Tanzania

Technology Needs Assessment Report

Climate Change Mitigation

DISCLAIMER

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Executive Summary

ES1 Technology Needs Assessment (TNA) process originates from the Poznan Strategic Programme on Technology Transfer that was established at the Fourteenth Conference of the Parties (COP 14) of the United Nations Framework Convention on Climate Change (UNFCCC).

ES2 TNA is a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties other than developed country Parties, and other developed Parties not included in Annex II, particularly developing country Parties. TNA identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. TNA addresses both soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity building.

ES3 The collaboration between the Global Environmental Facility (GEF), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), United Nations Environment Programme – Danish Technical University (UNEP DTU), Climate Technology Initiative (CTI), Expert Group on Technology Transfer (EGTT) and the UNFCCC secretariat has resulted in financial and technical support to assist developing countries to conduct TNAs. It is in this context Tanzania has undertaken its technology needs assessment.

ES4 The Vice President Office (VPO), Division of Environment (DoE) spearheaded the TNA project with the support from UNEP DTU Partnership to identify and analyze priority technology needs for Tanzania, which will form the basis for a portfolio of environmentally sound technology (EST) projects and programmes to facilitate the transfer of, and access to ESTs and know-how in the implementation of Article 4.5 of the UNFCCC.

ES5 The TNA will carry out the following activities (i) identify and prioritize through a country-driven participatory process, technologies that can contribute to mitigation and adaptation for selected sector/subsectors, while meeting national sustainable development goals and priorities; (ii) identify, analyse and address barriers hindering the acquisition, deployment, and diffusion of prioritised technologies including enabling the environment for the same; and (iii) develop Technology Action Plans (TAP) including suggested measures/actions. This step will include the development of project ideas (PI). This report covers the first part of TNA process, i.e. selecting and prioritising mitigation technologies.

ES6 The TNA Process in Tanzania began with a National Inception Workshop which was held on 29th – 30th September, 2015. The TNA Coordinator is Maximilian Mahangila (Division of Environment, Vice Presidents Office) and consultants for this project are Prof. Jamidu H.Y. Katima (mitigation, Energy Sector), Mr. Abdalla S. Shah (mitigation and adaptation, Forest Sector) Ms. Euster Kibona (adaptation, Agriculture and Water Sectors).

ES7 The roles of TNA Consultants in this process are (i) to provide support to the identification and categorisation of the country's priority sectors, and identification and prioritisation of technologies for mitigation through a participatory process with a broad involvement of relevant stakeholders; (ii) to facilitate the process with the work groups of analysing how the prioritised technologies can be implemented in the country and how implementation circumstances could be improved by addressing the barriers and developing an enabling framework; (iii) to prepare the National TAP, which will outline essential elements of an enabling framework for technology transfer and will consist of market development measures, institutional, regulatory and financial measures, and human and institutional capacity requirements.

ES8 The methodology used to prioritise the technologies include, identification of technologies by the Consultant, Presenting the technologies to Stakeholders for endorsement, applying the Multi Criteria Analysis (MCA) to rank the technologies. The criteria used to rank the technologies were developed and agreed upon by the national stakeholders. Therefore TNA involved extensive stakeholder participation at every stage of the needs assessment. Furthermore, methodology training, a stakeholder consultation for prioritization of sectors was done on 20th November 2015 (Energy sector), 23rd November 2015 (Water and Agriculture sectors), 25th November 2015 (Forest sectors) and 24th November 2015 for the Zanzibar Stakeholders. The final refinement of the prioritisation was done on 3-4th March 2016.

ES9 TNA process reviewed national policies, legislations and strategies that have bearing on the TNA in Tanzania. The relevant laws, policies and strategies are Environmental Policy, 1997, the Energy Policy (2003), the Water Policy (2002), the Wildlife Policy (1998), the Forestry Policy (1998), the Land Policy (1997), the National Agriculture and Livestock Policy (1997), the Zanzibar Environmental Policy (2013), the Zanzibar National Forest Policy (1999) The Zanzibar Environmental Management Act (2015), the Tanzania Climate Change Strategy, 2012 Tanzania Climate Change Strategy, 2012, Scaling-Up Renewable Energy Programme (SREP) Investment Plan for Tanzania (2011), the Zanzibar Climate Change Strategy (2014), the Zanzibar Forest Resources Conservation and Management Act (No. 10, 1996), The National REDD+ Strategy (2012), the National Framework for REDD+ (2009), the National Strategy for Growth and Poverty Reduction (MKUKUTA) (2010), Vision 2025 (2000). The relevant sections of these policies, laws, strategies and plans are discussed in the report.

ES10 The Selection of Sectors for TNA was based on the extent of GHG emission as per existing studies. Land use changes and Forestry sector made the largest contribution i.e. 53%, following by agriculture (33%) and energy (13%). Thus forestry and energy were selected for TNA for climate change mitigation.

ES11 According to International Energy Agency (IEA), Tanzania consumed a total of 19.6 MTOE, of which net imports were 1.7 MTOE in 2009. The GoT estimates this to have increased to 22 MTOE in 2010 (IEA, 2011). Biomass represented 88.6 percent of the total energy consumption in 2009. Electricity represented 1.8 percent, while petroleum products provided 9.2 percent of the total energy consumed in Tanzania. Total primary energy consumption is 0.45 tons of oil equivalents (toe) per capita, including biomass and waste which is principally used in the residential sector for cooking. The 2010 estimated emission, based on linear change of energy trend and assuming similar energy mix, is about 5283 Gg. Energy consumption is expected to increase as the country is undertaking a major drive of rural electrification and hence energy contribution CO_2 burden. As such this sector is very important for climate change mitigation.

ES12 Although the contribution of Tanzania to global GHG burden is low, the impacts of climate change are predicted to be severe. It is reported that most parts of the country, particularly the Central and Northern Zones, which are semi-arid are vulnerable to climate variability and they will be more vulnerable to the projected increase in frequency and amplitude of extreme climate events. Time series analysis show that the mean annual temperature for Tanzania is projected to increase by 1.7°c in the north eastern areas of the country and by

2.5°C,over Western parts of the country. Projections from Global Circulation Models (GCMs) are indicating that due to doubling of concentration of CO_2 in the atmosphere by 2100; there will be an increase in rainfall in some parts of Tanzania while other parts will experience decreased rainfall. The areas with two rainfall seasons that is, the north-eastern highland and Zanzibar, the Lake Victoria basin and the northern coast would experience an increase in March to May (long-rains) rainfall by up to 15 percent, While, southern, south-western, western and central areas will experience a decrease in March to May rainfall by up to 6%.

ES13 Climate change has multiple impacts on society and ecosystems. Climate change and its impacts are manifested in various forms. Socially it is commonly agreed that the phenomenon hit the poorer countries hard because they have low coping capabilities, low level of resilience and adaptive capabilities; and weak economies. Tanzania has experienced impacts of climate change in form of frequent droughts, which is a late oncoming of rain season or as a decrease of rainfall during dry months, or longer dry seasons can have significant social-economic and ecological consequences.

ES14 There have been several studies in Tanzania focussing on climate change mitigation in the energy sector. These include: (i) Identification of technologies that are associated with GHG emissions (ii) Identification of the technical possibilities of minimising GHG emissions (iii) Identification of the appropriate environmentally benign technologies available for Tanzania, including its specific reduction potential and associated costs (iv) Investigation of various options for GHG abatement including retrofitting of emissions reduction equipment (v) Exploration of the link between energy efficiency, mitigation of GHG emissions and associated costs (vi) Proposal of technological strategies and policy options to mitigate GHG emissions based on an abatement cost curve (vii) Recommendation of possible targets for GHG mitigation or stabilisation particularly in the national energy policy, and (viii) Building an indigenous capacity in the assessment of climate issues.

ES15 Tanzania has also implemented some technologies that reduce GHG emissions, although these were not done in the context of TNA. These include installation of a gas combined cycle power plants such as Ubungo 1 (102MW), Ubungo 2 (105 MW), Kinyerezi 1 (150MW). The interconnection between Kenya and Tanzania is being constructed. The national grid is being upgraded to 400 kVA to address the issue of power losses. Some mini / micro hydropower are already operational. These include Mwenga Hydropower Plant (4MW), Andoya micro hydropower plant (500kW). The TNA may act as catalyst to accelerate this process, considering that Tanzania is still in dire need of power.

