrid Promote use the electricity for income generating ventures.	Availability of alternative funding such as bank loans
Limited commercial use of the generated solar PV electricity	Establish programmes to train people on how to start an economic venture taking advantage of access to electricity	Availability of institutions and programmes (e.g awareness) to train people on how to start a business venture
	Implement the feed-in- tariff for decentralized electricity generation	Availability of incentives such feed in tariff
Limited financing mechanism for solar minigrids	Enhance and establish more financing mechanism for supporting entrepreneurs to embark on solar mini grid businesses	Availability of alternative funding such as bank loans
	Access to loans to households for financing their purchasing of renewable energy technologies should be enhanced	Availability of alternative funding such as bank loans
	Explore financing models that is ideal for different scenarios	Availability of alternative financing
	Make aware and support applications for alternative financing through CDM	Availability of alternative financing

In the case of forestry sector, the results of the barrier analysis and enabling framework for the mentioned top three prioritised technologies are given in Tables A2-1 to A2-3, as follows:

Table A2-1: Barrier Analysis and Enabling Framework for Forest and Landscape Restoration

Barrier	Identified Enabling Measures	Enabling Domain
Limited Financing Capacity	Establish workable financing options for FLR activities	Availability of functioning and regulated (e.g on interest rate) financial institutions to support investments in climate technologies in the forestry sector Presence of investment policies to contribute towards financing to mitigation technologies in the forest sector
	Involve private sector in FLR activities	Availability of favorable laws and regulatory systems encouraging participation of private sector involvement in climate hinge mitigation activities in the forestry sector

		Presence of public-private partnerships arrangement in the mitigation activities in the forestry sector
	Regulation of financial sector institutions	Availability of laws and regulatory framework, and institutional-set up for involvement of private sector in climate change mitigation in the forestry sector
High investment costs	Put in place measures to reduce cost of procured materials for FLR activities like herbicides and fertilizer, for example through removal of import duties for such products	Availability of incentives to reduce costs of comments of the technologies
	Use low-cost mechanization technologies for working on forest and land restoration activities	Availability of technical experts on forest an and restoration activities
Environmental challenges	Apply appropriate soil and land conservation measures when implementing FLR on degraded soils and lands	Availability of technical experts on forest and land restoration activities
	Implement training programmes in environmental management on degraded soils and lands	Availability of training institutions and programmes forest and land restoration activities
Competition for labour with other agricultural activities	Provide alternative and mechanized sources of power for both agriculture production and FLR activities	Availability of technical experts on forest and land restoration activities
	Increase the value FLR outputs to be competitive with agricultural outputs	Availability of industries on FLR products and services improvement to promote products and services derived from FLR activities above those from other activities
Governance Challenges	Enhance assess to land-tenure for investments in FLR.	Presence of land laws that are favorable to investments in FLR
	Develop laws to solve land governance issues.	Presence of land laws related to land governance
	Set an inclusive decision-making framework when planning and implementing for FLR activities.	Availability of experts to implement activities of FLR in the forestry sector
	Facilitate engagement of all relevant stakeholder groups in FLR activities	Availability of experts to implement activities of FLR in the forestry sector
Limitation in information and knowledge	Identify knowledge gaps in implementation of FLR activities.	Availability of knowledge repository system
	Provide support for testing and demonstration on FLR activities in Malawi	Availability of training, testing and demonstration institutions on mitigation technology in the forestry sector
	Set-put and Implement training special programmes in FLR	Availability of training, testing and demonstration institutions on mitigation technology in the forestry sector
	Carry out stocktaking of existing technologies and approaches for their sustainable land use	Availability of knowledge repository system
	Enhance the FLR activities by building on successful experiences and approaches already carried out on FLR projects.	Availability of knowledge repository system

	Set up a collection of cost-effective and ecologically robust restoration techniques, to be accessed without difficulties.	Availability of experts to implement activities of FLR in the forestry sector
	Set up knowledge nurturing sites on FLR in the country	Availability of training, testing and demonstration institutions on mitigation technology in the forestry sector
Limitation in policy and institutional set-up	Re-orient policies and institutions to ensure that investments in trees and landscape restoration are addressed in the decentralization agenda.	Availability of policies that promote uptake and wide scale diffusion of forestry mitigation technologies
	Establish an institution to coordinate FLR activities in different related sectors (forestry, agriculture, livestock/rangeland, energy, mining, etc.).	Availability of institutions to promote FLR activities
	Revise policies and strategies on FRL so that they are in harmony with the ones already in place that could be address FRL activities (e.g. National Charcoal Strategy, National Forest Policy, climate-change national strategy, biodiversity national strategy, national strategy for rural development, etc.).	Availability of policies and strategies that promote FRL activities
	Provide a platform for forest base organizations to re-orientate their current roles so they are geared towards stronger service delivery orientation and aligned with the poverty alleviation agenda.	Availability of institutions that promote FRL activities

Table A2-2: Barrier Analysis and Enabling Framework for Efficient Use of Forest Products

Barrier	**Identified Enabling Measures**	**Enabling Domain**
Limited financing capacity	Create and support institutions to extend credit to smallholders with an interest in investing use of forest products, e.g value-added processing and marketing of tree and forest products.	Availability of functioning and regulated (e.g on interest rate) financial institutions to support investments in climate technologies in the forestry sector Presence of investment policies to contribute towards financing to mitigation technologies in the forest sector
	Involve private sector in the business of forest products	Availability of favorable laws and regulatory systems encouraging participation of private sector involvement in climate hinge mitigation activities in the forestry sector Presence of public-private partnerships arrangement in the mitigation activities in the forestry sector
	Regulate financial sector institutions	Availability of laws and regulatory framework, and institutional-set up for involvement of private sector in climate change mitigation in the forestry sector
Limited access to market	Create new and improve existing market access to market of the forest products	Availability of market for products of forestry mitigation projects

	Develop niche market for high quality products	Availability of market for products of forestry mitigation projects
Limitation in forest products standards and certification	Establish forest products standards and certification process that includes a monitored permitting system	Availability of regulatory framework on forest products including certification
Challenges in processing of forest products	Establish opportunities for processing of forest products	Availability of expertise and enterprises on processing of forest products
Limitation in information and knowledge	Establish forestry information and knowledge management system	Availability of knowledge repository system.
	Implement and enhance training programmes in efficient use of forest products	Availability of training institutions with required programmes that support efficient use of forest products
Limitation in policy and institutional set-up	Develop and review policies that support uptake of forest products	Availability of policies that support uptake of forest products
	Develop and strengthen institutions to support sector activities and for an efficient management of the forest products	Availability of institutions that support

Table A2-3: Barrier Analysis and Enabling Framework for Urban Forestry

Barrier	**Identified Enabling Measures**	**Enabling Domain**
Limited financing capacity	Establish workable financing options for FLR activities	Availability of functioning and regulated (e.g on interest rate) financial institutions to support investments in climate technologies in the forestry sector Presence of investment policies to contribute towards financing to mitigation technologies in the forest sector
	Involve private sector in FLR activities	Availability of favorable laws and regulatory systems encouraging participation of private sector involvement in climate hinge mitigation activities in the forestry sector Presence of public-private partnerships arrangement in the mitigation activities in the forestry sector
	Regulation of financial sector institutions	
Limited access to market on urban forestry products and services	Create market for urban forestry products and services	Availability of market and its support infrastructure, for forestry products
Limited access to land	Secure land in urban areas for urban forestry activities	Availability of laws that allow access to land for forestry mitigation programmes
Limitation in knowledge and information	Document existing knowledge and launch new research	Availability of knowledge generation (training institutions) and demonstration system in forestry mitigation technologies
	Enhance forestry research and training institutions	Presence of vibrant research and training institutions

	Develop and review guidelines and standards to promote uptake and diffusion of urban forestry in Malawi	Availability of guidelines an standards in urban forestry management
	Enforce standards and regulations in urban forestry activities	Availability of regulatory framework on urban forestry activities
Limitations in inclusive planning and participation in implementing urban forestry programmes	Ensure local participation in implementing urban forestry programmes	Availability of inclusive participation in urban forestry programme
	Government should facilitate harmonization among all stakeholders involved in promoting and executing urban forestry activities	Availability of institutions to ensure harmonization of urban forestry activities done by stakeholders
	Develop partnerships with community groups, non-governmental organizations, research and academic institutions, and the private sector.	Availability of institutions to ensure harmonization of urban forestry activities done by stakeholders
	Implement participatory urban forestry approaches in forestry programme	Availability of expertise to implement participatory approaches in forestry programmes
Limited focus on services derived from urban forestry	Increase demand of services and products from urban forestry activities in urban area	Availability of demand for products and services of urban forestry
Limited laws and their enforcement in management of urban forestry	Develop appropriate legal framework and enforcement mechanism for urban forestry.	Availability of legal framework for guiding urban forestry activities. Availability of enhanced enforcement of regulations on urban forestry activities

CHAPTER 1: ENERGY SECTOR

1.0 Introduction

This Chapter is about identification and analysis of barriers that prevent wide-scale diffusion of the prioritized climate mitigation technologies in the energy sector of Malawi. The Chapter gives a background to the barrier analysis as well as the general methodology for barrier identification and analysis. Preliminary targets for technology transfer and diffusion are presented. Also presented in the Chapter are the analysis of the identified barriers for each of the top four prioritised technology as well as measures on how to overcome them. The enabling framework for the technologies to be widely transferred and diffused is also presented.

1.0.1 Background

According the Technology Needs Assessment Project, this work on analysis of barriers and creation of enabling framework for climate mitigation technologies in the energy sector of Malawi is the next step identification and prioritisation of such technologies, which culminated into the Technology Needs Assessment (TNA) Report. The top four prioritised technologies from the TNA Report are: liquefied petroleum gas (LPG) for cooking and heating services, biofuel as transport fuel, biomass gasification plants, and solar PV mini-grids.

In order to understand the context of barrier analysis and enabling framework, there is need to explain the concept of climate technology (or just technique as in this work). According to the IPCC (2000), the general definition of a technology is 'a piece of equipment, technique, practical knowledge or skills for performing a particular activity' and has three components, namely: hardware, software and orgware. This definition was used when developing the Technology Needs Assessment Report. In the barrier analysis, climate technologies are treated as goods or services that can be traded or not traded but supplied by entities. Technologies are not necessarily looked at in terms of their technical specifications. In general, technologies are lumped whether the goods or services involved are market-based or non-market-based.

According to Nygaard and Hansen (2015), market-based technologies (goods) can be categorized into consumer goods, capital goods or publicly provided goods. Generally, technologies are consumer goods if they are diffused in a mass market characterized with large supply chains and a high number of customers (which include households, businesses and institutions). Technologies are in the category of capital goods if they are intended for a restricted national market with only a few buyers (such as industries and utilities) and few national suppliers of the technology. Capital goods are associated with relatively big technologies (for example large scale power plants). Publicly provided goods are technologies that are procured and diffused by public entities to a large population of users and beneficiaries. Technologies in this category could be traded in a market places. However, the market is often not very liquid especially where the public entities purchase their goods through a tendering process, which may be restricted to a limited number of

players (e.g invited national and international construction companies and technology suppliers). The other category, other non-market goods are similar to publicly provided goods, but are dominated by the software and orgware dimensions of technology compared to hardware part of the technology.

In climate technology concept, a barrier could be looked at as reason why a target is adversely affected, including any failed or missing countermeasures that could or should have prevented the undesired effect(s) (Nygaard & Hansen, 2015). In this work, barriers that prevent the identified four climate mitigation technologies for the energy sector from being transferred and diffused widely have been identified and analyzed. The measures to overcome the barriers have also been identified. The enabling framework, in which the technologies would be transferred and diffused widely, is developed.

1.0.2 Methodology for Barrier Identification and Analysis

The process of identifying barriers started by looking at an ideal framework, which is a set of domain of resources and conditions that is required for successful diffusion and deployment of climate technologies in Malawi. These resources and conditions are generated by structures and institutions, which are usually beyond immediate control of the beneficiaries of the technologies. The ideal framework, also known as the enabling framework, therefore, encompasses elements of climate technology, as shown in Figure 1

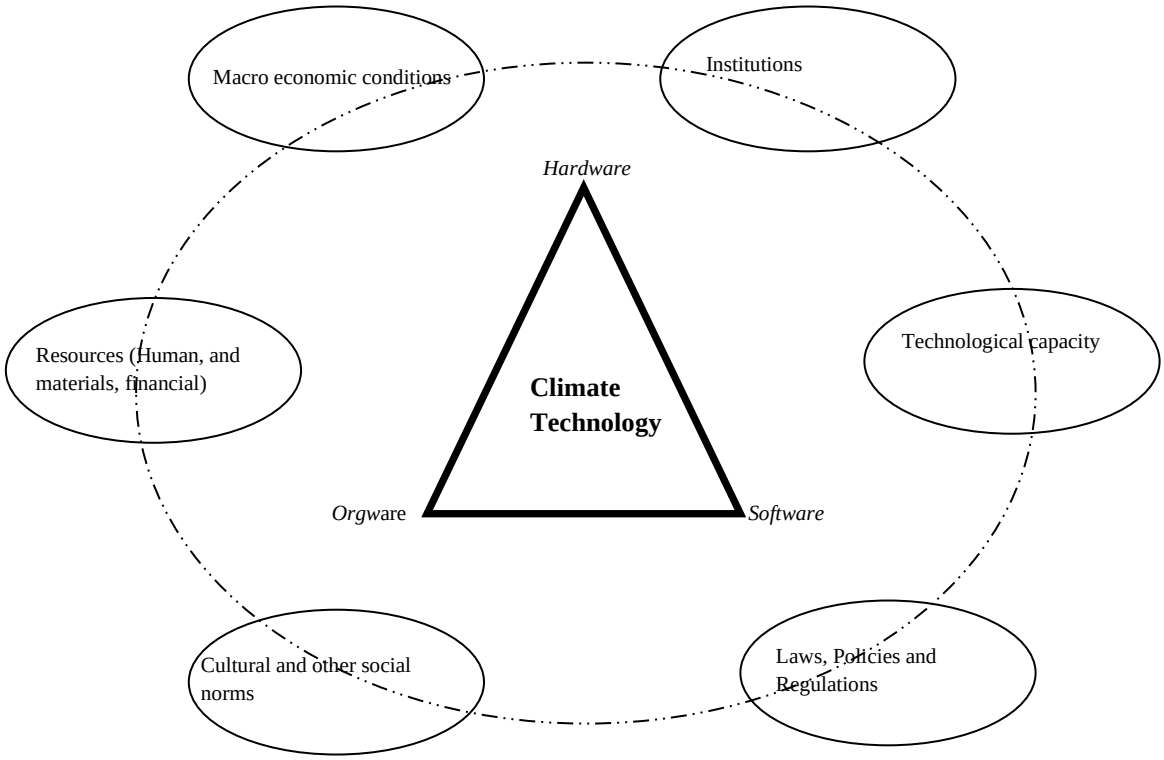

Figure 1: Ideal Schematic Framework showing link between climate technology and environment for transfer and diffuse of technology

With respect to Malawi, as presented in Figure 1, the identified domains for enabling framework are for successful diffusion and deployment of climate technologies: favorable macroeconomic conditions, favorable social and cultural norms, availability of required resources, availability laws, supporting policies and regulation, and availability of required technological capacity and institutions. The deviation between ideal environment and what is on the ground (national situation) indicates a barrier. In this work, the barriers were identified using document review and consultation with stakeholders. In using the document review methodology, the consultant employed content-based evaluation technique to identify the barriers. This involved reading through the documents and synthesizing parts of the documents that speak to the barriers against wide-scale transfer and diffusion of the particular technology. For barriers concerning climate mitigation in the energy sector, the documents reviewed included The National Energy Policy (2018), Technology Needs Assessment Report (Energy Sector), the Malawi Action Agenda to Sustainable Energy for All Initiative (2017), Malawi Sustainable Energy Investment Study, Market Assessment for modern energy cooking services in Malawi (Coley, 2020).

The process of identification of barriers was encompassing. In some of the cases, barriers mentioned in the documents were not clear and/or exhaustive enough. In such cases, consultation (through email and phone conversation) with experts for further information was conducted. Expert consultation also helped to unearth further barriers that were not mentioned in the documents. After identification of barriers from documents and experts, a report was written describing the nature and characteristics of the barriers. This report formed a reference document during the barrier analysis and enabling framework stakeholders' consultative workshop. The stakeholders' consultative workshop was conducted in Mponela, Dowa District on 24th September 2020. Figure 2 shows a picture captured during the workshop session. The conduction of barrier analysis was guided by a publication on Technology Needs Assessment (TNA) general set-up on barrier analysis (Nygaard & Hansen, 2015).

Figure 2: Picture showing participants in the Mponela Stakeholders Consultative Workshop

The first step in the barrier analysis and creation of enabling framework was to organize the process. The process was led by the Environmental Affairs Department through the TNA Coordinator. Key stakeholders that participated in the barrier analysis were identified by the Coordinator with inputs from the Consultant. The stakeholders included members of the Climate

Change Working Group on Mitigation (energy and forestry sectors). The list of stakeholders that attended the workshop is provided in Annex II. The second step in the barrier analysis was about presenting and screening the identified barriers. During the workshop, the consultant presented the identified barriers to stakeholders for selection and screening. The presentation provided further opportunities to stakeholders to contribute barriers that were not captured in the report. Selection of essential barriers for further analysis was achieved by voting, basing on the significance of each barrier taking into account national priorities. The selected barriers were then analyzed to their root causes using problem tree and market mapping approaches.

In general, the purpose of the TNA work is premised on promotion of actions that reduce GHG emissions, while at the same time achieving social and economic growth at national level. It is important therefore to frame the barrier identification and analysis work upon national target on targets of the technology transfer and diffusion, and on reducing GHG emissions. It is also important to present characteristics of the prioritized mitigation technologies (energy sector) in terms of type and generic market niches. Thus, the following section presents GHG mitigation targets and shares of technology units to be achieved. With respect to the targets on the prioritized technologies, the information on national targets was sourced from national documents like national policies and strategies. In some of the cases, information was sourced from industry involved in the production and transfer of that technology. However, some of the information was not available in the form required for example targets being given in form of shares and not in absolute terms.

1.1 Preliminary targets for technology transfer and diffusion

The Government of Malawi plans to reduce the per capita GHG emissions from 1.4t CO_2eq per capita in 2010 to around 0.7 to 0.8 tCO_2 equivalent per capita in 2030 compared to expected business as usual emissions of around 1.5t CO_2 equivalent per capita in 2030 (Tikiwa, 2018; GoM, 2016). This is the basis for employing climate mitigation technologies. Employment of climate technologies require technologies to be developed transferred and diffused in the target communities. For technologies to be widely used, their market niches must be identified, especially for market based technologies. Market niche could be specific group of users within private sector, government and communities (e.g non-governmental organizations that consume or make use of the technology. Through deliberations in the stakeholders' workshop, the market niches for the prioritized technologies are as indicated in Table 1.

Table 1: Market niches for each of the prioritize technologies in the energy sector

Technology	Type	Generic targets in terms of market niches
Liquefied Petroleum Gas (LPG) for cooking	Capital good	1. Communities *individual households (middle and high income household in urban areas)* *institutions e.g secondary schools, universities hospitals, prisons*

		restaurants (few use and many would switch to LPG) *bakeries (many would use LPG especially in district where electricity supply is erratic and firewood is becoming scarce)* 2. Private sector *Hospitality industry including hotels, lodges, Beverages and other processing industries e.g Chibuku products Limited* *Gas suppliers:* Afrox, Delta Gas, and GasMan 3. Government *Department of Environmental Affairs* *Energy Affairs Department* *Malawi Energy Regulatory Authority* 4. Electricity Utility Company *Electricity Supply Cooperation of Malawi (ESCOM). LPG as one of the technologies to manage power demand during peak hours (cooking times)*
Biofuel as transport fuel	Capital good	1. Communities *Biofuel crop growers association of jatropha carcus, sugar cane etc)* *Vehicle owners (individuals)* 2. Private sector *Oil selling companies like PUMA, Total* *Biofuel producing companies* 3. Government *Department of Environmental Affairs* *Energy Affairs Department* *Malawi Energy Regulatory Authority*
Biomass Gasification	Capital goods	1 Communities *Household users* *Institutional users e.g schools, hospitals, prisons* 2 Private *Gas producing and distribution companies e.g Affrox* *Hospitality companies e.g lodges and hotels* *Food and beverage producing industries like Chibuku Products, and Castel* 3 Government *Department of Environmental Affairs* *Energy Affairs Department* *Malawi Energy Regulatory Authority*
Solar PV minigrids		1. Off-grid communities

	Capital goods	*individual household users* *institutional users e.g secondary schools, universities hospitals, prisons* *small and medium scale businesses* 2 Private *Retailers of solar PV products* *Power generation company* *Electricity generation companies* *Independent power producers* *installers of solar energy systems* 3 Government *Department of Environmental Affairs* *Energy Affairs Department* *Malawi Energy Regulatory Authority* NGOs Several NGOs involved in conservation of environment and promotion of green energy e.g UNDP, Community Energy Malawi

1.1.1 Targets in terms of estimated national outputs and/ or emissions reductions

The targets in terms of outputs of technology units and/or GHG emissions reductions are presented in the following sub-sections.

1.1.1.1 Liquefied Petroleum Gas (LPG) for cooking

The Government of Malawi, plans to increase the contribution of LPG, Biogas and Natural Gas in the energy supply mix from 2% in 2020 to 9% in 2035 (GoM, 2018). Generally, LPG does not contribute a large share of cooking energy in Malawi. It is consumed in urban areas only. Even in urban area, only 12% of the population uses it for cooking as in 2020 (Coley, 2020). According to the Malawi Action Agenda on Sustainable Energy for All Initiative, the Government plans to replace wood with LPG for cooking, and that about 2% of households will cook using LPG by 2030, it is stated that represents an eightfold increase in LPG-using households by 2030 from 2016. Further, through the Malawi Sustainable Energy for All Initiative Action Agenda, the Government targets 54,000 LGP stoves in use in 2030 from 8600 stoves in 2016 (GoM, 2017). In the same Action Agenda document, as of 2016, the country had 6800 LPG cookers.

Promotion of LPG is supported in the Revised National Energy Policy of 2018, with its goal of increasing access to affordable, reliable, sustainable, efficient and modern energy for every person in the country. In order to achieve this, among others, the government will ensure availability of LPG, biogas and natural gas in sufficient quantities at affordable prices for industrial and domestic

use. It is estimated that the country will achieve a target of 75% of urban households and 5% of rural households cooking using LPG for by 2035.

1.1.1.2 Biofuel as vehicular fuel

Investment in local production and use of biofuel as transportation fuel to replace petrol and diesel are regarded as some of strategic directions to ensuring energy security and securing forex. The first Intended Nationally Determined Contributions (INDC) for Malawi, identified biofuel (ethanol and biodiesel) as a priority important mitigation action to be implemented unconditionally (GoM, 2016). The biofuels earmarked for promotion as transportation fuel are fuel grade ethanol and biodiesel. For relative a long period of time the country has been producing ethanol, a smaller proportion of which is fuel grade that is blended with petrol sold by oil service stations. At the time of compiling this report, only two companies were involved in fuel grade ethanol production in the country. These are Ethanol Company (EthCo) Limited, based in Dwangwa and Presscane Limited based in Nchalo. Both of these companies rely on molasses sourced from from Illovo Sugar companies the Dwangwa Factor and Nchalo factories that are located close to the ethanol production companies

The targets for biofuel are presented in government strategies and policies as well as from the strategic plans of biofuel industries in Malawi. The Action Agenda of the SEforALL Initiative states that the country plans to produce 40 million litres of fuel grade ethanol in 2030 from 19 million litres in 2016 (GoM, 2017).. Also, the biodiesel production is expected be 55 million litres by 2030 (GoM, 2017). Through consultation with the two biofuel industries in 2020, plans of expansion of production were unveiled. EthCo produces an average of 3 to 3.5 million litre per year of fuel grade. Presscane produces an average of 12 million litres, making a total of about 15 million litres per year. These companies have capacity to double production by year 2040. The targets of biofuel production is also available in form of shares. For example, in the Malawi Action Agenda to SEfor All Initiative, the ethanol-petrol blend ratio is targeted to be 30% in 2030, from 10% in 2016. Similarly, the blend ratio for biodiesel to diesel will be 16% in 2030 (GoM, 2017).

In terms of biodiesel production, the country current status is not it is not being produced as of 2020. Despite not being able to produce biodiesel at a commercial scale, there have been plans to produce biodiesel in the past. The example is that of Bio Energy Resources Ltd (BERL), which got government approval to embark on biodiesel production on commercial scale. In readness to biodiesel being used as transportation fuel, the Government consequently came up with standards. However, due to barriers, the company decided to close the business. The company estimated to be producing 150,000 litres of biodiesel in 2016, and negotiated with government to blend the biodiesel at a rate of 9% to diesel. It estimated to produce 55 million litres by 2035. Despite the investor abandoning the biodiesel business, the Government encouraged biodiesel production as evidenced in its being promoted in the revised National Energy Policy of 2018. In particular, the Government wants biodiesel blended with diesel at the ratio of 9:91.

The fuel-grade ethanol is not produced at the full rated capacity due to limitation of molasses. Most of the molasses is imported into the country. Also, there are some trade challenges with local suppliers of molasses (Illovo Sugar factories of Dwangwa and Nchalo). Through consultations, it was found out that purchase price of molasses from local market is on the higher side compared to international market. It was also found that ethanol production companies are planning to invest in sugarcane growing to meet their demand for molasses. The national capacity to produce more molasses will be enhanced because further molasses could come from local cooperatives of sugar cane growers and from the new Salima Sugar Company.

1.1.1.3 Biomass Gasification

Biomass gasification technology is about the conversion of solid fuels like wood and agricultural residues into a combustible gas mixture. According to Bhatt (2011) as reported in (Muzee, 2012), gasification is one of the best available technologies for harnessing biomass energy efficiently. The technology is not well matured in Malawi, being at research stage/product development in universities e.g The Polytechnic and other research based organisations like Chitedze Agriculture Research Station. Based on feedstock material, the most feasible biomass gasification technology for Malawi would be the one that uses rice husks. This is because rice husks are available from established rice schemes in the country. A feasibility study by Kazembe and others, estimated that rich husks biomass gasification alone have 83 MW potential of electricity (Taulo, et al., 2020). However, rice husks face competition from non-energy uses such as being used as poultry beddings. Also, the potential for biomass gasification using feedstock other than rice husks is relatively high. A research conducted by Gondwe *et al* (2017) revealed that Malawi has potential to produce 161 800 TJ, 189 747 TJ and 221 127 TJ of energy from crop residues in 2020, 2025 and 2030 respectively (Gondwe, et al., 2017). There has also been successful experimental fabrication of gasifiers at Malawi Industrial Research and Technology Development, now affiliated with Malawi University of Science and Technology.

