THE GOVERNMENT OF THE REPUBLIC OF MALAWI

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE MITIGATION

FORESTRY SECTOR

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MALAWI TECHNOLOGY NEEDS ASSESSMENT REPORT FOR CLIMATE CHANGE MITIGATION IN THE FORESTRY SECTOR

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FOREWORD

Climate change remains one of the major threats to Malawi's development and people's livelihoods. Over the last few decades, the country has experienced an increase in magnitude and occurrence of climate related disasters such as floods and droughts almost in all districts including cities of Lilongwe and Blantyre. In order to tackle such climate change threats in a systematic manner, the National Climate Change Management Policy (NCCMP) was formulated. The Policy got approved and adopted by the Government of Malawi in 2016. The NCCMP guides the integration and mainstreaming of climate change management in development planning and implementation by all stakeholders at local, district and national levels. The policy further creates an enabling policy and legal framework for a pragmatic, coordinated and harmonized approach to climate change management.

The Government of Malawi is aware of the importance of technology in managing impacts of climate change. Technology Needs Assessment (TNA), an initiative that originated from the fourteenth Conference of Parties (COP 14) to the United Nations Framework Convention on Climate Change (UNFCCC), is a country-driven set of activities directed mainly at the identification, selection and implementation of climate change mitigation and adaptation technologies. Also, the TNA tracks the evolving needs of developing countries for new equipment, techniques, practical knowledge and skills. In Malawi, the TNA is aligned with National Climate Change Management Policy under priority area 3.4: Research, Technology Development and Transfer, and Systematic Observation. Under this priority area, the Policy highlights the role and contribution of technology and its transfer in the management of climate change. The TNA therefore provides a link between National Climate Change Management Policy and other policies and strategies to achieve Malawi's overarching development plan presented in the Malawi Growth and Development Strategy III. Due to the crossing cutting nature of climate change and its related impacts on national developmental sectors, the TNA also provides a framework for implementation of national sectoral priorities, strategies and plans which are related to climate change.

The process of developing Technology Needs Assessment Report for Malawi in the adaptation (water and agriculture) and mitigation (energy and forestry) sectors involved stakeholder participation, ensuring gender inclusion at very stage. The implementation of the prioritised climate technologies in the TNA reports will require a collaborative approach of all stakeholders including government, Non-Governmental Organisations (NGOs), civil society, Faith Based Organisations (FBOs), the private sector and academia. It is my sincere hope that the TNA Report will serve as a shop list of climate change technologies which are key for climate resilient building of the economy and livelihoods of Malawians while ensuring reduction in greenhouse gases.

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(v). Mr. Patrick Mkwapatira
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(vii). Mr. Lyson Kampira (from National Commission of Science and Technology of Malawi).

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LIST OF ABBREVIATION AND ACRONYMS

AFOLU	Agriculture Forestry and Other Land Use
BERDO	Bwanje Rural Environmental and Development Organization
CH_4	Methane
CO_2	Carbon dioxide
COP	Conference of Parties
CTCN	The Climate Technology Centre & Network
DNPW	Department of National Parks and Wildlife
DoF	Department of Forestry
EAD	Environmental Affairs Department
FLR	Forest landscape restoration
FMNR	Farmer managed natural regeneration
FOREP	Forestry Replanting and Tree Nursery Project
GDP	Growth Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas
GOM	Government of Malawi
IFMSLP	The Improved Forestry Management for Sustainable Programme
IGPWP	Income Generating Public Works Programme
INC	Initial National Communication
INDC	Intended Nationally Determined Contribution
MBS	Malawi Bureau of Standards
MCA	Multi-criteria analysis
MDAs	Ministry, Departments and Agencies (of Republic of Malawi)
MEAs	Multilateral Environmental Agreements
MGDS	Malawi Growth and Development Strategy
N_20	Nitrous Oxide
NAMA	Nationally Appropriate Mitigation Actions
NAPA	National Adaptation Programme of Action
NCST	National Commission for Science and Technology
NFLR	National Forest Landscape Restoration
NORAD	Norwegian Agency for Development Cooperation
NSCCC	National Steering Committee on Climate Change
NTCCC	National Technical Committee on Climate Change
PERFORM	Protecting Ecosystems and Restoring Forests in Malawi
SADC	Southern Africa Development Community
SDG	Sustainable Development Goal
SMIF	Sustainable Management of Indigenous Forests Project
SNC	Second national Communication
TCRET	Test & Training Centre for Renewable Energy Technologies

TNA	Technology Needs Assessment
TNC	Third National Communication
TPMCSOES	Tree Planting and Management for Carbon Sequestration and Other Ecosystems Services
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Deforestation
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP DTU Partnership	United Nations Environment Programme - Technical University of Denmark Partnership
UNFCCC	United Nations Framework Convention on Climate Change
VFA	Village Forest Area
VNRMC	Village Natural Resource Management Committee
WESM	Wildlife and Environmental Society of Malawi

EXECUTIVE SUMMARY

This report presents the Climate Technology Needs Assessment (TNA) for Malawi in the Forestry Sector. Malawi, like the rest of the world, is facing the challenge of managing climate change that arises mainly due to accumulation of greenhouse gases (GHGs) in the atmosphere. It is proven that the GHGs are contributed through human activities, such as removal of forest cover through deforestation and forest degradation. Through the United Nations Framework Convention on Climate Change, the world aims to stabilize atmospheric GHG concentrations to a level that would prevent dangerous anthropogenic interference with the global climate system. As it is now, this requires substantial reduction in GHG emissions while at the same time adapting to eventual impacts of climate change. Under UNFCCC arrangements, developing countries like Malawi are encouraged to take part in efforts to reduce the emissions because these efforts support national sustainable development goals. Technology plays a great role in reducing GHG emissions and/or vulnerability to climate change; hence the importance of climate technology needs assessment for the country. The TNA process has three objectives, given as follows:

(i). to identify and prioritize mitigation technologies for selected sectors/sub-sectors,

(ii). to identify, analyze and address the barriers hindering the deployment and diffusion of the prioritized technologies, including enabling the framework for the said technologies,

(iii). based on the inputs obtained from the two previous steps, to draw up Technology Action Plans with suggested actions presented in the form of project ideas.

This report presents the output of the first objective as the Technology Needs Assessment (TNA) Report for Malawi in the forestry sector. The Report was developed through a stakeholder participatory process at every step including mitigation sector identification, technology prioritization. It was planned to incorporate gender, but equal gender representation was challenged by proportionately small number of women in the forestry sector. The TNA process was bottom-up, including all relevant stakeholders to ensure acceptability and use of the prioritized technologies. Further, as informed by guidebook for countries conducting a Technology Needs Assessment and Action Plan development by the UNEP-DTU Partnership, the TNA process must be aligned to existing national plans and strategies in order to maximize their relevance and increase their likelihood of being implemented successful.

Identification of technologies was done through reviewing of national documents, including policies, strategies and reports in which climate change mitigation options are highlighted. These documents included the National Forestry Policy, Charcoal Strategy, and Intended Nationally Determined Contribution. This was to make sure that the TNA falls within the strategic plans of the Government of Malawi. After identification of technologies, facts about each of the technologies were written down basing on literature review, making reference to the Climate

Technology Centre & Network (CTCN) online resource as well as basing on expert knowledge. The developed technology fact sheets were used as reference materials in the technology prioritization process. A total of nine technologies were identified, and their technology factsheets developed. The technology prioritization was achieved through multi-criteria analysis, using criteria that were formulated by the expert working group. Top five prioritized technologies, in the order of prioritization, are listed as follows.

1) Forest landscape restoration
2) Efficient use of forest products
3) Farmer managed natural regeneration
4) Urban forestry
5) Biochar production from forest waste

CHAPTER ONE

INTRODUCTION

1.1 Background about Technology Needs Assessment Project

Malawi, and the rest of the world, is facing the challenge of managing climate change that arises mainly due to accumulation of greenhouse gases (GHGs) in the atmosphere. It is proven that the GHGs are contributed through human activities such deforestation and forest degradation, which remove forest cover necessary for carbon sink. Through the United Nations Framework Convention on Climate Change (UNFCCC), the world aims to stabilize atmospheric GHG concentrations to a level that would prevent dangerous anthropogenic interference with the global climate system (UNFCCC, 2019). As it is now, this requires substantial reduction in GHG emissions while at the same time adapting to eventual impacts of climate change. Under UNFCCC arrangements, developing countries like Malawi are encouraged to take part in efforts to reduce the emissions because these efforts support national sustainable development goals. Technology plays a great role in reducing GHG emissions. According to the Kenya Climate Innovation Center, climate change solutions lie in the technological innovations and creativity (Kenya Climate Innovation Centre, 2018).

The importance of technology in relation to global climate change response is revealed through international commitments made at Conference of Parties (COP) of the UNFCCC meetings (Haselip, et al., 2019). In relation to enhancing technology development and transfer to developing countries, in 2010, the COP established the Technology Mechanism that consists of two bodies: the Executive Committee and the Climate Technology Centre and Network (CTCN).
The Executive Committee is the policy making body, while the CTNC is the implementing body, accelerating development and transfer of technologies through provision of technical assistance upon request, creation of access to information and knowledge, and fostering collaboration among climate technology stakeholders (UNFCCC, n.d.). The CTCN has focal points in each country. The focal points act as National Designated Entities responsible for development and transfer of climate technologies, among others. In Malawi, it is the National Commission for Science and Technology (NCST, n.d.).

The Paris Agreement of 2015[1] Article 10, places importance of technology development and transfer in implementing climate mitigation and adaptation actions (UNFCCC, 2015). Article 10 also calls for the support to developing countries for "strengthening cooperative action on technology development and transfer at different stages of the technology cycle, with a view to

[1] The Paris Agreement of 2015 aims to strengthen response to keep global temperature rise well below 2 degrees Celsius above pre-industrial levels and to increase the ability of countries to deal with impacts of climate change as well as making the finance flows consistent with low carbon and climate resilient pathway.

achieving a balance between support for mitigation and adaptation". The Paris Agreement established the Technology Framework to "provide overarching guidance to the work of the Technology Mechanism in promoting and facilitating enhanced action on technology development and transfer in order to support the implementation of this Agreement". The new Technology Framework has been worked upon by COP in 2018 to guide how best to facilitate technology transfer to developing countries, thus to guide the Technology Mechanism. The New Technology Framework places more emphasis on TNAs and on the TNAs' roles in promoting and facilitating enhanced action on technology development and transfer.

The UNFCCC, through the process of Technology Needs Assessment (TNA), is supporting some developing countries to come up with sound climate mitigation technologies that could accelerate national development. Malawi is among the countries that are supported through the Global TNA Project phase III, which is funded by Global Environmental Facility (GEF) and implemented by UNEP in partnership with the Technical University of Denmark (UNEP DTU Partnership). In reference to climate change, Intergovernmental Panel on Climate Change (IPCC) defines technology as "piece of equipment, technique, practical knowledge or skills for performing a particular activity". The IPCC envelops climate technology to include three components: hardware, software and orgware.

According to Technology Needs Assessment Guidebook (Haselip, et al., 2019), a Technology Needs Assessment for a country is defined as "participatory activities leading to the identification, selection and implementation of climate technologies in order to reduce greenhouse gas and/or vulnerability to climate change. It stressed that the assessment process should gender inclusive and bottom-up, including all relevant stakeholders to ensure acceptability and use of the identified and prioritized technologies. The TNA process must be aligned to existing national plans and strategies in order to maximize their relevance and increase their likelihood of being implemented successful (Haselip, et al., 2019). The TNA process has three objectives, given as follows:

(i). to identify and prioritize mitigation technologies for selected sectors/sub-sectors,
(ii). to identify, analyze and address the barriers hindering the deployment and diffusion of the prioritized technologies, including enabling the framework for the said technologies,
(iii). based on the inputs obtained from the two previous steps, to draw up Technology Action Plans with suggested actions presented in the form of project ideas.

1.2 National Context and Existing national policies about climate change mitigation and development priorities

The Technology Needs Assessment is conducted within a country’s development priorities to ensure the realization of the ultimate aim of spurring sustainable development. The technology needs are therefore, derived from ongoing policies, programmes and projects, long-term vision documents as well as strategies for climate change mitigation and adaptation that are already in

place. For Malawi, these documents are presented in the following sub-sections, starting with the national context that presents a background for policies and strategies in climate change management.

1.2.1 National Context

Malawi is a landlocked country in Africa bordering Tanzania to the north and north east, Mozambique to the east, south and south-west, and Zambia to the west. It has a total area of 118,484 km^2, of which 20 % is covered by water bodies (World Atlas, n.d.). According to the national census of 2018, Malawi's population was at 17.56 million, growing at an annual rate of 2.9%; with 85% of its people living in the rural area (NSO, 2019). Malawi is one of the most densely populated countries in the SADC region.

From the GHG inventories presented in the Initial and Second National Communications to the UNFCCC, Malawi is a net GHG emitter, though small in absolute terms. The country is vulnerable to impacts of climate change that hampers socio- economic development. For example, in 2015, floods affected 15 out of 28 districts in Malawi, about 1.1 million people were affected, 230,000 were displaced, 176 were killed and 172 were reported missing. The total cost of loss and damage that the Government of Malawi incurred during these severe floods was estimated to be US$335 million, and the recovery and reconstruction costs stood at US$494 million (GOM, 2015). Malawi has low adaptive capacity to climate change and the Intended Nationally Determined Contribution report of 2015 showed that most of the key socio-economic sectors were vulnerable to impacts of climate change and climate variability.

The majority of the population depends on rain- subsistence agriculture for their livelihood. About 90% of the population use traditional biomass (firewood and charcoal) for energy (GOM, 2018), which is unsustainably supplied, causing both climate and environmental consequences. The national electrification access level was estimated at 10% (JICA Malawi Office, 2018). The electricity sector is dominated by hydroelectric power (98%) that is generated from run-of-river power stations that are installed along the Shire River (GOM, 2018). The Shire River is the only outlet of Lake Malawi. The lake is thus modelled as a natural reservoir for generation of electricity down the Shire River.

The country faces 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.

Malawi suffers the impacts of deforestation. These include loss of biodiversity and reduction in ecosystem services that provide income and social benefits like energy, food and medicine to the people (Ngwira & Wanatabe, 2019). Also, deforestation and land degradation have reduced the capacity to arrest soil erosion and enhance water infiltration in the catchment areas of important rivers such as the Shire River (Africa Geographic, 2015). This has contributed to increased levels of flash floods due to increased run-off, increased deposits of silt in the rivers during the rainy season and reduced based flow of rivers (Africa Geographic, 2015). The siltation of the Shire River interferes with hydropower generation (JICA Malawi Office, 2018), which directly affects economic activities of the country. Flash floods have caused extensive damage, displacing people and destruction of infrastructure such as roads and bridges. According to the Malawi Environment State of Environment and Outlook Report of 2010, other impacts of deforestation in Malawi include decreased soil fertility, water depletion, increased soil erosion, loss of biodiversity and increased pollution (GOM, 2010; GOM, 2018). Floods dominate the natural disasters in Malawi, which cost the country 1.7% of GDP annually (Floodlist, 2019). The incidences and severity of these natural disasters are exacerbated by climate change (GOM, 2018).

Malawi has implemented programmes and projects to conserve and manage forest resources, but with limited success. The revised National Forestry Policy of 2016 mentions some reasons that limit the success, such as low participation of communities, poor governance structures, lack of knowledge on land tenure and tree ownership. Lack of knowledge on land tenure and tree ownership is said to have contributed significantly to deforestation of forest resources (GOM, 2016). Other reasons for limited success in forest resources management as highlighted in the policy include: the research outputs in the forestry sector on curbing deforestation and forest degradation not being available to users of the research information. There is also lack of an adequate knowledge network and suitable platform to upload and access information. The collection and management of forest revenue have been poor, with limited investment and re-investment in forestry programmes.