ES16 Another sector that has been identified to be important for mitigation of climate change in Tanzania is forestry. It is estimated that Tanzania has 48.1 million ha (481,000 km^2) of forests and woodlands equivalent to an average of 1.1 ha per capita. This means that forests and woodlands occupy an equivalent to 38.3 % of the total land area. These forests contain 3.3 billion m^3 of wood, which is equivalent to an average of 37.9m^3/ha or 74.4m^3 per person. Forest vegetation in Zanzibar covers about 63,908 ha, equivalent to 23.7% of the total land area. Zanzibar's forests form part of the East Africa Coastal Forests Eco-region, one of the world's 200 biodiversity hotspots. Deforestation rates are estimated to be at least 1% per annum.

ES17 Forestry like other land based undertakings is affected by climate change, but on the other hand forests can significantly contribute in mitigating climate change. The effects of climate change on forests can be both direct and indirect. The direct contribution could be through the shifts in agroecological zones, thus the species composition of a given forest may change and lead to reduction of quality of the forests.

ES18 As a result of the impact of climate change on forest ecosystems in Tanzania it is projected that there will be ecological zones shift, because some species vulnerable to the impacts of climate change will be affected and may become extinct. It is predicted that subtropical dry forest and subtropical moist forest will decline by 61.4% and 64.3% respectively, for example the subtropical acacia woodlands currently in existence will be completely replaced. There will be an increase in tropical dry forest and moist forest, which are likely to replace the current life zones. It is predicted that these ecological shifts will reduce the ability of the forests in providing the inherent goods and services and increase their vulnerability, hence reducing the mitigation and adaptive capacity of the ecosystems and the communities that depend upon the forests.

ES19 Forests do not only have important and critical ecological values, they are also sources of livelihoods and vital services such as conserving soils and water sources, harbouring rich biodiversity and important genetic resources. They provide services such as recreation and tourism, other non-wood forest products and as water catchment. In addition to all the goods and services they can help with carbon mitigation through carbon sequestration. Forest management decisions can enhance adaptation and mitigation capabilities of forests or can lead to contribution to GHG emission in the atmosphere. Climate change can potentially affect and compound degradation process and profoundly transform forest ecosystems, but sustainably managed forests can play an important role in climate change mitigation as sinks of carbon and be a basis for societal resilience and adaptive capacity. It is estimated that Tanzania's forests and woodlands have carbon stock in above ground and below ground biomass pool of 1060.8 million tons, that has been interpreted that the forests contain 36.5 tons of carbon per ha.

ES20 Ecologically, Climate Change can lead to low productivity level of ecosystems which can be further degraded by high human demand on ecosystems. Forest ecosystems are vulnerable when they have limited tolerance of climate variation or change.

ES21 The Coordination of TNA is under VOP and the TNA team is the umbrella body. The National Steering Committee is composed of following members: Permanent Secretary Vice Presidents Office, Permanent Secretary Ministry of Water and Irrigation, Permanent Secretary Ministry of Energy and Minerals, Permanent Secretary Ministry Natural Resources and Tourism, Permanent Secretary Ministry of Agriculture, livestock and Fisheries, Director General, Commission for Science and Technology, Director, Institute of Natural Resource Assessment, University of Dar es Salaam. National TNA Committee has eight members from different sectors as follows: Energy, Water, Agriculture, Forest, Environment, University of Dar es Salaam, Commission for Science and Technology and The First Vice President Office – Zanzibar. The Steering Committee will be responsible for Guiding the National TNA team and Providing political acceptance for the Technology Action Plan. The National TNA team comprises: National TNA Committee, National Consultants /experts, Workgroups, and TNA coordinator.

ES22 The technologies were selected through literature review and stakeholder consultations. The TNA processes looked at existing technologies in both energy and forestry sectors. These include Hydropower, Biomass Energy, Wind Energy, Geothermal Energy and Mini-Hydropower Sources, Agro-forestry, Mangrove ecosystems conservation, Rehabilitation and Restoration, Forest Landscape Restoration (FLR) Assessment, Sustainable forest

Management (SFM), Improved seed and Tree Production Technology, Sustainable charcoal production models and appropriate techniques.

ES22 Stakeholder consultations were done through an inception workshop and direct face to face focussed group discussion. The inception workshop was used to introduce the TNA to the stakeholders. It provided objectives and expected outputs. During the focused group discussion the Consultants presented the outcomes from literature review highlighting potential areas that have been identified through other processes. Also the Consultants presented the fact sheets for different technologies. This exercise was repeated in Zanzibar.

ES23 The stakeholders that were consulted include the following: Government departments dealing with energy and forestry; Industries and industry associations, businesses, and dealers in energy and forestry products. Civil Society dealing with energy and forestry issues, academia and research organisations dealing in energy and forestry issues etc.

ES24 The first consultation focussed on technologies identification. This step was crucial to get initial political and technical support. The following technologies were listed as being of importance by the stakeholders:
Energy Sector: Solar PV, mini and Micro Hydro, Efficient and clean fuel / cooking technologies, Sustainable use of biomass fuel, Waste to Energy, Wind energy (electricity /mechanical power), Geothermal power, Natural gas, LPG, Tidal and wave energies and Coal (however the coal was removed from the list as it does not mitigate GHG emission).
Forest Sector: Agroforestry, Mangrove Conservation Rehabilitation and Restoration, Tree and Seed Production Improvement (Improvement of Forest Germplasm), Forest Landscape Restoration, Sustainable (Improved) Charcoal Production Methods, Efficiency in Biomass Energy Utilization, Reducing Emissions from Deforestation and Forest Degradation and Sustainable Forest Management (REDD+), Timber and Non Timber forest Industries Technologies, and Strengthen National Carbon Monitoring Centres.

ES25 The prioritisation step was carried out to establish and rank the most appropriate technologies for low carbon emissions and reduced vulnerability. It involved the identification and classification of technologies for mitigation, starting by generating a comprehensive listing of technologies available, including new or unfamiliar technologies. This extensive analysis was performed using the Multiple- Criteria Decision Analysis (MCA), by quantifying the selection process and determining to what extent each potential technology contributes to sustainable development goals, reduces GHG emissions, while being cost effective. The results of this analysis produced a weighted score that was used to prioritise the technologies in the energy and forest sectors.

ES26 The steps for undertaking the MCA were (i) Identification of technology options (ii) Identification of criteria (iii) "Weighting" (Assign weights for each of the criteria to reflect their relative importance to the decision) (iv) Combining the weights and scores for each of the options to derive an overall weighted score (v) Prioritising/ranking technologies and selecting the highest priority technologies (vi) Examining the results (vii) Conducting a sensitivity analysis of the results to any changes in scores or weights.

ES27 For the Energy sector the following weightings were used (i) GHG emission reduction potential (20%): The selected technology should have potential to mitigate GHG (ii) Sustainability (environmental) (20%): The technology should be resilient to environmental variability (iii) Access potential (15%): The technology should be able to reach as many people as possible, particularly those who are living far away from the national grid (iv)

Maturity (15%): This defines the level of technology in Tanzania, for example are there existing installed facilities similar to the selected technology (v) Energy efficiency (10%): This criterion considered the conversion efficiency. Technologies with low efficiencies means will require high investment for a given power demand (vi) Capital cost (10%): this defines the easiness or difficulty to gent interested parties to invest in the technology (vii) Job creation (5%): This defines the level of job creation both directly and indirectly (ix) Social acceptability and gender equity (5%): This criteria was considered important since there many technologies that have failed because they were not socially acceptable.