The other positive element about biomass gasification plants is that they can be modularized. This is advantageous because units can be applied for diversified energy demand. For example, a smaller version of biomass gasification unit (also known as micro-gasifier) could provide both thermal and electricity per unit, becoming very much convenient to rural and urban households. In Malawi, the Jesuit Centre for Ecology and Development (JCED) has developed a prototype of the micro-gasifer that is able to generate heat for cooking and electricity for lighting and battery charging, using crop residues as feedstocks (Jesuit Centre for Ecology and Development, 2020). Due to the electricity generation part of the technology, the technology could easily be accepted in the off-grid communities. Thus, if well disseminated and diffused, smaller units of biomass gasifiers could be taken up by the majority of households in rural and urban areas.

Despite positive aspects of the gasification technology, gasification plants have not been included in the country's Integrated Resource Plan (upto 2040). Possibly this could be that biomass gasification plants are generally not yet mature in the country. However, the technology is used in other African countries (e.g Tanzania and Kenya), supplying heat and electricity to off-grid communities (Muzee, 2012). Still more, the gasification plants are promote in the revised national energy policy. In the policy, The Government of Malawi has set an ambitious target of increasing electricity access to 30% by 2040 from around 10% in 2018 (GoM, 2018). Off-grid electricity generation technologies, such as micro-gasifiers are among the recommended technologies for rural electrification.

Also, The Malawi Action Agenda to achieving SEforALL initiative recommends biomass gasification as viable future projects (GoM, 2017). A model design of a microgasifer plant in Malawi in 2019 showed an investment cost of 154,000 US$ for a 32 kWe installed capacity (Taulo, et al., 2020). For this system, the fuel cost (associated with feedstock to generate gas) per year was 10,741USD. This costs related to the gasifier are relatively high compared to baseline technologies for generating electricity (e.g solar PV system). The investment and fuel costs as well as operation and maintenance cost should be reduced if the biomass gasification technology could be competitive as one of the least-choice technology for off-grid energy applications.

1.1.1.4 Solar PV minigrids

It is viewed that solar PV technology is more prominent than any other renewable energy source in Malawi. Most of the solar technologies that have been taken up by Malawians are the solar home systems. Solar powered mini-grid to supply electricity to an off-grid community or to the grid are relatively rare. The first documented solar mini-grid system in Malawi is the Makanjira system, which was installed by the Malawi Industrial Research and Technology Development Centre (MIRTDC) in 1999. After, this, came the three solar minigrids were installed in 2006 in each of the 3 regions of the country as demonstration units under the Barrier Removal to Renewable Energy in Malawi (BARREM) Project. However, these solar minigrids, also known as solar villages, are currently non-functional. There are also some solar minigrids that have been installed with support from various sources including the Government of Malawi, Government of Scotland and the European Union. Of late, the country is registering interest to invest in independent power producing, especially in solar minigrids. In 2017, the country signed 14 PPAs in 2017 through ESCOM. The total installed capacity of the signed power systems is 542 MW. The list includes the Droege Energy plans to put up a 20 MW floating solar power plant in Monkey Bay, Mangochi (Bhambhani, 2019), and the 50 MW Quantel Renewable Energy solar PV to be developed in Ulalo Nyirenda Village in Mzimba district.

In terms of targets, the country's Action Agenda on SEforALL, Integrated Resource Plan (IRP), and revised energy policy of 2018 have information, though not agreeing on the targets. In all the documents, solar PV is presented as the renewable energy to significantly contribute on the

projected plans to increase renewable energy in Malawi..As stated in the energy policy, the country plans to achieve at least 6 IPPs by 2023 in solar PV electricity generation (contributing at least 160 MW) (GoM, 2018). On the other hand, from the IRP, the country plans to add 650 MW by 2032, which includes 165MW from solar electricity. The SEforAll Action Agenda for Malawi presents target to be achieved in terms of number of customers connected to solar minigrids. By 2030, the agenda states that the country shall have 13,500 customers connected to solar minigrids, up from 900 in 2016. The likelihood of attaining the targets depend on support and active participation from the private sector. In addition to the stated national documents that talks about targets on solar mini-grids, the Renewable Energy Strategy for Malawi also predicts a positive future for solar mini-grid grid technology. Just like the revised energy policy, the Strategy positions solar mini-grid as an important technology in sustainable electricity generation in Malawi (GoM, 2017). By 2025, through the strategy, the country targets to install least 50 mini-grids. Further, the strategy targets that by 2025 the country will have at least 500MW of installed power from renewable sources, majority of them being solar PV (GoM, 2017).

1.2 Barrier analysis and possible enabling measures for Technology1: Liquefied Petroleum Gas for cooking services

The barriers identified against wide-scale diffusion of Liquefied Petroleum Gas (LPG) as a cooking and heating fuel are presented in this Section. The section starts by briefly describing the technology. Then it presents barriers as identified and validated by stakeholders.

1.2.1 General description of the Technology

Liquefied petroleum gas (LPG) is a mixture of propane and butane, which are gases that become liquid under pressure and can then be stored in pressurized containers. LPG is manufactured during the refining of crude oil (40%) or from natural gas during extraction (60%).The proportion of each gas varies depending on the source. LPG has a high energy per unit volume and is convenient to use for thermal services such as cooking and heating. Its calorific value per unit volume is about 2.5 times larger than that of natural gas (methane). LPG can also be used for road transport, cooking, heating, refrigeration and air conditioning. Increased uptake of LPG as a fuel would replace firewood and charcoal; hence significantly reducing deforestation and enhancing carbon sink for Malawi. A typical composition of the LPG thermal energy system comprises stove, gas cylinder and the piping system. The cylinder has a regulator that controls the flow of the gas. The gas flow to the stove can also be controlled by the stove itself. Generally the LPG cooking technology is well mature, and it safe, despite the perception in Malawi that the LPG technology is unsafe. The technology can be bought off-the shelf and has several market players, including gas distributors, cylinder owners and technicians. Malawi, all of the LPG is imported.

The baseline technologies that the LPG technology would replace are biomass stove and electric stove for thermal application such as cooking. By replacing electricity for cooking, the LPG presents an alternative electricity demand side management since most of the peak load is for when

consumers are cooking and heating. The power utility (ESCOM) would support it. The LPG technology compares well with the baseline technologies. According to the Malawi SEforALL Action Agenda, the cost of electric cooking technology (equipment cost) was 70 USD in 2016, while that for LPG was 50USD. However, despite this, the use rate for electricity for cooking was 2%, while that for LPG was 0.2%. The Malawi SEforALL Action Agenda states that there were about 8600 units of LPG stoves in 2016, and the number is projected to be 893,000 units of LPG by 2030 (GoM, 2017). LPG Cooking is recognized as one of the viable technology for replacing charcoal use in urban areas in a significant way. The market potential for LPG in Malawi is huge, especially as a form of cooking energy. However, there are barriers that prevent wide scale diffusion, as explained the following sections.

1.2.2 Identification of barriers for the Technology

The stakeholders agreed barriers against wide scale transfer and diffusion of the LPG for cooking and heating were categorized into economic and financial barriers as well as non-financial barriers. The barriers are characterised in the following sub-sections:

1.2.2.1 Economic and financial barriers

The following are the economic and financial barriers that were identified, which were further categorized into market-based challenges (4 barriers), and limitations in financing capacity (3 barriers).

1.2.2.2 Market-based challenges

Four market based barriers were identified, and are explained henceforth.

a) Weak LPG distribution mechanisms

The distribution, storage, filling facilities and retail operations for LPG are very limited in Malawi. The consumers travel to LPG selling points (refilling stations), which are few and only available in the urban areas (cities only). Also, these selling points belong to the major gas suppliers. In addition, formal LPG distribution system is absent. All these factors give rise to high distribution costs of LPG. Further, delivery status (associated with customer after-sale services such as doorstep delivery) of LPG cooking system is almost absent for households. In rural areas, the support system for distribution of LPG is almost non-existence. Even if there are markets, poor conditions of roads in rural areas make LPG supply and service a very difficult and expensive exercise.

The other point that prevents wide scale diffusion of LPG cooking technology is the limited presence of infrastructure to ensure availability of LPG fuel itself all the times. This is so because Malawi imports all of its LPG; there are no significant LPG reserves like it is the case with petroleum products (petrol and diesel). This situation does not make the LPG fuel supply more secure for the consumers. Also, in the event that the demand for LPG increases, it would require

to be matched with increase in supply. With limitation in storage facility, this would cause a real barrier to accessing the fuel.

b) LPG market is still in its infancy stage

The LPG market is characterized by limited number of companies that sell LPG and few consumers. The consumers are usually the hotels and a proportion of well to do households in urban areas. The small market reduces economies of scale, which in turn contributes to increased costs of investment and operation. Also, since the market is at its infancy stage, the limitation of LPG suppliers makes LPG replacement an inconvenience for consumers, who refuel the relatively heavy gas cylinders by themselves. This is convenient to only those consumers have means of transport (cars).

c) Limitation in sustainable development business models

Limitation in business development models that would increase LPG consumption contributes to having very few players in the LPG business in the country. Also, as pointed out by (Fay, et al., 2020) clean cooking (including LPG for cooking) business models depend on economies of scale.

d) Low investment cost of the baseline technologies compared to LPG cooking system

The investment costs of baseline cooking technologies that utilize charcoal and electricity are relatively low compared to LPG cooking technology. In rural areas, baseline fuel for cooking (firewood) is still collected at a relatively low cost. The majority of the households use cheap but efficient clay firewood stoves (chitetezo mbaula). This presents a barrier, because consumers usually go for cheap technology since the buying decision is not exclusively influenced by reasons of climate related benefits.

1.2.2.2 Limitation in financing capacity

Three barriers identified under financing capacity are presented as follows:

a) Limited affordability

High upfront costs of LPG cooking equipment (comprising cylinder, gas, stove and accessories like piping and valves) limit access to majority of Malawians. This is partly due to all of the LPG cooking technology pieces of hardware being imported into Malawi. The import duties contribute to increasing capital cost of the equipment. Price of LPG fuel also limits affordability. The pump-price of LPG is relatively high, making the energy cost high compared to baseline technologies of charcoal and electricity. The deposit for the cylinder and the payments for a refill are much higher than the required expenses for daily purchase of wood fuel or charcoal or electricity. This barrier is significant for rural and peri-urban households; majority of them having relatively little income. Low affordability of an LPG cooking system for most of Malawians in rural and peri-urban areas is caused by their low levels income (Fay, et al., 2020).

Affordable would be enhanced if alternatives to financing, for example credits, are available and accessible. The opportunity to access credits and loans by most of the low income households is limited by them not having collateral as demanded by money lending institutions. This limits access of LPG fuel to only affluent consumers in urban areas, hotels and some restaurants. Also, it was revealed during the workshop that most banks are not well informed about the business opportunities associated with energy interventions like LPG for cooking for them to provide microfinance.

b) Low willingness to pay for investment

There is a low willingness to pay for LPG cooking technology by the majority of Malawian households. This is due to several factors such as lack of information on benefits of cooking with LPG, inertia to use new cooking technology, and perceptions that work against LPG cooking technology. The relatively high and unstable LPG fuel prices make LPG cooking technologies receive negative publicity, which exacerbate the challenge of low willingness to pay.

1.2.2.2 Non-financial barriers

The identified non-financial barriers were six, grouped into themes as follows:

a) Social and cultural practices and perceptions that work against promotion of LPG cooking technology

In Malawi, those who perform cooking services (mostly women and maids) do not have absolute power and control over decisions concerning household finances. The household resources are controlled by male members. Therefore, reasons to investment in LPG system for cooking would not be well understood by men. This affects wide-scale adoption of the LP cooking technology in the country since men have other priorities to spend resources on than on cooking chores. In terms of perception, majority of Malawian households perceive cooking with LPG fuel as not being safe. This pities the use of LPG against baseline cooking technologies. The other perception is that LPG is ideal being used only as a back-up cooking fuel.

b) Limitations in technical skills and knowledge in LPG cooking and heating system

Availability of technical personnel with required skills to maintain the equipment (hardware part of the technology) is important in achieving wide scale adoption of any technology. In Malawi, skills to design LPG cookstove, maintain the LPG cooking equipment system and manufacture parts are limited. In particular, spare parts for LPG stoves are not locally found, hence the need for local manufacture of parts. The lack of maintenance skills and lack of local availability of spare parts are among the causes of abandonment of LPG cooking system in Malawi.

In terms of knowledge, information about clean cooking and particularly cooking with LPG is limited. Further, knowledge on developing a viable LPG cooking business model among local entrepreneurs/enterprises is limited. Furthermore, knowledge on affordability and cultural acceptance of LPG cooking is limited. The prospective consumers are inadequately supplied with

information about LPG cooking. This information could be provided by the LPG marketers and Government's departments (e.g Energy Affairs Department), packaged in a way that appeals to households and institutions to switch to using LPG for cooking. The information could include what LPG cooking system is all about, safety issues concerning its use, where LPG could be bought, and any available financial support on purchase of the LPG cooking.

c) Presence of cooking fuel stacking that works to the disadvantage of LPG for cooking

In Malawi, choice of household's decision on cooking stove and fuel to use depends on largely on familiarity, ability to achieve multiple cooking sessions at the same time, and on the type and taste of food to be cooked. This leads to cookstove and fuel stacking phenomena that work against use of LPG cooking technology. It works against LPG technology because the is relatively an unfamiliar to most of the households in the country and is not preferred.

d) Absence of LPG specific policy and strategy in relation to cooking

The revised 2018 National Energy Policy of Malawi has one of its goals "to increase access to affordable, reliable, sustainable, efficient and modern energy for every person in the country". LPG is mentioned as the fuel to be prioritized, as indicated in one of the objectives to achieve the policy goal "is to ensure availability of LPG, biogas and natural gas in sufficient quantities at affordable prices for industrial and domestic use. However, there is no strategy (or master plan) to achieve this policy objective on LPG. Also, there is no standalone policy that could cross-cut other sectors that have a bearing on successful implementation of LPG consuming programme. These sectors include forestry, finance, transport, science and technology, industry, infrastructure development, and gender mainstreaming. Absence of LPG specific policy results in technology not receiving the required support (for example in forms of subsidy) from government and its development partners the way how other clean energy technologies (e.g solar) receive the support. Also, the key players in the LPG cooking technology chain are not coordinated. Also, the data on LPG consumption is scanty and not systematically collected by relevant authorities in Malawi. Therefore, LPG activities are not informed as well as not coordinated in the country.

Further, Malawi's energy policy (both first and the revised one) pays more attention to petroleum (petrol and diesel), and electricity than any to other sources of energy. This is because these two are seen by decision makers as the only energy sources that will drive Malawi into industrialization. Furthermore, policy elements on prioritizing and facilitating use in households including promotional activities involving education is missing. There are a number of organizations (both government and non-government based) involved in LPG promotion in Malawi, for example Energy Affairs Department, Department of Forestry, Environmental Affairs Department, Malawi energy regulatory Authorities, Consumers Association of Malawi. However, these organizations work in isolation, contributing to limited focus in designing and implementing policy issues.

e) Limitations in LPG standards, regulation and its enforcement

Malawi Energy Regulatory Authority (MERA) is mandated to be a energy sector-wide regulator. However, the stakeholders felt that MERA is seen to be more active on petroleum and electricity regulation. In terms of standards, standards on LPG fuel are available. Also safety standards are on design, construction and installation of tanks and cylinders are available. The safety standards on transport and distribution as well as on the end use of the LPG systems are not yet developed. Enforcement of the standards is challenge.

f) Limited information and awareness on LPG cooking system

The LPG cooking technology is still not well disseminated to the masses. The mode of dissemination is convenient only for a segment of populace: the elite. This is so because information is packaged in English and in most of time presented in technical terms. The critical information about the LPG cooking technology including its benefit as a clean cooking fuel, safety issues and economic issues is not make available to most of the prospective consumers.

1.2.3 Identified measures

The identified measures were identified from a solution tree. They are as follows, for each of the identified barrier.

1.2.3.1 Measures for economic and financial barriers

The following are the economic and financial barriers that were identified, which were further categorized into market-based economic challenges (4 barriers), and limitations in financing capacity (9 barriers).

1.2.3.1.1 Measures for market-based barriers

Under this category of measures, the following were identified.

a) Measures for Barrier: Weak LPG distribution mechanisms

The country needs to put in place and improve on LPG supply support infrastructure. This includes availability of storage facilities and LPG cylinder filling depots in the strategic places that are close to consumption points. There is also a need to improve on transportation of LPG fuel and cylinders through engaging private transporters in the country. In the case of rural towns with poor road network such that LPG business enterprises and transporters would be unwilling to invest, there is need for the country to improve on its road network and on the necessary logistics (like special delivery to customers). Further, there is need to establish energy kiosks in towns and important trading centres in rural towns and peri-urban areas, which could be stocking cylinders filled with LPG in exchange for empty cylinder according to agreed modalities with all players involved. The energy kiosks, apart from stocking energy system, they could also officer advise and further information about cooking using LPG technology. The country should furthermore encourage retailers to stock parts of the LPG cooking system (stove) for replacement when need arise

b) Measures for Barrier: LPG market is still in its infancy stage

For the LPG market to mature there is a need to encourage the private sector to invest in energy business like LPG supply and services. This could be achieved through creation of deliberate policy, attracting investors in this area. The policy would include elements like capital subsidies and tax exemption. Further, there is need to conduct awareness campaigns on LPG as an alternative fuel so that there is increased demand for it and thus, benefit from economies of scale. Furthermore, the country should protect the LPG business and consumers through development of LPG specific standards and regulatory framework.

c) Measures for Barrier: Limitation in sustainable development business models

There is need to engage the universities and other higher learning institutions to offer training and research on business development models that would increase clean cooking technologies like LPG. One of the business model that has been applied elsewhere (e.g Kenya and Bangladesh) with success is the "pay-as you go model". This business model would be piloted in Malawi to determine is effectiveness in wide-scale consumption of LGP for cooking. The other business model that could be piloted is the rent-to-own option, which allows payments to be made over time.

d) Measures for Barrier: Low investment cost of the baseline technologies compared to LPG cooking system

For the new technology to be introduced in the market, most of the times, its investment cost is high compared to baseline technologies. For the case of LPG for cooking technology, there is need for subsidies and tax exemption (import duty) on LPG system components so that the investment cost is compared to electricity cooking system, for example. The other measures would be to encourage local entrepreneurs to also focus on additional solutions presented by LPG cooking technology, for example lighting services by LPG and clean cooking as required in restaurants. These additional solutions should be the ones that cannot be provided by baseline technologies.

1.2.3.1.2 Financing based economic measures

Measures to remove barriers related to financing of LPG cooking technology are presented as follows.

a) Measures for Barrier: Limited affordability

To increase consumption of access of LPG cooking technology, hence increase LPG consumption, there is need to expand its market to consumers that have limited financial resources for investment and operational cost related to LPG cooking. In order to achieve this, there is need to reduce initial capital costs through subsidies on cylinder and stoves. The subsidies should also be extended to LPG fuel in order to reduce operational costs. The subsidies should be designed in a way that they target the low income households. Further, there should be access to financing mechanisms such as bank loans and credits from micro-financing organizations. The loans from commercial banks

are associated with high interest rates and require collateral. In this case, there is need to negotiate for soft bank loans as well as create an organization that would provide collateral services for households that do not have the required collateral materials.

The banks and micro-financing institutions should be informed on business ventures available in the clean cooking, such as LPG for cooking. This could be in the form of formalized training to banks and micro-financing institutions. Also, the training should include lack basic technical capacity to implement and manage microfinance in this field. Secondly, any financing institutions want data to base decision on credit facility. The country should institute data collection and management system on clean cooking technologies including LPG for cooking.

b) Measures for Barrier: Low willingness to pay

To increase willingness to pay, firstly there is need to conduct extensive LPG awareness campaigns for the technology to be accepted by the masses. Among others, awareness should include dissemination of LPG information on its fuel, its benefits as a clean cooking energy, safety issues associated with LPG and the investment and operational costs. Secondly, there is need to have a stable LPG fuel supply because there is publicity that LPG is not always available in the country, which erodes confidence for households to switch to LPG for cooking.

1.2.3.2 Measures to Non-financial barriers

The following were the non-financial barrier measures that were identified

a) Measures for Barrier: Social and cultural practices and perceptions that work against promotion of LPG cooking technology

To remove social and cultural practices and perceptions that work against promotion of LPG cooking technology**,** there is need for extensive LPG awareness campaigns for the technology to be accepted by the masses. Among others, awareness should include dissemination of LPG information on its fuel, its benefits as a clean cooking energy, safety issues associated with LPG and the investment and operational costs. The other measure is to link LPG cooking programs to gender-focused and women-led development initiatives. The women are best positioned promoters of clean cooking solutions because they are the first beneficiaries of improved indoor pollution and reduced time for cooking.

b) Measures for Barrier: Limitations in technical skills and knowledge in LPG cooking system

Firstly, to develop a critical mass of qualified technical expertise (technicians and engineers) to manage LPG cooking technology, there is need to establish and equip training institutions on design, operate and maintain LPG cooking technology. Higher education institutions such as University of Malawi-The Polytechnic are well placed to create centre for clean cooking technologies, where specialized training could be offered to the masses through short courses and

infusion of clean cooking in the current degree curriculums. The training should also include on - engineering aspects of LPG technology like marketing and business development.

Secondly, there is need to create an organization to certify technical experts that would be involved in installation and maintenance of LPG cooking systems. There is need to incorporate or affiliate this organization with National Construction Industry Council of Malawi.

c) Measures for Barrier: Presence of cooking fuel stacking that works to the disadvantage of LPG for cooking

It is difficult to completely eradicate fuel stacking. The Government should and other key stakeholders, therefore carryout programmes that would make LPG a significant fuel (fuel of choice) in the stack (mix). This can be done through awareness campaigns, promoting LPG as clean fuel and convenient cooking fuel.

d) Measures for Barrier: Absence of LPG specific policy and strategy in relation to cooking

There is need for Malawi come up with an LPG specific policy and strategy. In order to do this, the country to put in place a robust data collection system on clean cooking technologies (including LPG) in Malawi in order to determine the policy areas to put in the policy as well as to help make informed policy reviews and strategies. Generally, the LPG policy should be developed to include the following: Increasing the LPG availability; improving the supply chain, supporting public education on safe use and handling of LPG; and on facilitating the domestic manufacturing of LPG infrastructure and accessories. The LPG policy must be inclusive since the LPG cooking caters different sectors including energy, public transport, forestry, public health, gender, civic education, small scale business, finance, and consumer associations. Further, the policy must include incentives to promote LPG to be a significant fuel for cooking in Malawi. These incentives should include targeted subsidies on LPG equipment and fuel price, as well removal of import duties on LPG cooking equipment (stoves and cylinders).

Furthermore, the policy must encourage private-sector participation in scaling up access to LPG cooking technology. These include entrepreneurs and microfinance or microcredit organizations.

e) Measures for Barrier: Limitations in LPG standards, regulation and its enforcement

The Malawi Energy Regulatory Authority (MERA) must develop new and revise regulations specific to LPG consumption in the country. The regulations must include those concerning installation of LPG cooking systems, safety of LPG storage and filling depots and of cylinder, and safety features of stoves. Further, the regulation should focus on LPG transportation and distribution as well as on pricing of the LPG fuel. Regulation on pricing is important in order to make sure that the LPG price is even throughout Malawi. It is also important to regulate technical people and or companies that install and maintain LPG cooking systems. Regulation would entail that the country must come up with standards on variables that we are regulating on.

f) Measures for Barrier: Limited information and awareness on LPG cooking system

The barrier on limited information and awareness on LPG technology could be removed through conduction of national awareness programmes through avenues such as media and schools to promote information dissemination about the technology to the masses. Among others, important pieces of information to be disseminated are LPG cooking technology itself and its benefits, availability of LPG cooking system, availability of funding opportunities, and safety issues associated with LPG cooking technology. Demonstrational LPG cooking units could also be installed in typical consuming points for to demonstrate functionality of LPG cooking technology.

1.3 Barrier analysis and possible enabling measures for Technology 2: Biofuel as Transportation fuel

Identified barriers against wide-scale diffusion of biofuel as transportation fuel were many. This section presents these barriers, starting with general description of the technology.

1.3.1 General description of the Technology

Biofuels are produced from organic matter (biomass), which could be plant material and animal waste. Biofuels for transportation fuels are usually made from biochemical and thermochemical process. Common biofuels for transport sector are fuel-grade ethanol and biodiesel. Bioethanol is produced by fermenting sugars from biomass feedstock (e.g molasses as the feedstock) in biorefineries using enzymes and living microorganisms. Fermentation is the biochemical process that occurs when yeast break down glucose, producing ethanol, which 10-15% pure ethanol for each volume of the mixture (which is significantly water). To make it fuel grade, it must be concentrated. Thus, the mixture undergoes a distillation process, which produces fuel-grade ethanol. One of the challenges if that fuel-grade ethanol is relatively inferior to petrol in terms of energy value (calorific value) per liter, so if charged at the same price, consumers gets lower value compare to petrol. However, fuel grade ethanol has some advantages over petrol. Fuel-grade ethanol has a higher octane rating (107) compared to regular petrol (95) and premium petrol (98) (ePURE, 2017). The higher octane rating helps in improving efficiency of the engine.

On the other hand, biodiesel is made from a process known as transesterification. This process is achieved by adding methanol to vegetable oil. One of the important sources of vegetable oil of oil from jatropha seeds. The transesterification process requires a catalyst to increase the rate of the chemical reaction between the methanol and vegetable oil. The catalyst used in the creation of biodiesel is an alkaline. This can be either Potassium Hydroxide or Sodium Hydroxide. The crude biodiesel from the transesterification process is refined in refineries to make it a transportation fuel.

Both fuel-grade ethanol and biodiesel require relatively large equipment (a factory) including refineries. The process of producing biofuels (from biomass feedstocks) for the transport sector

involves a variety of players: starting from feedstock production, fuel production and its delivery. This technology (biofuels for transportation fuel) therefore falls in the category of capital goods.

Currently, Malawi has got only one biofuel being used in the transport sector. This is fuel grade ethanol, (99.5% v/v alcohol strength), which is produced by two companies: Ethanol Company Limited and Presscane Limited. Both of these companies use molasses from sugar factories located close to them. On average, the total fuel grade ethanol production is around 15 million litres per year. The fuel grade ethanol is blended with petrol. The Government approved blending ratio of 20:80 is not met due to limitation in supply of fuel grade ethanol. Ethanol producing companies have embarked on interventions increase production, among others through increasing processing capacity and investing in alternative sources of baggage through having own sugarcane farms and sourcing it elsewhere (e.g importing). Further, feedstock could come from local cooperatives of sugar cane growers.