1.2.2 Existing national policies about climate change mitigation and development priorities

Climate change is a global problem, thus, national policies and strategies on climate change management must be in tandem with regional and international policies as well as multilateral environmental agreements (MEAs). The management actions in form of reducing GHG emissions

(mitigation) are not only linked to lowering impacts of climate change but also linked to sustainable development. Thus, mitigation policies and strategies must be in tandem with development priorities at national, regional and international levels. Malawi signed the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro, Brazil in June 1992 during the United Nations Conference on Environment and Development (UNCED). The UNFCCC was then ratified by Malawi in April 1994. As a Party to the UNFCCC, Malawi has undertaken a number of studies and published reports in the areas of climate change mitigation and adaptation. The published reports are listed as follows:

(i). Initial National Communication (INC) in 2003;
(ii). Technology Transfer and Needs Assessment Report in 2003;
(iii). National Adaptation Programme of Action (NAPA) in 2006 (revised in 2015);
(iv). Second National Communication (SNC) in 2009;
(v). Nationally Appropriate Mitigation Actions (NAMA) in 2015; and
(vi). Intended Nationally Determined Contributions (INDC) in 2015
(vii). Third National Communication (TNC) is being developed, and expected to be completed by the end of 2019.
(viii). First Biennial Update Report is being developed, to be completed by the end of 2019

Malawi as a member of the United Nations, is committed to achieve Sustainable Development Goal (SDG) 15, which aims to aims to "*protect, restore and promote sustainable use of terrestrial ecosystems, managing forests sustainably, combat desertification, and halt and reverse land degradation and halt biodiversity loss*" by 2030 (United Nations, n.d.). Further, the country signed the Paris Agreement of UNFCCC in 2016, which is aimed at keeping the increase in global average temperature to well below 2 C above pre-industrial levels; and to pursue efforts to limit the increase to 1.5°C, recognizing that 1.5°C would substantially reduce the risks and impacts of global climate change (UNFCCC, 2016). The Paris Agreement mandates Malawi to determine, plan, and regularly report on the contribution that the country undertakes to mitigate climate change. This Technology Needs Assessment report provided a useful vehicle for Malawi to engage in mitigation activities in line with the Paris Agreement of 2016.

Malawi and the rest of the United Nations Member countries adopted the Sustainable Development Goals (SDGs) in 2015, which aim to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. At continental level, Malawi subscribes to the Agenda 2063 of African Union where among others; Africa aspires to be prosperous through inclusive growth and sustainable development. To achieve this, the Agenda 2030 is geared to make sure that, among others, Africa's unique natural endowments, its environment and ecosystems, including its wildlife and wild lands are healthy, valued and protected (African Union, 2013). The Malawi Government overarching development policy document, the Malawi Growth and Development Strategy (MGDS) III (2017-2022) has been framed to reflect these international policies in which the

country subscribes to. It aims to move Malawi to a prosperous, competitive and resilient nation, while addressing challenges such as climate change impacts and environmental degradation (GOM, 2017). In the MGDS III, just like the predecessors (MGDS I and II), the Malawi Government prioritizes climate change management such as mitigation and adaptation, under the Key Priority Area of "Agriculture, Water Development and Climate Change". Also, in order for the country to continue on actions to make the country environmentally sustainable, the MGDS III, through other development areas on "Environment and Sustainability" strategized promotion of integrated afforestation for wood fuel, fruit production windbreak and shade, timber and poles at household and community level to address wood fuel shortage and curb encroachment into reserves, for a strengthened environmental management (GOM, 2017). In order to achieve the international and national environmental and climate change management aspirations in the forestry sector, the Government has development strategic documents, among others the National Forestry Policy and the Climate Change Management Policy.

The Malawi Government, with support from CTCN through the Council for Scientific and Industrial Research (CSIR), developed the Incubator Programme of the Climate Technology Centre and Network (CTCN). The Incubator Programme is a capacity-building programme that is aimed at facilitating the implementation of Malawi's Nationally Determined Contributions (NDCs) through the identification and support for technology interventions to help reduce GHGs. The programme provides support to Least Developed Countries (LDCs) to increase and strengthen institutional capacities for NDC implementation. The Programme helps LDCs bring together key national stakeholders around the NDE to identify and prioritise specific technology actions for NDC implementation through the development of a technology roadmap. The Forestry Sector was one of the prioritised sectors for development of climate mitigation technologies, due to the sector being the highest contributor (83%) of GHG emissions in Malawi. Through stakeholder consultations, the Malawi Government selected agroforestry, and afforestation and reforestation as priority technologies to work with the CTCN to reach the targets included in Malawi's NDCs.

In addition to international instruments and national development strategy, the following sections present the national sectoral policies and strategies for climate change management in the forestry sector.

1.2.2.1 National Climate Change Management Policy

The Government of Malawi developed the National Climate Change Management (NCCM) Policy in 2016 (GOM, 2016) to act as a key instrument for managing climate change in the country and to act as a guide for integrating climate change into development planning and implementation by all stakeholders at local, district and national levels in order to foster the country's socio-economic growth and subsequently sustainable development. The overall goal of the Policy is to "To promote climate change adaptation, mitigation, technology transfer and capacity building for sustainable livelihoods through Green Economy measures for Malawi".

The NCCM Policy affirms the Government's commitment to fully addressing climate change issues in order to reduce the vulnerability of its people, ecosystems and socio-economic development to the effects of climate change through adaptation and mitigation, technology transfer and capacity building. Translating this Policy into action will build Malawi's resilience to overcome the challenges of climate change and embrace the opportunities that are available to enable the country lay a solid foundation for a sustainable and prosperous Malawi. The policy further demonstrates the commitment of Malawi Government to meeting its international obligations towards addressing the challenges of climate change, such as the Sustainable Development Goal 13 as well as the Paris Agreement of 2016.

1.2.2.2 National Forestry Policy

Trees and forests have a significant role in climate change mitigation and management of environment in general. Through photosynthesis process, trees and forests sequester carbon dioxide, contributing to balance of oxygen, carbon dioxide and humidity in the air. Forests also protect watersheds, which are important sources of freshwater, not only in Malawi, but worldwide. According to a report from the United Nations, about 75% of freshwater worldwide is sourced from watersheds (United Nations, n.d.). Further, forests reduce the risk of natural disasters, including floods, droughts, landslides and other extreme events. Furthermore, forests and trees provide important products and services of economic and social value to the country. As an example on economic benefits of forests, the Economic Valuation of Sustainable Natural Resources Use in Malawi, 2011, forests contribute 6.2% to the GDP (Gil, 2011). In Malawi, the contribution of forestry to Growth Domestic Product (GDP) are subsumed under agriculture and do not take into account the value of non-wood forest products, processed timber or the informal trade in fuel wood and charcoal (GOM, 2016). Thus, the potential of the forestry sector to contribute to national economic development is underestimated.

In Malawi, forestry matters are fully supported by the Government and other development partners. One such support is manifested through the formulation of the National Forest Policy (NFP) of 2016 (GOM, 2016), which is a revised version of the 1996 Policy. The goal of the revised policy is to conserve, establish, protect and manage trees and forests for the sustainable development of Malawi in a holistic manner, in a Malawi's democratic era operating within the *Decentralization in Forestry - Moving Forward Together* (GOM, 2006). The policy aspires to control deforestation and forest degradation through promotion of forest conservation technologies and practices, as well as through creation of an enabling framework for inclusive participation in forest conservation and management. Further, the policy promotes strategies that will contribute to increased forest cover by 2% from the current 28% to 30% by 2021 through sustainable management of existing forest resources. The revised policy has ten priority areas namely: Community Based Forest Management; Indigenous Forests, Forest reserves; ecosystem management; Industrial Forest Plantations and Estates Management; Forest Regulation and

Quality Control; Forestry Knowledge Acquisition and Management; Capacity Development for the forest sector; Biomass Energy Development; Development of Forest Based Industries; Regional and International Cooperation; and Financing Mechanisms.

The revised NFP is framed to support achievement of overarching policy of national growth and development, as stipulated in the Malawi Growth and Development Strategy III, while being aligned to other national policies. The other national relevant policies the revised NFP is aligned to are: the National Energy Policy of 2018, National Land Policy of 2002, National Environmental Policy of 2004, The Water Policy of 2005, National Parks and Wildlife Policy of 2000, and National Population Policy of 2013. Apart from being in line with other national existing policies and strategies, the revised National Forestry Policy also aligns to bilateral and multilateral agreements and conventions such as the Rio Declaration, United Nations Framework Convention on Climate Change (UNFCCC), the Montreal Protocol, United Nations Convention to Combat Desertification (UNCCD), United Nations Convention on Biological Diversity (UNCBD), United Nations Convention on International Trade in Endangered Species of wild fauna and flora (CITES).

In order to achieve the NFP goal, the Government of Malawi has laid down institutional arrangement to manage roles and responsibilities of several stakeholders in the forestry sector. The institutional arrangement include relevant Government of Malawi ministries and departments, Private Sector, Academia and Research Institutions, Civil Society, Development/Cooperating Partners, Traditional Leaders, City and District Councils, Forestry Management Board, Parliamentary Committee on Agriculture and Natural Resources, and Media.

1.2.2.3 National Energy Policy

The Malawi's energy supply sector is dominated by biomass energy. This biomass is mostly in form of firewood and charcoal, which is supplied unsustainably from trees and forests. As it has already been pointed out, unsustainable supply and inefficient use of biomass as a source of energy has contributed to deforestation and land degradation in the country. The country is committed to addressing the challenges facing the energy sector in the biomass component, with the aim of reducing the biomass mix in the total energy mix, which places the country in the path of management climate change and enhancing the environment. Through the first National Energy Policy of 2003, the Government of Malawi planned to transform the country’s energy economy from one that is overly dependent on biomass to one with a high modern energy component, in which the contribution of biomass to the total energy mix is reduced from 93% in 2000 to 30% in 2050 (GOM, 2003). This could be achieved through increasing the mixes of other modern energies like electricity and renewables. The Energy Policy of 2003 has been revised in 2018 to reflect emerging issues and incorporate lessons learnt in the implementation of the 2003 policy. The energy emerging issues in Malawi include the need in the following areas: diversity in the sources of supply of energy, economic efficiency in the supply of energy, efficiency in energy use, energy

security, the cost and availability of energy resources to low income groups, conservation of energy resources, and research in energy supply technologies.

Concerning diversification of sources of energy, the new Energy Policy of 2018 has revised the target of achieving biomass energy supply mix, such that by 2035 the biomass contribute 33.5% to the energy mix from 88% in 2008 (GOM, 2018). This is planned to be achieved through increasing mixes of modern sources of energy, as shown in Table 1. The reduction of biomass energy mix has a positive effect in the conservation of forest resources in Malawi.

Table 1: Projected energy supply mix from 2008 to 2035

Energy Source						
	2008	2015	2020	2025	2030	2035
Biomass	88.2	80.5	70.3	57.6	44.8	33.5
Liquid fuels and biofuels	6.4	9.9	11.6	13	14.2	14.7
LPG, Biogas and Natural Gas	0	0.1	2	3.7	6	9
Electricity from renewable sources	2.6	6.9	10.7	16	23	28.9
Electricity from non-renewable sources	0.0	0.3	1.8	5.6	7.5	8
Coal	2.8	2.3	3.6	4.1	4.5	4.9
Electricity from nuclear energy	0	0	0	0	0	1

The 2016 and 1996 National Forest Policies agree with the revised National Energy Policy (NEP) on the consequences of overreliance on biomass energy supply. In terms of policy directions, as far as biomass energy from trees and forests is concerned, its use as an energy source must comply with the National Forestry Policy, since biomass is a downstream product of forests. The Department of Forestry (DoF) is in charge of managing Malawi's forests and forest products. The Department of Energy Affairs (DoEA) is charged with formulating energy policy but has no authority over the use and management of forests and forest products. Within the biomass energy sub-sector, the prevailing policy and legal provisions consider biomass to be subject to forestry policy before it is harvested and energy policy thereafter. Therefore, a more coordinated effort is required by the DoF and the DoEA on interventions in sustainable supply and efficient use of biomass energy. For example, the coordinated approach need to address improved efficiency in the use of biomass (through end-use technologies efficient cook stoves) and preserving a sustainable supply of biomass through controls on forest clearing for agriculture and other land uses. The management of biomass energy supply in the country requires a holistic approach; this was one of the emerging issues that guided development of the Biomass Energy Strategy in 2009 (GOM, 2009). Under the institutional arrangement, to achieve energy policy objectives, the Department of Forestry has been included to ensure sustainable supply of biomass energy through adherence to regulations on biomass supply by all stakeholders. Apart from BEST, other strategy that supports implementation of energy policy on biomass sub-sector is the National Charcoal Strategy (GOM, 2017) and the National Forest Landscape Restoration Strategy (GOM, 2016).

1.2.2.4 Biomass Energy Strategy

To symmetrically respond to the challenges of deforestation resulting from unsustainable harvesting and use of biomass energy, Government of Malawi came up with the Biomass Energy Strategy (BEST) in 2009 (GOM, 2009). The Strategy is aimed at developing a rational and implementable approach to the management of Malawi's biomass energy sector through a combination of measures designed to improve the sustainability of biomass energy supply, raise end-user efficiencies and promote appropriate alternatives. The strategy, BEST, forecasted that the Malawian energy market would continue being heavily charcoal dominated, unless interventions on fuel substitution are implemented. By far, the demand for cooking energy dominates the thermal energy requirements, which is mostly supplied from charcoal in urban areas and firewood in rural areas. The demand for charcoal is already in excess of sustainable supply in Blantyre and Lilongwe. This scenario has negative consequences on forest resources of the country as already stated, as already stated. The Strategy is poised to guide the country to achieve the following objectives: increase the supply of sustainable wood-fuels; increase the efficiency of energy use; and create the institutional capacity to manage the biomass energy sector effectively and implement the Strategy.

1.2.2.5 The Malawi Charcoal Strategy

The Malawi Government recognizes that charcoal and firewood will remain the dominant sources of energy, until sometime in the future. Charcoal and firewood are the major sources of cooking energy in Malawi. Over, the years, it is seen the share of households cooking using charcoal has increased, for example, in 2018, 18% of households used charcoal (NSO, 2018), up from 8% in 2008 (NSO, 2008). This might be due to increased urban population as charcoal is the preferred cooking energy in urban areas. While firewood might be collected sustainably, charcoal is not, leading to deforestation and forest degradation. The country has had corrective efforts, but these have focused narrowly on prohibition of charcoal production, which has promoted illegality in production, transportation and marketing. Considering that charcoal is most important course for deforestation and forest degradation, in 2017, the Government of Malawi came up with the National Charcoal Strategy (NCS) to incrementally address problems of charcoal production and demand in the near, medium and long term. The NCS has a time period of 20 years (from 2017 to 2030). The goal of the National Charcoal Strategy is to provide a framework for the Government of Malawi and development partners to address the linked problems of increased deforestation and growing demand for cooking and heating fuel, with defined and prioritized near-term, medium-term and long-term actions. The National Charcoal Strategy (NCS) formulated around seven pillars, namely: promotion of alternative household cooking fuels; promotion of fuel-efficient cookstove technologies; promotion of sustainable wood production; strengthening of law enforcement; regulation of sustainable charcoal production; enhancement of livelihoods; and information, awareness and behavior change.

The NCS supports Government's objectives to *arrest and reverse deforestation and forest degradation and to reduce energy overdependence on solid biomass fuels.* In order to benefit from

synergies with other national development and international documents, the NCS is aligned with various strategies and policies including Malawi Growth and Development Strategy, Biomass Energy Strategy, Energy Policy, Climate Change and Management Policy, and National Forestry Policy, all of them promoting reduction of deforestation for sustainable development. The Strategy also supports the implementation of various global initiatives and goals, including the UN Sustainable Energy for All (SE4ALL) by 2030.