ES28 For the forest sector the following weightings were used (i) Cross cutting adaptation and mitigation benefits (15%): The technology has to be able to offer mitigation benefits. However, it is realized that many forestry technologies are likely to have both adaptation and mitigation benefits (ii) Accessible (10%): The technology needed should be easily reached and distributable to users (iii) Affordable and Acceptable (5%0: The financial investment cost in technology needed should be affordable at multiple scales so that even small investors can invest in the technology. The technology needed should have quality of being, practically, technically preferred and social acceptable by the users of the technology (iv) Economic value and (Viability) (5%): The technology to be chosen has to have economic viability, meaning the benefit of implementing or using the technology should be higher than the cost (v) Sustainable (20%): The technology has to be sustainable, indicating that once initially supported, it should continue to be used by the adopters of the technology with minimum or no outside support (vi) Replicable (15%): It should be possible for the technology to replicable and be used in other geographical or socio-cultural setting (vii) In line with existing policies and strategies (5%): The technology should be able to be supported by existing national socio-economic as well as environmental and forest management policies and strategies (viii) Compatible with other socioeconomic activities (15%) (ix) Job creation or Income Generation (20%): Technology needed should have a potential to generate income or offer employment.

ES29 After the MCA the stakeholder endorsed the following technologies as priority technologies that need further development:

For energy sector: (i) Mini and Micro Hydro (ii) Sustainable use of biomass fuel (iii) Solar PV

For energy forest sector (i) Sustainable Forest Management (ii) Agroforestry (iii) Mangrove Conservation Rehabilitation and Restoration.

ES30 The Fact Sheets for the technology selected are presented in Annex 1. These technologies will be subjected to barrier analysis, which will be presented in Report II

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1.0 INTRODUCTION

1.1. Background of TNA Project

Technology transfer started taking its roots during the Rio Summit in 1992, where issues related to technology transfer were included in Agenda 21 as well as in Articles 4.3, 4.5 and 4.7 of the United Nations Framework Convention on Climate Change (UNFCCC). TNAs were subsequently discussed during the Conference of Parties (COP) 1 in Berlin and COP 4 in Buenos Aires with Decision 2/ COP4 requiring GEF to provide funding to developing country Parties to enable them to identify and submit to the COP, their prioritized technology needs in particular sectors of their national economies which are conducive to addressing climate change and minimizing its adverse effects. The current TNA process originates from the Poznan Strategic Programme on Technology Transfer established at the Fourteenth Conference of the Parties (COP 14).

Technology Needs Assessments (TNAs), as defined by the United Nations Framework Convention on Climate Change (UNFCCC), are a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties other than developed country Parties, and other developed Parties not included in Annex II, particularly developing country Parties. The activities involve different stakeholders in a consultative process to identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity building [UNFCC, 2015].

Parties other than developed country Parties, and other developed Parties not included in Annex II, particularly developing country Parties, are encouraged to undertake assessments of country-specific technology needs.

The collaboration between the Global Environmental Facility (GEF), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), United Nations Environment Programme – Danish Technical University (UNEP DTU), Climate Technology Initiative (CTI), Expert Group on Technology Transfer (EGTT) and the UNFCCC secretariat has resulted in financial and technical support to assist developing countries to conduct Technology Needs Assessments (TNAs). The secretariat has published three synthesis reports on technology needs identified by non-Annex I Parties. These reports highlight priority technology needs identified to mitigate greenhouse gas emissions and adapt to the adverse impacts of climate change. They also highlight specific barriers to technology transfer and measures to address them. These reports have been used as resource material in this project.

In the recently completed TNAs, developing countries also prepared Technology Action Plan (TAPs) and project ideas. A TAP is an action plan containing a group of measures which address identified barriers to the development and transfer of a prioritized technology. In the TNA context, project ideas are concrete actions to implement prioritized technologies.

It is in this context Tanzania has undertaken its technology needs assessment.

The Vice President Office, Division of Environment Ministry spearheaded the Technology Needs Assessment (TNA) project with the support from the United National Environment Programme and Denmark Technical University partnership (UNEP DTU Partnership). The purpose of the TNA project was to assist Tanzania to identify and analyze priority technology needs, which formed the basis for a portfolio of environmentally sound technology (EST) projects and programmes to facilitate the transfer of, and access to ESTs and know-how in the implementation of Article 4.5 of the UNFCCC Convention (UNFCCC, 2015).

1.1.1. Objective of the TNAs

The purpose of Technology Needs Assessments (TNAs) is to assist developing countries to identify and analyse their priority technology needs, which can be the basis for a portfolio of Environmentally Sustainable Technology (EST) projects and programmes. This may facilitate the transfer and access to ESTs and know-how in the implementation of Article 4, paragraph 5, of the Convention.

The main steps of the TNAs project, which are guiding TNA activities in Tanzania, are:

- Step 1: To identify and prioritize through a country-driven participatory process, technologies that can contribute to mitigation and adaptation for selected sector/subsectors, while meeting national sustainable development goals and priorities.
- Step 2: To identify, analyse and address barriers hindering the acquisition, deployment, and diffusion of prioritised technologies including enabling the environment for the same; and
- Step 3: Based on the inputs obtained from the two previous steps, to develop Technology Action Plans (TAP) including suggested measures/actions. This step will include the development of project ideas (PI).

This report focuses on step 1.

The TNA Process in Tanzania began with a National Inception Workshop which was held on 29th – 30th September, 2015 at Giraffe Ocean View Hotel, Dar es Salaam (List of Participants are as shown in Appendix 1). The TNA Coordinator is Maximilian Mahangila (Division of Environment, Vice Presidents Office) and consultants for this project were Prof. Jamidu H.Y. Katima (mitigation, Energy Sector), Mr. Abdalla S. Shah (mitigation and adaptation, Forest Sector) Ms. Euster Kibona (adaptation, Agriculture and Water Sectors). Consultants participated in a methodology training workshop in Arusha, Tanzania from 22nd to 24th June 2015. The methodology used for the TNA process includes Multi Criteria Analysis (MCA) with extensive stakeholder participation at every stage of the needs assessment. Furthermore, methodology training, a stakeholder consultation for prioritization of sectors was done at Giraffe Hotel, Dar es Salaam, 20th November 2015 (Energy) (List of Participant is as shown in Appendix 2), 23rd November 2015 (Water and Agriculture) (List of

Participants is as shown in Appendix 3), 25th November 2015 (Forest), (List of Participants is as shown in Appendix 4), 24th November 2015 at MACEMP House, Zanzibar (Zanzibar) (List of Participants is as shown in Appendix 5), and final refinement of the prioritisation was done on 3-4th March 2016 at the Vice President's Office (List of Participants is as shown in Appendix 6. Pictures of some participants are shown in Figure 1. The Agenda for the workshops is as shown in Appendix 7) during the workshops, Stakeholders listed several technologies for adaptation and mitigation, which were subjected to Multi-criteria Analysis to select three technologies in each sector. This report provides information regarding the TNA process and outputs in Tanzania for the mitigation technologies.

Figure 1: Pictures of some of participants

1.1.2. The Role of National Consultant

The national consultants are national mitigation and adaptation experts, selected by the National TNA Committee in consultation with the UN Environment Programme (UNEP) DTU Partnership (UDP). The national consultant's overall task is to support the entire TNA process, by leading and undertaking activities such as research, analysis and synthesis in support of the TNA project. The National Consultant is responsible for providing process-related and technical advisory services needed for conducting TNAs and developing Technology Action Plans (TAPs) at the country level. National consultant is expected to:

1) Provide support to the identification and categorisation of the country's priority sectors, and identification and prioritisation of technologies for mitigation through a participatory process with a broad involvement of relevant stakeholders;
2) Facilitate the process with the work groups of analysing how the prioritised technologies can be implemented in the country and how implementation circumstances could be improved by addressing the barriers and developing an enabling framework. The results will be included in the barrier analysis and enabling framework report (BA&EF);
3) Prepare the National TAP, which will outline essential elements of an enabling framework for technology transfer and will consist of market development measures, institutional, regulatory and financial measures, and human and institutional capacity requirements. It will also include a detailed plan of action for implementing the proposed policy measures and assessing the need for external assistance to cover additional implementation costs.

Item 1 has been completed and is the subject of this report.