In Malawi, biodiesel production from jatropha was once demonstrated in 2016 by Bio Energy Resourced Ltd (BERL), but BERL did proceed to not produce biodiesel at commercial scale due to challenges. The company was premised to plant jatropha, using association of small scale formers, then the seeds to produce biodiesel. Further, BERL was to be responsible for the whole production chain and for the marketing. The Malawi government used biodiesel production from estimates of BERL to project biodiesel production for the country, as stipulated in the revised energy policy of 2018 and the Sustainable Energy for All action agenda for Malawi. To support the biodiesel industry, standards for biodiesel were formulated and the blending ratio of 9:91 (with diesel) was established.

1.3.2 Identification of barriers for the Technology

The identified barriers were grouped into economic and financial barriers as well as non-financial barriers.

1.3.2.1 Economic and financial barriers

The economic and financial barriers are presented as follows:

a) Biofuel (fuel grade ethanol) is not competitive with petroleum (e.g petrol) based on pump price per unit energy

On an energy basis, the consumers pay more on energy from petrol-ethanol blend than on pure petrol since calorific value of fuel grade ethanol is less compared to petrol and that the pump price for ethanol-petrol blend is the same as that for petrol. Therefore, consumers would prefer petrol.

b) Limitations in financial incentives for biofuels

There are limited financial incentives for biofuel like fuel grade ethanol compared to petroleum (petrol and diesel). The business of production of biofuels does not enjoy import duty tax reduction

on importation of raw materials like molasses for example. The fuel stabilization fund for fossil fuel business is not enjoyed by the companies that are into fuel grade ethanol production.

c) High investment cost of flex-fuel - vehicles and accessories

Due-fuel vehicles (flex-fuel - vehicles) are expensive for most of Malawians. Most Malawians buy used cars (run using petrol and diesel), which are relatively cheap. Also, fuel conversion kits to use for high blend ratio biofuel run vehicles are expensive. Further, these kits are imported into the country, which contributes to their being expensive.

d) Absence of retail market for biofuel

The retail market for biofuel is absent in the country. The only biofuel traded (fuel grade ethanol) in the country is sold at wholesale, thus only to big consumers which is only sold for blending with petrol.

1.3.2.2 Non-financial barriers

The identified non-financial barriers are presented hence forth.

a) Limitation in policy, standards and regulation

In Malawi, the Energy Regulation Act of 2004 and the Liquid Fuels and Gas Act of 2004 amended in 2017 are among the laws that govern the production of biofuels. In case of fuel grade ethanol, the biofuel has been produced in the country since the 1980s. The biodiesel has been produced at demonstration level in 2000s. The barriers identified associated with policy and regulation as follows:

Development of biofuels in Malawi is currently being hampered by the lack of a specific policy on biofuels. Promotion of biofuels is generally stipulated in Energy Policy, which is for the sector-wide energy sector. Specific issues requiring policy attention for biofuels to be dealt with holistically are therefore lacking. Examples of issues that could be paid attention to in specific biofuel policy include practical blending targets, support infrastructures and feedstock use.

Analysis and standardization of biofuels are in constant development. When compared to fossil fuels (mixture of hydrocarbons, relatively easy to analyze or predict their characteristics), they have significantly different chemical composition. This means different physical and fuel properties. There is need to revise the current standards on bioethanol and biodiesel produced in Malawi to be in line with dynamic requirements as a automotive fuel. Technologies producing biofuel also need standardization, which is absent in Malawi. Malawi therefore is required to establish technical standards as the country aim at the standardization of biofuel quality.

The other barrier against wide-spread diffusion of the biofuel technology as transport fuel is the selective policy support to promote biofuels as transport fuel in the country. In particular, biodiesel

despite demonstration of its potential as an automotive (transport) did not enjoy the Government policy support compared to fuel grade ethanol. This is arguably one of the reasons the BERL (company that was to produce biodiesel) was not able to operate the biodiesel business in the country. The policy support on biofuel, for example on guarantee of market, should be extended to technical and economic feasible biofuels.

b) Limitation in knowledge and technical skills

Despite being a mature technology, knowledge and technical skills about biofuel production and processing are still limited to the majority of Malawians. It is available particularly to those working in biofuel industries, also limited to fuel grade ethanol. The research and development institutions like University of Malawi - The Polytechnic have limited research infrastructure and human resource to support development of knowledge (through research and development) to inform policy and decision in biofuel as automotive fuel in Malawi.

End use pieces of equipment for use of fuel are not locally made in Malawi. The fuel convertors and other necessary accessories so that vehicles use fuel blends with high in bio-fuel are all imported. The skills requires for servicing of these equipment are also limited.

c) Limited availability raw materials for production of biofuels in Malawi

There is limited local supply of molasses to the bio ethanol production companies, which limits production of fuel grade ethanol for blending with petrol. The companies instead import additional molasses from outside the country. The limitation in molasses is due to limited amount of sugarcane grown for sugar production and reportedly high prices molasses from local suppliers (Dwangwa and Nchalo sugar factories, both belonging to Illovo Limited). Further, raw material used for production of bioethanol in Malawi, is only from molasses (a byproduct of sugar production).

d) Limited Infrastructure to support biofuel as transportation fuel

Limited support infrastructure to support increase production and use of biofuels. Fuel service stations are not installed with tanks and pumps for higher fuel grade ethanol blends for Flexible Fuel Vehicles (FFVs).

e) Limited institutional support for biofuels as transportation fuel

Institutional support for biofuels is generally weak. Biofuels do not have a specific policy or strategy. Policies for promotion of biofuels are not consistent to guide investors accordingly. Further several sectors are involved in biofuels including energy, forestry and agriculture. However, their efforts are not coordinated.

f) Limited awareness of the biofuel as transportation fuel

There is in general limited awareness on biofuel as fuel for vehicles. The Government of Malawi in partnership with stakeholders including fuel grade ethanol producers, demonstrated flex vehicle powered on FlexFuel Vehicles (higher blends of ethanol), but this was a research based project (done in collaboration with Lilongwe Technical College) and dissemination of results was limited to few stakeholders. It was also disseminated in form of research academic manuscript.

1.3.3 Identified measures

The identified measures correspond to the individual barriers identifies, whether economic and financial or non financial barriers. The following subsections provide the analysis of the barriers, with the help of market tree in Appendix I.

1.3.3.1 Measures for economic and financial barriers

Measures for the identified economic and financial barriers against wide-scale diffusion of biofuels as transport fuels are presented as follows:

a) Measures for barrier: Biofuel (fuel grade ethanol) is not competitive with petroleum (e.g petrol) based on pump price per unit energy

The Government, through the Malawi Energy Regulatory Authority (MERA), should set the price of biofuel used for transport (automotive) taking into account the energy content of the fuel.

b) Measures on barrier: Limitations in financial incentives for biofuels

The Government should put in place fiscal incentives for to promote wide scale production of biofuel like fuel grade ethanol compared to petroleum (petrol and diesel). The incentives should include guaranteed market on both fuel grade ethanol an biodiesel, reduction in import duties on importation of raw materials like molasses, fuel conversion kits, and flex-fuel vehicles (FFVs). Further, the fuel stabilization fund should revised to see that practicality of benefitting the biofuel production companies since the production of biofuels also depends of the value of the local currency.

c) Measures for barrier: High investment cost of flex-fuel - vehicles and accessories

The Government and other stakeholders should support purchase of fuel conversion kits to use in flexfuel vehicles (FFVs) for the consumers who cannot afford to purchase them. The support could be through a loan from the banks and other money lending institutions. Also, the Government should create a body to provide collateral services for those consumers that would not provide collateral to the bank.

The Government should remove import duties on flexfuel vehicles) to reduce its capital cost. Since FFVs are expensive cars, the removal of import duties would not meaningfully reduce the cost of the vehicle. Therefore, this support should be augmented with other support like

having access to loans from banks and other money lending institutions. Further, the Government should develop retail market for biofuel as transport fuel is in the country, just like it is for petrol and diesel.

d) Measures for barrier: Absence of retail market for biofuel

The Government and stakeholders should establish infrastructure that should support retailing of biofuel in Malawi. For example, the biofuels should be sold at oil filling (service) stations like petroleum is.

1.3.3.2 Measures for non-financial barriers

The identified non-financial barriers are presented henceforth, grouped according to themes

a) Measures for barrier: Limitation in policy, standards and regulation

Despite the fact that Malawi is one of the countries that have mainstreamed biofuels into its transport fuel mix, the country should develop a biofuel policy in harmony with other key sectors like agriculture and forestry to make sure that activities at promoting biofuels are achieved through biofuel-specific policy interventions such as on achievement of practical blending ratios, support infrastructure and feedstock production. Further, the biofuel policy should promote all technical and economic feasible biofuels in Malawi. Further the country should revise and develop new standards and regulations pertaining to production, distribution and use of biofuels as automotive (transport) fuel. This is so in order to keep pace with vehicle engine technology advances and quality biofuel quality requirements.

b) Measures for barrier: Limitation in knowledge and technical skills in biofuel as fuel for transportation

The knowledge and technical skills gaps were identified as one of the significant barriers against wide-scale diffusion of biofuel as transport fuel in Malawi. The measures to overcome this barrier are basically centred on training. The capacity of research and development institutions like University of Malawi - The Polytechnic need to be enhanced in the areas of research infrastructure and human resource to support development of knowledge (through research and development) to inform policy and decision in biofuel as automotive fuel in Malawi. There is also need to include and/or revise syllabi on biofuels to enhance knowledge acquisition. The technical skills to design and manufacture parts of the biofuel system in automotives also need to be developed and enhanced through establishment of practical training programmes in universities and vocational training institutions that should be accessible to general populace and the industry. The practical training programme, among others, should focus on manufacturing and servicing of biofuel pieces of equipment for example fuel conversion kits.

c) Measures for barrier: Limited availability raw materials for production of biofuels in Malawi

The Government should work with current companies (Presscane and EthCo) to invest in expanding the production capacity for biofuels. The investment could be in form of expanding the feedstock such as sugarcane and purchase of extra production equipment. Further, the Government should identify new investors in the biofuel sector to add extra biofuel production capacity for the country. Furthermore, the Government in partnership with other stakeholders should work out on how to improve feed stock supply infrastructure (such as road connectivity) to biofuel production points so that access to feedstock is available, which would further enhance the biofuel business.

d) Measures for barrier: Limited infrastructure to support biofuel as transport fuel

This barrier would be removed through putting in place the required biofuel for automotive support infrastructure in order to support increased production and use of biofuels. For example, the fuel service stations should be installed with tanks and pumps so that FlexFuel Vehicles (FFVs) that use higher fuel grade ethanol blends, are able to fuel.

e) Measures for barrier: Limited institutional support for biofuel as transportation fuel

Institutional support for biofuels in the country should be enhanced, in particular the established Biofuel Advisory Council and Biofuels Association of Malawi, so that they assist to unlock biofuel opportunities in the country. Further, the country needs to come-up with specific biofuel policy and strategy that compliments other development policies in Malawi. Further, the Government must create a platform where efforts and achievements concerning diffusion and dissemination of biofuel as automotive fuel is documented and coordinated.

f) Measures for barrier: Limited awareness of the biofuel as transportion fuel

The Government should put in place biofuel awareness programme that should include use of social media like Twitter and facebook to increase information dissemination on biofuel as fuel for automotive. Further, the demonstration of physical components of biofuel technology (for example FlexFuel Vehicles) should be enhanced, not only limited to specific stakeholders.

1.4 Barrier analysis and possible enabling measures for Technology 3: Biomass Gasification

The identified barriers for the biomass gasification technology are presented in this section, starting with brief description of the technology.

1.4.1 General description of technology

This technology is about converting biomass to gas (in a low oxygen environment), which then can be used directly for thermal applications like heating and cooking. The resulting gas is a mixture of carbon monoxide, water, carbon dioxide, char, tar and hydrogen. A biomass gasification plant can also be used to produce electricity using the conventional thermodynamic power cycle

(gas turbine power cycle) at higher efficiencies. According to Bhatt (2011) as reported in (Muzee, 2012), gasification is stated to be the best available technology for tapping the highest amount of energy content in the biomass. Biomass plants (also known as gasifiers) generate combustible gas (syngas) from solid biomass (any solid carbonaceous material) through series of thermo-chemical processes. The advantage of biomass gasification is that using the syngas is potentially more efficient than direct combustion of the original biomass because syngas can be combusted at higher temperatures or even in fuel cells so that the thermodynamic upper limit to the efficiency defined by Carnot's rule is higher. Apart from direct heat and electricity generation, the syngas could be used in fuel cells and internal combustion engine.

The gasifiers could be for industrial scale or households scale. The latter are commonly called biomass micro-gasifiers to be used for household cooking and other heating purposes. It is possible to incorporate a thermal-electric converter to the household micro-gasifier to generate electricity together with heat. Micro-gasifier stoves are currently the cleanest burning option to burn solid biomass in a cook stove. The technology is relatively new to Malawi: being at experimental stage at universities and research institutions (e.g Chitedze Agricultural Research Institution) and at Jesuit Centre for Ecology and Development in Lilongwe.

The Malawi Action Agenda to SEforALL Initiative recommends biomass gasification projects fuelled by crop residue or animal waste as viable future projects (GoM, 2017). Accordingly to Taulo and others, investment cost for a 32 kWe biomass gasification plant they designed in 2019 for Malawi is 154,000 USD (Taulo, et al., 2020), giving about 5000 USD/kWe. The capacity of 32kW is robust enough for powering an off-grid community and hence excellent demonstration of biomass gasification towards rural electrification. The total biomass cost per year was 10,741USD. However, the authors state that the capital investment cost, operation and maintenance cost, and the fuel cost should be reduced given that the biomass gasification technology represents the least-choice technology for rural electrification especially where there is no extension of electricity grid. They further said that can be done by developing the gasification system using local materials, purposeful and efficient plantation of biomass for electricity generation. The government can also provide financial incentives to the investors, and locate the power plant close to the source of feedstock generation. A similar study in Italy showed that the installation cost being around the plant is 6200 €/kWe (Porcu, et al., 2019).

1.4.2 Identification of barriers for the technology

The barriers were identified were economic and financial in natures as well as non-financial barriers, as detailed in the following subsections.

1.4.2.1 Economic and financial barriers

The identified economic and financial barriers are as follows:

a) High initial investment of biomass gasification plant

In most of the cases, biomass gasification plant is in most cases supplies electricity to a remote community (not connected to electricity grid). In general biomass gasification plant are associated with relatively high investment cost per kWe of installed power. The economic analysis study on small-scale biomass gasification plant for electricity generation in Italy showed that the installation cost being around the plant is 6200 € (about7600 USD) /kWe (Porcu, et al., 2019). In Malawi it is about 5000 USD/kWe (Taulo, et al., 2020). It is not easy to get the investment cost of a typical diesel power plant (baseline-line technology), for the sub-Saharan Africa it is reported to round 1000 USD/kWe on average (Baurzhan & Jenkins, 2017).

b) Limitation in financing installation of biomass gasification plant

The biomass gasification plants in Malawi are mostly at experimental and deployment level. The financing mechanisms available for this technology are almost absent, due to its being relatively unfamiliar technology compared to solar and small hydropower. There are also limited private sector investment interests in power production business, especially concerning biomass, as witnessed from Independent Power Producers (IPPs) applications that are dominated by solar.

a) Limitation in market conditions for successful commercialization of biomass gasification plant

Biomass gasification plants are among the robust thermal energy systems that supply gas for electricity generation as well as for heating and cooking purposes. In Malawi, the technology is unfamiliar, which affects acceptance rate. There is an absence of market pull due to competition from other sources of energy (like fossil fuel and traditional biomass) for electricity and heat production.

In most of the countries, electricity from decentralized energy systems like biomass gasification plant is sold at price that is higher than the price from the national grid (which is subsidized). When the grid electricity reaches the community, the decentralized energy systems do not get businesses because customers switch to grid electricity.

1.4.2.2 Non-financial barriers

Four non-financial barriers identified. These are explained hence forth.

a) Limitation in technical expertise and knowledge of biomass gasification plant

The technology is considered being at experimental level in the country, being at research stage/product development in Universities e.g The Polytechnic and other research based organisations like Chitedze Agriculture Research Station. The information about practical installed biomass gasification plant was not found by the consultant end the stakeholders could not recall any. As such, it is understandable that there is limited technical expertise for design, manufacture, and install of biomass gasification plants. The operation and maintenance skills are obviously limited.

b) Lack of institutions, laws and policies and strategies concerning biomass gasification plant

There is absence of standards and regulatory statutes for gas generated from biomass gasification. Also, there is lack of coordination between the Government and other stakeholders in promoting biomass gasification technology in the country. The institutional structure for diffusion of gasification technology is also absent. As stated by Practical Action in 2012, in general, in most of sub-Saharan African countries (including Malawi), there is absence of a connection between academic institutions, private sector, industries and government to prepare and link technology development with local needs (Muzee, 2012).

c) Limited availability of feedstock for biomass gasification plant

Biogas gasification technology requires feedstock to produce gas. In other countries there has been a challenge on supply of feedstock to make the gas production from the plant. While Malawi has relatively large amounts of agricultural waste that can be used for biomass gasification, the sustainability of supply would be a challenge since they are seasonal and that they face competition as animal feed.

d) **Limitation in technology awareness of biomass gasification plant**

From Malawi's relatively connectivity (phone and internet) and literacy levels, prevalent poverty and hard to reach rural areas, limitation of information (limited awareness) is an important barrier to biomass gasification technology as well as to other unfamiliar renewable energy technologies. There is limited information about the biomass gasification technology among institutions, entrepreneurs, local communities, beneficiary chain and consumers. Even among (Renewable Energy Industries Association of Malawi (REIAMA) members, there is no one who is involved in biomass gasification. This discourages the others private sector (IPPs) to venture gasification project alternative power sources. The renewable energy technologies that benefitted from popularization through Government and other stakeholders interventions are mostly solar and small hydropower. Lack of information on the biomass gasification has played part in its not being featured prominently in relevant national policies as well as in energy regulatory framework. Gas from biomass gasification technology is not regulated under MERA nor promoted in Energy Policy of 2018 and National Forestry Policy of 2016. Despite being one of the priorities technologies, biomass gasification plants are not included in the country's Integrated Resource Plan (upto 2040) because the authors of the plan considered gasification plants not to be among matured technologies in Africa. However, in East Africa, the technology has been tried in early 2000s. It is used in Tanzania and Kenya to generate fuel (combustible gas) for production of electricity and heat (Muzee, 2012) using feedstock from agricultural residues.

Further, there is generally low awareness level among public as well as decision-makers about the potential of biomass gasification for providing electricity and heat services. Also, the information on gasification is available only to researchers and technology development institutions in form of

project technical project reports. Therefore it is scattered among various players. The modern biomass energy technologies have not been promoted to interest private users. The intervention to promote biomass gasification is challenged by lack of data to better define project opportunities for investors.

1.4.3 Identified measures

The identified measures against wide-scale diffusion of biomass gasification technology, in relation to the identified measures, are presented in this section.

1.4.3.1 Measures for economic and financial barriers

The identified measures concerning economic and financial barriers are presented henceforth.

a) Measures for Barrier: High initial investment on installation of biomass gasification plant

The biomass gasification investment cost for the technology could be reduced, among others, through application of tax reduction on importation of renewable energy components including those of biomass gasification technology.

b) Measures for Barrier: Limitation in financing installation of biomass gasification plant

The limitations in financing can be removed through coming up of innovate financing options. These options include creation of renewable energy fund, through which the funds to finance renewable energy venture (e.g biomass gasification) could be drawn, in form of revolving fund. This option would be ideal for small scale gasifier projects at household level. The plant installed for commercial purpose (relatively large installed capacity) could be financed through to loans from money lending institutions like banks. There is therefore a need for the Government to an enabling environment where the lending rates that are control and affordable.

c) Measures for Barrier: Lack of market conditions for successful commercialization of biomass gasification plant

The Government must set up programmes to improve market conditions that are associated with biomass gasification technology. Among others, the Government must create an enabling environment where the gasification technology would be familiar and with high acceptance rate. There must also be a market pull programme for the gasification so that it is able to compete favorably with other decentralized sources of energy in Malawi. Further, the energy and electricity subsidies that the grid based electricity enjoy must be spread to decentralized energy to create a fair playing field.

1.4.3.2 Measures for non-financial barriers

The Measures for non financial barriers are presented, as follows.

a) Measures for Barrier: Limitation in technical expertise and knowledge of biomass gasification plant

This barrier, which is common to all climate mitigation technologies that have been discussed, could be removed through training and capacity building institutions that are involved in research and development. These institutions include relevant institutions of higher learning (e,g University of Malawi - The Polytechnic). It is important for the country to have a centre for technology development in renewable energy that would be involved in specialized training and knowledge generation through research in renewable energy including biomass gasification. Among others, the centre would focus training on designing, manufacturing, and installing such systems. There should also be established data collection system on renewable energy systems and their associated information (e.g feedstock) to collect information necessary for design and policy formulation.

b) Measures for Barrier: Lack of institutions, laws and policies and strategies concerning biomass gasification plant

For the gas derived from biomass gasification plants, the Government should establish of standards and regulatory statutes for the gas. The standards should include among others, quality of the gas and installation. Further, the government should put in place institutions responsible for promotion of climate mitigation technologies that include biomass gasification technology. Furthermore, the strategy on promotion of gas from biomass gasification plants should be developed to support the gas-specific policy.

c) Measures for Barrier: Limited availability of feedstock for biomass gasification plant

Planning for feedstock supply must take into account the production, harvest, transportation, and storage of the biomass (Bosworth, 2020). There is therefore need to conduct training programmes on how to availability and supply of feedstock for the gasification so that the power system is able to produce gas or electricity during most times of the year as designed.

d) Measures for Barrier: Limitation in technology awareness of biomass gasification plant

In order to increase awareness levels of unfamiliar renewable energy technologies like the biomass gasification technology, there is need to conduct awareness campaigns and installation of demonstrational plants. The awareness campaigns should target all stakeholders including the would-be users (e.g communities), private sector, entrepreneurs, and financing organizations. The awareness campaigns could include use of social media platforms (e.g Twitter, Facebook and WhatsApp), as well as through radio and television. Therefore, to have a successful awareness campaign, the Government must make sure that an enabling environment is created, for example the excellent internet and mobile connectivity.

1.5 Barrier analysis and possible enabling measures for Technology 4: Mini-grid Solar PV systems

1.5.1 General description of technology

Solar photovoltaic (PV) cells convert sunlight directly into electricity. Currently, crystalline silicon (c-Si) and the thin-film (TF) technologies dominate the global PV market. In a c-Si PV system slices (wafers) of solar-grade (high purity) silicon are made into cells that are assembled into modules and electrically connected. TF PV technology consists of thin layers of semiconducting material deposited onto relatively inexpensive, large-size substrates such as glass, polymer or metal. The solar PV systems are modular in structure, and thus, they can be built to meet almost any electric power need, small or large.

The technical requirements for the installation of solar PV vary greatly depending on the size of the system and kind of technology used. Small off-grid systems in remote/rural areas using solar home systems (SHSs) could be bought in off-the-shelve and installed with relatively little local expertise. These are the ones that are common in Malawi including phone charging solar cells, solar lighting lanterns, and solar lighting PV modules. Most of renewable energy enterprises are involved in selling and installation of SHSs. The major applications of SHSs are for lighting.

The other form of solar PV technology that is not common in Malawi is the solar minigrids. These are energy systems powered by a number of solar PV modules in a relatively large area. The minigrid energy system is able to power a community that is not connected to the grid. In other arrangements, the electricity generated could be sold to the main grid. In Malawi, this technology is referred to as solar villages. The Government, through BARREM project piloted 6 solar villages across the country, from 2006 to 2008. These demonstration units are currently not functioning and have been decommissioned. Due to size of the minigrids (being superior to SHSs), they are ideal for rural electrification to support offered based businesses enterprises, thus important ingredient to rural economic transformation. The majority of IPPs applications in Malawi are from solar minigrids. Some solar minigrids projects are:

The solar PV systems require relatively minimal maintenance, which involve cleaning of the solar panel to ensure efficiencies are maintained. Installation of SHSs has been increased in the country. Most of the SHSs are undocumented, and are mostly used for lighting and phone charging. The installation of large scale solar PV for electricity generation either as mini-grid or grid based is limited. The latter technology could greatly improve the contribution of renewables in electricity generation mix for the country, thus greater potential for climate change mitigation.

Malawi has instituted the Malawi Energy Regulatory Authority (MERA) that provides regulatory requirements for energy such as solar PV electricity generation. According to MERA, grid connected systems require an appropriate license or permit to export to the grid along with the necessary metering equipment, connected by a professional, to ensure that the level of export to the grid is measured for any subsequent compensation. Larger installations obviously require appropriate planning permissions that would accompany any moderate to large infrastructure

project. Also, the Malawi Bureau of Standards has developed standards on solar PV systems, however there are challenges on enforcement of the standards as evidenced by proliferation of poor quality solar products.

1.5.2 Identification of barriers for technology

The identified barriers against wide-scale diffusion of solar PV minigrids are presented in this section.

1.5.2.1 Economic and financial barriers

Four economic and financial barriers were identified, as presented as follows:

a) High investment cost for solar mini-grid

Most of the products of solar PV are imported into the country. High initial capital cost of solar product and batteries, fluctuations and inflation affecting the costs of equipments make the technology unattractive to investors and local developers. In addition, the available solar incentives (like removal of import duties) do not trickle down to the last mile consumer

b) Low affordability of consumers to pay for the electricity from solar mini-grid

In general, most rural Malawians have relatively low levels of incomes and the affordability for electricity without subsidies is much low. This low level of affordability is exacerbated that the consumer cost of electricity from mini-grids in most of the southern and eastern African countries are higher than tariffs for the national grid, which are generally cross-subsidized and not cost-reflective (EEP Africa, 2018). In most of the rural areas of Malawi, there are few households that can connect to a min-grid, which has the investment cost. This makes it difficult to recover the cost of investment and min- grid developers result to grants and for subsidies, in order to bring down the cost of energy (tariff) to a level that is affordable to customers. The grants and subsidies are usually not long lasting solutions since they are often tied to a project.