1.2.2.6 The National Forest Landscape Restoration Strategy

Malawi recognizes the challenges emanating from unpredictable climate and landscape degradation, which requires action. One of the actions was to develop the National Forest Landscape Restoration (NFLR) Strategy (GOM, 2016) in 2016, to act as a vehicle to address the challenges. NFLR assists the country to achieve the set goals in a number of policies such as the National Forest Policy (2016), the National Climate Change Management Policy (2016). Also, through the NFLR, potential avails to Malawi to mitigate the challenges of soil degradation and nutrient depletion. Further, the NFLR enhances the opportunity for obtaining greater output from degraded lands and forests, and carbon sink.

CHAPTER TWO

INSTITUTIONAL ARRANGEMENT FOR THE TNA AND STAKEHOLDER INVOLVEMENT

2.1. Institutional Arrangement for conduction of TNA Project in Malawi

The TNA Report forms an important reference document for identification and promotion of climate technologies for reduction of GHGs and adjustment to actual or expected climate and its effects in a particular country. The institutional arrangement is therefore important to make sure that there is provision for project oversight to ensure delivery of the project outcomes and achievement of the project objectives and goals that have been set up in Malawi. The institutional set up was guided by the following:

(i). The guidance notes on the institutional arrangement, presented in the UNEP DTU Partnership (UDP) Guidebook for conducting TNA project (Haselip, et al., 2019), and

(ii). The existing institutional structures already in place in Malawi for managing and coordinating climate change activities.

In line with the guidance from the UDP Guidebook for conducting TNA Project, the national institutional arrangement considered the critical components a TNA institutional structure including National Steering Committee, National TNA Committee, TNA Coordinator, National Consultants and Sector working groups. The setup of the national institutional arrangement was proposed and adopted by stakeholders at the Project inception meeting is given in Figure 1.

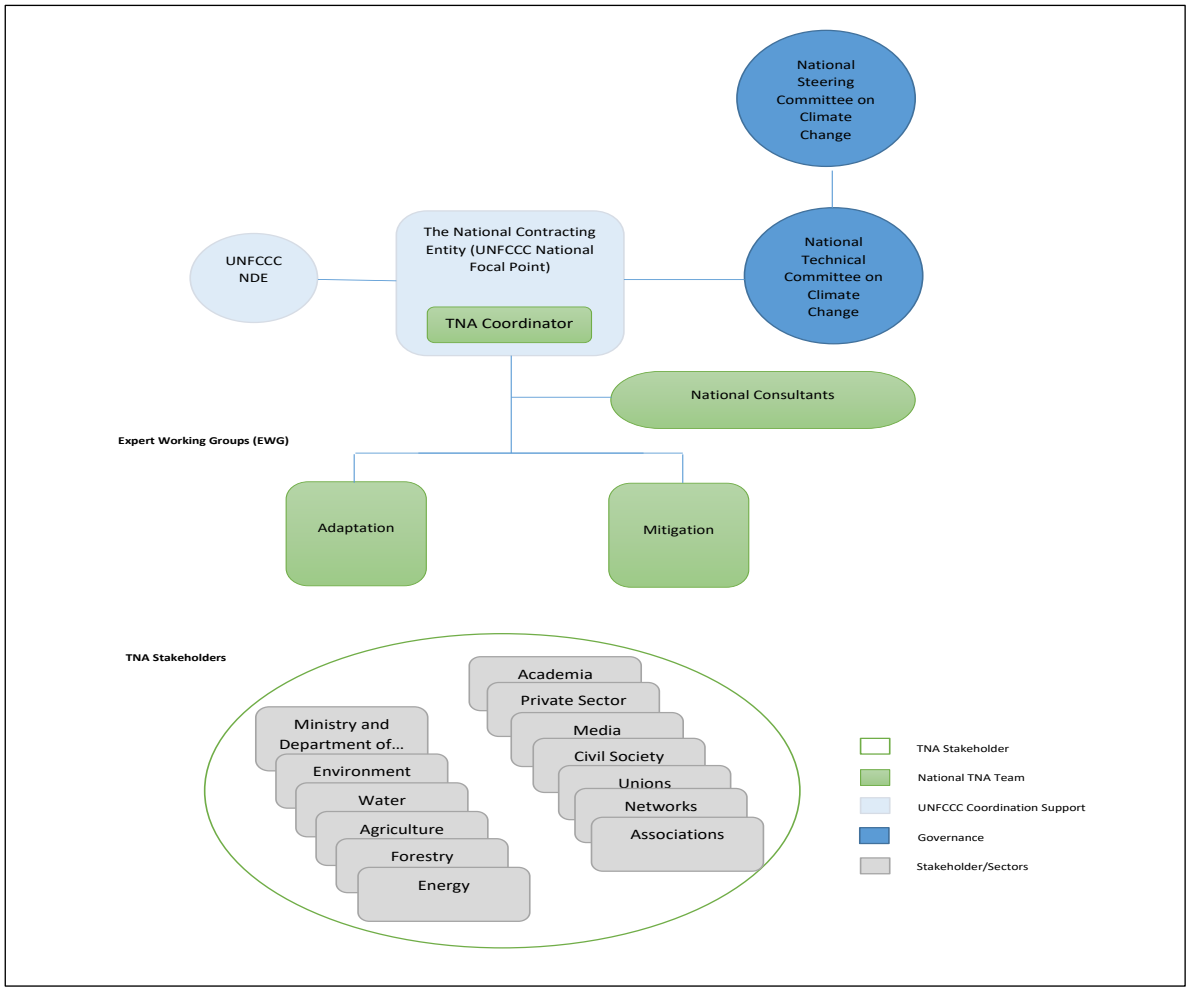

Figure 1 Malawi's institutional arrangement for managing the TNA project

The figure 1 also shows linkages between different elements of the TNA institutional arrangement in Malawi. The roles and responsibilities of each element are presented in the following sections:

2.1.1 National Steering Committee on Climate Change

In Malawi, the National Steering Committee on Climate Change (NSCCC) provides a high level guidance, political oversight and cross-sectoral coordination of the TNA Process. The Committee is the highest political level. It provides a political acceptance of the deliverables of the TNA Project. The NSCCC is one of the coordination bodies provided by Climate Change Management Policy of 2016 to provide policy direction on climate change issues in the country. The NSCCC is chaired by the Ministry of Finance and Development Planning and its Secretary is the Climate Change Secretariat in the Ministry of Natural Resources, Energy and Mining where the National Contracting Entity (UNFCCC Focal Point) is based. The NSCCC members include high level representatives from Government Ministries responsible for making policy related to climate change. The Committee is co-chaired by the Secretary to the Treasury who delegates to Chief Director of Economic Planning and Development and the Deputy Resident Coordinator for UNDP Malawi.

2.1.2 National Technical Committee on Climate Change

National Technical Committee on Climate Change (NTCCC) provided technical oversight of climate change management related projects, including the TNA Project, as provided for in the Climate Change Management Policy of 2016. It provides technical guidance to the NSCCC, described in Section 2.1.1, on all climate change issues in the country. The Committee comprises all key climate change related Government Ministries and Departments. Membership to the Committee (NTCCC) is at Director level. The NTCCC is chaired by the Department of Climate Change and Meteorological Services. The National Climate Change Management Policy (2016) provides room for co-opting other members to the Committee.

2.1.3 TNA Project Secretariat and Coordination

The TNA Project is housed in the Environmental Affairs Department (EAD), in the Ministry of Natural Resources, Energy and Mining, as its Secretariat and authority to oversee implementation of the TNA Project. The EAD is also the UNFCCC National Focal Point for Malawi. Among others, the Secretariat liaises with the UNEP DTU Partnership (UDP) and the Regional Centre (Energy Research Centre of the University of Cape Town in the Republic of South Africa) to ensure quality on the TNA process and its subsequent implementation. The Project has incorporated coordination unit to ensure that Project activities are coordinated well . The TNA Coordinator is Mr. Christopher Manda, based at the EAD. The Coordinator, among others, facilitated working sessions of the Adaptation and Mitigation Expert Working Groups (EWGs) under the National Technical Committee on Climate Change.

2.1.4 Expert Working Groups

Expert Working Groups (EWGs) are stakeholder platforms, through which the TNA Project is implemented. Again, establishment of EWGs is provided for in the National Climate Change Management Policy of 2016. The EWGs are formed under the National Technical Committee on Climate Change. There are two EWGs, each representing one priority theme of climate change management in Malawi (mitigation and adaptation). This TNA Project utilises the EWG on mitigation. Membership of the EWGs on mitigation priority sectors (Energy and Forestry) includes all TNA stakeholders, as indicated in Figure 1 (showing institutional arrangement for managing the TNA Project), summarised in Appendix 2.

2.1.5 National TNA Consultants

National TNA consultants are experts on climate change mitigation priority sectors (energy and forestry) responsible for supporting the TNA process in Malawi. The National Consultants selection went through a transparent and national procurement process guided by the Government of Malawi Public Procurement and Disposal of Asset Authority (PPDA) regulations. After the contracting processes were concluded in June 2019, the National Consultant made an inception report presentation to EAD and its management on 6th July 2019. This was done to ensure that the National Consultant get proper guidance on the expected roles in the TNA Project in Malawi. The

National Consultant for mitigation priority sectors (Energy and Forestry) is responsible for the following tasks:

(i). identifying and prioritizing technologies for the energy and forestry sectors through a participatory process with the broad involvement of relevant stakeholders and experts and the development of the TNA report;

(ii). leading the process of barrier analysis and development of an enabling framework for the prioritized technologies and development of the BAEF report; and

(iii). development of a technology action plan and awareness materials on the outputs of the TNA process in Malawi such as policy briefs.

Additionally, the National Consultant was responsible for capacitating the Mitigation Expert Working Group (EWG) members on the Multi-criteria Analysis (MCA) process. This was key in the prioritization of climate technologies in the mitigation and adaptation sectors and for the members own knowledge.

2.2 Stakeholder Identification and Engagement Process

TNA Project is a participatory and stakeholder-driven process. Stakeholder engagement enhances legitimacy and ownership of the Project and its related outputs. Also, stakeholders are different in nature; therefore their importance in actualization of the TNA goals qualifies the significance of paying attention to stakeholder engagement process. In this TNA Project, the guidebook by the UNEP DTU Partnership on Identification and Engagement of Stakeholders in the TNA Process (Rogat, 2015) informed on the stakeholder engagement process that was followed. Further, to ensure that all relevant stakeholders were identified in this TNA Project, stakeholder analysis grid approach, development by Hovland (2005) was employed. Then, the list of identified stakeholders was compared and aligned to the proposed membership set out in the Mitigation Expert Working Group terms of references. Additional stakeholders to the Mitigation EWG membership were Government Ministry responsible for Local Government, utility companies and media. These additional stakeholders were co-opted to form part of the identification and prioritization of technologies. Stakeholders were engaged at all stages in the TNA process including project inception, NTCCC and climate technologies prioritization meetings.

The official stakeholder engagement was initiated during the inception meeting of the TNA Project, held at Sunbird Lilongwe Hotel on 6th November 2018. At this meeting, the stakeholders were briefed about the TNA Project, including its processes, outputs and timelines. Appendix 2 provides a list of stakeholders who attend this meeting. This meeting was followed by another one,

where the potential national consultants who would be recruited to support the TNA process attended.

Figure 1: Group photo of Participants of the TNA Project Inception Meeting (*Photo credit:* Chris Manda)

The TNA Project was introduced to the National Technical Committee on Climate Change (NTCCC) during a meeting held at Golden Peacock Hotel on 15th November 2018. A presentation was made by the TNA Coordinator on the TNA process, outputs and implementation structure, status of implementation and way forward. Figure 3 is a picture showing stakeholders in attendance of the meeting.

Figure 2: Photo of members and stakeholders of the National Technical Committee on Climate Change attending the meeting (*Photo credit:* Chris Manda)

The Secretariat, through the TNA Coordinator conducted a third stakeholder meeting was in Salima District, at Matundu Lodge, from 17 - 19th September 2019. This meeting was to prioritize the consultant-identified climate technologies on mitigation. The meeting was attended by the Mitigation Experts Working Groups (EWGs) members, including the co-opted stakeholders. At this meeting, apart from the presentation on the TNA Project, stakeholders were introduced to principles of multi-criteria (MCA) analysis, the concept that was used in technology prioritization. The output of this meeting was a list of prioritized climate technologies in the energy and forestry sectors. The stakeholders prioritized climate technologies using the MCA analysis tools. Some of the highlights of the stakeholder involvement during the technology prioritization meeting are presented in Figures 4 and 5 in the form of pictures.

Figure 3: Photo showing TNA consultant for adaptation facilitating the MCA process (*Photo credit:* Mathew Malata)

Figure 4: Photo of Expert Working Groups at a technology prioritization workshop (*Photo credit:* Mathew Malata)

2.3 Gender Inclusiveness in the TNA Project

Women play an important role in supporting households and communities to mitigate and adapt to climate change (UNDP, 2009), for example in the promotion of management and efficient uses of forest resources. However, gender inequality is among other factors that impedes them. For example, women do not have equal participation in decision making compared to men in investment and access to mitigation technologies. Therefore, gender inclusiveness in climate change actions, should be encouraged in order to achieve sustainable development. The United Nations Climate Change (UNCC) recommends equal women participation when it comes to climate policy or project implementation to ensure improved outcome and effectiveness (United Nations Climate Change, n.d.). In addition, gender inclusiveness makes the process of implementing a climate change project (like TNA) complete, and the relevance of its implementation is well understood by all stakeholders. In this TNA Project, gender consideration was guided by the UNEP DTU guidance document on *gender responsiveness when conducting TNA* (De Groot, 2018).

The TNA process was designed to include women at all stages, including project inception, NTCCC and climate technologies prioritization meetings. However, the representation of men still dominated those of women at every stage of the process, which calls for more work to be done to ensure equal representation in future TNAs. The forestry sector is generally male dominated and thus, continued mainstreaming of gender inclusiveness policies at ministry and department levels should be encouraged and supported.

CHAPTER THREE

TECHNOLOGY PRIORITIZATION IN FORESTRY SECTOR

3.1 Malawi's forest resources

Technologies to mitigate greenhouse gas in the forestry sector could be well understood by first characterizing the Malawi's forest resources. Food and Agricultural Organization (FAO) defines forest and woodland based on area of tree crown cover and size of the area under trees (FAO, n.d.). It is a forest when land with tree crown cover (or equivalent stocking level) is more than 10 percent and area is more than 0.5 hectares (ha). Also, the trees should be able to reach a minimum height of 5 meters (m) at maturity in situ. It is a woodland when land is either with a tree crown cover (or equivalent stocking level) of 5-10 percent of trees and is able to reach a height of 5 m at maturity in situ. This report maintains these definitions but encompasses trees, forests and woodlands in "forest resources". The Malawi State of Environment and Outlook Report of 2010 was referred to in characterization of forest resources in Malawi, where the forest resources in the country are classified in form of land tenure as follows:

3.1.1 Government Forests on Public Land

Government forests include forest reserves, national parks and wildlife reserves. These are protected. The Department of Forestry (DoF) manages forest reserves and the Department of National Parks and Wildlife (DNPW) manages national parks and wildlife reserves. While the main objective of the DPW is to protect wild animals, all wildlife, including forests, is protected. Forests reserves comprise mostly natural forests, with only 90,000 Ha (representing 11.5% of forest reserve area) of exotic trees. All of the 28 districts of Malawi, with the exception of Likoma Island and Balaka, have at least one or more gazetted and/or proposed forest reserves. These are strategically located in hills and mountain catchment areas in order to protect water catchments and fragile areas from environmental degradation. Although access is controlled, forest reserves are a de facto source of livelihoods for adjacent communities, resulting in extensive deforestation. Local communities collect firewood and non-timber forest products which they also sell. In a few selected areas, the government has entered into co-management agreements with adjacent communities to achieve sustainable forest management through the sharing of management responsibilities and utilization rights.