1.2. Existing National Policies on Climate Change Mitigation and Development Priorities

1.2.1. Environmental Policy, 1997

The National Environmental Policy (NEP) is the overarching policy that sets broad goals for environmental protection and committing Tanzania to sustainable development. The policy provides the framework for the formulation of plans, programmes and guidelines for the achievement of sustainable development. The key objectives of the policy are to:

- Ensure sustainability, security and equity in the use of resources;
- Prevent and control degradation of land, water, vegetation and air resources;
- Conserve and enhance the natural and manmade heritage; and
- Raise awareness and promote public participation; enhance international cooperation on the environmental agenda.

The policy promotes the use of the 'polluter pays principle' and the use of the 'precautionary principle' (i.e. it recognises that it is better to be roughly right in time, than to be precisely right too late). The policy also advocates the use of other relevant approaches in environmental management such as economic instruments, environmental standards, indicators and legislation.

Relevant sections of the policy are:

a) Sections 28 and 29, which requires that technologies used should be those that generate no or low waste or protect environment, use resources efficiently are less polluting etc.
b) Section 52 which advocates for the sound management of the impacts of energy development and use in order to minimise environmental degradation. 52(b) advocates for promotion of sustainable renewable energy resources and 52(d) advocates for energy efficiency and conservation.

The identified Energy technologies in this report, i.e. the micro and mini-hydropower, biomass to electricity and solar power, do address some of the objectives of this policy.

1.2.2. Energy Policy of 2003

The national energy policy objectives are to ensure availability of reliable and affordable energy supplies and their use in a rational and sustainable manner in order to support national development goals. The national energy policy, therefore, aims to establish efficient energy production, procurement, transportation, distribution and end-use systems in an environmentally sound and sustainable manner. Although the policy does not specifically mention the impact of energy sector on climate change, it promotes the use of renewable energy. It advocates for the establishment of institutional framework with conceptual, administrative and financial resources to play the mobilising, co-ordinating and guiding role in the development of renewable energy. The institutional framework needs to have a legal backing and mechanisms to establish standards, guidelines and codes of practice and norms for safe use of environmentally friendly renewable energy technologies.

The energy policy provides a good basis for promoting ESTs that can contribute to CC mitigation.

1.2.3. Zanzibar Environmental Policy 2013

The policy acknowledges that fuel wood, charcoal and agricultural residues account for 97 percent of the domestic energy consumption and more than 90% of the population of Zanzibar continue to rely on wood-fuel as a source of domestic supply of energy for cooking. Erratic power supply has compelled the islands of Zanzibar to revert back to the use of fossil fuel-powered generators for domestic and industrial electricity back up supply. Solar power is used in a few places for lighting especially for the rural population, but is not widespread yet and very little has been done in the exploration of potential renewable energy sources such as Wind and Sea Wave Power. Application and diffusion of Biogas technologies in Zanzibar continues to progress, albeit, at a slow pace.

The policy acknowledge that Climate change is one of the biggest global problems posing challenges to sustainable livelihoods and economic development, particularly for Least Developed Countries (LDCs) like Zanzibar. Climate Change adaptation and mitigation remains a major national priority as mentioned in Zanzibar Strategy for Growth and Reduction of Poverty (ZSGRP).

The policy further acknowledges inadequate reliable and affordable environment - friendly energy sources in Zanzibar caused by limited knowledge, technology and capital investment. Among the strategies contained in the policy objectives is promotion of use of renewable energy, promotion of use of energy efficient appliances, promotion of efficient use of affordable energy sources such as biomass etc.

1.2.4. Environmental Management Act, Cap 191

The Environmental Management Act (EMA) Cap 191 (2004) seeks to provide for legal and institutional framework for sustainable management of the environment in the implementation of the National Environmental Policy. Section 64 promotes the use of renewable sources of energy by, among other things, creating incentives for the promotion of renewable sources of energy. Section 75, requires the Minster in consultations with relevant sector Ministries to (a) take measures to address climate change, particularly the impact of climate change and adaptation measures (b) issue guidelines periodically to Ministries and any other institutions in order to address climate change and its impacts as a result of global warming.

1.2.5. The Zanzibar Environmental Management Act, 2015

The Act establishes a climate change unit in each Ministry and Local Government Authority which is responsible for environmental and climate change issues.

1.3. Sector Selection

The study on sources and sinks of Greenhouse Gases that was done in 1993 established that the GHG emission in 1990 was about 55,208 $GgCO_2$. Land use changes and Forestry sector made the largest contribution i.e. 53%, following by agriculture (33%) and energy (13%) (CEEST, 1999)[1]. Although there has not been a study of similar magnitude to the one done in 1993, it assumed the land use change and forestry is still a major contributor to GHG emission.

According to Tanzania Intended National Determined Contribution (INDC) document of 2015 Tanzania is a net carbon sink country. This is because the country has negligible, total and per capita emissions of greenhouse gases, whereby per capita emissions are estimated at 0.2 tCO2e1. On the other hand, the country has a total of 88 million hectares of land areas, of which 48.1 million hectares are forest land, which contain an estimated total of 9.032 Trillion tons of carbon stock.

The INDC development process identified priority sectors on both adaptation and mitigation through a review of various climate change and economic development sector documents. The documents included, National Climate Change Strategy (VPO 2012) and The Country Study on Sources and Sinks of GHG (CEEST, 1999), The Nationally Appropriate Mitigation Actions (NAMA). The INDC process identified adaptation priority sectors as Agriculture, Livestock, Coastal and Marine Environment, Fisheries, Water resources, Forestry, Health, Tourism, Human Settlement and Energy. The INDC also identified mitigation priority sectors as Energy, Transport, Forestry and Waste management. These were presented to TNA stakeholders during the sector prioritization workshop held on 20th November 2015. The Energy and forestry sectors were selected for Tanzania Technology Needs Assessment.

[1]CEEST (1999). Climate Change Mitigation in Africa – Country Study)

1.3.1. Energy Sector

According to IEA, Tanzania consumed a total of 19.6 MTOE, of which net imports were 1.7 MTOE in 2009. The GoT estimates this to have increased to 22 MTOE in 2010 (IEA, 2011)[2]. Biomass represented 88.6 percent of the total energy consumption in 2009. Electricity represented 1.8 percent, while petroleum products provided 9.2 percent of the total energy consumed in Tanzania. Total primary energy consumption is 0.45 tons of oil equivalents (toe) per capita, including biomass and waste which is principally used in the residential sector for cooking. Most of the energy is used in the residential sector, and the vast majority of it is biomass and agricultural waste. Eighty percent of the biomass is used in the residential sector for cooking. Energy consumption in Tanzania is one of the lowest in the world. The per capita energy consumption is 66 percent of the average consumption in Sub-Saharan Africa developing countries. In its campaign manifesto the Ruling Party (Chama Chama cha Mapinduzi) promised that by 2020 the electricity would reach 75% of the Tanzanians comparing with the current <25%.

1.3.1.1. Previous initiatives and plans

A study on technological and other options for the mitigation of greenhouse gas emissions was undertaken in 1993. The mitigation analysis had the following objectives:

a) Identification of technologies that are associated with GHG emissions in various sectors; Identification of the technical possibilities of minimising GHG emissions;
b) Identification of the appropriate environmentally benign technologies available for Tanzania, including its specific reduction potential and associated costs;
c) Investigation of various options for GHG abatement including retrofitting of emissions reduction equipment;
d) Exploration of the link between energy efficiency, mitigation of GHG emissions and associated costs;
e) Proposal of technological strategies and policy options to mitigate GHG emissions based on an abatement cost curve;
f) Recommendation of possible targets for GHG mitigation or stabilisation particularly in the national energy policy; and
g) Building an indigenous capacity in the assessment of climate issues.

A summary of technologies identified to have potential to mitigate climate change as shown in Table 1.