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c) Limited commercial use of the generated solar PV electricity

The electricity produced should be consumed since it is difficult to store it. If not consumed then it is wasted. Most of the consumers should be those for that use electricity for business purposes. These consumers are very few in most of the communities. The consumers for domestic applications do not warrant installation of sola PV mini-grid. This is the same problem facing the mini-hydro mini-grid system in Mulanje district. The mini-grid is negotiating to be selling power to the minigrids result to the national grid to sustenance the business.

d) Limited financing mechanism

In general, the available financing mechanisms for mini-grids in Malawi are few. Again, most local would be developers are not aware of funding mechanism that might be available from banks and other money lending institutions. There are also other funding opportunities from international

organizations, which local private investors may not be aware of. Example of such opportunities is the African Development Bank which approved new financing program for energy providers in sub-Saharan Africa to benefit from off-grid power by 2025 (African Development Bank, 2019). Also, local expertise in coming up with bankable business proposals for financing solar PV mini-grid projects is lacking. This explains why the majority of the current IPPs in solar mini-gird are international enterprises.

1.5.2.2 Non-financial barriers

The identified non-financial barriers (7 of them) are presented as follows:

a) Challenges implementation of Feed-in Tariff policy for increasing uptake of solar PV

Implementation of interventions for increasing uptake of renewable energy face challenges. For example, Feed-in Tariff (FiT) initiative which was put up in 2012, is facing implementation challenges. According to (Chitedze, et al., 2020), the implementation challenges facing FiT in Malawi are that the FiT was developed without stakeholder consultation, but adapted from Kenya, which has different macroeconomic decisions compared with Malawi. The other challenge is limitation of policy funding. Malawi has no practical mechanism in place, detailing how to fund the FiT policy cost to ensure policy sustainability or guarantee investors security. Further, the FIT policy provides ESCOM to recover 85% of the portion of FIT from electricity customers. However, the policy does not stipulate the reclaiming procedure of the remaining 15%. Relatively, the rates in the FIT policy are higher than the existing end-user tariff. This poses a challenge as to how ESCOM will be able to pay for electricity purchased from renewable energy generators. This makes generators request for sovereign guarantees from a government, but the latter does not make provision for any. In addition, the low tariff level poses another challenge to implementation of FIT in Malawi. The Low tariff offered discourages private investment in the power sector as the projects are deemed unprofitable.

The other challenge concerns limitation of the national electricity grid capacity to accommodate major power to the grid. Even though the country had a major energy project funded through The Millennium Challenge Account-Malawi which started in 2013 and completed in 2019, which worked on increasing the national grid capacity, the electricity network infrastructure in Malawi is still limited. This limits amount of solar PV power that can be put into the national grid.

b) Limitations in technical expertise

There is a general limitation among the local expertise to design, install and maintain the mini-grid-solar PV systems. For examples the three mentioned solar village (solar mini-grids) installed in Malawi as demonstration systems failed partly due to limitation in local capacity to maintain the systems. This is mapped to the Malawian current tertiary education system where training on technical courses like engineering is pitched at Bachelors levels, which have very little practical or hand-on training. The technician training at diplomas levels, which are trained on hands-on is

becoming limited. This creates a gap in the industry on skilled manpower to maintain engineering based systems like solar PV mini-grids. The available technical training institutions at technician's level must have curricula that respond to the dynamic needs of renewable energy industry like solar PV mini-grids. This is so critical now because it seems that solar PV electricity production is the most preferred technology for the IPPs.

c) Limited research and development in solar PV minigrids

Most of the solar PV components are imported into the country. There is need for the country to invest in research and development of solar PV components and systems so that costs associated with importation of components are minimized as well as the local capacity to develop and maintain the technology is enhanced.

d) **Poor quality of solar PV components**

Malawi 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.

e) Limited networking among key players in the solar PV sector

Groups are few and operation of the Renewable Energy Industry Association of Malawi (REAIMA) is challenged. Key stakeholders in the solar PV such as practitioners, researchers, investors and policymakers could form networking groups to discuss how to advance the sector.

f) The bureaucracy in processing Independent Power Producers' applications

There is bureaucracy in processing of IPP applications. The time for potential IPPs to acquire concessions, licenses and environmental approvals is substantial. This is true for when it comes to acquiring generation and distribution licenses. The bureaucracy has delayed solar PV project development.

g) Consumers preference of grid-based electricity

Consumers prefer grid-based electricity to electricity supplied by mini-grid. Due to this, whenever the grid is expanded to the community, the consumer abandons electricity from min-grids. This was the experience from the solar villages (solar mini-grid) piloted by the Government of Malawi.

1.5.3 Identified measures

This section presented identified measures to remove barriers against wide-scale diffusion of solar PV minigrids in Malawi.

1.5.3.1 Measures for Economic and financial barriers

The identified measures to remove economic and financial barriers are presented as follows:

a) Measures for Barrier: High investment cost

Most of the components of solar PV systems are imported. Just like other renewable energy technologies, the high investment cost can be reduced by Government reducing or removing import duties on imports. Also, if some of components are manufactured locally, the investment cost could be reduced further. Furthermore, there should be access to loans and other funding sources provided by the banks and other financing organizations to individual consumers and private investors are able to in solar PV mini-grid electricity supply business.

The barrier of high investment cost can be removed through local production of some solar PV system components, as it is with Kenya. In this case, there is need to come up with manufacturing centres for solar PV system components.

b) Measures for Barrier: Low affordability of consumers to pay for the electricity

The Government and other stakeholders should create programmes that would increase affordability of consumers to pay for electricity generated by decentralized power systems like the solar PV minigrids. The programmes would include working on tariff subsidy for electricity generated from these solar PV systems. The other would to make sure the consumers use the electricity for income generating ventures.

c) Measures for Barrier: Limited commercial use of the generated solar PV electricity

The Government and other stakeholders should create programmes to train people on how to start an economic venture taking advantage of access to electricity. The other measure on this barrier is to implement the feed-in- tariff.

d) Measures for Barrier: Limited financing mechanism for solar minigrids

The Government and other stakeholders should enhance and establish more financing mechanism for supporting entrepreneurs to embark on solar mini grid businesses. Further, the access to loans to households for financing their purchasing of renewable energy technologies should be enhanced. Furthermore, financing models that are ideal for different scenarios should be explored. In addition, the Government should make aware and support applications for alternative financing through CDM, for example.

The Government therefore should create an enabling environment in which financial institutions are able to provide financial resources to developers and consumers of solar PV minigrids.

1.5.3.2 Measures for Non-financial barriers

The identified measures to remove non-financial based barriers are presented as follows:

a) Measures for Barrier: Challenges implementation of Feed-in Tariff policy for increasing uptake of solar PV

The Government should revise the Feed-in-Tariff policy, through a stakeholder consultative process to make sure that it is up-to-date and is accompanied by a robust implementation strategy. The stakeholders include EGENCO, ESCOM, IPPs, MERA, Energy Consultants, and Consumer Association of Malawi (CAMA).

b) Measures for Barrier: Limitations in technical expertise

There is need for the country's higher learning institutions to establish and enhance research and development centres in renewable energy technologies where issues of design, install and maintain the mini-grid-solar PV systems could be addressed. Further, the universities should revise curriculums to make practical element of renewable energy technologies prominent. Furthermore, there should be a platform where university and industry would work together in the training of renewable energy technicians.

c) Measures for Barrier: Limited capacity research and development in solar PV minigrids

There is need to capacity-build human resource and research facilities in university and other research based organizations to that they are engaged in meaningful research and development in renewable energy technologies such as in solar minigrids. In order to do this, there is need to audit research institutions in the country to documents capacity gaps.

d) Measures for Barrier: Poor quality of solar PV components

Standards enforcement body, the Malawi Bureau of Standards (MBS) should ensure enforcement of solar PV standards (both on components and installation). This is necessary to safeguard quality and enhance consumers' confidence concerning installed solar mini-grid systems in Malawi. Further, the MBS should develop capacity of their staff that is stationed at Malawi boarder stations on performance testing of renewable energy components that are imported into the country so that they can enforce standards accordingly. The proliferation of poor quality solar PV products is also attributed to corruption involving the importers and the standards certification and the enforcers. Corruption in importation of renewable energy products could be removed through strengthening the Anti-Corruption Bureau, taking renewable energy sector as one of the corruption-sensitive sectors.

e) Measures for Barrier: Limited networking among key players in the solar PV sector

The Renewable Energy Industry Association of Malawi (REIAMA) should be revive and active its mandate of promoting renewable energy technologies (RETs) in a sustainable manner to the satisfaction of renewable energy consumers in Malawi. REIAMA should have strong institutional and legal framework to guide its operations.

f) Measures on Barrier: The bureaucracy in processing Independent Power Producers' applications

The Government should come up with an initiative that can increase efficiency in IPP application process. This would reduce time to get a decision over applications.

g) Measures on Barrier: Consumers' preference of grid-based electricity

The universities and other research institutions should be supported to conduct research and development that would improve quality of electricity from mini-grids so that it is at par with quality from grid-based electricity.

1.6 Linkages of the barriers identified

Linkages between barriers of the prioritized technologies were identified during the barrier analysis in order as to maximize synergies and optimize the effects of recommended measures. Refer to Table 2, in which the barriers are analyzed into barriers themes and then, the themes are analyzed for each of the technologies for linkages. The developed themes for each of the technologies are linked. The linking of themes present opportunities for synergies when implementing identified measures to remove those barriers.

Table 2: Summary of barriers for each climate mitigation technology in the energy sector

No	Financial Barriers	Theme of barrier	Technologies	No	Non-financial barriers	Theme of the barrier
1	Weak LPG distribution mechanisms	Market and business limitations	Liquefied Petroleum Gas for cooking services	1	Social and cultural practices and perceptions that work against promotion of LPG cooking technology	Unfavorable social and cultural circumstances
2	LPG market is still in its infancy stage	Market and business limitations		2	Limitations in technical skills and knowledge	Limitations in technical skills and knowledge
3	Limitation in sustainable development business models	Market and business limitations		3	Presence of cooking fuel stacking that works to the disadvantage of LPG for cooking	Competition from baseline technology
4	Low investment cost of the baseline technologies compared to LPG cooking system	Market and business limitations		4	Absence of LPG specific policy and strategy	Limitation in policy and strategy
5	Limited affordability	Limited affordability		5	Limitations in regulation and its enforcement	Limitation in standards and regulation Limitation in standards enforcement
6	Low willingness to pay for investment	Market and business limitations		6	Limited information and awareness	Limited information and awareness
7	Biofuel (fuel grade ethanol) is not competitive with petroleum (e.g petrol) based on pump price per unit energy	Market and business limitations	Biofuel as Transportation fuels	7	Limitation in policy, standards and regulation	Limitation in standards and regulation Limitation in standards enforcement Limitation in policy and strategy
8	Limitations in financial incentives for biofuels	Financing Limitations High initial investment		8	Limitation in knowledge and technical skills	Limitation in knowledge and technical skills
9	High investment cost of flex-fuel - vehicles and accessories	High initial investment		9	Limited availability raw materials for production of biofuels	Limitation in availability of raw materials
10	Absence of retail market for biofuel	Market and business limitations		10	Limited Infrastructure to support biofuel transport Fuel	Limitation in technology support infrastructure
				11	Limited institutional support for biofuels	Limitation in institutional structures
				12	Limited awareness of the biofuel as transport fuel	Limitation in information and awareness
12	High initial investment	High initial investment	Biomass Gasification	13	Limitation in technical expertise and knowledge	Limitation in knowledge and technical skills
13	Limitation in financing	Financing Limitations		14	Lack of institutions, laws and policies and strategies	Limitation in institutional structures Limitation in enabling laws Limitation in policy and strategy
14	Limitation in market conditions for successful commercialization	Market and business limitations		15	Limited availability of feedstock	Limitation in availability of raw materials
				16	Limitation in technology awareness	Limitation in awareness

15	High investment cost	High Initial investment	Mini-grid Solar PV systems	17	Challenges implementation of Feed-in Tariff policy for increasing uptake of solar PV	Limitation in policy and strategy
16	Low affordability of consumers to pay for the electricity	Market and business limitations		18	Limitations in technical expertise	Limitation in knowledge and technical skills
17	Limited commercial use of the generated solar PV electricity	Market and business limitations		19	Limited research and development in solar PV minigrids	Limitation in knowledge and technical skills
18	Limited financing mechanism	Financing Limitations		20	Poor quality of solar PV components	Limitation in standards enforcement Poor quality of available products
				21	Limited networking among key players in the solar PV sector	Limitation in institutional structures
				22	The bureaucracy in processing Independent Power Producers' applications	Bureaucracy
				23	Consumers preference of grid-based electricity	Consumer preference for baseline technologies

It is evident from table 2 that the barrier theme “market and business limitations”, is present in all of the technologies. For LPG cooking technologies, the identified barriers under this theme are: weak LPG distribution mechanisms; LPG market is still in its infancy stage; limitation in development business models; low investment cost of the baseline technologies compared to LPG cooking system; and low willingness to pay for investment. Whereas for biofuel as transportation fuel, the identified barriers under this theme are biofuel (fuel grade ethanol) being not competitive with petroleum (e.g petrol) based on pump price per unit energy; and absence of retail market for biofuel. For biomass gasification, the identified under this theme is the limitation in market conditions for successful commercialization. For mini-grid Solar PV systems, the identified barriers under this theme are low affordability of consumers to pay for the electricity; and limited commercial use of the generated solar PV electricity. Also, all of the technologies have limitation in financing capacity and limitation in affordability as barrier themes.

In terms of non-financial identified barriers, the following barrier themes were linked to all the technologies: limitations in technical skills and knowledge; limitation in policy and strategy limitation in standards and regulation; limitation in standards enforcement; limited information and awareness; limitation in technology support infrastructure; limitation in institutional structures; and bureaucracy. The themes of barriers specific to each of the technologies are as follows: Consumer preference for baseline technologies, which was identified for solar PV minigrid and LPG for cooking technologies; unfavorable social and cultural circumstances, which was identified only LPG for cooking technology, limitation in enabling laws for biomass gasification, and limited availability of raw materials for biofuels as transportation fuel.

1.7 Enabling framework for overcoming the barriers

As stated in Section 1.0.2 Methodology for Barrier Identification and Analysis), the enabling environment for a particular technology is described by domains that make diffusion of the technology take place without barriers. These domains include as favorable macroeconomic conditions, social, availability of resources, availability laws, supporting policies and regulation, and availability of required technological capacity and institutions. The deviation between ideal environment and what is actually on the ground (national situation) gives rise to barrier. Thus, the enabling framework has to be linked to measures to overcome the barriers. For the Energy Sector, the enabling framework for each technology is presented in Table 3,Table 4,Table 5, andTable 6.

Table 3: Enabling framework for overcoming barriers in Energy Sector: LPG for cooking

Barrier Theme	Barrier	Identified Enabling Measures	Enabling Domain
market and business limitations	Weak LPG distribution mechanisms	Put in place and improve on LPG supply support infrastructure	Availability of LPG supply support infrastructure
		Establish energy kiosks in towns and important trading centres in rural towns and peri-urban areas	Availability of energy kiosks in towns and important trading centres in rural towns and peri-urban areas
		Encourage retailers to stock parts of the LPG cooking system (stove) for replacement when need arise	Availability of parts of LPG cooking system throughout the country
	LPG market is still in its infancy stage	Promote the private sector to invest in energy business like LPG supply and services	Robust participation of private sector in LPG supply and provision of services
		Establish an investment policy that is guided by transparency, property protection and non-discrimination as key principles.	Availability of investment policy that presents investment environment for all.
		Conduct awareness campaigns on LPG as an alternative fuel so that there is increased demand for it	Consumers are well aware of LPG an alternative fuel for cooking
		Protect the LPG business and consumers through development of LPG specific standards and regulatory framework	Availability of standards and regulatory framework for LPG as cooking fuel and its cooking components
	Limitation in sustainable development business models	Engage the universities and other higher learning institutions to offer training and research on business development models that would increase clean cooking technologies like LPG	Availability of expertise to promote LPG for cooking as in the case of coming up with business development models
	Low investment cost of the baseline technologies compared to LPG cooking system	Introduce subsidies and tax exemption (import duty) to reduce investment cost	Availability of incentives for promotion of LPG for cooking, like subsidies on fuel and tax reduction on import of it LPG for cooking system components
		Capacity build local entrepreneurs to exploit opportunities of additional solutions presented by LPG thermal services e.g lighting, refrigeration system	Increased demand for LPG fuel
	Low willingness to pay for LPG cooking system	Conduct extensive LPG awareness campaigns for the technology to be accepted by the masses.	Malawians are well aware of LPG an alternative fuel for cooking

Limited affordability	Limited affordability for LPG cooking system	Introduce subsidies on LPG fuel and import duty exemption on cylinder and stoves	Availability of incentives to promote LPG for cooking like subsidies on LGP fuel and reduction or exemption of import duty on LPG stoves and other LPG cooking accessories
		Increase access to financing mechanisms such as bank loans and credits from micro-financing organizations	Availability of financing mechanisms like loans
Unfavorable social and cultural circumstances	Social and cultural practices and perceptions that work against promotion of LPG cooking technology	Conduct extensive LPG awareness campaigns for the technology to be accepted by the masses	Malawians are well aware of LPG an alternative fuel for cooking
		Link LPG cooking programs to gender-focused and women-led development initiatives	Inclusion of LPG cooking in other developmental projects
Limitation in technical skills and knowledge	Limitations in technical skills and knowledge in LPG cooking system	Establish and equip training institutions on design, operate and maintain LPG cooking technology	Availability of research and training institutions on clean cooking such as those using LPG fuel
		Establish a centre of excellence in clean cooking technologies	Availability of research and training institutions on clean cooking such as those using LPG fuel
		Create an organization to certify technical experts that would be involved in installation and maintenance of LPG cooking systems	Availability of a certification body on installation and maintenance of LPG cooking systems
Competition from baseline technology	Presence of cooking fuel stacking that works to the disadvantage of LPG for cooking	Carryout programmes that would make LPG a significant fuel (fuel of choice) in the stack (mix)	Availability of programmes to promote clean cooking, such as using LPG
		Conduct awareness campaigns, promoting LPG as clean fuel and convenient cooking fuel	Malawians are well aware of LPG an alternative fuel for cooking
Limitation in policy and strategy	Absence of LPG specific policy and strategy in relation to cooking	Establish a robust data collection system on clean cooking technologies (including LPG) in Malawi in order to determine the policy areas	Availability of information on clean energy for cooking in Malawi including cooking with LPG
		Develop clean-cooking policy and its implementation strategy	Availability of policy on clean cooking and its strategy like LPG for cooking
		Develop new and revise regulations specific to LPG consumption in the country	Availability of regulations on LPG consumption

Limitation in standards an regulation Limitation in standards enforcement	Limitation in LPG standards, regulation and its enforcement	Regulate technical people and or companies that install and maintain LPG cooking systems.	Availability of a certification body on installation and maintenance of LPG cooking systems
Limitation in information an awareness	Limitation in information an awareness on LPG cooking system	Conduct national awareness programmes	Availability of institutions and programmes (e.g awareness) to support promotion of biofuels in Malawi
		Install demonstrational LPG cooking units	Availability of institutions and programmes (e.g awareness) to support promotion of biofuels in Malawi

Table 4: Enabling framework for overcoming barriers in Energy Sector: Biofuel as Transportation Fuel

Barrier Theme	**Barrier**	**Identified Enabling Measures**	**Enabling Domain**
Market and business limitations	Biofuel (fuel grade ethanol) is not competitive with petroleum (e.g petrol) based on pump price per unit energy	Revise pump price of biofuel used for transport (automotive) taking into account the energy content of the fuel	Availability of regulation on pricing of biofuels
Financing Limitations High initial investment	Limitations in financial incentives for biofuels	Put in place fiscal incentives for to promote wide scale production of biofuel like fuel grade ethanol compared to petroleum (petrol and diesel) including import duty exemption, subsidies and guaranteed market for all technical and economic proven biofuels (fuel grade ethanol and biodiesel)	Availability of incentives to promote biofuels as automotive fuel like subsidies on biofuels and reduction or exemption of import duty on components of biofuels production systems
		Revise fuel stabilization fund to also benefit biofuel production companies	Availability of financial support to investors in biofuel
High initial investment	High investment cost of flex-fuel - vehicles and accessories	Revise import duties for flexfuel vehicles (FFVs) and its accessories so that importation of FFV is promoted	Availability of incentives to promote biofuels as automotive fuel like subsidies on biofuels and reduction or exemption of import duty on components of biofuels production systems
		Manufacture the conversions kits locally in Malawi	Availability of local manufacturing ability of conversion kits

Market and business limitations	Absence of retail market for biofuel	Establish infrastructure that should support retailing of biofuel in Malawi.	Availability of biofuel retail infrastructure
Limitation in standards an regulation Limitation in standards enforcement	Limitation in policy, standards and regulation	Develop a biofuel policy in harmony with other key sectors like agriculture and forestry	Availability of biofuel policy that is in harmony of other policies in key sectors like agriculture and forestry
		Revise and develop new standards and regulations pertaining to production, distribution and use of biofuels as automotive (transport) fuel	Availability of standards and regulation on biofuel as transportation fuel
Limitation in technical skills and knowledge	Limitation in knowledge and technical skills in biofuel as fuel for transportation	Enhance capacity of research and development institutions in the areas of research infrastructure and human resource	Availability of well capacitated research and development institutions
		Revise curricula/ syllabi on biofuels for higher education institutions to enhance biofuel knowledge acquisition as transportation fuel	Availability of education and training institutions to support promotion of biofuel as transportation fuel
		Establish practical research and training programmes in universities and vocational training institutions.	Availability of well capacitated research and development institutions
Limitation in availability of raw materials locally	Limited availability raw materials for production of biofuels in Malawi	Support current companies (Presscane and EthCo) to invest in expanding the production capacity for biofuels	Vibrant private sector involvement in biofuel production
		Identify new investors in the biofuel sector to add extra biofuel production capacity for the country	Vibrant private sector involvement in biofuel production
		Improve and create new feed stock supply infrastructure (such as road connectivity) to biofuel production points so that access to feedstock is available	Availability of feedstock supply support infrastructure
Limitation in technology infrastructure	Limited infrastructure to support biofuel as transportation fuel	Establish support infrastructure required biofuel as automotive fuel. The infrastructure would be increased production and usage of biofuels	Availability of feedstock supply support infrastructure
Limitation in institutional structures	Limited institutional support for biofuel as transportation fuel	Enhance institutional support for biofuels in the country	Availability of institutions to support promotion of biofuels in Malawi
		Develop specific biofuel policy and strategy that compliments other development policies in Malawi	Availability of biofuel policy that is in harmony of other policies in key sectors like agriculture and forestry

		Establish platform where efforts and achievements concerning diffusion and dissemination of biofuel as automotive fuel is documented and coordinated	Availability of institutions and programmes to support promotion of biofuels in Malawi
Limitation in information and awareness	Limited information and awareness of the biofuel as transportation fuel	Establish biofuel awareness programme	Availability of institutions and programmes (e.g awareness) to support promotion of biofuels in Malawi

Table 5: Enabling framework for overcoming barriers in Energy Sector: Biomass gasification plant

Barrier Theme	**Barrier**	**Identified Enabling Measures**	**Enabling Domain**
High initial investment	High initial investment on installation of biomass gasification plant	Apply tax reduction on importation of renewable energy components including those of biomass gasification technology	Availability of incentives such as reduction of import duties
Limitations in Financing	Limitation in financing installation of biomass gasification plant	Establish innovate financing options such creation of renewable energy fund, through which the funds to finance renewable energy venture (e.g biomass gasification) could be drawn, in form of revolving fund	Availability of financing mechanisms like loans
Market an business limitation	Lack of market conditions for successful commercialization of biomass gasification plant	Establish programmes to improve market conditions that are associated with biomass gasification technology	Availability of programmes to improves market conditions for gasification plants
Limitation in technical expertise and knowledge	Limitation in technical expertise and knowledge of biomass gasification plant	Capacity-build institutions that are involved in research and development.	Availability of well capacitated research and development institutions
		Establish data collection system on renewable energy systems and their associated information (e.g feedstock) to collect information necessary for design and policy formulation	Availability of information collection and archiving system on biomass gasification plants in Malawi
Limitation in institution, laws, policies and strategies	Lack of institutions, laws and policies and strategies concerning biomass gasification plant	Establish of standards and regulatory statutes for the gas	Availability of standards and regulatory frame to promote biomass gasification plants
		should put in place institutions responsible for promotion of climate mitigation technologies that include biomass gasification technology	Availability of institutions that promote biomass gasification plants

		Develop strategy on promotion of gas from biomass gasification plants	Availability of policies and strategy to promote biomass gasification technology
Limited availability of feedstock	Limited availability of feedstock for biomass gasification plant	Conduct training programmes on how to availability and supply of feedstock for the gasification so that the power system is able to produce gas or electricity during most times of the year as designed	Availability of feed stock for production of gas
Limitation in awareness	Limitation in technology awareness of biomass gasification plant	Conduct awareness campaigns and installation of demonstrational plants	Availability of institutions and programmes (e.g awareness) to support promotion of biomass gasification plants in Malawi

Table 6: Enabling framework for overcoming barriers in Energy Sector: Solar PV Minigrids

Barrier Theme	**Barrier**	**Identified Enabling Measures**	**Enabling Domain**
High investment cost	High investment cost for solar mini-grid	Waive or reduce import duties on solar mini-grid components imports.	Availability of incentives such as reduction of import duties
		Produce solar PV system components locally	Availability of local manufacturing units an assembly companies in Malawi for solar PV system
Market and business limitations	Low affordability of consumers to pay for the electricity	Increase affordability of consumers to pay for electricity generated by decentralized power systems like the solar minigrid Create opportunities for consumers to use electricity for income generating ventures.	Availability of alternative funding such as bank loans
Market and business limitations	Limited commercial use of the generated solar PV electricity	Establish programmes to train people on how to start an economic venture taking advantage of access to electricity	Availability of institutions and programmes (e.g awareness) to train people on how to start a business venture
		Implement the feed-in- tariff for decentralized electricity generation	Availability of incentives such feed in tariff
Limited financing capacity	Limited financing mechanism for solar minigrids	Enhance and establish further financing mechanism for supporting entrepreneurs to embark on solar mini grid businesses	Availability of alternative funding such as bank loans

		Provide access to loans to households for financing their purchasing of renewable energy technologies should be enhanced	Availability of alternative funding such as bank loans
		Explore financing models that is ideal for different scenarios	Availability of alternative financing
		Dvelop and implement awareness programmes on availability of alternative financing through CDM	Availability of alternative financing

CHAPTER 2: FORESTRY SECTOR

This chapter is on about identification and analysis of barriers that prevent wide-scale diffusion of the prioritized climate mitigation technologies in the forestry sector. Just like in Chapter 1, this chapter gives a background to the barrier analysis as well as the general methodology for barrier identification an analysis. Preliminary targets for technology transfer and diffusion are presented. Also presented in the Chapter are the analysis of the identified barriers for each of the top four prioritised technology as well as measures on how to overcame them. The enabling framework for the technologies to be widely transferred and diffused is also presented.