3.1.2 Customary Forests

Customary forests are those located on unallocated common access land, and Village Forest Areas (VFA) under the jurisdiction of Traditional Authorities. They cover about 1.1 million hectares, 11.7% of total land area. The Forest Act of 1997 allows communities to form Village Natural Resource Management Committees (VNRMCs) for the management of these forests. Although there are no restrictions on forest product use for domestic purposes, a license is required by the

VNRMC for commercial usage of forests. A registered VNRMC or a Forestry official is empowered to confiscate and prosecute anybody found with forest products without a license or permit. A registered VNRMC is also empowered to manage forests in VFAs and on common access land. However, this is not implemented. The 1997 Forest Act also makes provisions for any village headman in consultation with DoF to designate any area of unallocated land as a VFA, to be managed according to a management plan and agreement signed at the District Council level. According to the Malawi State of Environment and Outlook Report of 2010 (GOM, 2010), by 2010 there were 2,565 VFAs. A number of VFAs were reported not to have been surveyed and as a result the total area under VFAs was not known.

3.1.3 Private Forests (Leasehold and Freehold)

Private forests are either freehold, leasehold or privately owned forests on customary land. Freehold forests are mostly owned by tea estates and leasehold forests are owned by tobacco estates. There is no current data on the size of private forests, however, in 2010, The Malawi State of Environment and Outlook Report estimated that they cover 275,000 hectares out of 365,000 hectares which is the total area of plantations and 90,000 hectares belong to Government.

3.2 GHG emissions of forestry sector

According to the GHG emission estimates presented in the Nationally Appropriate Mitigation Action (NAMA) plans for Malawi, the Agriculture, Forestry and Other Land Use (AFOLU) Sector is the dominant emitter of GHG. Figure 6, shows the emission trend, in which the emissions from 2005 to 2030 were project from INC and SNC emissions data. It is seen from Figure 6 that the GHG emissions shows a steady increase to 29,373.15 in 2030, from 21,007 Gg CO_2 equivalent in 1995. The majority of GHG emissions in the AFOLU come from Forestry Sector.

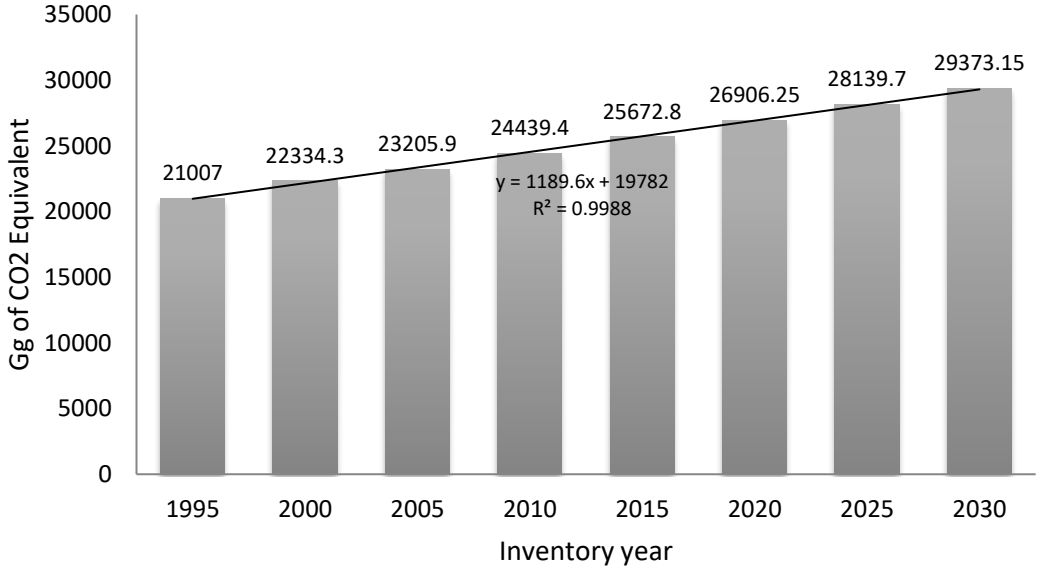

Figure 5: GHG emissions in the Agriculture, Forestry and Other Land-use Sector

3.3 Existing mitigation technologies of Forestry sector

The Government of Malawi, through the Department of Forestry, has implemented a number of large-scale projects to create sustainable supplies of timber and fuel wood. Examples of such programmes and projects are presented as follows, extracted from (Mauambeta, et al., 2010)

3.3.1 Wood Energy Plantations or Reforestation/Afforestation

In the long-term, it is clear that in most situations an improvement in fuelwood supplies require the creation of additional wood resources. The Malawi Government launched the Wood Energy Project in 1980 that was financed by the World Bank. The Project entails planting of more wood resources, either to replace the ones which have been cut down or cover the previously unwooded areas. The objective of the project was to improve fuel wood and pole supplies to both rural and urban population for domestic and commercial purposes. The Project is being championed by government Ministries, Departments and Agencies (MDAs), non-governmental organizations (NGOs), individuals and/or in groups.

3.3.2 Blantyre City Fuel wood Plantations

Realizing the dwindling forest resources on customary land, the Malawi Government, with funding from the Norwegian Agency for Development Cooperation (NORAD) implemented the Blantyre City Fuelwood Project from 1987 to 2001. The objective was to contribute to fuel requirements of low-income groups living in Blantyre and Zomba. A total of 4,700 ha were established on customary land in Blantyre, Chikwawa and Zomba Districts. However, all the plantations were later handed over to 98 village local communities in 2001, as part of decentralization process and poverty reduction strategy.

3.3.3 Improved Forest Management for Sustainable Livelihoods Programme

The programme focused on improving the management of trees and forest resources, improving access to income generating opportunities and enhancing rural livelihoods through sustainable management of forest areas in the country. The programme was financed by the European Union. The first phase ended in August of 2009 and activities planned for the second phase are expected to resume immediately after the activation of the Forest Management and Development Fund. The Improved Forestry Management for Sustainable Programme (IFMSLP) operates in 12 of Malawi's 27 Districts, namely: Chikhwawa, Chitipa, Dedza, Karonga, Kasungu, Mchinji, Mzimba, Nsanje, Ntcheu, Ntchisi, Rumphi and Zomba.

The Programme has developed interventions that aim at contributing towards increased household income and food security. The interventions range from tree planting and forest conservation to the promotion of forest based income-generating activities such as honey, mushroom and timber production and processing. The programme has facilitated development of management plans and co-management agreements between Government and local communities living around forestry reserves. During the lifespan of the programme over 8 management agreements were signed

between Government and Village Natural Resource Management Committees through their Block Committees. The signing of the management agreements for example in Malosa, Zomba and Liwonde Forestry Reserves improved access to natural resources by communities.

As stated by (Mauambeta, et al., 2010) despite these agreements, encroachment and charcoal production continued uncontrolled in other forest reserves. Since the project was implemented in selected areas, people from the non project areas interpreted the co-management agreements to mean that government had approved cutting down of trees in the forest reserves. Though the blocks under co-management agreement were not seriously affected by encroachment and charcoal burning, the surrounding and nearby areas were affected by heavy deforestation and encroachment for farming like in the case of Malosa and Zomba Forestry Reserve

3.3.4 Forestry Replanting and Tree Nursery Project

Forestry Replanting and Tree Nursery Project (FOREP) is a Government of Malawi supported project, which aims at rehabilitating the degraded industrial forest plantations to ensure sustainable supply of timber to both the wood processing and construction industries. The project encourages planting and management of trees in selected industrial timber plantations. During the year under review, the department with funding from the project planted 901.76 hectares in different industrial softwood plantations. In addition, the project funds assisted in the management and protection of the old stands from fire within the plantations.

3.3.5 National Tree Planting and Management for Carbon Sequestration and Other Ecosystems Services

Through the Department of Forestry, The Malawi Government supported the Tree Planting and Management for Carbon Sequestration and Other Ecosystems Services (TPMCSOES) Project. The project, launched in 2007, promotes tree planting and management by giving financial support to farmers (Chiotha & Kayambazinthu, 2009). In this project, farmers were financially compensated for the land that they put aside for tree growing and subsequently paid for trees that survive.

3.3.6 The Income Generating Public Works Programme

The Income Generating Public Works Programme (IGPWP) was designed to promote income generating activities as well as productive activities for the rural and peri-urban poor. One of the objectives was to develop productive local forestry and agriculture activities. The target is to plant 42,500,000 trees and assist in the management of 2,250 ha of existing forest areas. By 2010, 37,500,000 trees had been planted and 1,800 ha of existing forest area had been managed.

3.3.7 Sustainable Management of Indigenous Forests Project

Community-based forest management is a strategy being adopted by many governments in developing countries. One objective is to enhance local control of, and benefits from, local forest resources. The Wildlife and Environmental Society of Malawi (WESM) has been implementing a

community-based project called “Sustainable Management of Indigenous Forests" (SMIF) at Kam’mwamba in Neno District (formerly known as Mwanza East). The Sustainable Management of Indigenous Forests Project (SMIF) was implemented in 1996 with the objective of sustainably managing these forests through tree planting, encouraging natural regeneration, fire protection and engaging the communities in a number of income-generating activities (IGAs) such as bee keeping (honey production), fruit juice making and guinea fowl rearing. 242,021 trees of various species were planted for soil amelioration, firewood, timber and nutritional (fruits) purposes over the project period. This translates into 96.8 hectares of forest cover if planted at 2 m by 2 m spacing. Most of the trees were planted by individuals (181,144 trees).

3.3.9 Bwanje Rural Environmental and Development Organization

Bwanje Rural Environmental and Development Organization (BERDO) is based in Ntcheu District in the Bwanje Valley. BERDO, launched in 2009, is implementing livelihood security and watershed management projects amongst many other projects focusing on income generating activities. The two main goals of these projects were to improved sustainable livelihoods in Bwanje area particularly of female headed and HIV and AIDS affected households, and to promote participatory watershed management in the Bwanje valley.

3.3.10 Protecting Ecosystems and Restoring Forests in Malawi

In Malawi, due to deforestation, forest ecosystem losses are eroding access to vital community resources and contributing to environmental degradation that negatively impacts the future of local and regional economic potential. To address deforestation and land degradation problem in Malawi, the Protecting Ecosystems and Restoring Forests in Malawi (PERFORM) was a five-year project funded by the U.S. Agency for International Development (USAID) and implemented by Tetra Tech, in association with five subcontractors: Total LandCare, Centre for Environmental Policy and Advocacy, Michigan State University, Winrock International, and World Resources Institute (TertaTech, 2014). To improve quality of life across Malawi, PERFORM promotes forest conservation and green growth, while working to reduce greenhouse gas (GHG) emissions from forestry land use and strengthen climate resilience. The PERFORM also worked to increase low-emissions land use opportunities in rural Malawi. Further, PERFORM works to build Malawian capacity to systematically collect, analyze, and report on GHG emissions. The project started in September 2014 and completed in September 2019. The Project has supported Government of Malawi and other local stakeholders to develop and implement a new approach to forest co-management, which capitalizes on sound forest inventories that inform planning and articulates the rights, roles, and responsibilities needed to promote the transparency and accountability of national, district, and local partners.

3.2.11 National Tree Planting Season

The Malawi Government through Department of Forestry carries out a yearly national tree planting season, where citizens, schools and organisations are urged to plant trees. One of the activities

during the planting season is the Dzalanyama Forest Tree planting exercise (JICA, 2019). Despite many forest projects and programmes the Malawi Government and its development partners have put in place to address issues of deforestation and environmental degradation in Malawi, challenges still persist.

3.2.12 Malawi Youth Forest Restoration Programme

In 2016, Malawi Government embarked on a programme, named: Malawi Youth Forest Restoration Programme (MYFRP), with the aim of restoring 4.5 million hectares of degraded land, or 38% of its total landmass (GOM, 2016). This programme is part of the African Forest Landscape Restoration Initiative (AFR100) and Bonn Challenge. The AFR100 is a country-led initiative that aims to bring 100 million hectares of land into restoration by 2030. The country notes that the restoration has many benefits, such as increasing agricultural productivity and water security, improving resilience to climate change and severe weather, limiting erosion, and spurring sustainable economic growth. The Programme will contribute to building a resilient nation, with livelihoods and local economies supported by healthy ecosystems. The Programme targets the youth because Malawi is a young country with an entrepreneurial and ambitious youth. Despite the potential, many of the 64% of Malawians that are under the age of 24 are unemployed. Therefore, apart from contributing towards building a resilient nation, this Programme tackles both youth unemployment and improving the productivity of the land.

3.4 Decision Context

The forests in Malawi play an important role in the livelihoods of many communities and in the economic development of the country. These forests provide energy, food, timber, non-timber products. They also contribute to wealth and health at the household, community and national levels. The forests resources in Malawi contribute up to about 4.4% of the GDP if sustainably managed. According to the National Forestry Policy, the rate of deforestation in Malawi is at about between 1.0 to 2.8% per annum. Despite the programme to decentralize some of the forestry management to district councils, and presence of rules and regulations, there is still wanton cutting down of trees and forest resources for energy supply, agriculture extension and other land uses. The impacts of deforestation are severe and cross-cutting. Deforestation is known to be responsible for severe land degradation, loss of biodiversity, decline in agricultural productivity, exacerbating seasonal flooding, disrupting hydroelectric power generation, reducing the quality of water and causing erratic river flows. As already stated, due to deforestation, the capacity for carbon sink is greatly reduced and Malawi is net GHG emitter.

3.5 Process of identifying climate change mitigation technologies

The process of identification of climate change mitigation technologies in the forestry sector were guided by requirements that the identified technologies must be supported by the Government of Malawi's strategic documents such as policies and strategies. The identification used the desk research as well as expert consultation. In desk research process, information was collected from Government of Malawi policy documents and strategies (refer to Section 1.2.2) such as Intended

National Designated Contribution (INDC) of 2015, National Forestry Policy of 2006, the National Climate Change Management Policy of 2016 (GOM, 2016), Malawi's Nationally Appropriate Mitigation Actions (GOM, 2015), Biomass Energy Strategy, National Charcoal Strategy, and the National Forest Landscape Restoration Strategy (NFLR). The Incubator Programme of the Climate Technology Centre and Network (CTCN) for Malawi (EAD, 2018) also provided useful literature on identification of technologies for climate change mitigation in the forestry sector.

Nine technologies were identified. Technology facts on each of the identified technology were written down, again, with information being sourced from literature and expert opinion. The facts included details on how the technology works, advantages and disadvantages, recommendations on how to overcome the disadvantages associated with the technology, how much the technology cost, its benefits and sustainability. The Technology Facts Sheets are attached in the Appendix 3. The identified technologies were then prioritized at an expert working group meeting that took place in Salima from 17th – 19th September 2019. The mitigation technologies that were reviewed and adopted for prioritization using participatory multi-criteria analysis (MCA) tools in the forestry sector are described in Table 2.