Table 1: The identified technological mitigation measures

Mitigation option	Description
Advanced electricity generation technologies	• Install 230 MW of combined-cycle power plants instead of simple cycle gas turbines • Interconnecting to neighbouring countries by the year 2000 • Installation of gas power by the year 2000
Efficiency improvements	Increase the efficiency of existing power generation systems by repowering and improving transmission and distribution systems
Charcoal production	Improve the conversion efficiency of charcoal kilns

[2] International Energy Agency (2011). Energy Statistics

Mitigation option	Description
Coal mining	Optimize methane release from coal mines
Renewable technologies	Use large scale hydropower, mini-hydropower, solar collectors, photovoltaic, wind turbines, and biomass energy sources including biogas

Some of the above technologies have been implemented. Tanzania has installed combined cycle power plants with capacities > 100 MW. These include Ubungo 1 (102MW), Ubungo 2 (105 MW), Kinyerezi 1 (150MW). The interconnection between Kenya and Tanzania is being constructed. The national grid is being upgraded to 400 kVA to address the issue of power losses. Some mini / micro hydropower are already operational. These include Mwenga Hydropower Plant (4MW), Andoya micro hydropower plant (500kW). Even with these initiatives Tanzania still has a huge electricity deficit.

This study also identified other GHG mitigation technologies as follows:

a) Efficient lighting
b) Power factor correction
c) Efficient motors
d) Biogas from landfills
e) Biogas for rural household
f) Efficient boilers
g) Efficient furnaces

1.3.1.2 Scaling-Up Renewable Energy Programme (SREP) Investment Plan for Tanzania, 2013

The SREP Investment Plan, which was developed through intensive consultation with key stakeholders, outlines the activities that should be undertaken to increase access to modern energy and it establishes specific goals, objectives and targets that the government, development partners, businesses, private sector, financial institutions, civil societies and the community must achieve together. Special attention is given to increasing energy access using renewable energy resources which are abundantly available throughout the country.

The role of SREP is to catalyze large scale deployment of renewable energy technologies in addressing the issue of energy poverty for our country and communities through its contribution in delivering energy from the geothermal and other renewable energy resources.

The SREP lists the following potential renewable energy sources:

a) Large scale hydropower
b) Small-scale hydropower
c) Geothermal energy
d) Wind energy
e) Solar energy (both off – grid solar PV, grid connected Solar PV and Solar Thermal Power Plants)
f) Biomass energy

The identified technologies should address objectives of the SREP.

1.3.1.3 Tanzania Climate Change Strategy, 2012

The goal of the Tanzania Climate Change Strategy is to enable Tanzania to effectively adapt to climate change and participate in global efforts to mitigate climate change with a view to achieving sustainable development.

The specific objectives of this Strategy are:

a) To build the capacity of Tanzania to adapt to climate change impacts.
b) To enhance resilience of ecosystems to the challenges posed by climate change.
c) To enable accessibility and utilization of the available climate change opportunities through implementation.
d) To enhance participation in climate change mitigation activities that lead to sustainable development.
e) To enhance public awareness on climate change.
f) To enhance information management on climate change.
g) To put in place a better institutional arrangement to adequately address climate change.
h) To mobilize resources including finance to adequately address climate change

The Strategy acknowledges that the potential sources of GHG emissions include: traditional energy sources, transportation systems, and waste disposal management activities. It provides a list of mitigation strategies as follows:

a) To promote use of efficient energy technologies
b) To enhance supply and use of renewable energy
c) To promote use of other clean energy technologies

The proposed strategic interventions include:

a) Enhancing use of renewable share in the national grid and off-grid
b) Enhancing off-grid power supply to rural areas
c) Promoting diversification of energy sources
d) Supporting exploitation of geothermal, clean coal and safe nuclear energy
e) Promoting energy efficient technologies and practices
f) Developing NAMAs focusing on energy generation and conservation
g) Promoting green energy related technologies

The identified technologies address some of the objectives of this Tanzania's national climate change strategy.

1.3.1.4 Zanzibar Climate Change Strategy 2014

Because of vulnerability of Zanzibar to Climate Change the Climate change strategy is focussing on adaptation. Even the energy sector focuses on adaptation.

1.3.2. Forest Sector

1.3.2.1. Forestry Sector in Tanzania

Tanzania mainland has a total area of 945,087 km^2 of which 886,037 km^2 of it is land surface and the remaining is water. The country has a population of 43.6 million people (NBS and OCGS 2013)[3]. It is estimated that Tanzania has 48.1 million ha (481,000 km^2) of forests and woodlands equivalent to an average of 1.1 ha per capita (MNRT 2015)[4]. This means that forests and woodlands occupy an equivalent to 38.3 % of the total land area. These forests contain 3.3 billion m^3 of wood, which is equivalent to an average of 37.9m^3/ha or 74.4m^3 per person (MNRT 2015). Out of the total forest land 16 million ha are in reserved forests, 2 million ha are forests in national parks and 30.1 million ha are unprotected forests in General Land. Forests in General Land are characterized by unsecured land tenure and high rates of deforestation due to heavy pressure for conversion to other competing land uses (MNRT 2015).

Forest vegetation in Zanzibar covers about 63,908 ha, equivalent to 23.7% of the total land area. Zanzibar's forests form part of the East Africa Coastal Forests Eco-region, one of the world's 200 biodiversity hotspots. Deforestation rates are estimated to be at least 1% per annum (URT 2010).

Forest Sector is grappling with deforestation and forest degradation as a major socioeconomic and environmental challenge. This is evidenced by the fact that Tanzania loose about 400,000ha of forests annually due to various reasons, which include unsustainable agricultural practices, forest fires and unsustainable charcoal production (MNRT 2015).

1.3.2.2. Forestry and Climate Change in Tanzania – Impacts of climate change to forest sector

Forestry like other land based undertakings is affected by climate change, but on the other hand forests can significantly contribute in mitigating climate change. The effects of climate change on forests can be both direct and indirect. Directly this could be through the shifts in agroecological zones, thus the species composition of a given forest may change and lead to reduction of quality of the forests. Similarly, due to change in climate induced biophysical factors, appropriate tree species to be planted in given areas may have to change. Indirectly, the effects could include transformation and degradation of forest resources that can result due to over dependence upon forest by humans for their livelihood. Moreover the increase in atmospheric temperature will increase the threat, incidences and intensity of forest fires.

1.3.2.3. Existing National Policy Implications to Forestry in Tanzania

A number of national policies including their associated national strategies, their objectives, have implication on forest resource management, as well as in the capabilities of forests in addressing climate change. These include the forestry policy and its national forest programme, wildlife policy, water policy and agriculture policy. The implications can either be positive or negative. For example the wildlife policy objectives aim at maintaining conservation of national parks, game reserves and

[3] 2012 Population and Housing Census Tanzania
[4] National Forest resources Monitoring and Assessment of Tanzania (NAFORMA) Main Result

other categories of wildlife conservation areas (URT1998)[5]. Also water policy has among its objectives, the water resources conservation. In pursuing these objectives these policies supports forest conservation. Also agriculture policy recognizes the value of forests in supporting agriculture productivity. However it also realizes that extensive intensification of agriculture can, potentially, exert pressure on forest resources and thus debilitating the climate change ameliorative capacity of forest resources.

The national REDD+ Strategy has been developed based on the National Framework for REDD+ developed in 2009. The framework is based on the objectives of reducing emissions related to deforestation and forest degradation as well as reducing poverty of forest dependent communities. The Strategy is thus closely linked to the current national growth and development policies, strategies and commensurate legislation such as Vision 2025, the National Strategy for Growth and Poverty Reduction (MKUKUTA), the National Environmental Policy (1997), the Forest Policy (1998) which encourages participatory forest management and seeks to integrate biodiversity values in forest management, and the Land Policy (1997). Others are the National Agriculture and Livestock Policy (1997), the National Forest Programme and strategies which contribute to effective conservation of Tanzania's natural resources while improving the livelihoods of its people.

The Zanzibar National Forest Policy sets forth the interest of the government and the people of Zanzibar in the conservation and development of forest resources. The general goal of the policy derives from the principles of sustainability and welfare improvement of the people. The policy is legislatively supported by the Zanzibar Forest Resources Conservation and Management Act (No. 10 of 1996) which provides legal room for communities to participate and engage in forest management programmes in the islands. Formulation of Community Forest Management Agreements is a result of this Act.