2.0 Methodology for barrier identification and analysis

The methodology for barrier identification an analysis used in the forestry sector is the same as hat used in the energy sector, as presented in Section 1.0.2 Methodology for Barrier Identification and Analysis).

2.0.1 Background

The country faces a decrease in tree and forest cover due to deforestation and forest degradation. The forest cover was 47% in 1975, 36% in 2005 (Mauambeta, et al., 2010) and 33% in 2015 (FAO, 2015). The deforestation rate is at 2.8% per year, thus losing about 250,000 ha of forest cover per year (GoM, 2016). The human activities are the major causes of deforestation and forest degradation, such as expansion of farming land and other land uses, extensive biomass harvesting for household fuel and tobacco curing energy supply, selective tree felling for timber and curios, uncontrolled forest fire (which is also blamed on arsonists, especially in industry forest like Viphya Plantations), and tree debarking for herbal medicine and bee keeping. Deforestation and forest degradation are exacerbated by population pressure, poverty and limitations in alternative livelihoods. Further, the coming in democracy in 1994 resulted in some misconceptions about ownership of forests, which resulted in extensive cutting down of trees in protected forests, especially in urban areas. Furthermore, the non adherence to 10% land covenant by agricultural estate owners has also contributed to the loss of forest cover as they continue to harvest trees for their operational requirements. Some of the challenges that also exacerbate deforestation and forest degradation are inadequate forest law enforcement, weak regulatory framework, corruption, low penalties and fines, and policy conflicts in the natural resources management sector.

The state of deforestation and forest degradation shows that the Forest Sector is one of the significant sectors in terms of GHG emissions. This is shown in a study done by the Protecting Ecosystems & Restoring Forests in Malawi (PERFORM) Project, in 2017, which revealed that emissions from deforestation and forest degradation had accounted for 33% of Malawi's total greenhouse gas emissions (GoM, 2018). Also, Malawi's First Intended Nationally Determined

Contributions[1] (INDC) report, on an annual basis, reported that Malawi emits approximately 0.8 million tCO_2e from deforestation, and approximately 10 million tCO_2e from forest degradation (GoM, 2016).

According to technology transfer and diffusion, barriers and enabling measures are closely related. This Chapter presents the barrier analysis and enabling framework (BAEF) for the prioritized climate technologies for mitigating climate change in the forest sector. It presents methodology on how the barriers were identified and analyzed. In addition, the chapter presents linkages of the barrier identified and the measures to overcome the barriers. The prioritized top three climate technologies in the Forest Sector are:

a) Forest and landscape restoration
b) Efficient use of forest products
c) Urban forestry

All of the prioritized barriers are in the category of publicly provided goods. This means that there is a high degree of government's direct influence in overcoming barriers against their wide scale diffusion.

2.0.2 Barrier identification and analysis

The methodology on barrier identification and analysis is the same as those outlined for Energy Sector. The Consultant, using document review, expert consultation and consultant's expert opinion, came up with the barriers against diffuse of the prioritized technologies. The experts that were consulted were mostly from the Department of Forest, Forest Research Institute of Malawi and the Lilongwe University of Agriculture and Natural Resources (Department of Forestry). The methods of consultation were phone interviews and through email interaction. The barriers were then presented become specially invited stakeholders (Climate Change Mitigation Sectoral Working Group Committee members) to review and analyze them and then come up with measures to and enabling framework on overcoming them. In addition, at the workshop, stakeholders were involved in creating linkages among barriers. Analysis of the barriers involved use of tools such as Problem Tree and Market Mapping. This meeting/workshop was held in Mponela, Lilongwe from 24 September 2020. The BAEF process was guided by the guidebook on Overcoming Barriers to the Transfer and Diffuse of Climate Technologies published by the UNEP DTU Partnership (Nygaard & Hansen, 2015).

[1] The timeframe for implementation of the Malawi INDC is 2015 to 2040. By the time of writing this TNA BEAF Report, the NDC were being revised.

2.1 Preliminary targets for technology transfer and diffusion

The preliminary targets are mapped to the optimised climate mitigation technologies in the forest sector. These targets are presented in Table 7.

Table 7: Generic targets for technology transfer and diffusion in the forestry sector

Technology	Type	Generic targets in terms of coverage
Forest and landscape restoration	Publicly provided goods	According to the National Forest and Landscape Restoration Strategy of Malawi (FLR), nearly 8 million hectares of degraded and deforested lands across the country can potentially be restored through a wide range of FLR interventions (GoM, 2018). Also the strategy seeks to improve protection and management of 2 million ha of natural forest, restore 500,000 ha of degraded forest, and establish 100,000 ha of commercial plantations by 2030. Further, strategy seeks increase area of community forests and woodlots to 200,000 ha by 2020 and 600,000 ha by 2030. In terms of agriculture, the FLR strategy Achieve at least 10% tree cover on 50% of cropland in Malawi by 2020 and 80% of cropland by 2030. Also, the strategy seeks to regenerate or plant 20 million trees along river- and stream banks by 2020 and 50 million trees by 2030. These strategic goals will be achieved through governance, movement building, equitable benefit distribution and policy coordination. The target group for FLR include Farmers (both commercial and subsistence), Rural communities, Traditional authorities, NGOs; Government; Private sector, and other Partners.
Efficient use of forest products	Publicly provided goods	National demand for forest products is much greater than supply. Annual consumption of forest products, estimated at 15 million m^3, far exceeds the sustainable supply of 7-8 million m^3. Efficient use of forest products would therefore increase and help meet the demand. In general, the option of efficient use of forest products includes the following: reduction in the waste of wood residues; improvements in tree felling operations; low impact wood extraction systems; and changing processing technology and product development. The target group includes wood based industries, forest plantations and community managed forest. Other targets are NGOs, forest users at community levels, and traditional authorities.

Urban forestry	Publicly provided goods	Urban forestry, defined as the planned, integrated and systematic approach to the management of trees in urban and peri-urban areas for their contribution to the physiological, sociological, and economic well-being of urban society is relatively new to Malawi. However it has great potential for environmental conservation in urban areas as well as in climate change management. The possible target groups are the city and town councils, NGOs, City residents, companies and organizations/institutions

2.2 Barrier analysis and possible enabling measures for Technology1: Forest and landscape restoration

The identified barriers against wide-scale diffusion of forest and landscape restoration technology are presented in this section, starting with description of technology.

2.2.1 General description of the technology

Forest and land degradation is stated to be serious problem in developing countries, where the majority of the population lives in degraded areas. According to (Sabogal, et al., 2015), land degradation is generally defined as a persistent decline in the provision of goods and services that an ecosystem provides, including biological and water related goods and services as well as land-related social and economic goods and services. Restoration is defined as any intentional activity that initiates or accelerates the recovery of an ecosystem from a degraded state. On the other hand, forest degradation refers to a reduction of the capacity of a forest to provide goods and services. Also, according to the International Union for Conservation of Nature (IUCN), Forest and landscape restoration (FLR) is the ongoing process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes. FLR can take many forms such as: new tree plantings, managed natural regeneration, agroforestry, or improved land management to accommodate a mosaic of land uses, including agriculture, protected wildlife reserves, managed plantations, riverside plantings and more. FLR landscapes are typically categorized in three ways, each incorporating different types of restoration:

Forest land: This is land where forests are or are meant to become the dominant land feature. It can include both protected and productive forests. If the land is without trees, it can be restored either through planting or natural regeneration. Degraded forests can be restored through rehabilitation and silvicultural treatments.

Agricultural land: This is land that is being managed to produce food. If the land is under permanent management, it can be restored through agroforestry. If it is under intermittent management, it can be restored through improved fallow. Protective lands and buffers: This is land that is either susceptible to, or critical in safeguarding against, climatic or other events. While the land may be used for agricultural or forest production it also has a very special value in

safeguarding lives, property and ecosystem services. It is typically – but not always – closely associated with marine and freshwater ecosystems. FLR interventions can involve mangrove restoration or watershed protection and erosion control, protected wildlife reserves, managed plantations, riverside plantings and more.

Forest and landscape restoration therefore complements other approaches to improving food security and climate change mitigation and adaptation, including climate-smart agriculture and The Reducing Emissions from Deforestation and Forest Degradation (REDD+) programme. Successful FLR programme is able to strengthen the resilience of landscapes and creating future options to adjust and further optimise ecosystem goods and services as societal needs change or new challenges arise. It integrates a number of guiding principles, including:

(i). Focus on landscapes: FLR takes place within and across entire landscapes, not individual sites, representing mosaics of interacting land uses and management practices under various tenure and governance systems. It is at this scale that ecological, social and economic priorities can be balanced.

(ii). Maintain and enhance natural ecosystems within landscapes: FLR does not lead to the conversion or destruction of natural forests or other ecosystems. It enhances the conservation, recovery, and sustainable management of forests and other ecosystems.

(iii). Engage stakeholders and support participatory governance: FLR actively engages stakeholders at different scales, including vulnerable groups, in planning and decision making regarding land-use, restoration goals and strategies, implementation methods, benefit sharing, monitoring and review processes.

(iv). Tailor to the local context using a variety of approaches: FLR uses a variety of approaches that are adapted to the local social, cultural, economic and ecological values, needs, and landscape history. It draws on the latest science and best practices, and traditional and indigenous knowledge, and applies that information in the context of local capacities and existing or new governance structures.

(v). Restore multiple functions for multiple benefits: FLR interventions aim to restore multiple ecological, social and economic functions across a landscape and generate a range of ecosystem goods and services that benefit multiple stakeholder groups.

(vi). Manage adaptively for long-term resilience: FLR seeks to enhance the resilience of the landscape and its stakeholders over the medium and long-term.

Restoration approaches should enhance species and genetic diversity, and should be adjusted over time to reflect changes in climate and other environmental conditions, knowledge, capacities, stakeholder needs, and societal values. As restoration progresses, information from monitoring activities, research, and stakeholder guidance should be integrated into management plans. In

general, the FLR programme could ultimately be enhanced so that it is implemented on millions of hectares of land in Malawi. This presents a significant opportunity to achieve many of Malawi's sustainable economic development goals, as outlined in the Malawi Growth and Development Strategy (MGDS III) and in Malawi 2063 on the pillar of agricultural productivity and commercialization.

2.2.2 Identification of barriers for the Technology

The Process of identification of barriers is explained in Section 2.0.2 (Barrier identification and analysis).

2.2.2.1 Economic and financial barriers

a) Limited financing capacity

Opportunities for accessing financial resources for investing in Forest and landscape restoration projects for example in farmer managed landscape regeneration are limited. Also, the financial institutions are not motivated enough to provide loans and credits to non-commercial investments. In addition, private commercial entities are not involved in investment in the land restoration as business, for example in eco-tourism. Furthermore, farmers have limited economic means to invest in Forest and landscape restoration projects. They have limited access to financial resources and very low purchasing capacity to opt for high quality tree seeds. Likewise, the cost of herbicides to control pests and disease is quite expensive and out of reach for most of rural communities who have no regular income. Herbicides are expensive and are not readily available locally and require additional equipment and facilities to apply them, which all increased the investment cost, requiring financial support from elsewhere.

Most importantly for Malawi, the central and local government authorities dedicate most of the resources to other sectors that are considered most important, like education, health, water and infrastructure. Therefore, financial support from government to stakeholders that promote Forest and landscape restoration is limited.

b) High investment costs

Forest and landscape restoration programme involves high up-front costs, emanating from the procurement of inputs such as forest conservation techniques, herbicides and labour. As stated in the Malawi National Forest and landscape restoration Strategy of 2018, forest management interventions require substantially more financial and labor investment in proportion to the degree of the degraded land use. Further, investment in Forest and landscape restoration takes considerable time (5 to10 years), before the benefits are realized. This indirectly, increases the investment cost as the maintenance costs keep on accruing during the period.

2.2.2.2 Non financial barriers

a) Environmental and social challenges

The environmental challenges, like desertification and degradation of land and soils impede on the success of Forest and landscape restoration activities. Most of the country has lost trees and desertification limits regeneration of trees and forest. Also, the heavily deforestated areas, as a result of other land uses (like farming), leaves the soil degraded through uncontrolled extensive soil erosion. This, again, limits regeneration of trees and forests. Further, the country's overdependence on natural resources like trees and forests for livelihood puts pressure on the available resources, which undermines the Forest and landscape restoration activities through illegal harvests.

b) Competition for labour with other agricultural activities

Forest and landscape restoration programme is labour intensive. In Malawi, where over 80% are subsistence farmers (growing mostly maize, a staple food), most of labour used in agricultural activities is family labour. As a result, the family is unable to engage in the production of other crops and non-agricultural goods, and communities are unwilling to invest labour resources into Forest and landscape restoration activities.

c) Land Governance challenges

The stakeholders raised several governance issues that prevent FLR from being diffused widely. The land-tenure issues, especially the difficulty to secure tenure for investors, as a key issue to allow investments in FLR. Also, there are challenges against people's anticipation in FLR activities, including access to land. Most of the Malawians (85%) live in rural areas. The majority of them are subsistence farmers, controlling a relatively small piece of land mainly for farming due to high population density. Access to land for large scale forest restoration landscape project is therefore a challenge. The challenge is more pronounced in the southern and central areas of Malawi. The people have customary rights to the land. Further, there is pressure on the unprotected trees and forest emanating from their use as the dominant source of livelihood, for example for charcoal production for sale. This contributes to unsustainable land use pressures. The access of land to for forest restoration activities is therefore very limited, which limited local enterprises from participating in the Forest and landscape restoration ventures.

In addition, the power of making decision is usually with a male, at a household and community levels. The decision on FLR activities are often challenged because aspirations from the women and other marginalized groups are not well represented.

d) Limitation in information and knowledge

During the group discussions on barriers that impede the forest restoration projects, stakeholders noted that limitation in information and knowledge of one of the important barriers against diffusion of Forest and landscape restoration activities in Malawi. The limitations in information and knowledge are exacerbated by the following: low literacy rate especially in rural areas, few action-oriented leaders on Forest and landscape restoration, lack of information about cost-effective restoration practices and their benefits, limited extension, training, technical support for adoption of restoration practices, lack of information about integrated landscape management, limitations of top-down approaches without full participation of communities, and conflicting approaches among development projects.

Further, there is limited knowledge on technologies and approaches for sustainable land use (for example on reforestation, assisted natural regeneration, agro-forestry, climate-smart agriculture), as well as in cost-effective and ecologically robust restoration techniques. Also, there limitation in demonstration of successful experiences and approaches that have already carried out in Malawi and/or elsewhere with social-economic status similar to Malawi. .

e) Limitation in policy and institutional set-up

In general, the devolution of full control over land and other natural resources to local institutions and organizations is increasingly seen as a requirement for bringing about better natural resource management. Policies and institutions must be designed to ensure that investments in trees and landscape restoration are addressed in the decentralization agenda. The National Forest Policy of 2016, which advocates devolution of forest management activities at a district levels, implementation of policy objectives is challenged by effects of poor understanding of democracy among the general populace, when it comes to destruction of natural resources.

Also, an important goal of FLR is to create landscape conditions that incentivize the sustainable use of natural resources. Therefore, for the success of FLR, it is important that policies, administrative frameworks, and institutional strategies create the conditions within which social and economic activities either exploit or sustainably use natural resources. This is a challenge currently in Malawi. Another challenge on institutional set-up concerns limitations in coordination of FLR activities amongst the players. Forest-based organizations, for example local based non government based organizations are generally underfunded or not funded at all, and are not with aligned with the major thrusts of rural development efforts. Further, in other cases, the organizations need to reorientation from their current roles, which are largely on advocacy and little on implementation, to roles with a much stronger service delivery orientation aligned with the poverty alleviation agenda in the country.

2.2.3 Identified measures

The measures to remove the barriers against wide-scale diffusion of forest and landscape restoration technology were arrived at after deliberations in the Stakeholders meeting, after reaching a consensus with the aid of a problem tree and market mapping. They are presented in the following subsections.

2.2.3.1 Measures for Economic and financial barriers

There were two barriers identified under economic and financial category. The measures to remove them are presented henceforth.

a) Measures for barrier: Limited financing capacity

The barrier limited financing capacity could be removed through establishing workable financing options for FLR activities. The options could include access to loans from banks and other money lending institutions. Therefore, the Government and other stakeholders should work out on modalities on how to assist those that could not afford to access loans to start FLR activities. Modalities could include setting a trust, which among other responsibilities, be offering collaterals to banks on behalf of those that are not able to possess the required collaterals.

Also, involvement of the private sector in FLR activities could provide a significant source for financing FLR activities in the forestry sector. Further, there is need for regulation of financing institutions so that there is supervision, ensuring financial services providers operate in a safe and sound manner and effectively serve credit markets to the benefit of FLR activities.

b) Measures for barrier: High investment and operation cost

FLR activities require investment, herbicides, fertilizer and pavement on labour. The initial investment costs could be reduced through removal/reducing of import duties for such products. Local manufacturing of herbicides and fertilizer could significantly reduce the cost of purchase. Therefore, Government should encourage private sector investment in herbicides and fertilizer manufacturing in the country. Barrier on operational cost (labour cost) be removed through use of low-cost mechanization technologies, e.g. on tilling land. Local industries that are involved in production of farm machinery Agrimal Malawi Limited, should supported to manufacture low cost but efficient machinery that could be used in the FLR activities.

2.2.3.2 Measures for non financial barriers

The measures on barriers that not financial in nature are presented as follows:

a) Measures for barrier: Environmental challenges

The degraded soils and lands could be improved through applying appropriate soil and land conservation measures when implementing FLR on degraded soils and lands. Also, there is need to enhance and implement training programmes in environmental management on degraded soils and lands in Agricultural Research Stations and other agricultural and forestry training institutions.

b) Measures for barrier: Competition for labour with other agricultural activities

Competition for labour with other agricultural activities could be reduced through provision of alternative and mechanized sources of power for both agriculture production and FLR activities. This could be achieved through acquisition and training in mechanised machinery. Also, increasing the value FLR outputs to be competitive with agricultural outputs could help households place importance on FLR activities.

c) Measures for barrier: Land Governance Challenges

The benefits of FLR activities take relatively longer period of time to reap. The barriers on land governance challenges could be reduced through assessing land-tenure issues and securing tenure, especially for local stakeholders, as a key issue to allow secure investments in FLR. There is also a need to develop a deliberate policy/strategy to solve governance issues. Further when planning and implementing for FLR activities, there is need to set up an inclusive decision-making framework so that decisions are accepted by all land stakeholders. The Government should facilitate engagement of all relevant land stakeholder groups to solve governance challenges.

d) Measures for barrier: Limitation in information and knowledge

Limitation in information and knowledge could be removed through several strategies. As a starting point, there is need for the appropriate institution, for example Forestry Research Institute of Malawi (FRIM) to identify knowledge gaps in implementation of FLR activities, as well as to carry out stocktaking of existing technologies and approaches for their sustainable land use. There should be institution for example FRIM to provide support for testing and demonstration on FLR activities in Malawi. There need for special programmes in FLR set up and administered by forestry institutions such as FRIM and Natural Resources College of the Lilongwe University of Agriculture and natural Resources (LUANAR). There is also need to enhance the FLR activities by building on successful experiences and approaches already carried out on FLR projects. The Government should also set up a collection of cost-effective and ecologically robust restoration techniques, to be accessed without difficulties, and knowledge nurturing sites on FLR in the country.

e) Measures on Barrier: Limitation in policy and institutional set-up

Measures to remove the barrier concerning limitation in policy and institutional set-up are as follows: The Government should re-orient policies and institutions to ensure that investments in trees and landscape restoration are addressed in the decentralization agenda. The institutions that coordinate research activities in the country (FRIM), should be supported and enhanced: making sure the they work in harmony with other sectors like agriculture, livestock and mining. The Government should support implementation of policies and strategies that are already in place that could be mapped to addressing FRL activities (e.g. National Charcoal Strategy, National Forest Policy, climate-change national strategy, biodiversity national strategy, national strategy for rural

development, etc.). There is need for establishment alternative funding for organizations involved in FLR advocacy and implementation activities. The Government should also provide a platform for organizations to reorient their current roles so they are geared towards stronger service delivery orientation and aligned with the poverty alleviation agenda.

2.3 Barriers analysis and possible enabling measures for Technology 2: Efficient use of forest products

The identified barriers that prevent widespread diffusion of technology: efficient use of forest products, are presented in this section, starting with description of technology.

2.3.1 General description of the technology

A forest product is any material derived from forestry for direct consumption or commercial use, such as wood, timber and poles. The product can be wood based or non-wood (e.g honey from bee keeping). Wood is by far the dominant product of forests in Malawi. It is used for many purposes, such as for energy (in the form of firewood and charcoal), as well as for construction of infrastructures such as buildings. Residues from forestry could also be among the examples of forest products.

Residues in the forest and in the wood industry are in reality by-products predominantly used as raw material for recycled wood-based products and as a renewable fuel, which could contribute to efficient use of forest products. Derivation of wood based forest products is among the major causes of deforestation. Efficient use of forest products could therefore reduce deforestation since it would now require less wood to produce a unit wood product or service. There are also non-wood products derived from forest resources. Non-wood forest products are viewed to have fewer negative effects on forest ecosystem when providing income sources for local community.

Efficient use of forest products is applied in Malawi, but not well documented. There include efficient wood fuel cooking stoves being developed and promoted and efficiency in timber making process from wood. The operational necessities would include purchase of efficient appliances and well trained working personnel. In general, the option of efficient use of forest products includes the following: reduction in the waste of wood residues; improvements in tree felling operations; low impact wood extraction systems; and changing processing technology and product development.

2.3.2 Identification of barriers for the Technology

The identified barriers for the efficient use of forest products were both economic and financial as well as the non-financial barriers. The barriers are explained in the following sub-sections.

2.3.2.1 Economic and Financial barriers

The identified economic and financial types of barriers were two: Limitations in financing capacity, and limited access to market. These are explained in the following sub-sections.

a) Limitations in financing capacity

There are financing limitations in community members to creating viable business ventures from forest products. Most of the members have low disposable income. The same imitations in financing contribute to the members not applying value additions to forest products. Further, the financing challenges limits participation of private-sector investors and entrepreneurs engaged in sustainable use and value-added processing and marketing of forest products. Furthermore, efficient use of forest products requires operational necessities, including purchase of efficient appliances and well trained working personnel. This contributes to financing challenges to most of the Malawian would-be investors.

b) Limited access to market for the forest products

Except for the timber products, there is a limited market for many of the forest products like wood carvings/curios, which are only available in cities and some tourists' spots. There is also limited value addition for forest products, which fail to compete on the market against imported similar products. For example, the honey produced from bee-keeping in the forest is mostly sold in raw form without processing and value addition. Also, marketing of a range of timber and non-timber forest products from community forests and woodlots has no formal markets. For non timber forest products, the sub-sector is dominated by micro and small enterprises, which have relatively low production volumes. Further, limitation in business and marketing skills among local enterprises dealing in forest products impacts negatively in exploring further markets for the products. Further challenges include market inefficiencies for products that are produced in low volumes, especially when both the quantity and quality of the products can vary due to changes in the weather and other production conditions. The barrier related to unpredictability of the forest products (especially the non-timber products) has been observed, caused by demand fluctuations because of, for example, changing trends or the varying availability (with coming in of products from outside Malawi) and prices of substituting products.

2.3.2.2 Non Financial Barriers

Four non-financial barriers were identified. These are limitation in forest product certification, challenges in processing of forest products, limitation in information and knowledge, and limitation in policy and institutional set-up. These identified barriers are explained henceforth.

a) Limitation in forest product certification

Forest certification is a process by which stakeholders agree and commit themselves to defined forest management standards, accreditation of certifiers and labeling of products (including effective tracking in the chain of custody) from certified forests. The certification should be acceptable to stakeholders and credible in the marketplace, and that it is non-distorting of trade. This is lacking in Malawi. In the case of non-wood forest products, the key requirements for the

certification include the establishment of a limited and monitored permit system, the development of clear tenure rights, limited access to harvesting sites, the development of niche markets and the implementation of quality control measures. These are absent in the country. Also, once the certification is achieved, there is a challenge in other African countries in creating and sustaining demands for the certified forest products and services in local, regional and external markets.

b) Challenges in processing of forest products

The non-financial challenges in procession forest project are many and pronounced. Some of the challenges include, long processing processes where sawmilling involves debarking and cutting of logs into sections, which are sawn into timber boards. Also, there are different processing and types of machining, such as timber processing and manufacturing involves different types of machines and processes such as sawing, drying, machining, jointing, gluing, and finishing, which can be connected to both environmental hazards and workers occupational health and safety. Further, the use of toxic chemicals especially in wood processing, such as preservative treatment, adhesive application and coating of final products can be detrimental to the environment. The other challenge associated with processing of forest products is the scarcity of raw materials for processing, in terms of both quantity and seasonal availability.

c) Limitation in information and knowledge

Promotion of efficient forest products is hampered by lack of information on important issues like certification and on value addition for example, on processing of edible fruits, financing avenues and on available markets. Further, use of modern technologies that increase efficiency and add value, for example in wood carving, is limited. Furthermore, there is limited vocational training in sawing, tree felling and harvesting operations, which would help to ensure that skilled operators carry out harvesting and thereby reduce wastage and ensure optimum quality and value of logs.

The primary forest products industry is a dynamic sector, which should respond to a range of changing conditions involving environmental, economic and market concerns, and changes in technology as well as the location and changing characteristics of its raw material. The Malawi industry has not made significant advances in the past few years in the use of more efficient and environmentally-friendly processing technologies, achieving higher recovery rates, improving product quality and diversifying the use of raw materials (producing the product from other materials other than wood).

d) Limitation in policy and institutional set-up

Just like in Forest and landscape restoration, promotion of forest products suffer from institutional set-up concerns limitations for institutions for coordination their activities.

2.3.3 Identified measures

The identified measures to overcome identified barriers against wide scale diffusion of efficient use of forest products are presented in the following sub-sections.

2.3.3.1 Measures for economic and financial barriers

Identified measures for barriers in the category of economic and financial are presented henceforth.

a) Measures for barrier: Limited financing capacity

Just like in promoting FLR activities, for the Government to remove barrier concerning limited financing capacity, the Government should create and support institutions to extend credit to smallholders with an interest in investing use of forest products, e.g value-added processing and marketing of tree and forest products. Also, there must be enhanced involvement of private sector in the business of forest products. The Government must also regulate financial sector institutions.

b) Measures for barrier: Limited access to market

Limitation in access to market of forest products can be removed through creation and improving the existing market. The Government should also identify and develop niche market for quality forest products. Furthermore, there should increased awareness of forest products to create demand for them. Increasing the business potential, especially for non-timber forest products and services, could increase further demand; hence market potential for forest products. These would include recreation, and products that include experiential services, such as guided tours, fairs or events. Further, there is need for the Government to establish support for small-scale entrepreneurs that are involved in forest products business.