Table 2: Description of the identified mitigation technologies in the Forestry Sector

Technology	**Description of the Technology**
Biochar production from forest waste	Biochar is a name for charcoal when it is used for particular purposes, especially as a soil amendment. Biochar is a charcoal-like substance produced from agriculture and forest wastes which contains 70% carbon. It is used as soil enhancer to increase fertility, prevent soil degradation and to sequester carbon in the soil. Biochar can store carbon in the soil for as many as hundreds to thousands of years. Biochar can be produced through pyrolysis, gasification and hydrothermal carbonization, which leaves bio-oil and syngas as by-products. The syngas is an important source of clean energy, which could reduce charcoal and firewood use for energy. Further, Biochar technology is different from the conventional charcoal production because it is highly efficient in the conversion of carbon and harmful pollutants are not released upon combustion. Hence, it is a cleaner and more efficient technology. Small scale production can be through pyrolysis using modified stoves and kilns which are low cost and relatively simple technologies. For large scale production, larger pyrolysis plants and adequate feedstocks are required which is more capital cost intensive. The main quality of biochar is its carbon-rich fine-grained, highly porous structure and increased surface area that makes it an ideal soil amendment for carbon sequestration.
Farmer managed natural regeneration (FMNR)	Farmer-managed Natural Regeneration (FMNR) is a deliberate act of allowing regeneration and then the managing of trees and shrubs that sprout from tree stumps, roots and seeds found in degraded soils, such as those currently in

	agricultural production. FMNR places emphasis on the farmer to manage the land restoration process. The technique/innovation if carried out successfully could reduce poverty and hunger amongst subsistence farmers in Malawi through enhancement of food production and derivation of forest related products such as timber for social and economic development. The resulting restored forest would help in enhancing the carbon sink for Malawi as well as environmental protection. There is a relatively large potential for FMNR for Malawi. According to National Forest Landscape Restoration Strategy, Malawi has great potential of 3, 730, 790 hectares that could be used for FMNR (which represents 39% of total land area of the country)
Forest landscape restoration (FLR)	Forest landscape restoration (FLR) is the process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes. FLR is more than just planting trees – it is restoring a whole landscape to meet present and future needs and to offer multiple benefits and land uses over time. 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. FLR landscapes are typically categorised in three ways, each incorporating different types of restoration that is based on type of land: Forest Land, Agricultural Land, and Protective lands and buffers Forest landscape restoration could complement other interventions to improving food security and climate change management (mitigation and adaptation), such as the Smart Agriculture and Reducing Emissions from Deforestation and Forest Degradation - REDD+. Just like Famer Managener Natural Resource Generation, Malawi has potential for Forest Landscape Restoration programme, to achieve social-economic benefits such as improved food security; increased energy resources; increase in climate resilience; improve water quality and supply; ensure gender equality and alleviate poverty
Agroforestry	Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. As stated by the World Agroforestry Centre, stated that through the integration of trees on farms and in the agricultural landscape, Agroforestry diversifies and sustains production for increased social, economic, and environmental benefits for land users at all levels. Further, Agroforestry offers great potential for carbon sequestration as well as environmental protection.
Efficient use of forest products	A forest product is any material derived from forestry for direct consumption or commercial use, such as wood, timber and poles. Wood by far the dominant product of forests in Malawi, is used for many purposes, such as source of energy (e.g. in form of firewood and charcoal), and as materials for construction (timber for construction).

	Residues in the forest and in the wood industry could be used as raw material for wood-based products and as a renewable source of fuel. This could contribute to efficient use of forest products and help in forest conservation. Malawi has potential for commercial use of forest and wood based residues.
Fruit tree planting outside the forest	Malawi has had some challenges concerning sustainable forest harvesting for several applications, which has resulted in deforestation. Reforestation programmes, such as the National Tree Planting has not been very much effective. This is partly due to lack of care for the new/young trees. The trees planted are mostly non-fruit trees. It has been argued that the promotion of fruit trees outside the forest could lead to enhanced protection and management of such trees because of the increased non-wood value derived from fruit trees. Thus, promotion of fruit trees is a viable way of making Malawi a green country once again.
Urban forestry	Urban development results in the depletion and degradation of natural trees and forests in and around urban areas causing loss of vital ecosystem services and, potentially, rendering little resilience to disasters, such as those from climate change impacts. As Malawi continues to urbanize, with insufficient and or absence of strategic planning, it will result in unsustainable patterns of land use, which could exacerbate the mentioned challenges. 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, is developed to address the issue of impact on forestry by urbanization. The urban forestry comprises all green elements under urban influence.
River and stream bank restoration	River restoration is a practice of set activities that help improve the nature and environmental health of a river stream. The goal is to return to it, the stream's natural functions and to reconnect the stream back to its floodplain. River and stream-bank restoration focuses on establishing buffers of trees along streams and rivers courses to stabilize the soil, either through active planting or natural regeneration. The benefits of these protective buffers include decreased erosion and sedimentation into waterways, which improves water quality and quantity. This practice is particularly important in watersheds with downstream hydropower and reservoir infrastructure, where sedimentation is a major impediment to their efficiency and sustainability. More than 36,000 hectares in Malawi are suitable for river and stream-bank restoration.
Bamboo in Social Forestry	Forestry practices which aim at provides goods and benefit to a nearby society are usually referred to as Social Forestry. In Malawi, forests have always played an important role in bettering the lives of the local population. Bamboo is one of the multipurpose species and therefore, it could be introduced in a large scale under various programmes of social forestry in the country.

	Bamboos are shrubs, which have a tree like habit; their culms are erect and sometimes climbing. Bamboos are of notable economic and cultural significance in South Asia being used for building materials, and as a versatile raw product. Bamboo has a higher specific compressive strength than wood, brick or concrete. Further, bamboo has many other qualities, as follows: it is one of the fastest growing plants; it is an enduring natural resource, thus ideal for plant for adapting to climate change in Malawi; it is versatile with a short growth cycle; and it acts a natural controllable barrier. The bamboo should also supply biomass energy. Thus promotion of bamboo as a form of social forestry could results in enhancement of carbon sink directly as well provision of alternative renewable source of energy (to replace firewood and charcoal from trees and forests).

3.6 Process of prioritization of climate change mitigation technologies

The technology prioritization is a stakeholder participatory process. The prioritization employed the multi-criteria analysis (MCA) approach. In order to refresh stakeholders' knowledge, so as to ensure a perfect prioritization process, the TNA consultants organized a one-day training (first day of technology prioritisation workshop) on the MCA process. Each step of the MCA process was thoroughly discussed and illustrated using examples. An UNEP-DTU MCA excel-based template was also introduced and thoroughly discussed. Upon concluding the capacity building on MCA, Expert Working Group members employed a stepwise approach of MCA in the prioritization of the identified mitigation technologies for the forestry sector. The stepwise approach of MCA process that was employed is presented in the following subsections.

3.6.1 Identification of evaluation criteria

The first step was to develop the evaluation criteria for prioritisation of the identified technologies. This was premised on the fact that the MCA approach is about making a decision based on several factors (which could sometimes be conflicting), using an established evaluation criteria. The Consultant facilitated development of evaluation criteria, being guided by TNA Guidebook for evaluating mitigation technologies (Haselip, et al., 2019). In this TNA process, the Expert Working Group (EWG) firstly agreed on factors to use in the evaluation. Factors chosen (which are the criteria), were on costs and benefits. Cost factors were broken down into capital costs and operating costs of the technology. The benefit factors were categorized into economic, social, environmental, and climate related, technology related, and institutional related benefits. These factors were further sub-categorized into downstream factors (criteria), for example, Climate related benefits were sub-categorised into GHG reduction potential and vulnerability & climate resilience reduction potential, while the institutional benefits were sub-categorized into ease of implementation and coherence with national goals. A total of 17 criteria developed, as presented in Table 3.

Table 3: Evaluation criteria used in the MCA prioritization process

Criteria category	Criteria and description	Sub-criteria
COSTS	1. *Capital costs*. Cost of setting up the technology – often incurred during start-up phase	1 Capital costs
	2. *Operating and maintenance costs* – costs of maintenance and implementation of the technology;	2 Operating and maintenance costs
BENEFITS	3. *Economic benefits* – the ability of the technology to improve local economy; catalyze private investment; and create jobs;	3 improve economic performance
		4 private sector investment
		5 job creation
	4. *Social benefits* – the ability of the technology to reduce poverty and inequity between social classes; improve the health of the people; and preserve cultural heritage;	6 poverty reduction
		7 reduce inequity
		8 improve gender equality
	5. *Environmental benefits* – the ability of the technology to protect the environment and/or biodiversity;	9 protect environment
		10 protect biodiversity
	6. *Climate related benefits* – the ability of the technology to reduce vulnerability and build climate resilience, and reduce GHG - as a co-benefit.	11 GHG reduction potential
		12 reduce vulnerability & climate resilience
	7. Technology related benefits - the ability of the technology to increase the rate of diffusion of the technology, bringing transformational change and maturing and effectiveness	13 rate of diffusion
		14 potential for transformational change
		15 maturity & effectiveness
	8. *Institutional related benefits.* ability of ease of implementation and its being coherence with national goals	16 ease of implementation
		17 coherence with National goals

After establishment of the evaluation criteria, the Consultant presented technology factsheets (Appendix 3) for all of the 9 identified technologies, to the EWG members, where cost and benefits details about the technology are explained.

3.6.2 Evaluation of the technologies

The second step in the technology prioritization process using MCA was the coming up of a rating scale to use. The EWG members employed a rating scale of 1 to 5 to evaluate the performance of the identified technologies, based on the criteria presented in Table 3. A scale of 1 was attached to a technology that was deemed least performing against the criterion, while a scale of 5 was for the most performing one. Members then evaluated the technologies using the UNEP-DTU MCA

excel-based calculator. Results are presented in a performance matrix table, presented in Table 5. During the process of evaluation, the Consultant appealed to the EWG members to focus on the characteristics of the identified technologies, not on the technologies themselves. The EWG members deliberated on the technologies basing on the details presented in fact sheets, which created a thorough-thought about the consequences of each of the technologies.

3.6.3 Scoring the technologies

The EWP members scored the identified technologies using interval scale method. In establishing an interval scale for a criterion, members firstly defined the levels of performance corresponding to any two reference points on a scale of 0 to 100. The score of 0 was associated with the performance level of the technology in the currently considered set of technologies, which performs the least and 100 with that which performs the best. Table 4 provides a description of the rest of scores used. The advantage of using interval scale was that differences in scores among technology options had consistency within each criterion.

Table 4: Description of the scores used in the MCA process

SCORE	General description
0	Information on technology does not apply to a particular criteria
1 - 20	Extremely weak performance, strongly unfavorable;
21 - 40	Poor performance, major improvement needed;
41 - 60	An acceptable or above level;
61 - 80	Very favorable performance, but still needs improvement;
81 - 100	Clearly outstanding performance which is way above normal.

Scoring of technologies resulted in the completion of scoring matrix. Refer to Table 6, which show perceived relative contribution of each criterion towards the choice of priority mitigation technologies. They show the importance of each criterion according to the judgment of EWG members.

Table 5: Performance evaluation matrix for identified mitigation technologies

Technology	Costs		Benefits														
			Economic		Social			Environment			Climate related		Technology related			Institutional	
	Capital	Operational	Improve economic performance	Private sector investment	Job creation	Poverty reduction	Reduce inequity	Improve gender equality	Protect environ	Protect biodiversity	Reduce GHGs	Reduce vulnerability & climate resilience	Rate of diffusion	Potential for transformational change	Maturity &effectiveness	Ease of implementation	Coherence with National goals
Bamboo in Social Forestry	1	1	4	3	3.5	3.5	3	2.5	5	3.5	4	4	3	3	2	2	4
Forest landscape restoration	5	4	3.5	0	0	3	3	5	5	4	5	4	5	3.5	3	5	5
Efficient use of forest products	1	4	3.5	3.5	4	4	3	4	5	4	4	4	5	3.5	3	5	5
River and stream bank restoration	2	3	3	3	3	3	3	3	4	3	3	4	4	3	3	4	4
Urban forestry	1	3	3	3	5	4	4	3	4	3	5	4	4	3	3	4	4
Biochar production from forest waste	1	2	4	3	4	2	3	3	4	4	5	4	4	3	3	4	4
Agroforestry	3	3	4	3	3	3	3	4	4	3	3	3	4	3	3	4	4
Fruit tree planting outside the forest	1	1	4	4	4	4	4	4	5	3	4	4	4	3	3	4	4
Farmer managed natural regeneration	1	2	4	4	4	4	4	4	5	3	4	4	4	3	3	4	4
Score	16	23	33	26.5	30.5	30.5	30	32.5	41	30.5	37	35	37	28	26	36	38
Criterion Relative Weight	0.9	0.1	0.1	0.3	0.6	0.2	0.1	0.7	0.5	0.5	0.6	0.4	0.1	0.3	0.6	0.3	0.7
Criteria Weight	20		10		10			20			25		10			5	
Criterion weight	**18**	**2**	**1**	**3**	**6**	**2**	**1**	**7**	**10**	**10**	**15**	**10**	**1**	**3**	**6**	**2**	**3**

Table 6: Scoring matrix for evaluating the climate change identified mitigation technologies.

Technology	Costs		Benefits														
			Economic		Social			Environment			Climate related		Technology related			Institutional	
	Capital	Operational	Improve economic performance	Private sector investment	Job creation	Poverty reduction	Reduce inequity	Improve gender equality	Protect environ	Protect biodiversity	Reduce GHGs	Reduce vulnerability & climate resilience	Rate of diffusion	Potential for transformational change	Maturity &effectiveness	Ease of implementation	Coherence with National goals
Bamboo in Social Forestry	20	20	80	60	70	70	60	50	100	70	80	80	60	60	40	40	80
Forest landscape restoration	100	80	70	0	0	60	60	100	100	80	100	80	100	70	60	100	100
Efficient use of forest products	20	80	70	70	80	80	60	80	100	80	80	80	100	70	60	100	100
River and stream bank restoration	40	60	60	60	60	60	60	60	80	60	60	80	80	60	60	80	80
Urban forestry	20	60	60	60	100	80	80	60	80	60	100	80	80	60	60	80	80
Biochar production from forest waste	20	40	80	60	80	40	60	60	80	80	100	80	80	60	60	80	80
Agroforestry	60	60	80	60	60	60	60	80	80	60	60	60	80	60	60	80	80
Fruit tree planting outside the forest	20	20	80	80	80	80	80	80	100	60	80	80	80	60	60	80	80
Farmer managed natural regeneration	40	40	80	80	80	80	80	80	100	60	80	80	80	60	60	80	80
Criterion weight	**18**	**2**	**1**	**3**	**6**	**2**	**1**	**7**	**10**	**10**	**15**	**10**	**1**	**3**	**6**	**2**	**3**

After scoring the technologies against the criteria (result being the performance matrix), weighted scores (normalised scores) were assigned to each of the criteria to express the relative importance of each criterion with respect to the other criteria. The weighting scores were derived from the relative importance the EWG members attached to each criterion with respective to the others in achieving the desired outcome. The sum of the normalized scores was set to equal to 1 or 100%. Table 7 provides the normalized (weighted) scores determined by the panelists of the expert working group. This was done to evaluate total score for each technology, taking into account contributions from all criteria.

Table 7: Evaluation criteria used in the MCA prioritization process

COSTS	Costs	20	Capital costs	0.9	18
			Operating and maintenance costs	0.1	2
BENEFITS	Economic benefits	10	improve economic performance	0.1	1
			private sector investment	0.3	3
			job creation	0.6	6
	Social benefits	10	poverty reduction	0.2	2
			reduce inequity	0.1	1
			improve gender equality	0.7	7
	Environmental benefits	20	protect environment	0.5	10
			protect biodiversity	0.5	10
	Climate related benefits	25	reduce GHGs	0.6	15
			reduce vulnerability & climate resilience	0.4	10
	Technology related benefits	10	rate of diffusion	0.1	1
			potential for transformational change	0.3	3
			maturity & effectiveness	0.6	6
	Institutional related benefits.	5	Ease of implementation	0.3	1.5
			Coherence with National goals	0.7	3.5

The total score taking contributions from all the criteria was found by multiplying the weighting coefficient for each criterion (refer to Table 7) to its corresponding scores presented in Table 6. The resulting weighted scores were summed up for each technology option to derive an overall score value. The aggregation of the weighted scores was also conducted using the UNEP-DTU MCA calculator. The results of the aggregation of the weighted scores resulted into decision matrix (Table 8), from which the decision on the prioritized technologies was based.