This policy is supported by a number of other policies that include the Zanzibar Environmental Policy (1992), which aims at conservation and protection of environment and efficient utilization of natural resource assets for sustainable development. Others include, the Agricultural Sector Policy (ASP) and Strategic Plan (SP) which recognize the importance of forests in agricultural productivity, and the National Tourism Policy which underlines the importance of environmental conservation in tourism development, especially conservation of ecologically sensitive areas for development of eco-tourism activities. The latter policy, calls for the enforcement of Environmental Management and Sustainable Development Act, which accommodates the need for tourism sector to make efforts in mitigating and adapting to climate change.

Other policies and legislations that are relevant to sustainable forest management include the National Land Use Policy and Plan that provides planning recommendations for different sectors including forestry. Moreover, the Fisheries Policy recognizes the importance of mangroves to the productivity of fishing industry. Also the Energy Policy recognizes the contribution of the forest sector in support of sustainable energy production for the people of Zanzibar, it also recognizes the impact of the energy demand on forest resources and its contribution to GHG emissions even though at a small scale.

[5] Wildlife Policy of Tanzania

1.4. Overview of Energy Sector in Tanzania

Tanzania consumed a total of 8.42 Million TOE[6], 19.6 Million TOE[7] and 22 Million TOE in 1990, 2009 and 2010 respectively. Biomass represented 88.6 percent of the total energy consumption in 2009. Charcoal made from wood was the single largest source of household energy in urban areas with about half the annual consumption occurring in Dar es Salaam. Electricity represented 1.8 percent, while petroleum products provided 9.2 percent of the total energy consumed in Tanzania. Other energy sources, such as solar represent a small share, see Table 2.

Table 2: Primary energy Source (2010)[8]

Energy Source	Quantity (Million TOE)	Percentage
Coal	23	0.13%
Oil Products	1,558	9.15%
Natural gas	63	0.37%
Electricity	293	1.72%
Biomass	15,085	88.62%

The majority of the rural population, which is estimated at 80% of the Tanzania population, relies on biomass as fuel for cooking. Biomass use in homes has significant environmental and health consequences. The nearly 1 million tonnes of charcoal consumed annually is estimated to require 30 million cubic meters of wood. The annual average loss of forest cover attributed to charcoal production is estimated at about 100,000–125,000 hectares[9] (World Bank 2009). This has significant contribution to climate change.

Total primary energy consumption is 0.45 tons of oil equivalents (toe) per capita, including biomass and waste which is principally used in the residential sector for cooking. Most of the energy is used in the residential sector, and the vast majority of it is biomass and agricultural waste. Eighty percent of the biomass is used in the residential sector for cooking. Per capita energy consumption in Tanzania was about 447.57 kg of oil equivalent in 2011, which is very low compared with other countries in Africa. For example per capita energy consumption in South Africa was 2,740.85 kg of oil equivalent in 2011.[10] The Tanzania's per capita energy consumption is 66 percent of the average consumption in Sub-Saharan Africa. This shows an expressed need for accelerating the electricity generation capacity.

[6] CEEST (1999) Climate Change Mitigation in Southern Africa – Tanzania Country Study
[7] See IEA, 2009 Energy Balance for Tanzania http://www.iea.org/stats/balancetable.asp?COUNTRY_CODE=TZ
[8] IEA (2011). Energy Statistics
[9] Mashauri Adam Kusekwa (2011). A Review on the Renewable Energy Resources for Rural Application in Tanzania. Renewable Energy – Trends and Applications - *www.intechopen.com/.../a-review-on-the-renewable-energy-resources-for-r.*
[10] data.worldbank.org › Indicators

While the electricity subsector contributes to less than 2 percent of the total energy consumption, it has a very large impact on the economy. The country's main installed power generation capacities are based on hydropower (around 50 percent) and natural gas (around 35 percent), with diesel making up for most of the remainder, and providing most of short-term and emergency capacity. TANESCO also imports a total of 10 MW of electric power for Kagera Region from Uganda while Sumbawanga, Tunduma and Mbozi districts receive about 3 MW from neighbouring Zambia.[11]

Demand for electric power is growing and typically exceeds supply. In the short to medium term generation expansion plan (up to 2016), the majority (59 percent) of the planned generation capacity additions are expected to be based on hydropower, coal and natural gas, but also additional sources such as biomass (combustion), wind and hydropower. Most of the new generation sites for hydro and wind are located in the southern regions of the country (WB, 2010).

1.4.1. Projected Climate Change in Tanzania

It is reported that most parts of the country, particularly the Central and Northern Zones, which are semi-arid are vulnerable to climate variability and they will be more vulnerable to the projected increase in frequency and amplitude of extreme climate events (URT, 2007)[12]. The projection of rainfall and temperature due to global climate change for Tanzania has been reported in the Initial National Communication to the UNFCCC, 2001 and in the 2007 NAPA.

Temperature

Time series analysis show that the mean annual temperature for Tanzania is projected to increase by 1.7°c in the north eastern areas of the country and by 2.5°C,over Western parts of the country.

Rainfall

Projections from Global Circulation Models (GCMs) are indicating that due to doubling of concentration of CO2 in the atmosphere by 2100; there will be an increase in rainfall in some parts of Tanzania while other parts will experience decreased rainfall (Matari *et al.,* 2008). The areas with two rainfall seasons that is, the north-eastern highland and Zanzibar, the Lake Victoria basin and the northern coast would experience an increase in March to May (long-rains) rainfall by up to 15 percent, While, southern, south-western, western and central areas will experience a decrease in March to May rainfall by up to 6%.

1.4.2. GHG Emission Status and Trend

An inventory of greenhouse gases emission and removals in Tanzania was developed in 1993 – 1994. The major sectors addressed in the inventory include energy, agriculture, industrial process, waste management, forestry and land use. For each of these sectors an estimation of CO_2, CH_4, N_2O and other gases has been done. It was estimated that energy sector was emitting 6% and the agriculture sector 5.7 percent. Least emitting sectors were industrial processes (0.5 percent) and waste

[11] https://www.usea.org/...-/**Tanzania**%20**P**

[12] URT (2007). National Adaptation Programme of Action (NAPA)

management (0.07 percent). Table 3 shows GHG emission from different energy sources. The contribution of Land use change and Forestry are described in details in section 1.5 below.

Table 3: GHG Emission in the Energy Sector[13]

Fuel combustion	Emissions of Carbon Dioxide (CO_2) in Gigagrams (Gg) (1990)
Stationary Combustion in Industry	559
Thermal Power Generating Plants	74
Mobile Combustion	1,124
Activities Others (fossil fuels in households)	265
Total	**2022**

Source: Initial National Communication 2003

The 2010 estimated emission, based on linear change of energy trend and assuming similar energy mix, is about 5283 Gg.

1.5. An overview of Forest Sector

A study to identify and quantify anthropogenic sources and sinks of greenhouse gases from forestry, land-use changes and agriculture in Tanzania revealed that, in the land-use sector, methane (CH_4) and carbon dioxide (CO_2) are the primary gases emitted. Although deforestation results in greenhouse gas emissions, the managed forests of Tanzania are a major CO_2 sink.

An inventory of GHG emission and removal was developed in 1993 and 1994 based on data obtained from 1988 to 1990. Energy, Forestry and land use were among the major sectors addressed in the inventory. For each of the sectors the emission of CO_2, CH4 and N_2O were estimated. The total emission was estimated at 64,885Gg, out of these 91%was CO_2, 2.8% was CH_4, 6% was CO and 0.01 was N_2O (URT 2003). Land use and forestry were the two major sectors in GHG emission. The sectors contribute 87% of all GHG emission in Tanzania, followed by energy and agriculture sectors which were recorded to contribute 12% of the emission, see the contribution of land use and forestry in table 4 below. This information is used due to absence of any current inventory in the country.