2.3.3.2 Measures for non-financial barriers

Identified measures for barriers that are not financial in nature are presented as follows:

a) Measures for barrier: Limitation in forest certification

The Government must establish an institution responsible for certification of forest products including its monitoring. This is to ensure standards adherence, hence promotion of forest products.

b) Measures for barrier: Challenges in processing of forest products

The Government must establish a programme that aims at removing challenges associated with processing of forest products. These include access to finances for purchase of efficient processing tools for both timber-based and non-timber-based forest products. The challenges associated with

processing of forest products could be solved through implementation of higher technological innovation. The innovations should shift towards greater product differentiation and higher value-added products.

c) Measures for barrier: Limitation in information and knowledge

To reduce limitations in information and knowledge, The Government must establish and enhance forestry information and knowledge management system. There must also be enhancement of training on efficient use of forest products. Further, there must an institution to promote information sharing among actors in efficient use of forest products.

d) Measures for barrier: Limitation in policy and institutional set-up

The Government must develop and review policies that support uptake of forest products. Also, the Government must strengthen adequate institutions to support sector activities and for an efficient management of the forest products.

2.4 Barrier analysis and possible enabling measures for Technology 3: Urban Forestry

This section presents identified barriers against wide-scale diffusion of urban forestry in Malawi. It starts with description of the technology.

2.4.1 General description of the Technology

Urban development, results in the depletion and degradation of natural ecosystems in and around urban areas. This causes drastic loss of vital ecosystem services and, potentially, little resilience to disturbances, such as those caused by climate change. As Malawi continues to urbanize, sustainable development challenges will increasingly concentrate in urban areas. Urbanization in Malawi is taking place rapidly (at 4%), spontaneously and with insufficient strategic planning, resulting in unsustainable patterns of land use. Urban forests defined as the sum of all woody and associated vegetation in and around dense human settlements, ranging from small communities in rural settings to big cities regions, are considered as one of the major land uses, especially in human settlements.

Urban forestry is concerned about the care and management of tree populations in urban settings for the purpose of improving the urban environment. The concept of urban forestry, which advocates the role of trees as a critical part of the urban structure, was developed to address the issue of impact on forestry by urbanization. The urban forestry comprises all green elements under urban influence. Most of the Malawian cities have departments of parks and wildlife, which are sometimes engaged in urban forestry at a limited scale. The concept of urban forestry is feasible in Malawi The concept of urban forestry, which advocates the role of trees as a critical part of the urban structure, should be encouraged to address the issue of impact on forestry by urbanization in Malawi. The urban forestry comprises all green elements under urban influence, which could present potential for popularization of the practice, such as:

(i). Street trees and road plantations

(ii). Public green areas, such as parks, gardens, cemeteries,

(iii). Semi-private space, such as green space in residential areas and in industrial or specially designated parks

(iv). Public and private tree plantations on vacant plots, green belts, woodlands, rangelands, and forests close to urban areas

(v). Natural forests under urban influence, such as nature reserves, national parks and forests for eco-tourism.

(vi). Urban agricultural land, such as orchards, allotments

Urban forestry has been in practice in Malawi's major cities, but at a limited scale. Thus, the practice is feasible in Malawi. However, the main operational requirement is on management of the forests. A forest management activity by urban forestry could be done by planting trees and maintaining them within cities, suburbs and towns. Selections of trees are important for urban forestry as trees in urban areas face more stress than those in rural areas. Few common stresses faced by urban trees are the restrictive soil volume and crown space, soil pollution, air pollution, wind and drought.

2.4.2 Identification of barriers for the Technology

Barriers and limitations faced in promoting urban forestry are presented in the following sub-sections:

2.4.2.1 Economic and financial barriers

The identified economic and financial barriers are two: limitations in financing capacity and limited access to market on urban forestry products and services. These are explained henceforth.

a) Limitation in financing capacity

The main operational requirement is on management of the forest in urban area requires investment, which most of the times is outside the operational budget of the cities and towns. If budgeted for, it is very inadequate to support forest programmes. The cities that have some level of urban forestry, like Blantyre, Lilongwe and Mzuzu, fail to expand their forestry activities due to inadequate funding. The private sector has not generally exploited the business opportunities in urban forestry business.

b) Limited access to market on urban forestry products and services

The cities and towns have not exploited market on urban forestry products and services such as source of timber and of recreation and tourism.

2.4.2.2 Non financial barriers

Six non financial barriers were identified that prevent the technology from its wide scale diffusion.

a) Limited access to land

Ownership of, or access to, the site to be planted urban trees may determine not only who decides what is planted, but also what they choose. There are challenges to access to land for urban forestry in urban areas, especially in urban areas that are undergoing rapid population growth and frequent movement of dwellers. The conflicts between the land owner and municipalities can be a major hurdle. Further, urban land is dominated by few individuals who are not interested in urban forestry activities.

b) Limitations in policy and institutional set-up

The cities and towns lack strategies to develop urban forestry, according to the needs urban communities within a national context. There is also a challenges in coordination and integration among players of urban forestry live town/city assemblies, private industries, and town/city dwellers. There are limitations in appropriate policy on urban forestry by the city and town councils. The available generic policies that could be applied in urban forestry suffer from poor implementation. Failing in empowering the urban forestry related policies into action due to improper planning and convincing the citizens to implement those policies. Further, there is lack of relevant tree and related laws, and anachronistic standards. Furthermore, there are no standards for green space and greening.

The policy which promotes social cohesion of people located in a spatial unit would make urban forestry participatory programmes easier to carry out. This is absent in Malawi. Further, participatory approaches as in the main forestry programme could be adapted in urban forestry. Furthermore, a number of institutional issues are lacking in Malawi in developing urban forestry programmes. These issues relate to the capabilities and roles of municipal and national governmental agencies involved in urban forestry; encouraging the involvement of other potentially important partners; the legal basis for urban tree and forest management; and technical know-how related to urban forestry.

c) Limitation in information and knowledge

Generally, key players in urban forestry lack key information on pertinent roles of urban forestry, aiming squarely at high density development with limited requirements for green space development. There is also limited knowledge and skill among horticultural workers attached to

the city/town councils. Further, there is low societal status accorded to landscape management. Furthermore, some of the knowledge lacking on attractive carbon market for the urban forestry as well as limited business opportunities available in urban forestry, for example recreation.

Much of the technical information on urban forestry originates from temperate, developed countries, which is not applicable to the Malawi scenario. For example, it was reported in stakeholder consultative meetings that less is known about arboriculture, ornamental tropical species, adjusting planting and management practices to conform to the urban environment in Malawi. In addition, comparatively little attention has been paid to exploring the potential of using urban and peri-urban tree resources for productive purposes and developing management strategies and methodologies accordingly.

d) Limitations in inclusive planning and participation in implementing urban forestry programmes

There is challenge in planning for urban forestry in Malawi. There is no inclusive planning for urban forestry, to take into account complementary plans in the energy, water supply, urban infrastructure, waste disposal and other municipal services, food and agriculture, and transportation sectors. Also, urban forestry plans should seek the involvement of various public, private, academic and community entities as well as concerned and informed individuals. This is currently not the case. Further, there is challenge in local participation in implementing urban forestry programmes. In most countries, urban forestry programmes cannot be carried out solely by the public sector. Government and town/city councils do not work with other entities in promoting and executing urban forestry activities.

e) Limited focus on services derived from urban forestry

The urban forestry activities in Malawi have concentrated on environmental services (including water supply, and air quality) and amenity; relatively little attention has been paid to the role of urban forestry in addressing immediate needs of the urban poor, including access to food and fuelwood.

f) Limited laws and its enforcement in management of urban forestry

Setting up of a strong legal basis (comprehensiveness and enforcement of laws) for the protection and use of trees in urban areas is important. Legislation related to protection of urban trees Malawi, it is relatively weak and so is its enforcement.

2.4.3 Identified measures

The measures to overcome the identified barriers were deliberated and are presented in **Error! Reference source not found.**.

2.4.3.1 Measures for economic and financial barriers

Measures for economic and financial barriers are provided in the following sub-sections.

a) Measure for barrier: Limited financing capacity

The barrier on limited financing capacity is common to all technologies. The Government should create favorable policies and strategies to encourage private sector financing of the urban forestry activities. Also, creation of stable economic conditions of the country would remove economic and financial barriers because it would lead to investors to be more optimistic about the future and potentially invest more in urban forestry as they expect positive returns. Further, there is need training of would be investors on funding options. It is also important for the Government to regulate institutions that provide financial services to investors so that interest rates on loans are not unnecessarily on higher side.

b) **Measures for barrier: Limited access to market on urban forestry products and services**

The Government and their stakeholders should explore and create market for urban forestry products and services. The common urban forest products in Malawian cities include firewood, herbal medicine, timber, and poles. The services from urban forestry, such as tourism and paid recreation centres, have not been exploited extensively in Malawian cities. This presents opportunity for market.

2.4.3.2 Measures for non-financial barriers

Measures on non-financial barriers are presented as follows:

a) Measures for barrier: Limited access to land

Land is limited in urban areas, especially for forestry purposes. However, the Government could establish a programme where individuals are allowed to manage urban land that is under forestry but facing management challenges and other urban degraded lands for purposes of individuals' investing in urban forestry. In order to achieve this, there is need for formal agreement between landlords (e.g city councils) and investors.

b) Measures for barrier: Limitation in knowledge and information

Limitation in knowledge and information is a common barrier to all of the technologies in the forestry sector. This barrier can be removed through research and training in urban forestry, which could be offered by forestry related institutions like FRIM and LUANAR. There is need to document existing knowledge about urban forestry, including the current species of trees that are found in urban areas of Malawi, how they are managed and products and services that are derived from them,

c) Measures for barrier: Limitations in policy, standards regulations and institutional set-up

The Government should review and develop policies and standards to promote uptake and diffusion of urban forestry in Malawi. Also, to there must be establishment of institutions for enforcing standards and regulations with respect to urban forestry activities.

d) Measures for barrier: Limitations in inclusive planning and participation in implementing urban forestry programmes

To ensure inclusive planning for all stakeholders (e.g. planners, investors and urban dwellers) involved in urban forestry programme/project, The Government must establish institution that can facilitate inclusive planning at a local level. Also Government should work with other entities in promoting and executing urban forestry activities. There is also need to develop partnerships with community groups, non-governmental organizations, research and academic institutions, and the private sector. Further, the Government must enhance participatory approaches in the forestry sector and particularize it to the urban forestry.

e) Measures for barrier: Limited focus on products and services derived from urban forestry

The limited focus on services derived from urban forestry affects wide-scale transfer of the technology. Urban forestry stakeholders (for example city and municipality councils) should involve investors that could promote production and service delivery from urban forestry within the greater urban area.

f) Measures for barrier: Unavailability of bylaws and their enforcement in management of urban forestry

The bylaws in the city and municipality councils specific on urban forestry are not available. The city and municipality councils must come up with bylaws that would promote urban forestry.

2.5 Linkages between the barriers identified

The barriers identified against one of the 3 prioritized technologies were compared against barriers identified for the other 2 technologies. The aim was to identify common barriers among the 3 technologies and thus, link them up. Table 8 shows the results on the analysis of the common barriers.

Table 8: Linkage of barriers for each technology

Financial barriers	Technologies	Non-financial barriers

S/N	Barrier	(number of barrier)	S/N	Barrier
A	Limited Financing Capacity	Forest and Landscape Restoration (A, B, 1, 2, 3, 4)	1	Environmental challenges
B	High Investment Cost		2	Competition for labour with agriculture activities
C	Limited Access to Market		3	Limitation in information and knowledge
		Efficient use of forest products (A,C, 3,4,5,6)	4	Limitation in policy and institutional set-up
			5	Limitation in forest product certification
			6	Challenges in processing of forest products
		Urban Forestry (A,C,3,4,7,8,9,10)	7	Limitation in accessing land
			8	Limitation in inclusive planning and participation in urban forestry programmes
			9	Limited focus on services derived from urban forestry
			10	Unavailability of bylaws and its enforcement in managing forest products

Referring to Table 8, it can be seen that identified barriers A, 3, and 4: Limited financing capacity, limitation in information and knowledge, and limitation in policy and institutional set-up are the common identified barriers for each of the prioritized technologies. Also, barrier C: limited access to market is common to both efficient use of forest products and urban forestry. The identified barriers (1, and 2): environmental challenges, and competition for labour with agriculture activities are specific to forest and landscape restoration. Despite the fact that the environmental challenge was not mentioned by stakeholders as one of the barriers under urban forestry, the barrier could be linked to barriers against wide scale diffusion of urban forestry. This is because the environmental degradation in cities and town affects management of urban forestry. The degradation mostly come from industrial and domestic affluent being deposited into rivers and other undesignated places, deforestation of trees along river banks in cities, and from urban land surfaces that are becoming impervious due to construction and without adequate number of surface water ground discharge units.

The identified barriers were organized into themes, according to their similarities on barrier issues they are addressing. Referring to Table 9, the identified categories are: Financial and Economic;

Knowledge and Information; Policy, Standards and Certification Technical; and Laws and Regulation.

Table 9: Analysis of barriers against wide-scale diffusion of prioritized technology in the forestry sector into themes

Barrier	Category	Identified themes
Limited Financing Capacity	Financial and economic limitations	1 Financial and economic limitations 2 Market and business limitations 3 Knowledge and information limitations 4 Standards, certification and enforcement limitations 5 Policy and institutional limitations 6 Technical skills limitation 7 Laws and regulations limitations 8 Environmental limitations
High Investment Cost	Financial and economic limitations	
Limited Access to Market	Market and business limitations	
Environmental challenges	Environmental limitations	
Competition from other agricultural and forestry activities	Knowledge and information limitations	
Limitation in information and knowledge	Knowledge and information limitations	
Limitation in policy and institutional set-up	Policy and institutional limitations	
Limitation in forest product certification	Standards, certification and enforcement limitations	
Challenges in processing of forest products	Technical skills limitations	
Limitation in accessing land	Laws and regulation limitations	
Limitation in inclusive planning and participation in urban forestry programmes	Technical skills limitations	
Limited focus on services derived from urban forestry	Knowledge and information limitations	
Limited laws and its enforcement in managing forest products	Laws and regulation limitations	

Therefore the enabling framework would be focused to creating an environment in which the common and other significant barriers identified for each of the technology, according to the set of category of barriers they belong to.

2.7 Enabling framework for overcoming the barriers

As stated in Section 1.0.2 Methodology for Barrier Identification and Analysis**)**, the enabling environment for a particular technology is described by domains that make diffusion of the technology take place without barriers. These domains include as favorable macroeconomic conditions, social, availability of resources, availability laws, supporting policies and regulation, and availability of required technological capacity and institutions. The deviation between ideal environment and what is actually on the ground (national situation) gives rise to barrier. Thus, the enabling framework has to be linked to measures to overcome the barriers. For the Forestry sector, the enabling framework is presented in Table 10,Table 11, and Table 12.

Table 10: Enabling framework for overcoming barriers in forestry sector: Forest and Landscape Restoration

Barrier Theme	Barrier	Identified Enabling Measures	Enabling Domain
Financial and economic limitations	Limited Financing Capacity	Establish workable financing options for FLR activities	Availability of functioning and regulated (e.g on interest rate) financial institutions to support investments in climate technologies in the forestry sector Presence of investment policies to contribute towards financing to mitigation technologies in the forest sector
		Involve private sector in FLR activities	Availability of favorable laws and regulatory systems encouraging participation of private sector involvement in climate hinge mitigation activities in the forestry sector Presence of public-private partnerships arrangement in the mitigation activities in the forestry sector
		Regulation of financial sector institutions	Availability of laws and regulatory framework, and institutional-set up for involvement of private sector in climate change mitigation in the forestry sector
	High investment costs	Put in place measures to reduce cost of procured materials for FLR activities like herbicides and fertilizer, for example through removal of import duties for such products	Availability of incentives to reduce costs of comments of the technologies
		Use low-cost mechanization technologies for working on forest and land restoration activities	Availability of technical experts on forest an and restoration activities

Environmental Limitations	Environmental challenges	Apply appropriate soil and land conservation measures when implementing FLR on degraded soils and lands	Availability of technical experts on forest and land restoration activities
		Implement training programmes in environmental management on degraded soils and lands	Availability of training institutions and programmes forest and land restoration activities
Competition from other agricultural and forestry activities	Competition for labour with other agricultural activities	Provide alternative and mechanized sources of power for both agriculture production and FLR activities	Availability of technical experts on forest and land restoration activities
		Increase the value FLR outputs to be competitive with agricultural outputs	Availability of industries on FLR products and services improvement to promote products and services derived from FLR activities above those from other activities
Laws and regulations limitations	Governance Challenges	Enhance assess to land-tenure for investments in FLR.	Presence of land laws that are favorable to investments in FLR
		Develop laws to solve land governance issues.	Presence of land laws related to land governance
		Set an inclusive decision-making framework when planning and implementing for FLR activities.	Availability of experts to implement activities of FLR in the forestry sector
		Facilitate engagement of all relevant stakeholder groups in FLR activities	Availability of experts to implement activities of FLR in the forestry sector
Knowledge and information limitations	Limitation in information and knowledge	Identify knowledge gaps in implementation of FLR activities.	Availability of knowledge repository system
		Provide support for testing and demonstration on FLR activities in Malawi	Availability of training, testing and demonstration institutions on mitigation technology in the forestry sector
		Set-put and Implement training special programmes in FLR	Availability of training, testing and demonstration institutions on mitigation technology in the forestry sector

		Carry out stocktaking of existing technologies and approaches for their sustainable land use	Availability of knowledge repository system
		Enhance the FLR activities by building on successful experiences and approaches already carried out on FLR projects.	Availability of knowledge repository system
		Set up a collection of cost-effective and ecologically robust restoration techniques, to be accessed without difficulties.	Availability of experts to implement activities of FLR in the forestry sector
		Set up knowledge nurturing sites on FLR in the country	Availability of training, testing and demonstration institutions on mitigation technology in the forestry sector
Policy and institutional limitations	Limitation in policy and institutional set-up	Re-orient policies and institutions to ensure that investments in trees and landscape restoration are addressed in the decentralization agenda.	Availability of policies that promote uptake and wide scale diffusion of forestry mitigation technologies
		Establish an institution to coordinate FLR activities in different related sectors (forestry, agriculture, livestock/rangeland, energy, mining, etc.).	Availability of institutions to promote FLR activities
		Revise policies and strategies on FRL so that they are in harmony with the ones already in place that could be address FRL activities (e.g. National Charcoal Strategy, National Forest Policy, climate-change national strategy, biodiversity national strategy, national strategy for rural development, etc.).	Availability of policies and strategies that promote FRL activities
		Provide a platform for forest base organizations to re-orientate their current roles so they are geared towards stronger service delivery orientation and aligned with the poverty alleviation agenda.	Availability of institutions that promote FRL activities

Table 11: Enabling framework for overcoming barriers in forestry sector: Efficient Use of Forest Products

Barrier Theme	Barrier	Identified Enabling Measures	Enabling Domain
Financial and economic limitations	Limited financing capacity	Create and support institutions to extend credit to smallholders with an interest in investing use of forest products, e.g value-added processing and marketing of tree and forest products.	Availability of functioning and regulated (e.g on interest rate) financial institutions to support investments in climate technologies in the forestry sector Presence of investment policies to contribute towards financing to mitigation technologies in the forest sector
		Involve private sector in the business of forest products	Availability of favorable laws and regulatory systems encouraging participation of private sector involvement in climate hinge mitigation activities in the forestry sector Presence of public-private partnerships arrangement in the mitigation activities in the forestry sector
		Regulate financial sector institutions	Availability of laws and regulatory framework, and institutional-set up for involvement of private sector in climate change mitigation in the forestry sector
Market and business limitations	Limited access to market	Create new and improve existing market access to market of the forest products	Availability of market for products of forestry mitigation projects
		Develop niche market for high quality products	Availability of market for products of forestry mitigation projects

Standards, certification and enforcement limitations	Limitation in forest products standards and certification	Establish forest products standards and certification process that includes a monitored permitting system	Availability of regulatory framework on forest products including certification
Technical skills limitation	Challenges in processing of forest products	Establish opportunities for processing of forest products	Availability of expertise and enterprises on processing of forest products
Knowledge and information limitations	Limitation in information and knowledge	Establish forestry information and knowledge management system	Availability of knowledge repository system.
		Implement and enhance training programmes in efficient use of forest products	Availability of training institutions with required programmes that support efficient use of forest products
Policy and institutional limitations	Limitation in policy and institutional set-up	Develop and review policies that support uptake of forest products	Availability of policies that support uptake of forest products
		Develop and strengthen institutions to support sector activities and for an efficient management of the forest products	Availability of institutions that support

Table 12: Enabling framework for overcoming barriers in forestry sector: Urban Forestry

Barrier Theme	**Barrier**	**Identified Enabling Measures**	**Enabling Domain**
Financial and economic limitations	Limited financing capacity	Establish workable financing options for FLR activities	Availability of functioning and regulated (e.g on interest rate) financial institutions to support investments in climate technologies in the forestry sector

			Presence of investment policies to contribute towards financing to mitigation technologies in the forest sector
		Involve private sector in FLR activities	Availability of favorable laws and regulatory systems encouraging participation of private sector involvement in climate hinge mitigation activities in the forestry sector Presence of public-private partnerships arrangement in the mitigation activities in the forestry sector
		Regulation of financial sector institutions	
Market and business limitations	Limited access to market on urban forestry products and services	Create market for urban forestry products and services	Availability of market and its support infrastructure, for forestry products
Laws and regulations limitations	Limited access to land	Secure land in urban areas for urban forestry activities	Availability of laws that allow access to land for forestry mitigation programmes
Knowledge and information limitations	Limitation in knowledge and information	Document existing knowledge and launch new research	Availability of knowledge generation (training institutions) and demonstration system in forestry mitigation technologies

		Enhance forestry research and training institutions	Presence of vibrant research and training institutions
		Develop and review guidelines and standards to promote uptake and diffusion of urban forestry in Malawi	Availability of guidelines an standards in urban forestry management
		Enforce standards and regulations in urban forestry activities	Availability of regulatory framework on urban forestry activities
Technical skills limitation	Limitations in inclusive planning and participation in implementing urban forestry programmes	Ensure local participation in implementing urban forestry programmes	Availability of inclusive participation in urban forestry programme
		Government should facilitate harmonization among all stakeholders involved in promoting and executing urban forestry activities	Availability of institutions to ensure harmonization of urban forestry activities done by stakeholders
		Develop partnerships with community groups, non-governmental organizations, research and academic institutions, and the private sector.	Availability of institutions to ensure harmonization of urban forestry activities done by stakeholders
		Implement participatory urban forestry approaches in forestry programme	Availability of expertise to implement participatory approaches in forestry programmes
Technical skills limitation	Limited focus on services derived from urban forestry	Increase demand of services and products from urban forestry activities in urban area	Availability of demand for products and services of urban forestry

Laws and regulations limitations Standards, certification and enforcement limitations	Limited laws and its enforcement in management of urban forestry	Develop appropriate legal frameworks and enforcement mechanism for urban forestry.	Availability of legal framework for guiding urban forestry activities. Availability of enhanced enforcement of regulations on urban forestry activities