Table 8: Decision matrix on prioritization of mitigation technologies

Technology	Costs		Benefits															Scores and ranking	
			Economic		Social			Environment			Climate related		Technology related			Institutional			
	Capital	operational	improve economic performance	Private sector investment	job creation	poverty reduction	reduce inequity	improve gender equality	protect environ	protect biodiversity	reduce GHGs	reduce vulnerability & climate resilience	rate of diffusion	potential for transformational change	maturity &effectiveness	Ease of implementation	Coherence with National goals	Total Scores	Technology rank
Bamboo in Social Forestry	360	40	80	180	420	140	60	350	1000	700	1200	800	60	180	240	60	280	6150	9
Forest landscape restoration	1800	160	70	0	0	120	60	700	1000	800	1500	800	100	210	360	150	350	8180	1
Efficient use of forest products	360	160	70	210	480	160	60	560	1000	800	1200	800	100	210	360	150	350	7030	2
River and stream bank restoration	720	120	60	180	360	120	60	420	800	600	900	800	80	180	360	120	280	6160	8
Urban forestry	360	120	60	180	600	160	80	420	800	600	1500	800	80	180	360	120	280	6700	4
Biochar production from forest waste	360	80	80	180	480	80	60	420	800	800	1500	800	80	180	360	120	280	6660	5
Agroforestry	1080	120	80	180	360	120	60	560	800	600	900	600	80	180	360	120	280	6480	7
Fruit tree planting outside the forest	360	40	80	240	480	160	80	560	1000	600	1200	800	80	180	360	120	280	6620	6
Farmer managed natural regeneration	720	80	80	240	480	160	80	560	1000	600	1200	800	80	180	360	120	280	7020	3
Criterion weight	18	2	1	3	6	2	1	7	10	10	15	10	1	3	6	1.5	3.5		

3.6.4 Results of technology prioritization

The Table 9 shows the results of the technology prioritization following the MCA process. The table presents top 5 priority mitigation technologies in the forestry sector with "*Forest landscape restoration*" topping the list, seconded by "*Efficient use of forest products* ". The third priority technology optimized by the expert working group is "*Farmer managed natural regeneration* ". *Urban forestry* and *Biochar production from forest waste* came on position 4 and 5 respectively. On the technology Biochar production from forest waste, members thought that despite it being among the efficient use of forest products, the technology could stand on its own due to its uniqueness and importance in controlling deforestation.

Table 9: Prioritized mitigation technologies in forestry sector

Rank	Technology	Total score
1	Forest landscape restoration	8180
2	Efficient use of forest products	7030
3	Farmer managed natural regeneration	7020
4	Urban forestry	6700
5	Biochar production from forest waste	6660

CHAPTER FOUR

CONCLUSION

Stakeholder participatory process, as described in the "*A guidebook for countries conducting a Technology Needs Assessment and Action Plan*" developed by the UNEP DTU Partnership, was used in the development of the TNA report for Malawi. The process started by the prioritization of the sectors for mitigation, which identified Energy and Forestry as the key sectors. The institutional arrangement for conduction of the TNA in Malawi was instituted, and consultants recruited. The Consultants were briefed about the scope of work. Firstly, the consultant reviewed strategic documents, including policies and strategies in which climate change mitigation options are highlighted, so that the TNA falls within the strategic position of the Government of Malawi. The Consultant then identified climate technologies for mitigation in the forestry sector through document review, and reference to the CTCN website for technology specifics when coming up with technology factsheets for the identified technologies. A total of 9 technologies were identified, and their technology factsheets developed, customized to Malawi.

The process of prioritizing the identified technologies followed the stakeholder participation, while incorporating gender issues through every step. The expert working group, using the multi-criteria analysis, prioritized the identified technologies against criteria that were established by the Expert Working Group members. The top five prioritized technologies are listed as follows, in the order of prioritization.

1. Forest landscape restoration
2. Efficient use of forest products
3. Farmer managed natural regeneration
4. Urban forestry
5. Biochar production from forest waste

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APPENDICES

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APPENDIX 3: TECHNOLOGY FACT SHEETS

1. Biochar production from forest waste

Technology Characteristics	Narrative description of the characteristic
General information	Biochar is a charcoal-like substance produced from agriculture and forest wastes, and it could contain upto 70% carbon or more. The remaining elements are hydrogen, oxygen and nitrogen. Biochar can store carbon in the soil for many years, thus its importance in climate change mitigation is evident. It could also be used as a soil enhancer to increase fertility, prevent soil degradation. The main quality of biochar is its carbon-rich fine-grained, highly porous structure and increased surface area that makes it an ideal soil amendment for carbon sequestration. Biochar is produced through thermal decomposition of the biomass (waste from agriculture and forest). This takes place through a series of processes, as follows: pyrolysis, gasification and hydrothermal carbonization. In all these processes, biomass is heated at a high temperature in the absence of air. This releases the volatile gases leaving behind carbon rich biochar. During pyrolysis, a high proportion of carbon remains within the biochar giving it a very high recalcitrant nature. The by-product of biochar formation processes included bio-oil and syngas, which could be used as sources of energy. As with any other technology, biochar could be produced at small and large scale levels. Small scale production can be through pyrolysis using modified stoves and kilns, which are of relatively low cost due to less-complicated technologies (stoves and kilns). This could be ideal for households or for a relatively small community purposes. But for large scale production, larger pyrolysis plants and adequate feedstocks are required, which could be capital intensive. Biochar producing cook-stoves are more popular in developing countries of Asia and some African Countries like Kenya. Production of biochar has some disadvantages, including the following: 1. Biochar applications sometimes disturb the physical and chemical balances of nutrients in the rhizosphere. 2. Biochar generally helps the growth of undesirable weeds. 3. Biochar manufacturing is relatively expensive.

Status of the technology and its future market potential	Biochar technology is a mature technology internationally. In Malawi, the technology is not available, but not popularised. It is available as demonstration units (small scale) at universities and other research based institutions like Chitedze Research Station. However, the technology has potential for being popularised because of its application in the agriculture sector (boosting harvests, as a source of fertiliser) and as a source of clean energy supply. The raw material from forest products, for example, saw dust are readily available, and could as well create employment for selling and delivering the materials to the biochar production unit. Also, biochar carbon sequestration is fundamentally different from other forms of bio-sequestration, which could further potential for technology acceptance and diffusion in Malawi. The issues of permanence, land tenure, leakage, and additionally are less significant for biochar projects than for projects sequestering carbon in biomass or soil through management of plant productivity. Biochar carbon sequestration might avoid difficulties such as accurate monitoring of soil carbon which are the main barriers to inclusion of agricultural soil management in emissions trading. Using turnover rate and quantity of carbon has been suggested as a method to be used in assessment of the carbon sequestration potential and that could be done independently from biochar's use as a soil amendment or other non-fuel purposes.
Feasibility of technology and operational necessities	Technically, technology is feasible in Malawi, due to the availability of knowledge as research works are being conducted. The raw materials would not be expensive to source to its being abundant. However, there is a need to work on building capacity on manufacturing technology. Biochar could be feasible in a small-scale industry like saw mills, where woody biomass waste is readily available. Large scale biochar production can be done through the cultivation of crops, but this would require adequate land for its cultivation. The greatest economic potential of biochar for carbon sequestration can be realized if crop residues or waste biomass are used rather than purpose grown crops. Biochar application has been introduced in some Asian countries like Vietnam, Mongolia and India and cost effective approaches are being identified for widespread introduction of biochar in these countries. When deploying biochar technology, a potential barrier could be that communities have to be convinced to accept the new

	technology instead of their traditional practices. An imminent risk of this technology is that when promoted at a large scale with dual goals of achieving agricultural and forestry as well as environmental benefits, environmental goals may be overridden by the agricultural and forestry goals. Investors might likely give more value to its agronomic benefits than its carbon sequestration potential.
Institutional framework for adoption and diffusion	The Department of Agriculture in the Ministry of Agriculture Irrigation and Water Development provides an institutional framework for technology adoption and diffusion
Cost	Since Biochar technology is relatively new, costs and impacts associated with would be relatively high in Malawi, than where the technology is popularised already. A potential financial barrier to the development and transfer of technology could be: the high costs of large scale pyrolysis plants, the required investments in biomass feedstocks, infrastructure and access to the upfront capital. According to Climate Technology and Network Center (CTNC), internationally, the total cost of biochar production ranges from US $194- US$424 per ton of feedstock. This is equivalent to MK140,000.00 -MK 300,000 in 2019. These figures were based on results on production of biochar from sustainable forest, non-farm and ranch-based biochar. Also from CTCN, the cost of simple biochar stoves could range from $6-$40 (MK5,000 to MK30,000), depending on the type and application of the stoves.
Benefits	The benefits associated with biochar production from forest products are economic, social and environment, described as follows
Economic	(i). Farmers could have an additional source of income through collection and sale of forestry waste to used as raw material in biochar production (ii). The increased yields following improved soils, as a result of use of biochar as fertilizer. (iii). Using fuel (syngas) from biochar production, could reduce dependence on fossil fuel, resulting in savings. (iv). Employment opportunities can be created in the course of development of biochar technology, for example selling of forest waste.

	(v). Revenue can be generated through carbon trading. (vi). Since biochar can be used as a fertilizer, alternative fertilizers no longer need to be purchased (imported) which helps developing countries to reduce trade and fiscal deficits.
Social	(i). biochar can be used for forestry management and hence land and wildlife habitat conservation. (ii). There are health benefits as biochar stoves (using syngas) are more efficient and produce less air pollutants compared to traditional charcoal stoves used in Malawi. (iii). Promoting biochar does not jeopardize the food security by displacing the cropland with biochar feedstock since forest and agricultural waste are the principal raw materials
Environment	(i). With the use of biochar on soils, reduced GHG emission is achieved: Reduced use of fertilizer results in reduced emissions from production and use of other fertilizer products. Retention of nutrients like nitrogen in the soil limit consequent emission of nitrous oxide into the atmosphere. Further, as agricultural and forest wastes are turned into biochar, emission of methane resulting from natural decomposition of biomass is reduced. Furthermore, biochar increases the microbial life in the soil and increases carbon storage in the soil. (ii). Enhanced soil fertility and food security: Biochar increases the number of soil microbes, retains nutrients in the soil and hence increases the soil fertility and subsequently there is increased food security. Derived biochar may enhance the loss of forest humus. Therefore identification of specific niches for biochar application is crucial to exploiting its benefits. (iii). Reduced water pollution: Groundwater and surface water pollution through leaching and erosion is reduced through lower use of chemical fertilizer and reduced degradation of soils. As the nutrients and agrochemicals are retained in the soil due to use of biochar, pollutants produced through agriculture in water is reduced. notes that biochar can remove nitrate and phosphate from water. Biochar also has an

	affinity for organic compounds which can help retaining toxic organic compounds from water (iv). Waste management: Biochar technology offers a simple and sustainable solution to waste management because agricultural wastes are used as feedstocks. During the pyrolysis process no waste is produced and by-products include syngas and bio-oils can be recycled and used further
GHG mitigation potential	The technology presents a greater potential for sequestering carbon dioxide in Malawi
Applicability* of the technology in Malawi (short, medium and long term)	Short term
Size (household and large-scale)	Household scale and large scale

*On Applicability of the technology

- Applicability of technology is defined as follows: short term is the technology that is proven to be liable and is commercially ready in similar market
- Medium term refers to the technology that is in pre commercial in a similar market
- Long term refers to the technology that is still under research and Technology phase

Figures

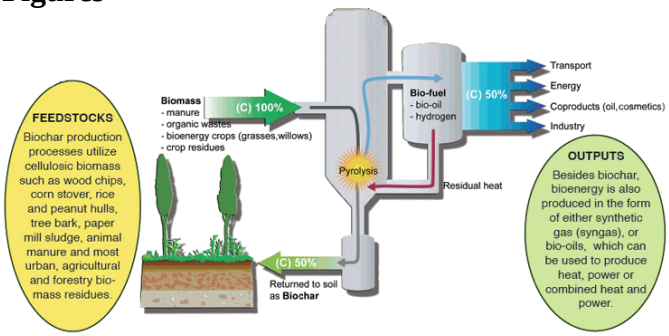

Figure 1: Biochar production process

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https://www.ctc-n.org/technologies/biochar

2. Farmer managed natural regeneration

Technology Characteristics	Narrative description of the characteristic
General information	Farmer-managed natural regeneration (FMNR) is a low-cost, sustainable land restoration technique for the systematic regeneration and management of trees and shrubs from tree stumps, roots and seeds. It is a form of coppicing and pollarding, drawing on traditional practices and could be sensitive to local variations. FMNR could return degraded cropland and grazing lands, as it is the current case in Malawi, to productivity. It can be used to restore degraded forests, thereby reversing biodiversity loss and reducing vulnerability to climate change, while at the same time increasing carbon sink through the resulting tree and forest regeneration. The actual practice of FMNR includes 3 steps: (i). Farmers select desired tree stumps and for each stump choose a number of the tallest and straightest stems to leave. (ii). Remove the unwanted stems and side branches. Manage any threats to remaining branches from livestock, fire and competing vegetation (weeds) (iii). Cull emerging new stems and prune side branches from time to time.
Status of the technology and its future market potential	The practice is relatively new in Malawi. However, it has the history of being was co-developed with farmers in Niger, and in each new context, it is adapted with land users to suit the unique needs and goals of local communities in line with their environment. Along with its low cost, this freedom and "farmer managed" aspect of FMNR has enabled FMNR to spread rapidly. According to National Forest Landscape Restoration Strategy, Malawi has great potential of 3, 730, 790 hectares that could be used for FMNR (which represents 39% of total land area of the country). This is a great potential.
Feasibility of technology and operational necessities	The technology is feasible to be implemented in Malawi, according to the National Forest Landscape Restoration Strategy. The implementation procedure could include the following:

	(i). Conduct FMNR participatory sensitisation meetings with traditional and government leaders, forestry and agriculture department staff, other NGOs/CBOS and community members. This enlightens them on what FMNR is and how it connects in to their livelihoods. Planning meetings can be held at the same time or later. (ii). FMNR training for project and government extension agents. Communities select FMNR champions who will actively teach and lead by example. (iii). Extension Agents train farmer champions and provide follow up and monitoring, giving encouragement and assistance with problem solving. Following adoptions, exchange visits from neighbouring districts are facilitated. Most 'farmers believe by seeing' and hearing from peers, triggering adoption. (iv). Tree product value chains are developed. FMNR is integrated with other livelihood options enabling poor communities to let the trees grow as they will have diversified income sources to meet immediate needs.
Institutional framework for adoption and diffusion	There must be a communications strategy which includes education in schools, radio programs and engagement with religious and traditional leaders to become advocates. Also, there is a need for the establishment of a legal, transparent and accessible market for FMNR wood and non-timber forest products, enabling practitioners to benefit financially from their activities. The technology would benefit from the institutional framework available in the Department of Forestry for adoption and use. The National Forestry Policy provides guidance on facilitating the spread of FMNR.
Cost	A typical project costs $40-$50 (MK30,000.00 - MK40,000.00)/hectare, however major costs are typically include those of complementary project activities such as water harvesting, promotion of horticultural crops, fuel efficient stoves and improved livestock breeds. Once introduced, FMNR costs nothing to the farmer except his/her labour. Because FMNR continues to spread beyond the life of a project and beyond project areas, over time, the cost per hectare was demonstrated to decline in other countries like Niger.