Table 4: Summary of the Inventory of Land-use Change & Forest based GHG Emission and Removals (Gigagrams - Gg) for 1990

Forest Management and Land Use Activities	Emission of Carbon Dioxide CO_2	Carbon Dioxide Removals	Emission of Methane CH_4	Emission of Nitrogen Oxide	Emission of Nitrous Oxide N_2O	Emission of Carbon Monoxide N_2O
Forest clearing for agricultural lands	727	NA	2.483	0.617	0.017	27.2
Abandonment of Managed Lands	NA	1,931.00	NA	NA	NA	NA

13 URT (2003) Initial National Communication – www.unfccc.int/.../tann..

Forests subject to human activities	55,938.00	1,815.00	NA	NA	NA	NA
Others (shifting cultivation and dams)	NA	NA	0.579	0.139	0.005	4.2
Total	**56,665.00**	**3,746.00**	**3.062**	**0.756**	**0.022**	**31.4**

Source: Tanzania Initial National Communication under the UNFCCC (2003)

As a result of the impact of climate change on forest ecosystems in Tanzania it is projected that there will be ecological zones shift, because some species vulnerable to the impacts of climate change will be affected and may become extinct. It is predicted that subtropical dry forest and subtropical moist forest will decline by 61.4% and 64.3% respectively, for example the subtropical acacia woodlands currently in existence will be completely replaced (URT 2003). There will be an increase in tropical dry forest and moist forest, which are likely to replace the current life zones. It is predicted that these ecological shifts will reduce the ability of the forests in providing the inherent goods and services and increase their vulnerability, hence reducing the mitigation and adaptive capacity of the ecosystems and the communities that depend upon the forests (URT 2003).

1.5.1. Key Climate Change and Forestry Relationship

Forests do not only have important and critical ecological values, they are also sources of livelihoods and vital services such as conserving soils and water sources, harbouring rich biodiversity and important genetic resources. They provide services such as recreation and tourism, other non-wood forest products and as water catchment. In addition to all the goods and services they can help with carbon mitigation through carbon sequestration.

Forests have a number of linkages with climate change. Forest management decisions can enhance adaptation and mitigation capabilities of forests or can lead to contribution to GHG emission in the atmosphere. On one hand, if the decisions are bad, they can mean increased contribution to global GHG emissions such as when forest are cleared by burning, overused or degraded; on the other hand they react sensitively to a changing climate. This is to say that, Climate change can potentially affect and compound degradation process and profoundly transform forest ecosystems, but sustainably managed forests can play an important role in climate change mitigation as sinks of carbon and be a basis for societal resilience and adaptive capacity (Rizvi *et al.*, 2015)[14].

Forests also have a potential to absorb significant percentage of global GHG emissions, into their biomass, soils and products. Thus Forests play an important role in climate change mitigation as carbon dioxide (CO_2) sinks. Forests act as carbon sinks when their area or productivity increases, resulting in an increased uptake of CO_2 from the atmosphere (Gelman, *et al.*, 2013)[15].

[14] Rizvi, A.R., Baig, S., Barrow, E., Kumar, C. (2015) Synergies between Climate Mitigation and Adaptation in Forest Landscape Restoration. Gland Switzerland: IUCN.
[15] Valeria Gelman, Ville Hulkkonen, Roni Kantola, Mitja Nousiainen, Vesa Nousiainen, Michael Poku-Marboah (2013) Impacts of forest management practices on forest carbon. HENVI University of Helsinki

In countries like Tanzania forests significantly contribute to carbon sequestration, thus they can absorb local emission and emission from other countries. It is estimated that Tanzania's forests and woodlands have carbon stock in above ground and below ground biomass pool of 1060.8 million tons, that has been interpreted that the forests contain 36.5 tons of carbon per ha (MNRT2015).

1.5.2. Impact of climate change to society and ecosystems

Climate change has multiple impacts on society and ecosystems. Climate change and its impacts are manifested in various forms. Socially it is commonly agreed that the phenomenon hit the poorer countries hard because they have low coping capabilities, low level of resilience and adaptive capabilities; and weak economies. This is in spite of the fact that poor countries contribute the least in emitting the GHGs that exacerbate climate change. In Tanzania, these can be seen from the increase in frequency and impact of drought and floods. For example drought which is a late oncoming of rain season or as a decrease of rainfall during dry months, or longer dry seasons can have significant social-economic and ecological consequences. These include, crop failure, loss of livestock, and destruction of other means of livelihoods. The loss of livelihood can, and do sometimes lead to human displacement and be a cause of refugees. In extreme cases the human lives can be lost due to drought. Similarly, extreme floods which, can be caused by torrential rains, or extended erratic rainfall patterns, can have similar social effects.

Ecologically, Climate Change can lead to low productivity level of ecosystems which can be further degraded by high human demand on ecosystems. Forest ecosystems are vulnerable when they have limited tolerance of climate variation or change. This can be caused when a system contains significant mass of species with limited drought or flood tolerance, low germination rate, low survival rate, and limited seed dispersal capabilities (URT-VPO 2012). Other causes include the human activities that lead to forests ecosystem weakening, such as deforestation and forest degradation; or forest transformation (Including Forest fires and agriculture) which lead to change of forest type, species composition and distribution.

Furthermore it is worth to note that the socioecological interaction of Climate change processes and impacts are intricate. Ecosystems are affected by the extreme dryness or wetness. Natural systems, including forests, that cannot cope with extreme weather conditions can be degraded, thus various flora and fauna, including microbes can be decimated. That means the contents and value of ecosystems will deteriorate. Where natural systems, such as forests and river systems are degraded it results in limiting communities adaptive capacities (URT, 2007).[16] The low adaptive capacity can further be exacerbated by population growth and or low capability to transform productive capacity, due to youth emigration to urban areas and lack of improved equipment.

Lack of access to markets can also be a cause of vulnerability when producers cannot transform their product into cash. These situations can affect food security, which can mean increased dependency on natural systems, but if the natural systems are already impacted by climate change, the increased human dependency can further worsen the quality of the ecosystem. On the other hand the causes of

[16] URT (2007) National Adaptation Programmes of Action Country Report – Tanzania

forest ecosystem vulnerabilities are indirectly driven by market and policy failure, rapid population growth and rural poverty, weak state of local and national economy (URT, 2007).

1.6. Process and Results of Sector Selection

The technologies were selected through literature review and stakeholder consultations.

1.6.1. Energy Sector

Overview of existing energy technologies

Hydropower

Hydropower currently contributes about 35 % of electricity generated in Tanzania;[17] this may be attributed to the changing weather patterns in the past few years. The climatic variability as exemplified by droughts in the years 2000 and late - 2010, 2011 and 2012, reduced hydropower generation and led to severe energy shortages which culminated in load shedding. Tanzania has six large hydro power plants, namely Hale, Kidatu, Kihansi, New Pangani Falls, Mtera and Nyumba ya Mungu. Large reservoirs are located at Mtera, Kidatu and Nyumba ya Mungu with storage capacity of about 4,200 Million cubic metres [Casmiri, 2009]. Electricity generated from hydropower is given in Table 4. The re-filing of the above mentioned reservoirs depends on the availability of sufficient rainfall from various basin including Rufiji, Ihefu and Pangani basins.

Table 5: Electricity Generated from Hydro Source (Source TANESCO, 2009)

Energy Source	Plant Name	Installed Capacity [MW]
Hydropower	Kidatu	204
Hydropower	Kihansi	180
Hydropower	Mtera	80
Hydropower	New Pangani Falls	68
Hydropower	Hale	21
Hydropower	Nyumba ya Mungu	8
TOTAL		**561**

Some hydropower potential has not been exploited. Future hydropower projects under plan are shown in Table 5.

Table 6: Future Hydropower projects (Source EWURA Annual Report 2008/09)

Energy Source	Plant Name	Installed Capacity [MW]
Hydropower	Stiegler's Gorge	2,100
Hydropower	Mpanga	165

[17] *https://**energy**pedia.info/wiki/**Tanzania_Energy**_Situation*

Hydropower	Ruhudji	358
Hydropower	Rumakali	222
Hydropower	Lukose & Masigira	118
Hydropower	Rusumo Falls	21
TOTAL		**2,984**

These could be some of the projects that may be developed under ESTs umbrella.