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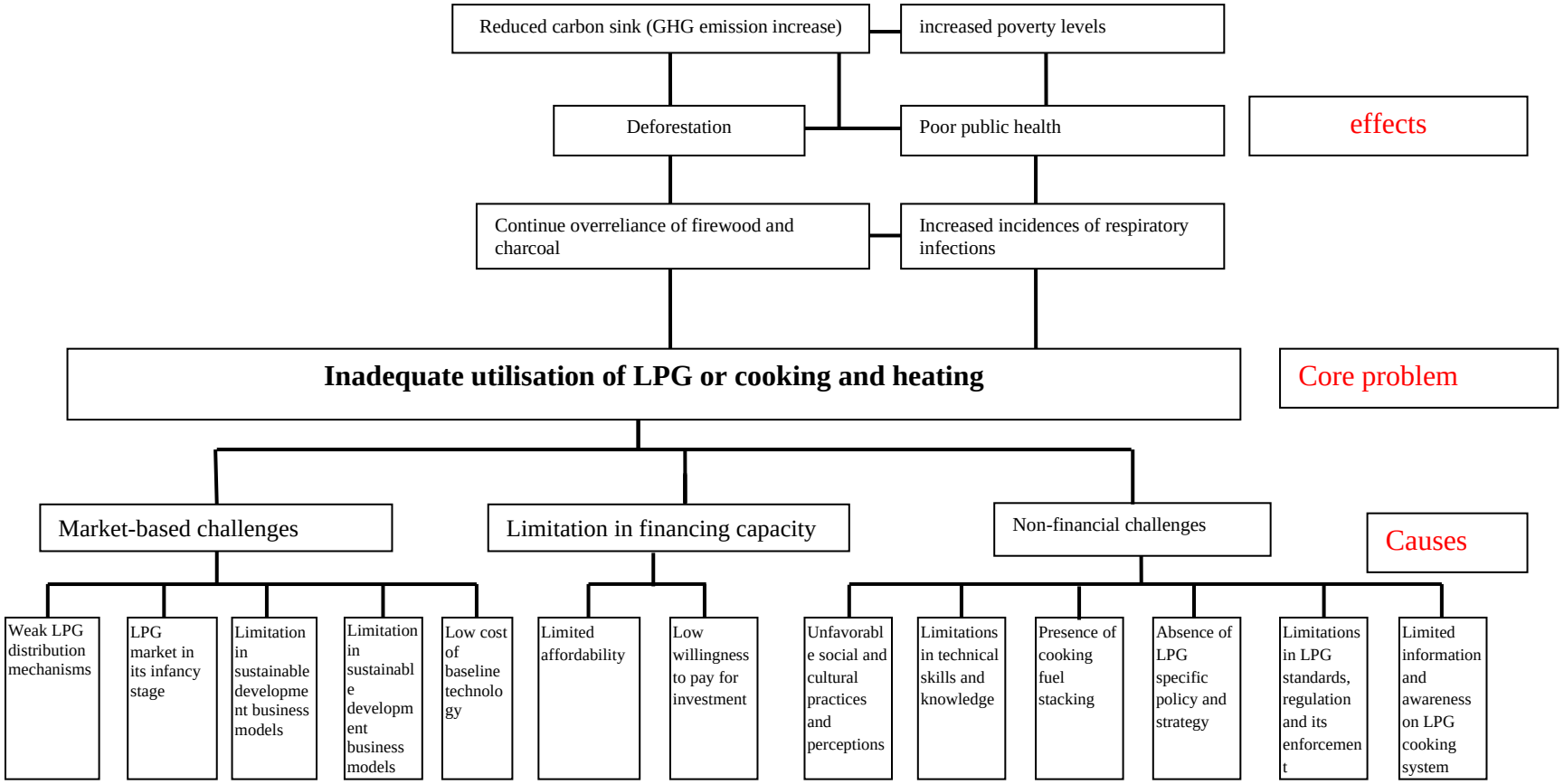
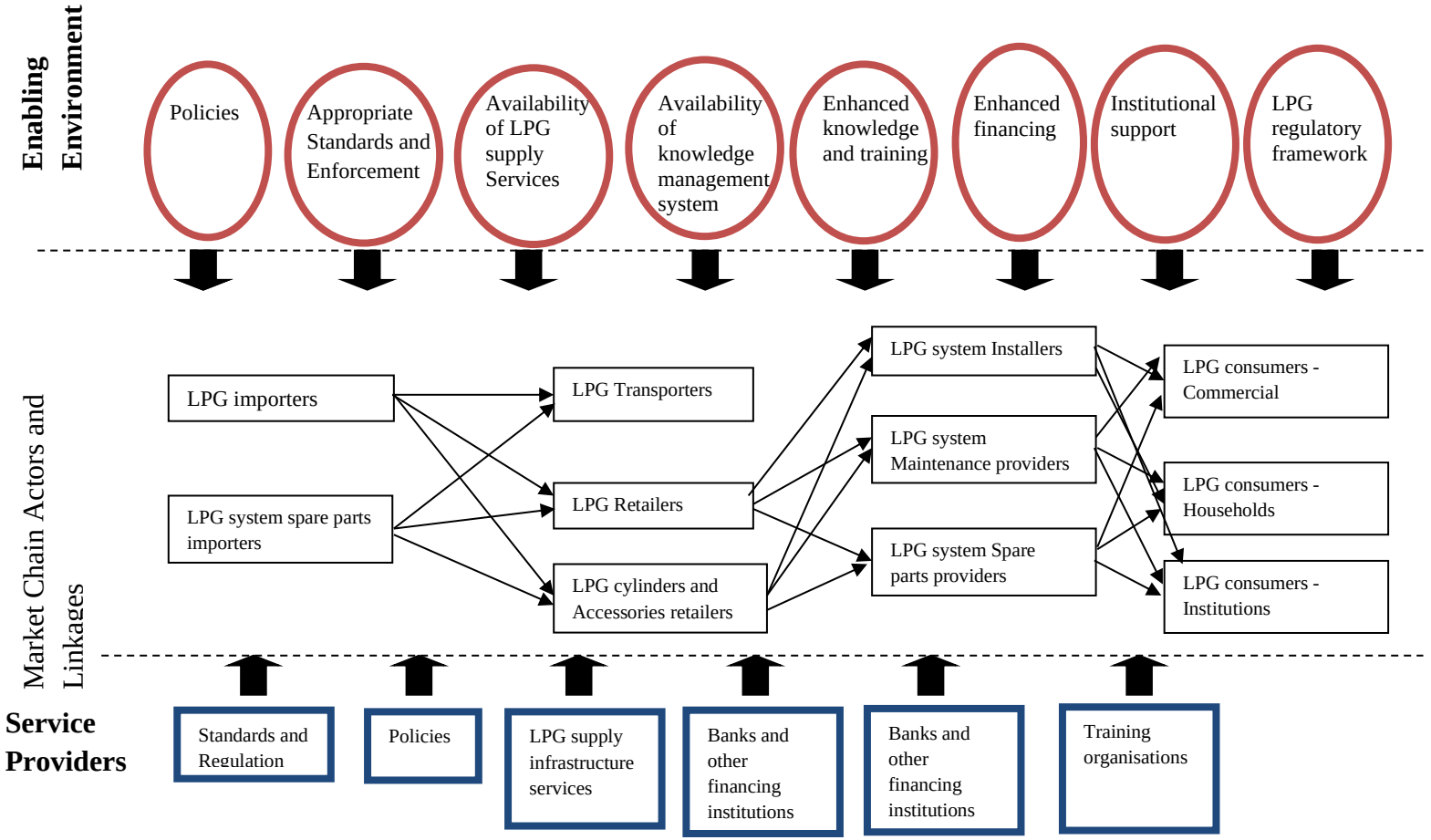
Annex I: Market Maps and problem trees

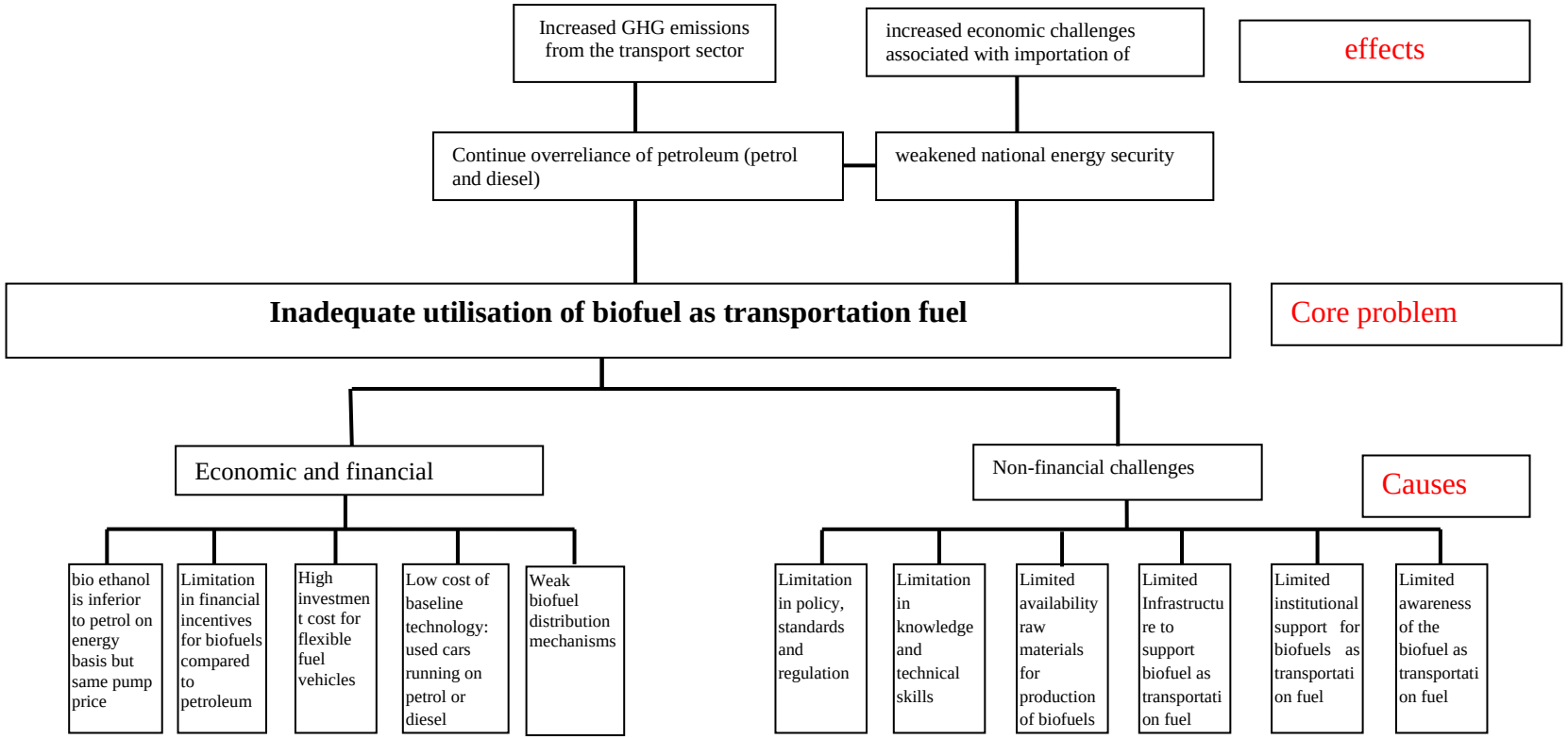
Problem tree for LPG for cooking and heating



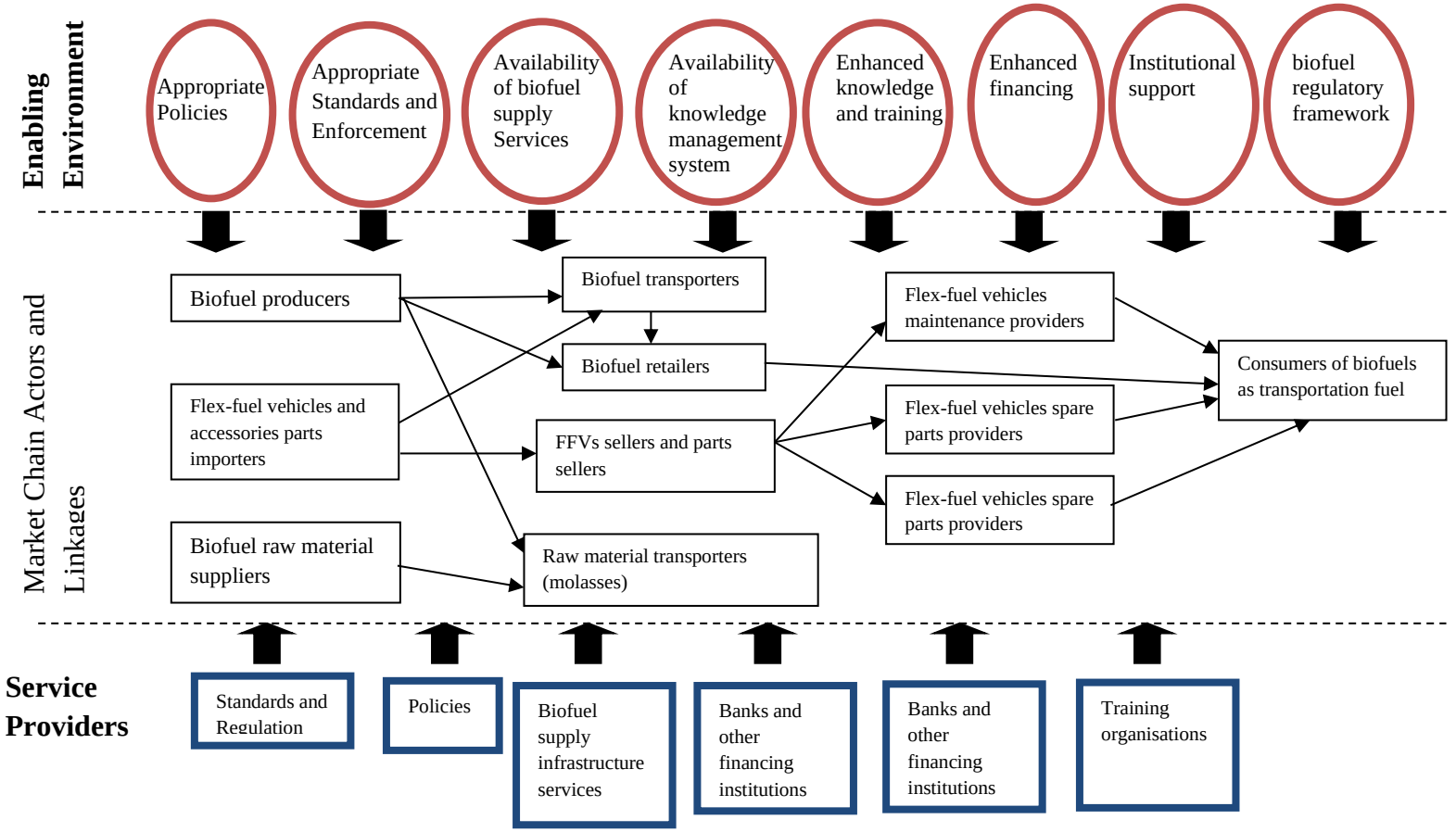
Market mapping for LPG for cooking and heating



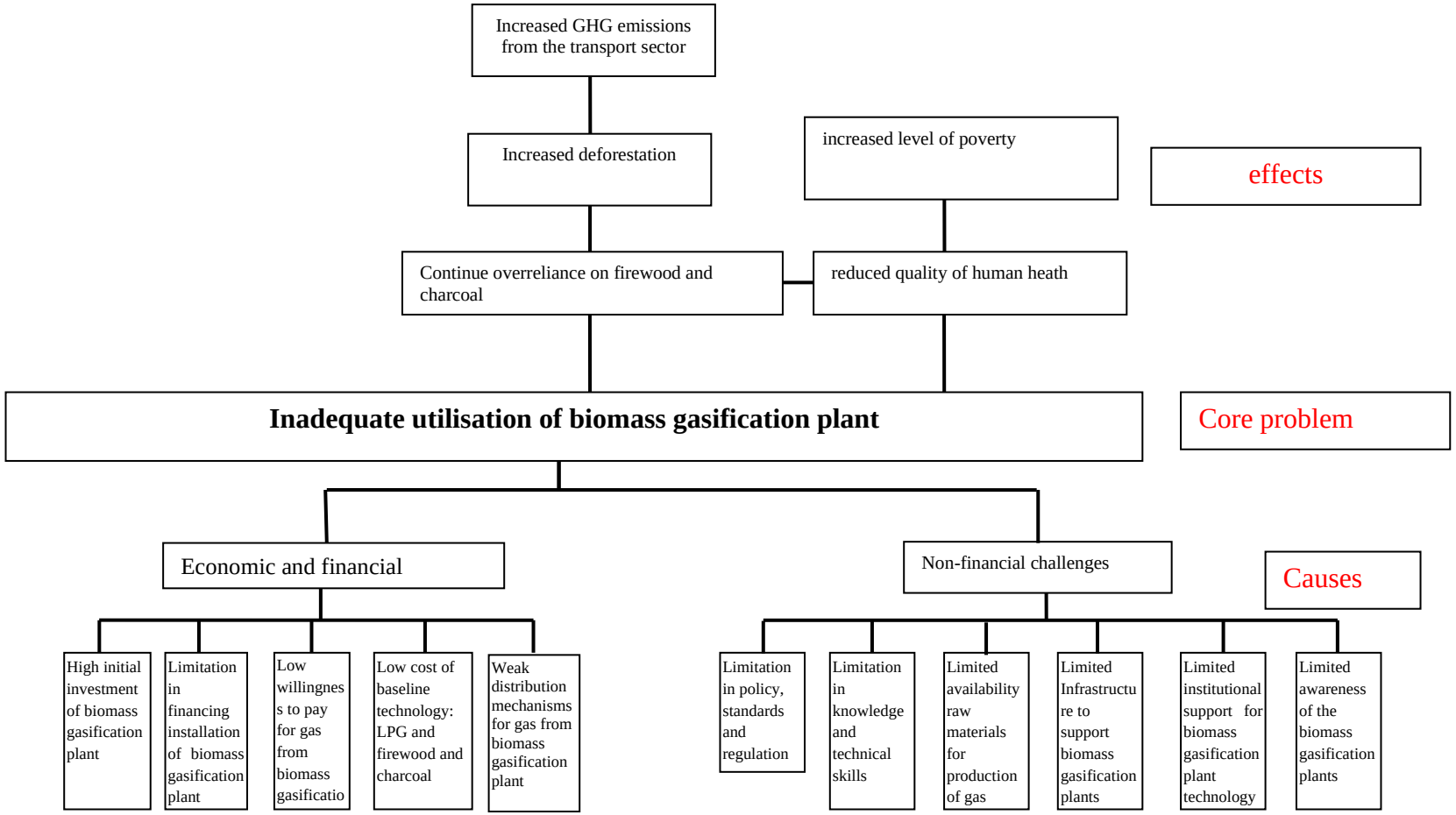
Problem tree for Biofuel as Transportation fuel



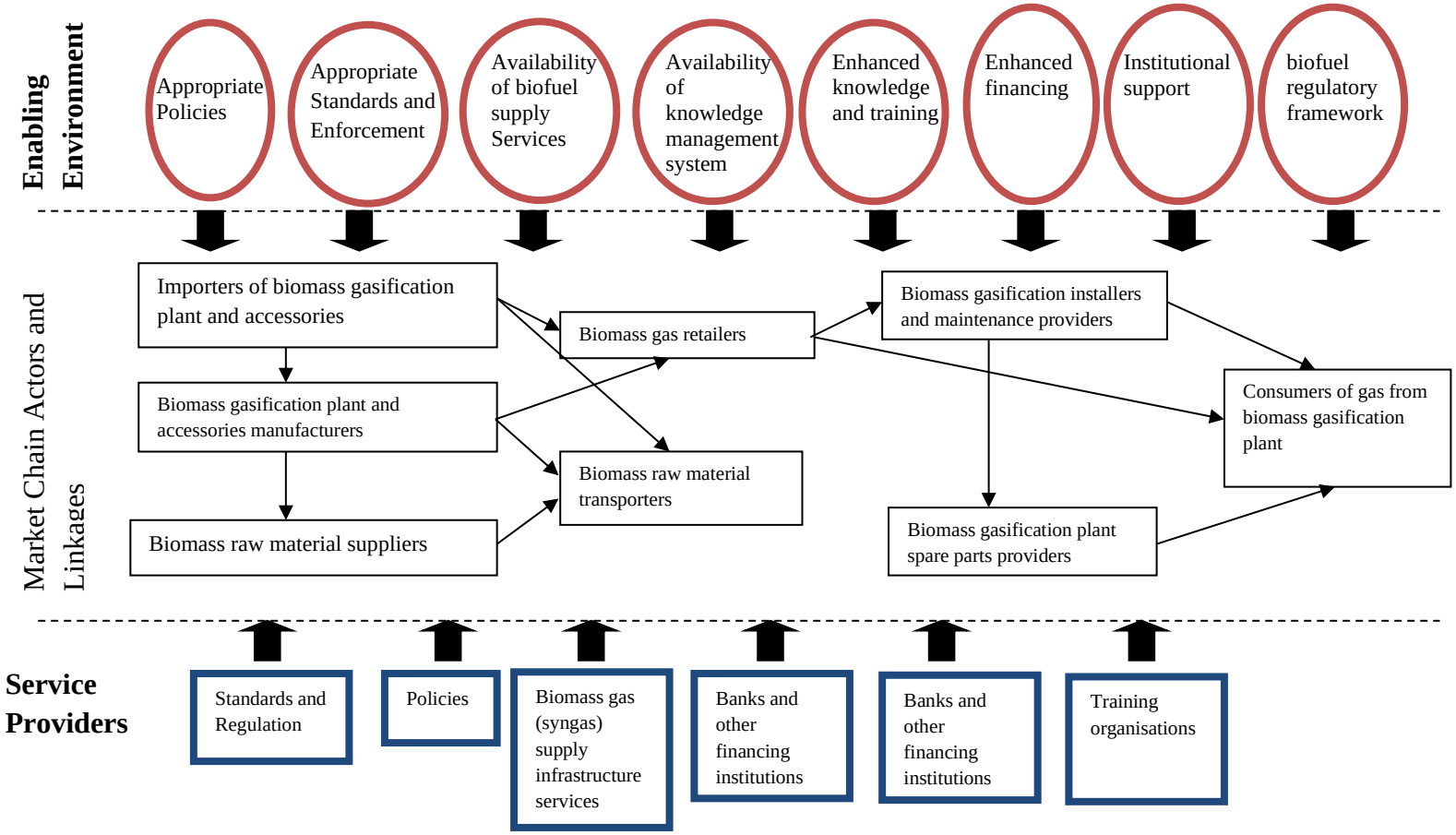
Market mapping for biofuel as transportation fuel



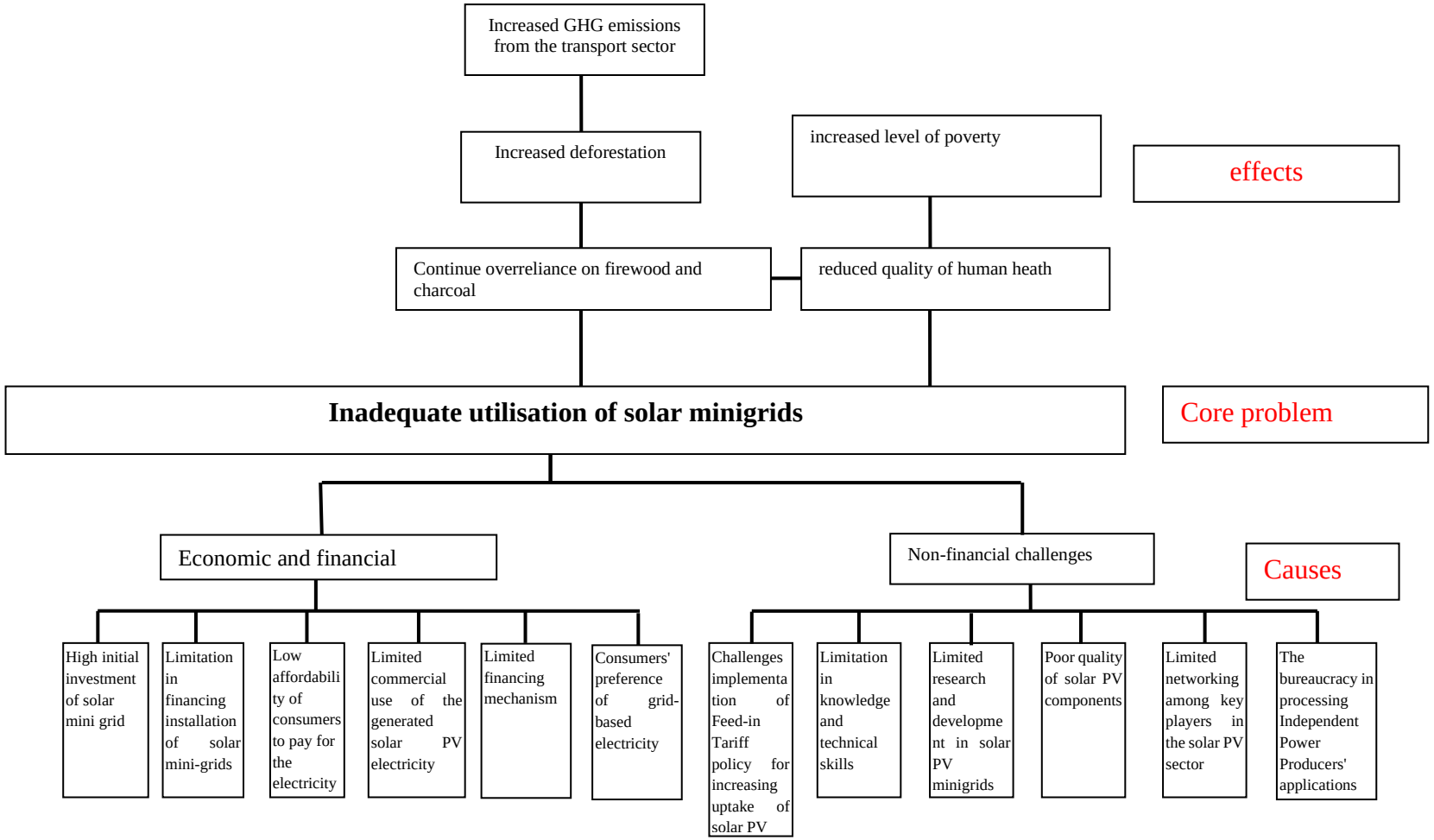
Problem tree for biomass gasification plant



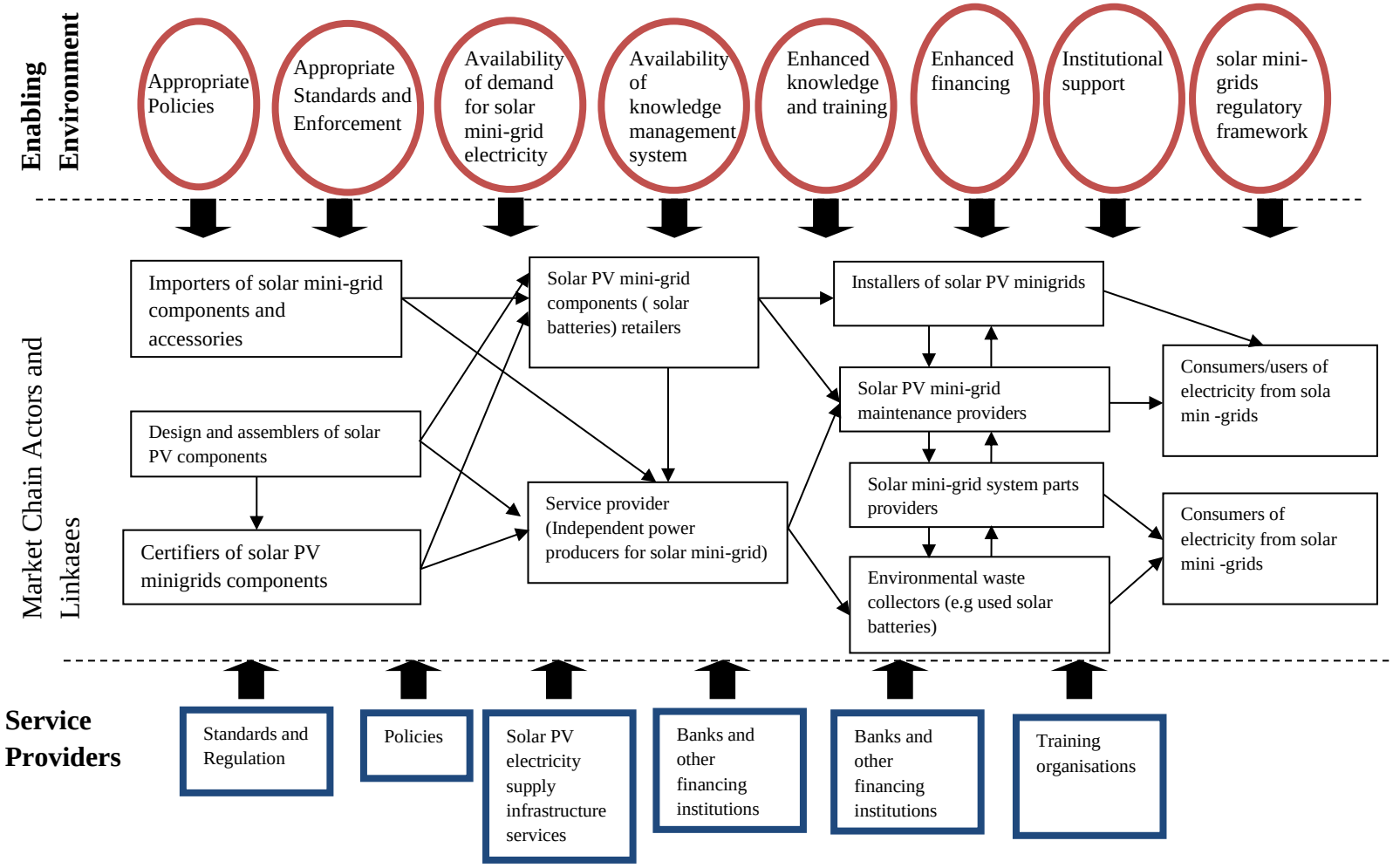
Market mapping for biomass gasification plant