Benefits	Benefits for FMNR are many. They are categorised into economic, social and climate related, as discussed henceforth.
Economic	(i). Increased crop yields, which could result in increased income for the farming household (ii). Increased fodder from edible leaves and seed pods, and increased pasture growth for livestock production (iii). Increased income generation through diversification (e.g. timber and fuel wood) and intensification of activities (iv). Increased economic activity creates opportunities, e.g., development of new business models such as cooperatives
Social	(i). The regeneration of trees and forests would increase food security and nutrition (ii). There would be available source of woodfuel and thus, less distance for women and children to travel to collect firewood (iii). Improved governance through clarification of tree ownership laws and regulations (iv). Empowerment for community members to live independently with hope for the future
Environment	(i). Regeneration which could result in tree and forest conservation would reduce erosion (ii). Reduced soil-moisture evaporation due to wind breaks shading and mulching (iii). Improved soil structure through greater quantities of organic matter (iv). Increased water infiltration and groundwater recharge (v). Increased biodiversity, environmental restoration and tree cover (vi). Enhanced resilience to climate change (vii). Reduced impact from floods and drought – trees provide alternative income and livelihood sources making impacts less severe and recovery faster

GHG mitigation potential	The re-vegetated forest enhances carbon sink and the potential depends on the amount of the regenerated area
Applicability* of the technology in Malawi (short, medium and long term)	Short term
Size (household and large-scale)	household and large-scale

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Figures

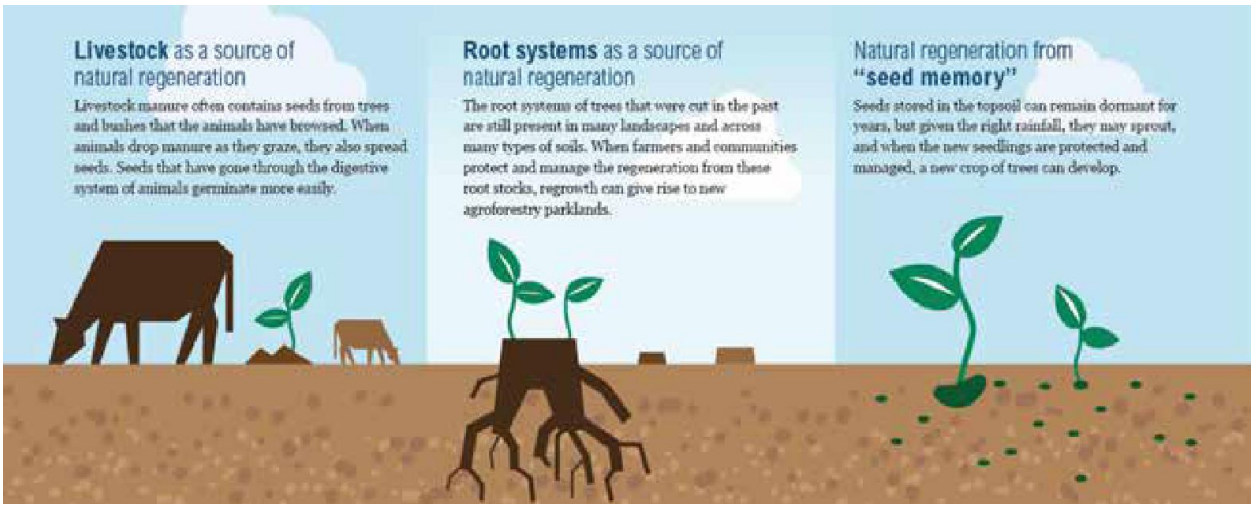

Figure 1: Illustration of farmer managed natural regeneration.

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3. Forest landscape restoration

Technology Characteristics	Narrative description of the characteristic
General information	According to the International Union for Conservation of Nature (IUCN), Forest 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 categorised 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 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 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.
Status of the technology and its future market potential	FLR could ultimately be implemented on millions of hectares of land within Malawi and 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). FRL could have potential to contribute the following to the national goals: (i). improved food security (ii). increased energy resources (iii). increase in climate resilience (iv). improve water quality and supply (v).ensure gender equality (vi). alleviate poverty Thus, the FLR would acceptable to Government, Development partners and households aimed at building a climate resilient while achieving sustainable development objectives for Malawi.
Feasibility of technology and operational necessities	The technology is practiced in many countries, including Malawi. The technology to be successful, it must be implemented within the principles presented in the Introduction section of this Fact Sheet. Further, the technology must incorporate the following land-use planning and management practices: 1. identify priority areas for restoration; 2. prioritise relevant and feasible restoration intervention types across the assessment area; 3. quantify costs and benefits of each intervention type; 4. analyse the finance and investment options for restoration in the assessment area; 5. estimate the values of additional carbon sequestered by these intervention types; and

	6. come up with a diagnostic of 'restoration readiness' and strategies for addressing major policy and institutional bottlenecks.
Institutional framework for adoption and diffusion	The availability of Malawi Forest Landscape Restoration Strategy in the Ministry of Natural Resources Energy and Mining presents opportunity for a framework for adoption and diffusion
Cost	According to IUCN, FLR is one of the most cost-effective and least labor-intensive technologies in that it does not require acquiring and planting seeds or seedlings but rather allows trees to re-grow naturally. The cost of management is comparable to other technologies like FMNR.
Benefits	The benefits of FLR are many, being categorised into economic, social, environment and climate related. The benefits are discussed henceforth.
Economic	Landscape approach and bringing degraded land back into production, thus, FLR helps expand the Malawi stock of agricultural, agroforestry and forested land to be used for economic activities.
Social	Over 85% people in Malawi depend on forests for at least part of their well-being. The vast majority are from more vulnerable groups such as poorer households, women and those living in remote communities. FLR have several social benefits, including the following: (i). Provision of forest products such as poles and construction timber, folder, edible fruits and other non-timer products (ii). Provision of sustainable bio-energy (iii). Provision of cultural and health benefits. (iv). FLR can lead to an increased number of seasonal streams and more opportunities for dry-season irrigation. (v). Reduce landslide risks, reduce consequences of flooding/extreme weather events (vi). Increased resilient to climate relative disasters such as flooding and droughts

Environment	i). FLR has the potential to generate significant biodiversity benefits. ii). Control erosion mitigation and reduce sedimentation iii). Support ecosystem-based adaptation
GHG mitigation potential	FLR has major potential as a climate mitigation mechanism through increased carbon sequestration
Applicability* of the technology in Malawi (short, medium and long term)	Short term
Size (household and large-scale)	Both at household and large scale levels

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4. Agroforestry

Technology Characteristics	Narrative description of the characteristic
Status of the technology and its future market potential	Agroforestry, also known as agro-sylviculture is a land use management system in which trees or shrubs are grown around or among crops or pastureland. Agroforestry, as defined by the World Agroforestry Centre, is "a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic, and environmental benefits for land users at all levels". On the other hand, the Association for Temperate Agroforestry describes it as "an intensive land management system that optimises the benefits from the biological interactions created when trees and/or shrubs are deliberately combined with crops and/or livestock". Agroforestry offers great potential for carbon sequestration. As with most of the climate technologies in the forestry sector, terrestrial sequestration is based on the fact that plants take CO_2 out of the atmosphere through photosynthesis and store it as organic carbon in above-ground biomass (trees and other plants) and in the soil through root growth and the incorporation of organic matter (Figure 1). Thus, the process of carbon loss through land use change can be reversed, at least partially, through improved land use and management practices. In addition to afforestation, changes in agricultural land management, such as the adoption of tillage practices that reduce soil disturbance and incorporate crop residues into the soil, can remove carbon from the atmosphere and store it in the soil as long as those land use and management practices are maintained. Agroforestry systems will vary by region. However, crops and forests together will elevate the carbon conserving capacity of the agro-ecosystem of a region. Agroforestry has several benefits, including the following: (i). Trees act as a buffer against storms to prevent crop destruction. (ii). Dry land forests apparently manage to sequester carbon by reducing respiration rates and growing rapidly in early spring to take advantage of temperatures most favorable for growth.

	(iii). Agroforestry trees also improve land cover in agricultural fields in addition to providing carbon inputs (root biomass, litter and pruning) to the soil. These often reduce soil erosion, which is a crucial process in soil carbon dynamics. (iv). An agro-forestry induced micro-climate improves quality and increases the yield of some crops, although it is difficult to provide an estimation of the yield increase. (v). Increasing soil carbon greatly benefits agricultural productivity and sustainability. (vi). Cost of carbon sequestration through agroforestry appears to be much lower than through other CO_2 mitigation options However, the agroforestry has the following disadvantages (i). This technology involves a very slow process of marginal carbon conservation. (ii). Soil carbon increases only in drier sites and actually decreases in wetter sites of agroforestry regions. As a result, the net carbon balance may be marginally positive for the dry sites but negative for the wet sites. (iii). Under dry environments, the tree-crop competition for water usually results in low crop yields, which makes this technology unattractive for dryland farmers. Under dryland conditions, trees with their effective rooting systems take more water compared to crops with relatively less effective rooting systems, so the crops are more vulnerable to water stress with consequent lower yields. (iv). Various species of damaging insects, pests, and diseases have been associated with dead or dying trees. These are a major threat to the development of agroforestry in the tropics like Malawi. Agroforestry systems may be classified based on the following criteria: (i). On a structural basis: this refers to the composition of the system and the arrangement of it in space and time. Adding woody species into different niches (different

	parts of farms and the agricultural landscape) can increase diversity, sustainability and productivity. (ii). On a functional basis: this refers to the role or use of the tree component, such as timber, fruit, fodder, medicine. Typically, the inclusion of trees increases the number of products generated by the system, which then acts as a safety net for farmers. Services such as the use of trees as windbreaks and to prevent soil erosion may also be important in addition to tree products. (iii). On a socioeconomic basis: this refers to the purpose of the system with regard to human livelihoods, usually broken down into subsistence, commercial, and/or intermediate production systems. Agroforestry may be promoted to meet specific social goals such as poverty alleviation and food security. (iv). On an ecological basis**:** this refers to the suitability of the agroforestry system for a given environment. Thus there are different types of agroforestry for tropical, temperate and arid environments that take into account the environmental, ecological and biological conditions of each area.
Status of the technology and its future market potential	Adoption of agroforestry technologies (incorporation of trees in farming systems) is well known to Malawi's Agricultural and forestry personnel. Government of Malawi and several non-governmental organisations have supported agroforestry projects in the country such as the ADDFOOD project implemented by the Ministry of Agriculture with financial support from the European Union, and the Malawi Agroforestry Extension Project (MAFE) in the early 1990s. However, their adoption and use have been limited by the intended beneficiaries such as farmers. The potential for popularisation of the technology is great.
Feasibility of technology and operational necessities	Agroforestry is feasible in Malawi. However, the challenge of finding market for agroforestry products is not well established.
Institutional framework for adoption and diffusion	The Department of Forestry and the National Forestry Policy as well as National Agricultural Policy provides framework for adoption and diffusion of the agroforestry

Cost	The cost of implementing agroforestry vary on size, and other factors. The variable costs of implementing the programme include, (i). *Establishment:* The costs of establishment include those for site preparation, seedlings, planting (labor and equipment), watering, staking (ii). *Maintenance:* Under maintenance costs include for fertilization, pest and disease control, grafting, thinning, pruning (iii). *Harvesting,* and (iv). *Marketing:* Under marketing, the costs include those for Advertising, packaging, transportation The fixed costs include the cost of purchase or lease of land, interest payments (intermediate debt), lease agreements, land - interest
Benefits	The benefits of agroforestry are grouped into economic, social, environmental and climate related, as discussed henceforth.
Economic	Agroforestry contributes to increased crop production through the use of fertilizer trees, for example. Also, agroforestry increases land productivity through crop production, animal grazing and other derivation from trees (e.g poles). These translate to increased income for farmers.
Social	Agroforestry has several social benefits, presented as follows: (i). Poverty reduction through increased crop production and tree products e.g poles (ii). Enhancement of food security through increased crop production (iii). Agroforestry presents opportunity for growing medicinal plants. This enhances human health in situations where people have limited access to mainstream medicines.
Environment	Agroforestry practices may realize other environmental benefits such as: (i). Enhancement and maintenance of biodiversity (ii). Improves the greenness and the visual aesthetics of agricultural land

	(iii). Reduced deforestation and pressure on trees and forests through providing farm-grown fuel wood (iv). Agroforestry offers a great potential for adaptation to impacts of climate change for both subsistence and commercial farmers
GHG mitigation potential	Agroforestry can sequester significant amounts of carbon dioxide through
Applicability* of the technology in Malawi (short, medium and long term)	Short term
Size (household and large-scale)	Both household and large-scale

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Figures

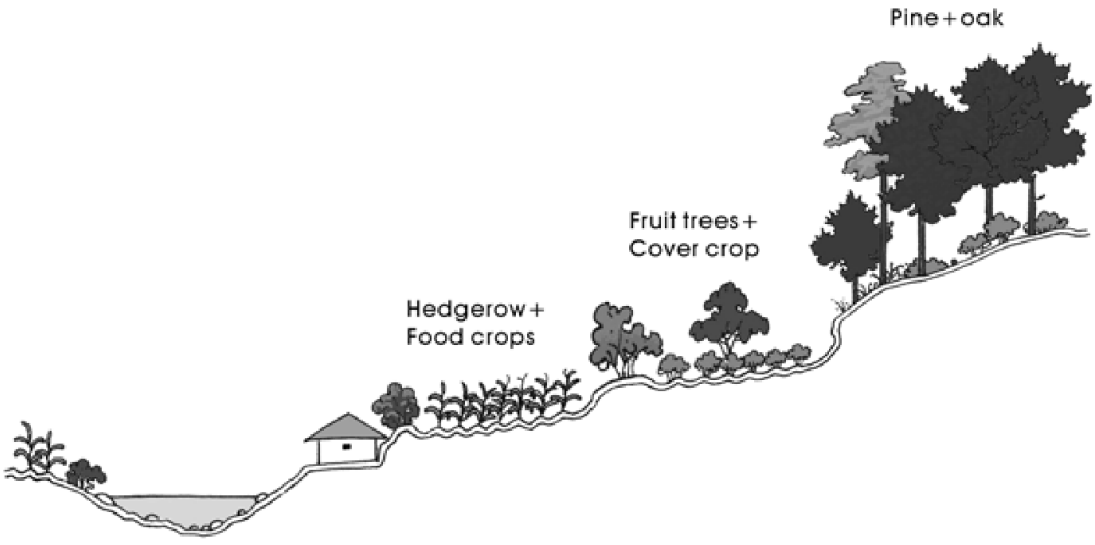

Figure 1: Schematic diagram for agroforestry for sloping land management

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5. Efficient use of forest products

Technology Characteristics	Narrative description of the characteristic
General information	A forest product is any material derived from forestry for direct consumption or commercial use, such as wood, timber and poles. Wood 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. The residues (or waste) from forest products could be categorized as follows: (i). thinning and harvesting residues; (ii). sawmill residues (slabs, off-cuts, trimmings, edgings, chips, sawdust, bark); (iii). residues of furniture industry (planer chips, sawdust); (iv). residues from veneer slicing and veneer peeling process (solid wood pieces, peeler cores, veneer residues); (v). timber in building constructions; and (vi). waste paper for recycling. 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.
Status of the technology and its future market potential	Malawi uses forest products and services in almost any facets of life. The market for forest products is therefore big.

Feasibility of technology and operational necessities	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. These are briefly explained below: *Reduction in the waste of wood residues* Studies and observations show that of all the wood felled for timber and poles in tropical forests, a significant proportion remains in the forest as unused wood residues. For example, Chikangawa Forest in the Northern Region of Malawi, where a lot of unused wood is evident in the harvested forests. While leaving a certain amount of residues in the forest is environmentally beneficial, improved utilization would result in less timber felled for the same volume of industrial round wood produced, thus allowing for harvesting on a smaller forest area thereby reducing deforestation. The forest enterprises in Malawi can be classified into either formal or informal sector enterprises. The formal sector enterprises include the organized wood based industries such as sawmills, plywood mills, particleboard mills and furniture factories. The informal enterprises are small forest based enterprises operating without formal corporate entity, this includes enterprises that engage in the production of firewood, charcoal, and sculptured wood items. The formal enterprises constitute the forest industries in the country. In case of timber harvesting, there are three different types of operators in Malawi, which could be categorized as follows: (i). large industrial wood processors that operate in public plantations under license,

	(ii). small and medium scale processors operate in public plantations and in community/private forests. These are poorly equipped (iii). individuals using bench-saw or mobile saws operating mainly in farmlands. Efficiency in timber processing decreases from the industrial operators to the individuals. *Wood residues from timber harvesting and primary processing:* What remains after timber arrives at a mill for processing is commonly referred to as primary and secondary wood processing residue or waste. This residue is prepared for utilization because generally it is clean, uniform, on-site, and low in moisture content. Examples include bark, sawdust, and black liquor. Vocational training in sawing, tree felling and harvesting operations would help to ensure that skilled operators carry out harvesting and thereby reduce wastage and ensure optimum quality and value of logs. With correct supervision, improvements in forest sawing practices would help to ensure product specifications are met when cutting trees into logs and help to increase production rates of harvesting crews. Wood processing residue can be used directly to produce heat and electricity, or indirectly to produce bio-based products such as bio-char, pellets and wood based recycled materials (toilet paper) depending on their quality grade. Some of the wood processing residues are used in the manufacturing of other products such as particleboard, nonstructural panels, and animal bedding. The secondary use of wood residues increases the efficiency of use of forest products. The rising cost of waste material disposal and a growing consciousness for the environment also contribute to the increasing importance of waste wood recycling. Recycled waste wood is often used as raw material for the production of chipboard or other wood-based materials. *Improvements in tree-felling operations* Properly conducted cutting operations can help minimize damage to residual trees and maximize volume and value of logs harvested. Cutting of climbers and vines before tree felling, and directional felling, are now used in some tropical forests to reduce damage to trees. Recent studies by United Nations Food and Agriculture Organization (FAO) indicate that improved

	felling operations can result in increases in wood volume recuperated of up to 30 percent, and that damage to the residual forest stand can be reduced by more than 20 percent. *Changing processing technology and product development* 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).
Institutional framework for adoption and diffusion	Department of Forestry offers the institutional framework that could support the adoption and diffusion of promotion of Promotion of efficient use of forest products.
Cost	The cost of promotion of efficient use of forest products depends on size and nature of forest product. The cost could be high if purchase of an expensive but efficient hardware if needed to convert forest raw material into finished product.
Benefits	The benefits of efficient use of forest products are many. They are categorised into economic, social, environmental and climate related, as discussed henceforth.
Economic	Promotion of efficient use of forest products increases the productivity level since wastes are put into economic use. Also, there are indirect economic benefits from saved forests as a result of promotion of efficiency in the use of forest products.
Social	The saved forests provide various social benefits such as those derived from the ecosystem as well as continued social benefits from forest products, such as source of woodfuel, medicine, and food.
Environment	Promotion of efficient use of forest products is recommended as one way of minimising deforestation by reducing the amount of trees felled down a unit product. The saved forest encourage provision of watershed, protecting and enhancing Malawi's water resources

GHG mitigation potential	Forest products can work towards reducing global warming trends. One core idea is that forest products themselves are storage for carbon dioxide. Also, directly, for example, bio-energy could replace fossil energy and reduces greenhouse gas emissions directly.
Applicability* of the technology in Malawi (short, medium and long term)	This could be applied in short and medium term because some of the elements of the technology are not very much familiar to Malawi like use wood waste for production of electricity.
Size (household and large-scale)	Household and large scale

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Figures

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6. Promotion of fruit tree outside the forest

Technology Characteristics	Narrative description of the characteristic
General information	Malawi has had some challenges concerning sustainable forest harvesting for several applications, which has resulted in deforestation. Reforestation programmes, such as the National Tree Planting has not been very much effective. This is partly due to lack of care for the new/young trees. The trees planted are mostly non-fruit trees. It has been argued that the promotion of fruit trees outside the forest could lead to enhanced protection and management of such trees because of the increased non-wood value derived from fruit trees. In horticultural usage, the term 'fruit tree' is limited to those that provide fruit for human food. It is practically convenient to promote fruit tree planting in Malawi because the country possesses fertile land with which it could produce all the fruit it needs.
Status of the technology and its future market potential	The practice planting of fruit trees outside forest is already happening, but at a smaller scale (subsistence level). This has also been limited to urban areas, while the great potential is also in the rural areas where trees and forests are being depleted. However, broad structural issues are prohibiting the development and success of the fruit product industry. The infrastructure is plagued by poor transport (e.g. road conditions) and fresh fruit storage capability. There is lack of smallholder farmer expertise in sustainable propagation methods and business skills. Smallholder farms have difficulty obtaining the capital they need to start-up, purchase inputs and equipment. Finally, export opportunities are limited for many processed fruits, as most neighboring countries can grow or process the same exotic fresh fruits as Malawi. Furthermore, the country imports most of the fruits and fruit juices from southern African countries. Many fruits imported could grow well in some parts of Malawi, such as oranges and mangoes.
Feasibility of technology and operational necessities	The practice of planting trees outside the forest is feasible in Malawi. However the operational necessities include availability of storage appliances, transportation and markets. In general, in order to make the promotion of tree planting a success, it is advisable to carry out the following activities:

	(i). Access to improved (high-yielding, quick maturing or pest-resistant) seeds of fruit tree varieties that are adapted to Malawian conditions and ecological sustainability, including: avocados, mangoes, guava, citrus, jackfruit and papaya. (ii). Access to forestry inputs (including fertilizers and pesticides) necessary to enhance fruit tree production and productively use them; (iii). Adopt appropriate agricultural technologies and farming practices (including techniques for sustainable soil and water management, integrated pest management, weed control etc) (iv). Access credit to buy basic farming tools and equipment (including spray pumps, watering cans, etc) and improved storage equipment and facilities (v). Enhance the quality of agricultural products by improving post-harvest processing, handling and storage, including through training in efficient processing and appropriate handling practices for different agricultural products and quality control systems and techniques (vi). Add value to the harvested fruit including through small-scale agro-processing (vii). Access and maximize new and existing markets for the harvested fruits
Institutional framework for adoption and diffusion	The promotion of fruit tree plantation could benefit from existing frameworks in The Departments of Forestry and Agriculture for adoption and diffusion of the technology
Cost	The cost involved will depend on size, land acquisition/use and fruit tree management processes
Benefits	The benefits of practising fruits outside the forest are many, categorised into economic, social, economic, environmental and climate related, as discussed henceforth.
Economic	Improvement in livelihood from selling of fruits
Social	Improvement nutrition derived from fruits Planting of fruit trees is one of the adaptation options to impacts of climate change e.g droughts that could lower crop production

Environment	Fruit trees, as any other tree enhances air quality. It is also one of the practices that controls soil erosion and could enhance biodiversity.
GHG mitigation potential	Increased carbon sequestration through additional fruit trees
Applicability* of the technology in Malawi (short, medium and long term)	Short term
Size (household and large-scale)	Household scale and large scale

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None

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7. Urban forestry

Technology Characteristics	Narrative description of the characteristic
General information	Urban development – as often practiced – results in the depletion and degradation of natural ecosystems in and around urban areas, the 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. Some barriers and limitations faced in promoting urban forestry are as follows: (i). There could be a conflict between the land owner and municipalities can be a major hurdle (ii). Failing in empowering the urban forestry related policies into action due to improper planning and convincing the citizens to implement those policies (iii). Lack of attractive carbon market for the urban forestry.
Status of the technology and its future market potential	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 popularisation 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 etc.
Feasibility of technology and operational necessities	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.
Institutional framework for adoption and diffusion	The four City Assemblies in Malawi (Blantyre, Lilongwe, Mzuzu and Zomba) have departments of Parks and Wildlife that would provide institutional framework for adoption and diffusion of promotion of urban forestry
Cost	The cost of urban forestry depends on location, species and maintenance required. Urban forest cost depends on variables like weather and policies. Proper planning and designing are required to gain maximum benefits from the urban forestry and also to minimize cost.
Benefits	The magnitude of benefits available through forestry-sector activities will depend on the amount of land available, improvements of forest productivity and technical developments in the efficiency with which forest products are harvested and used.

Economic	Urban forestry is also eligible to be a Clean Development Mechanism (CDM) project and could generate forestry carbon credits. Since forest could beautify a place, the practice of urban forestry could enhance the business of events such as weddings, parties
Social	Urban forests can help improve the quality of urban life. Tangible benefits to urban dwellers are fuel wood, food, fodder and building materials, as well as social recreation.
Environment	Urban forest could enhance the protection of biological diversity, and of watersheds
GHG mitigation potential	Urban trees reduce the amount of greenhouse gases in the air by sequestering carbon dioxide and by reducing the amount of energy needed to heat and cool buildings.
Applicability* of the technology in Malawi (short, medium and long term)	Short term
Size (household and large-scale)	Household and large scale

*On Applicability of the technology

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- Medium term refers to the technology that is in pre commercial in a similar market
- Long term refers to the technology that is still under research and Technology phase

Figures

None

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8. River and stream bank restoration

Technology Characteristics	Narrative description of the characteristic
General information	River - and stream- bank restoration would be net beneficial in areas with steep slopes that are near important water features, like the Shire River. In these areas, the returns to agriculture are likely to be low because the steep slopes make cultivation difficult and costly and, more importantly, reducing soil erosion and increasing water yields in these areas will create large benefits for downstream users, such as the Electricity Generation Company (hydroelectric power producer) and downstream agriculturalists.
Status of the technology and its future market potential	The practice of riverbank restoration is not new to Malawi, only that it has not been implemented by the intended stakeholders. As the practice is recommended as one of the strategies to control river flooding, the potential for its application is high in Malawi since the country suffers from floods, with increasing frequency and magnitude.
Feasibility of technology and operational necessities	The practice of river bank restoration is feasible in Malawi. It is recorded that there are more than 36,000 hectares in Malawi are suitable for river and stream-bank restoration. The restoration involves channel monitoring, erosion protection, sediment transport and streambank stabilization amongst other processes. Streambank erosion is a common and natural occurrence due to changes in watershed reaches levels, vegetation loss and channel excavation. Streambank restoration requires regarding the ground to follow a gentler slope in order to allow for more stability and better protection for existing trees. As for erosion protection, adding more vegetation and rocks to the terrain and building a wall between the water and the streambank will reduce erosion and downstream sedimentation.
Institutional framework for adoption and diffusion	The availability of Malawi Forest Landscape Restoration Strategy in the Ministry of Natural Resources Energy and Mining presents opportunity for a framework for adoption and diffusion
Cost	River- and stream-bank restoration requires substantially more financial and labor investment compared to the degraded land use, and as such the net present value is 4.3 million MWK/ha when only private benefits are accounted for.

Benefits	The benefits of practicing river bank restoration are many. These benefits are discussed below under economic, social, environment and climate related.
Economic	River- and stream-bank restoration is most beneficial when it is done on landscapes with low agricultural and forestry opportunity costs or in areas where the public benefits of reducing erosion and increasing water quality are high.
Social	Streambank restoration safeguards human settlement during flooding. It also provides proper aesthetic for those who want to recreationally enjoy the benefits of a river.
Environment	River- and stream-bank restoration helps in sediment retention The practice also ensures a healthy habitat for fish and other wildlife,
GHG mitigation potential	The trees on the river and stream bank increase carbon sequestration
Applicability* of the technology in Malawi (short, medium and long term)	Short term
Size (household and large-scale)	Both household and large scale

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Figures

None

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9. Bamboo in Social Forestry

Technology Characteristics	Narrative description of the characteristic
General information	Forestry practices which aim at provides goods and benefit to a nearby society are usually referred to as Social forestry. In Malawi, forests have always played an important role in bettering the lives of the local population. Bamboo is one of the most important multipurpose species and therefore, it is being introduced in a large scale under various programmes of social forestry. It is a domestic arborescent grass and people like to plant it home gardens, around wells, compounds and in the agricultural fields. Bamboo is highly versatile. It is capable of growing in a variety of soils derived from different parent rocks, within its climatic habitats. Bamboo has also been planted on a large scale along roadsides and canals. It is also planted in degraded forest areas particularly near habitations. This can also be planted on agricultural fields and homestead plantations. In social forestry programmes bamboo is grown mainly in the following systems: Strip plantation; Community forestry programme; Agroforestry plantation; Rehabilitation of degraded forest; and Reclamation of wastelands. Bamboo is the fastest-growing plants in the world, due to a unique rhizome -dependent system. Certain species of bamboo can grow 910 mm within a 24-hour period, at a rate of almost 40 mm an hour (a growth around 1mm every 90 seconds, or 1 inch every 40 minutes). Giant bamboos are the largest members of the grass family. Bamboos are shrubs, which have a tree like habit, their culms are erect and sometimes climbing. Bamboos are of notable economic and cultural significance in South Asia being used for building materials, and as a versatile raw product. Bamboo has a higher comprehensive strength than wood and concrete.. Bamboo has many other qualities, as follows: (i). it is one of the fastest growing plants (ii). it is an enduring natural resource, thus ideal for plant for adapting to climate change in Malawi (iii). it is versatile with a short growth cycle (iv). it acts a natural controllable barrier

Status of the technology and its future market potential	Bamboo planting is not new to Malawi, but this technology concern the innovative way of enhancing carbon sink in the forest sector through effective promotion of bamboo forest in degraded landscapes such as fragile riverbanks and deforested areas. The potential for bamboo as social forestry is relatively high due to other benefits from the bamboo such as as a source of energy and construction material, as wood based energy and construction material supply is dwindling in the country.
Feasibility of technology and operational necessities	Bamboos have been planted in Malawi, but at a limited scale. The practice is being promoted by forestry personnel, but the practice has not been adopted widely by the intended beneficiaries. The technology involves securing land for bamboo plantation, which is available in Malawi, such as those from fragile riverbanks and deforested areas. Community bamboo growing programmes are crucially dependent on the collaboration of village councils, community groups (or) other local institutions. The village community groups should be trained (or) given proper instructions about the growing of bamboo in the barren land by the specialists - in the field, while selecting the village community groups, preferring educated unemployed youths.
Institutional framework for adoption and diffusion	Extension services available in the Forestry Sector will be responsible for adoption and diffusion of the promotion of community bamboo forest.
Cost	The cost of the technology is dependent on several factors, such as seedling preparation, planting and management of forest. These depend on the size of the forest. However, with community participation, the cost would be reduced significantly.
Benefits	The benefits of bamboo social forestry are categorised into economic, social, environmental and climate related, as discussed henceforth.
Economic	The bamboo forestry could provide raw materials for use in product development for sale. For example, it supports basketry and furniture making industry with raw materials. The bamboo is also an essential construction material. It is a viable replacement for wood for production of charcoal for sale
Social	(i). Bamboos could be used as a traditional medicine

	(ii). It is integrally involved in culture and the arts
Environment	Especially for Malawi, as a soil conservation tool, bamboo forest is an instrumental component that could positively transform the country's landscape due to its anti-erosion properties that creates effective watershed by stitching the soil together. Due to pressure on natural resources, the country has several fragile riverbanks, and deforested areas which could be bamboo forested.
GHG mitigation potential	It plays a crucial role in the balance of oxygen and carbon dioxide in the atmosphere, thus a very important plant in enhancing Carbon sink in Malawi
Applicability* of the technology in Malawi (short, medium and long term)	Both short term and medium term
Size (household and large-scale)	Both household and commercial scale

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Figures

Figures showing a bamboo plant (a) and forest (b)

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