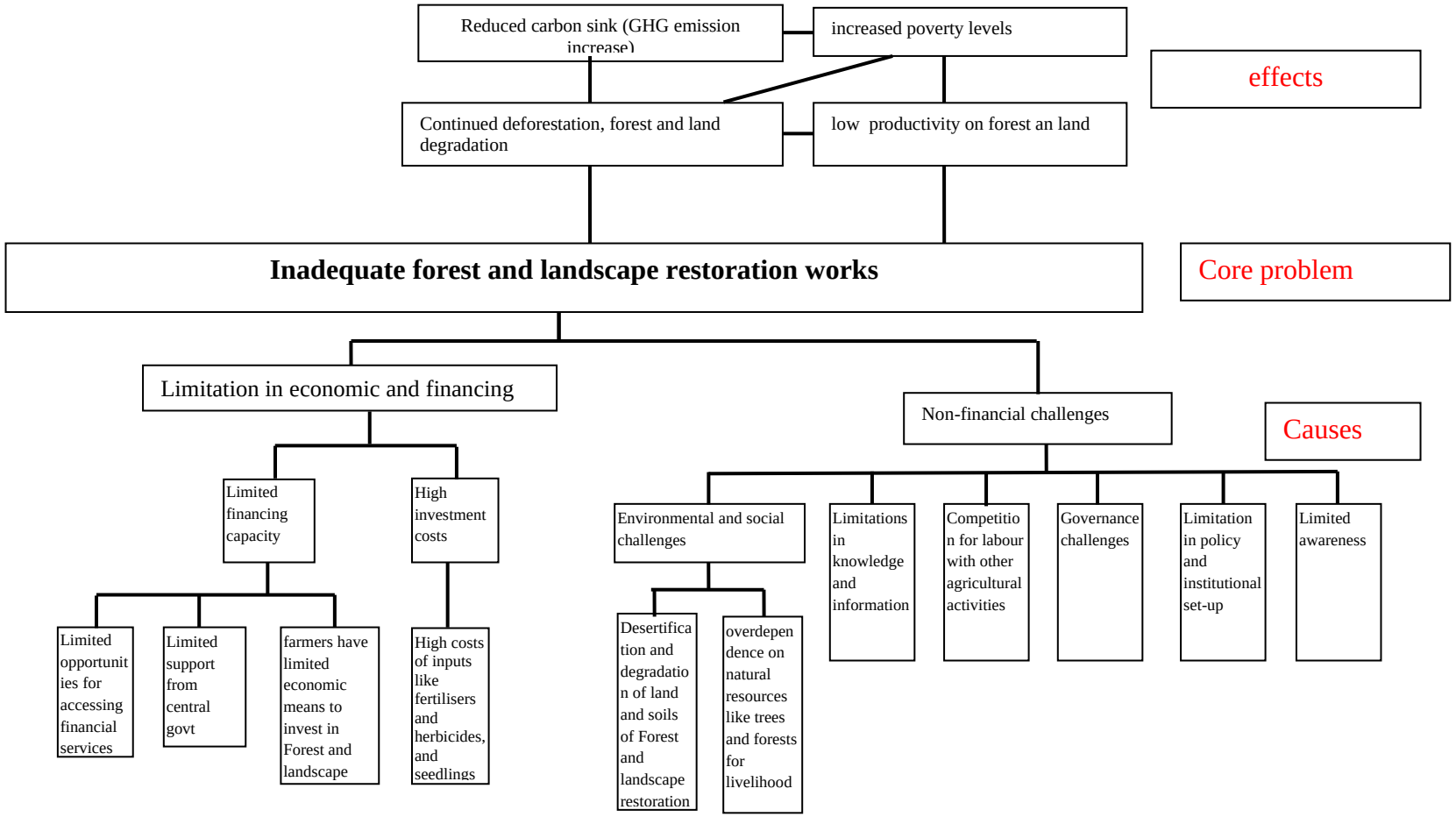
Problem tree for solar mini grids



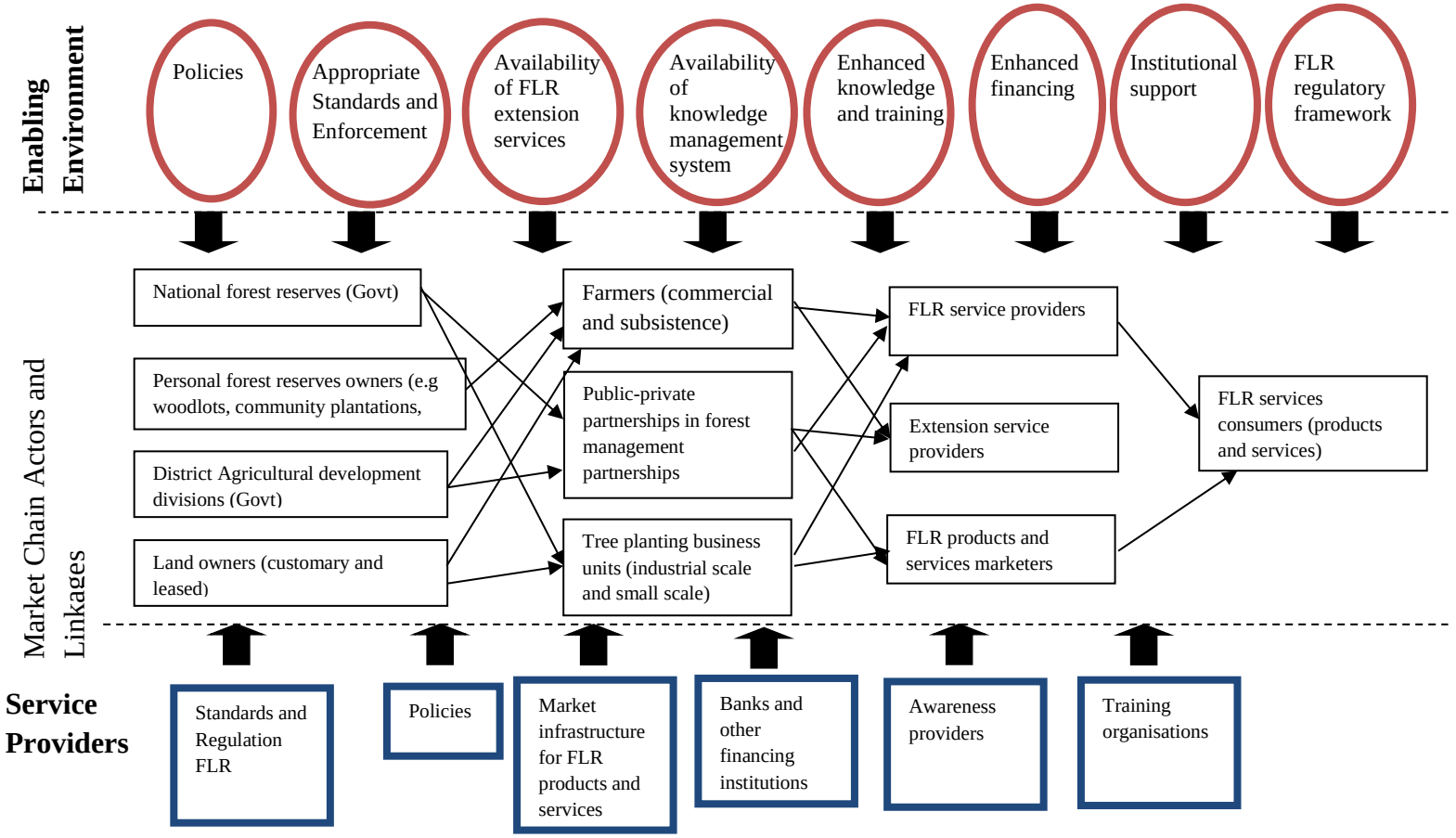
Market mapping for solar PV minigrids



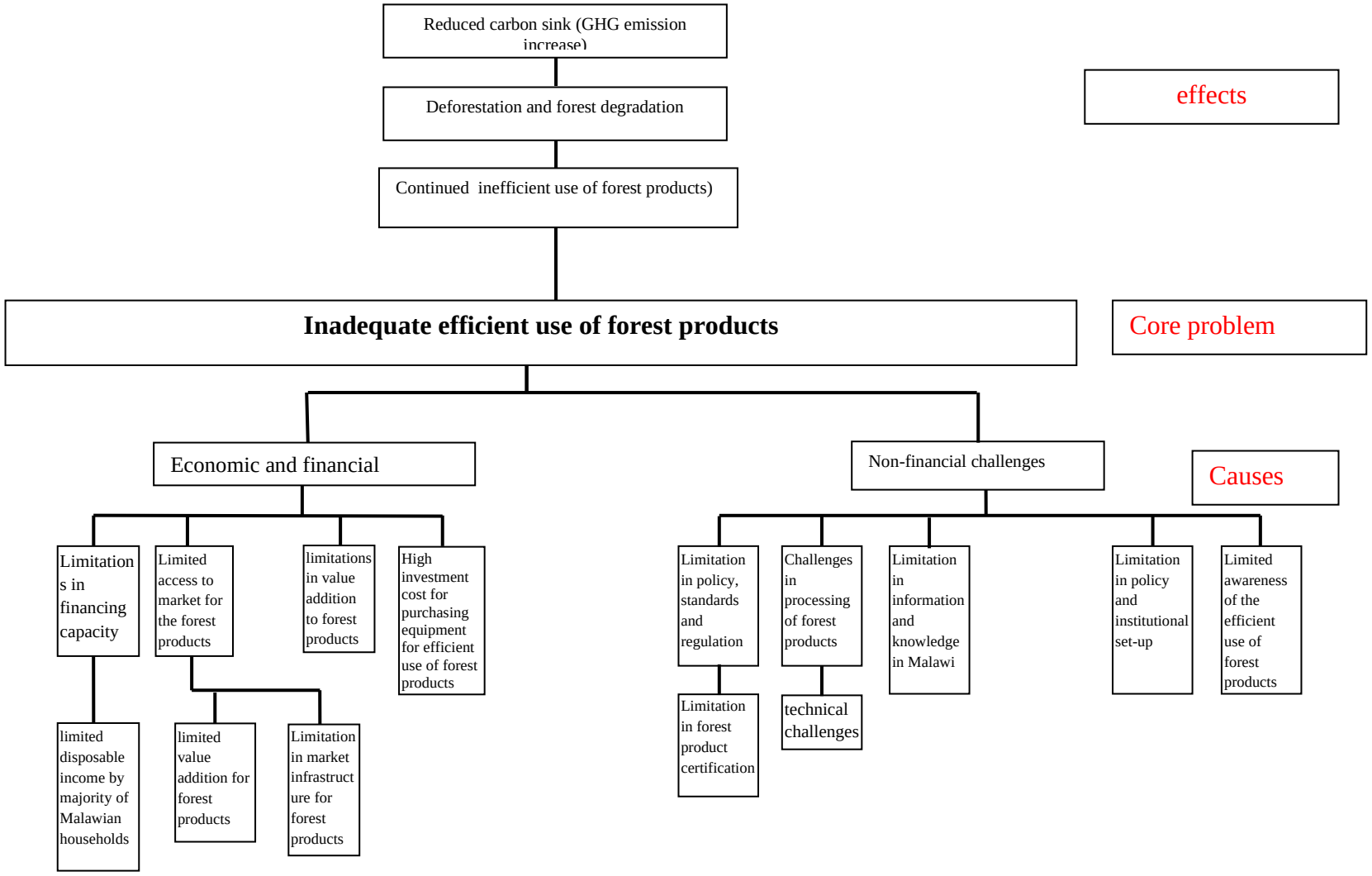
Problem tree for Forest and landscape restoration



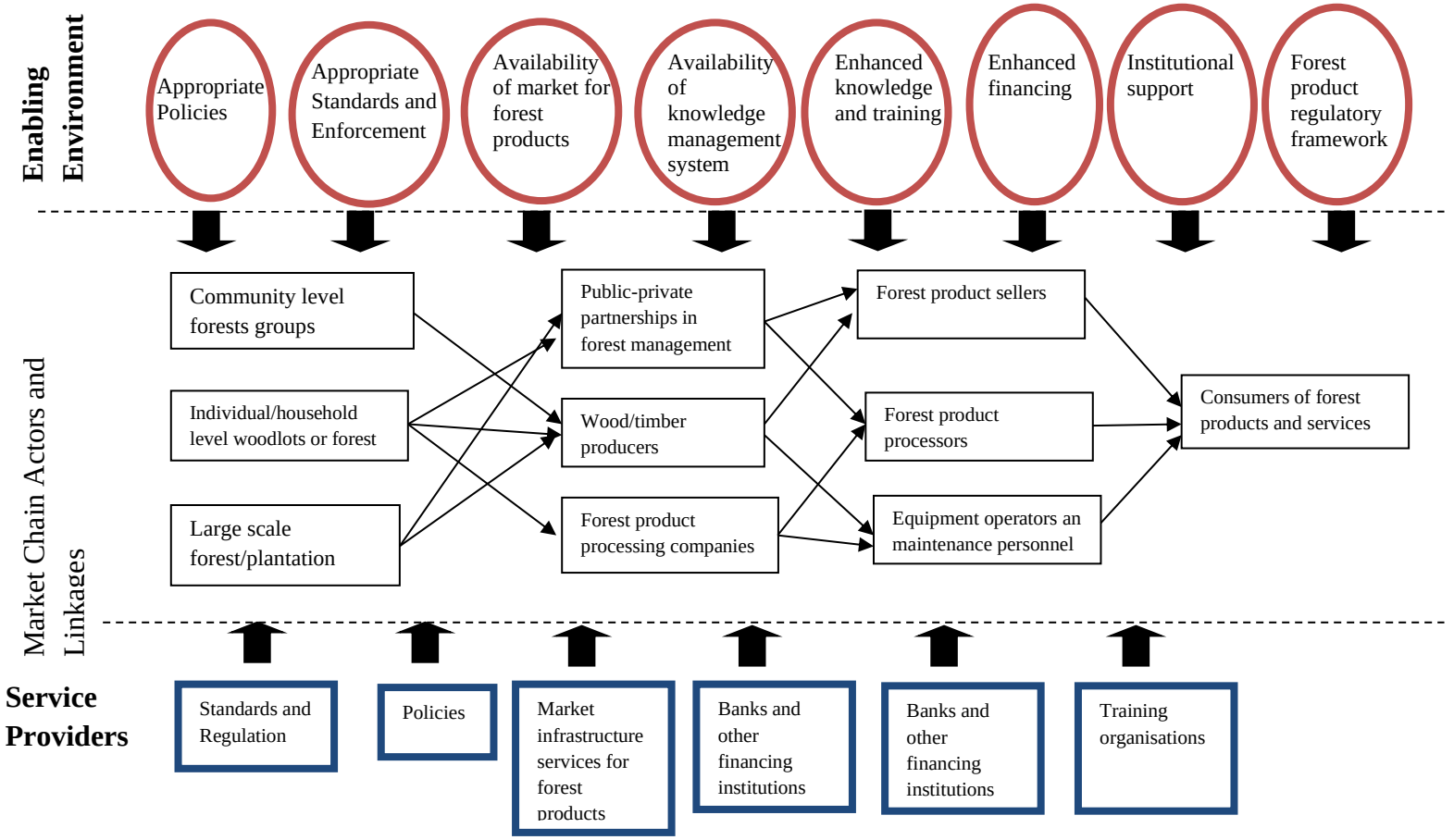
Market mapping for Forest and landscape restoration



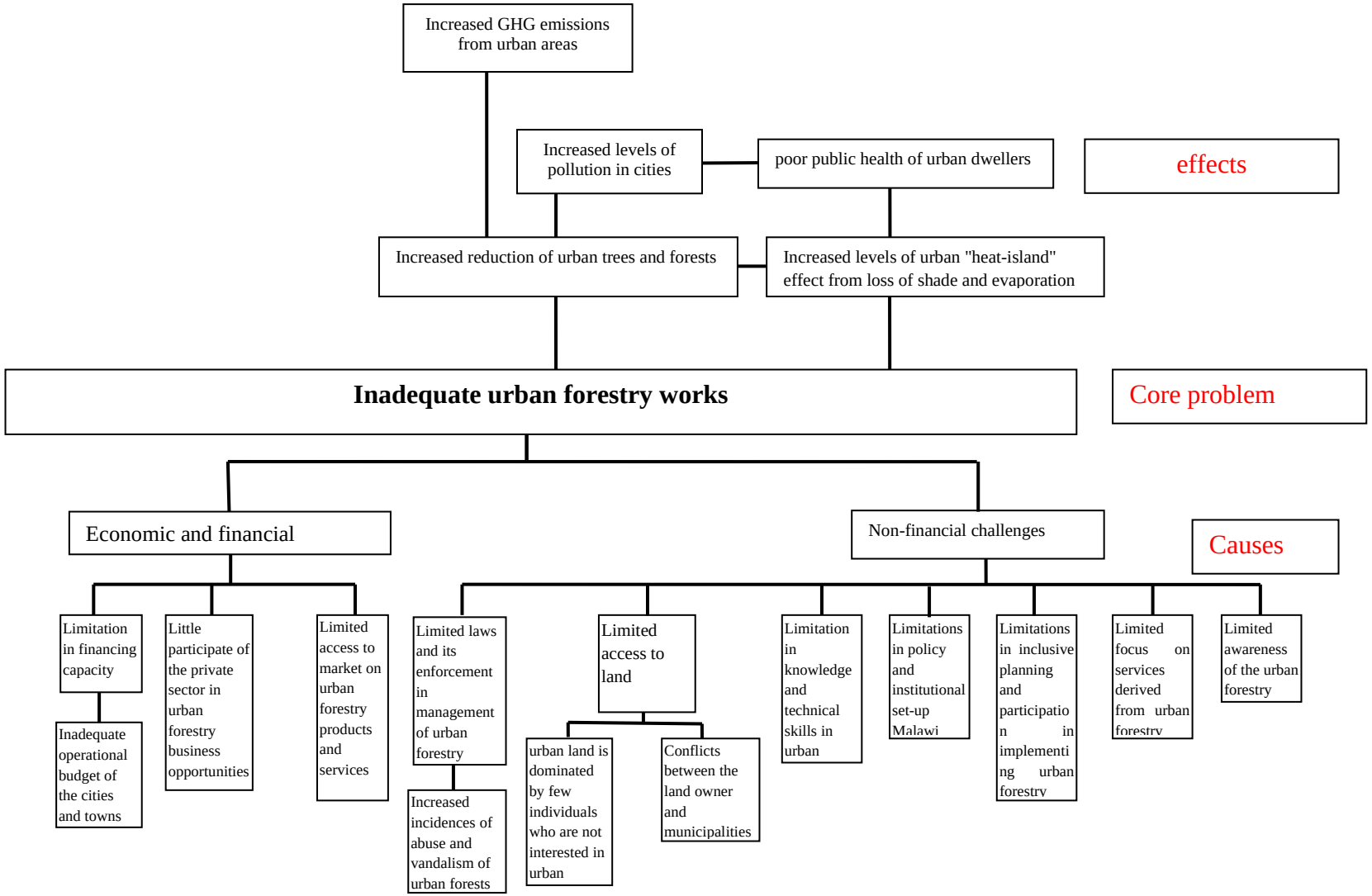
Problem tree for efficient use of forest products



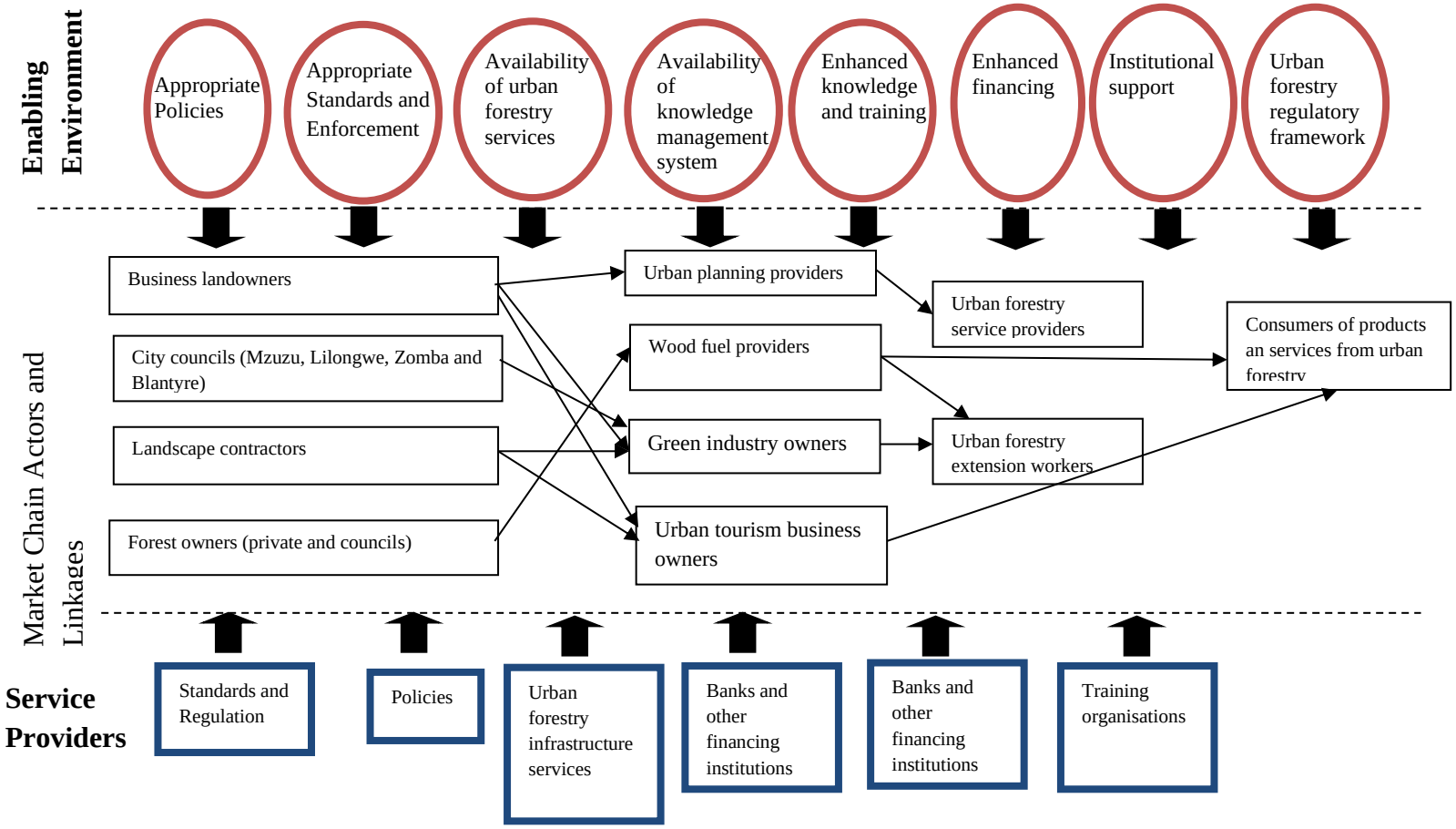
Market mapping for efficient use of forest products



Problem tree for urban forestry



Market mapping for urban forestry



Annex II: List of stakeholders involved and their contacts

No.	Name	Institution	Email
1	Dr Kazembe	Chitedze Research Station	hendrexkazembe@gmail.com
2	Mr Manase	Fisheries Department	moffatmanase@gmail.com
3	Mr Titus Zulu	Forestry Department	tituszulu2@gmail.com
4	Cornwell Chisale	Department of Energy	cchisale@energy.gov.mw
5	Innocent Nkangala	Department of Animal Health and Livestock Development	nkangalainno@yahoo.co.uk
6	Blessing Susuwele	Department of Agricultural Extension Service	susubless@gmail.com
7	Atupele Dzinkambani	Department of Economic Planning and Development	aprildzinkambani@gmail.com
8	Hanke Ndau	Department of Disaster Management Affairs	ndauhanke@gmail.com
9	Sydney Kamtukule	Water Resources Department	slkamtukule@gmail.com
10	Raphael Lali	Local Government	lali.raphael@gmail.com
11	Getrude Kambauwa	Land Resources Conservation Department	gkambauwa@gmail.com
12	Julius Ng'oma	Civil Society Network on Climate Change (CISONECC)	julius@cisoneccmw.org
13	Cynthia Chawani	Malawi Energy Regulatory Authority (MERA)	cchawani@mera.mw
14	Yohane Chimbalanga	National Commission of Science and Technology (NCST)	ychimbalanga@ncst.mw
15	Nelson Ngoma	Lilongwe Water Board (LWB)	nngoma@lwb.mw

16	Mathews Malata	Association of Environmental Journalist (AEJ)	malatamathews@yahoo.com
17	Judith kamoto	Lilongwe University of Agriculture and Natural Resources (LUANAR)	judithkamoto@gmail.com
18	Lawrence Chilimampunga	Electricity Generation Company (Malawi) Limited (EGENCO)	lchilimampunga@gmail.com
19	Karen Price (Coordinator)	Malawi Environmental Endowment Trust (MEET)	karen@naturetrust.mw
20	Mr Nkhokwe	Department of Climate Change and Meteorological Services (DCCMS)	j.nkhokwe@yahoo.com
21	Prof Chiotha	Leadership for Environment and Development (LEAD SEA)	schiotha@leadsea.mw
22	Henry Utila	Forestry Research Institute of Malawi (FRIM)	heutila@gmail.com
23	Harold Matola	National Statistical Office (NSO)	willardharold@gmail.com
24	Sipho Billiat	National Planning Commission (NPC)	siphobilliat@yahoo.com
25	Tawonga Mbale-Luka	Environmental Affairs Department	tawongam@yahoo.com
26	Shamiso Najira	Environmental Affairs Department	shamiso_b@yahoo.com
27	Ben Yassin	Environmental Affairs Department	benyassin@gmail.com
28	Evans Njewa	Environmental Affairs Department	evansnjewa@gmail.com
29	Chimwemwe Yonasi	Environmental Affairs Department	cyonasi@gmail.com

30	Golivati Gomani	Environmental Affairs Department	ggomani87@gmail.com
31	Hannah Siamme	Environmental Affairs Department	hannahkasongo@yahoo.com
32	Patrick Mkwapatira	Environmental Affairs Department	patmkwapa3@gmail.com
33	Christopher Manda (TNA Coordinator)	Environmental Affairs Department	mandachristophers@gmail.com
34	Dr Steve Makungwa	Centre for Applied Science (CASA)	smakungwa@gmail.com
35	Dr Suzgo Kaunda	Malawi Polytechnic	skaunda@gmail.com