Biomass Energy

As already stated energy consumption in the Tanzanian households accounts for more than 88 percent of the total energy, most being biomass. Due to rapid increase in population and slow pace of rural electrification, it is expected that biomass will continue to be a significant energy source for the majority of Tanzanians. However, inefficient utilization of conventional biomass sources i.e. direct use of firewood, dung or semi processed in the form of charcoal, is still high in most rural areas.

Biomass sources suitable for energy generation in Tanzania covers a wide range of materials from firewood collected in farmlands; natural woods from agricultural and forestry crops grown specifically for energy generation or other purposes; crop residues and cow dung, solid waste, timber processing residues etc. The most significant energy end-user is cooking and heating. The biomass resources in Tanzania can be divided into four major categories:[18]

- Wood, logging and agricultural residue
- Animal dung
- Solid industrial waste
- Landfill biogas

There are several forms in which biomass can be used for energy generation, namely residue, natural sources and energy crops. Residues are divided into three categories, namely primary, secondary and tertiary residues, as shown in Table 7.

Natural sources

Natural sources include biomass gathered from natural resources such as fallen tree branches, woody weeds, etc.

Energy crops

Energy crops include biofuel as sole or principal product such as trees, grasses, and sugarcane, sorghum and oil crops. In addition, biofuel co-production is also part of energy crop category. Biofuel-co-production is a pre-planned multi-output production including biofuel i.e. sugarcane to produce sugar, ethanol, electricity, timber or tree-fruit production to deliver thinning and harvest waste as biofuel. Generation of biofuel is expected to increase in the near future.

[18] Mashauri Adam Kusekwa (2011). A Review on the Renewable Energy Resources for Rural Application in Tanzania. Renewable Energy – Trends and Applications

Table 7: Types of Biomass Supply

Primary residues: are usually from forestry, agricultural crops and animal rising. Primary residues can be categorized either as residues arising in concentrated form(dung from stalled livestock, harvested cereal straw, stalk, husk) or residues that must be gathered together (dung from grazing livestock, crop residues which are not harvested such as cotton and maize stalks)	**Secondary residues** Include materials from • Processing wood • Food organic materials in concentrated from suck as • Sawmill bark • Tree chips • Sawdust	**Tertiary residues** Include waste arising after consumption of biomass such as sewage, municipal/city solid waste, landfill gas etc.

Potential of biomass sources (residual) in Tanzania are given in Table 8.

Table 8: Residual Biomass Resource

S/No	Renewable Energy Sources	Estimated potential [MW]	Remarks
1	Saw dust	100	More studies are required to establish actual value
2	Sisal Residue	500	Will increase in near future
3	Crop residue	212	Initial estimation. Expected to increase
4	Cattle, Pig dung	-	More studies are required to establish actual value
5	Baggasse	57	Initial estimation. Expected to increase.
	TOTAL	**869**[19]	

Estimated average annual production levels of wood fuel and its associates such as tannin residue are shown in Table 9.

Table 9: Wood Biomass Resource

S/NO	Renewable Energy Sources	Estimated Potential [MW]	Remarks
1.	Forest residue	523	Initial estimation. Its value could be high
2.	Wattle residue	15	Initial estimation
	TOTAL	538	

Solar Energy

Tanzania is well situated near the equator; as such solar capture and utilization as energy source has huge potential in the country [Nzali et *al*., 2001]. Tanzania has high levels of solar energy, ranging between 2800 – 3500 hours of sunshine per year and a global radiation of between 4 to 7 kWh/m/day. Table 10 gives the insolation levels values in some areas of Tanzania. Solar photovoltaic energy is uniquely useful in rural areas not served by the National grid to provide basic services such as irrigation, refrigeration, communication and lighting, but also can be utilised in urban areas to minimise the use of fossil based electricity. Solar energy is often more efficient source of energy than traditional sources such as kerosene, charcoal and fire wood. An additional advantage of solar photovoltaic is that it is cheaper to install and operate

[19] Mashauri Adam Kusekwa (2011). A Review on the Renewable Energy Resources for Rural Application in Tanzania. Renewable Energy – Trends and Applications

than electricity. The pollution problem of photovoltaic is very much lower than the standard fossil-fuel power plant.

Table 10: Mean monthly Daily Insolation totals in kWhm^{2}/day for period of ten years [source A.H. Nzali 2001]

Station	Month												
	Jan	Feb	March	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Average
Dodoma	6.1	6.0	6.1	5.7	5.6	5.8	5.7	6.0	6.3	6.4	6.5	6.2	6.0
D’Salaam	5.2	5.3	4.9	4.0	4.3	4.4	4.4	4.0	4.9	5.1	5.8	5.6	4.8
Iringa	6.0	6.1	5.7	5.9	6.2	6.3	6.1	6.6	6.7	7.0	6.7	6.2	6.3
Kigoma	4.3	4.5	4.9	4.3	4.4	4.8	4.3	4.9	4.9	4.7	4.1	4.3	4.5
Mtwara	4.4	4.5	4.3	4.0	4.4	4.4	4.5	4.6	4.9	4.9	5.2	4.8	4.6
Musoma	5.4	5.0	5.4	5.4	5.4	5.0	5.2	5.4	5.4	5.4	5.7	5.4	5.3
Same	5.6	5.5	5.6	4.7	3.6	3.8	4.0	4.1	4.6	5.0	5.4	5.6	4.8
Songea	4.2	4.3	4.2	3.9	3.9	3.6	3.7	3.9	4.4	4.5	4.5	4.4	4.1
Tabora	5.6	5.5	5.8	5.4	5.6	5.5	5.1	5.7	5.6	6.0	5.2	5.4	5.5
Zanzibar	5.1	5.2	4.9	4.2	4.4	4.7	4.5	4.8	5.1	5.3	5.0	5.0	4.9

Wind Energy

Table 11 shows power densities for given wind velocities. In Tanzania we have some sites which have wind speeds shown in Table 11. Such wind sites where commercial wind farms are being contemplated include Makambako and Kititimo in Singida region as well as Mkumbara, Karatu and Mgagao. Areas along rift valleys, the southern high lands and along Lake Victoria are reported to have some possibilities of potential wind sites.

The number of wind mills available in the country is given in Table 12. So far, four companies have shown interest in investing in wind energy, namely Geo-Wind Tanzania Ltd and Wind East Africa, both in Singida Region; Sino Tan Renewable Energy Limited and Wind Energy Tanzania Ltd at Makambako in Iringa Region. These companies are considering investments in wind farms in the 50 to 100 MW range.

Table 11: Wind Power Densities [Source Mmasi *et al.*, 2001]

Wind Power Class	Wind Power Density, [W/m]	Wind Speed [m/s]	Wind Power Density W/s	Wind Speed [m/s]	Wind Power Density, [W/m]	Wind Speed [m/s]
1	100	4.4	160	5.1	200	5.6
2	150	5.1	240	5.9	300	6.4
3	200	5.6	320	5.5	400	7.0
4	250	6.0	400	7.0	500	7.5
5	300	6.4	480	7.4	600	8.0
6	400	7.0	640	8.2	800	8.8
7	1000	9.4	1600	11.0	2000	11.9

Table 12: Number of Wind mills in Tanzania (Source: Renewable Energy in East Africa – 2009)

Region	Number of Wind Mills
Singida	36
Dodoma	25
Iringa	16
Shinyanga	6
Tabora	4
Arusha	4
Kilimanjaro	1
Mara	8

Geothermal Energy

Surface hot geothermal assessments started in 1976 and to-date more than 50 sites have been identified. These are grouped into three main prospect zones: the North- eastern Zone (Kilimanjaro Arusha and Mara regions), the South-western Zone (Rukwa and Mbeya regions), and the Eastern coastal belt which is associated with rifting and magmatic intrusions (Rufiji Basin). Only the South-western zone has undergone exploration studies. The MEM in collaboration with Geological Survey of Tanzania (GST), the German Federal Institute for Geosciences and Natural Resources (BGR) and TANESCO carried out surface exploration in the south-western zone and did detailed studies in the Ngozi-Songwe prospect in Mbeya region between 2006 and 2010. The geo-thermometers showed that the reservoir temperature exceeds 200 ^{o}C.[20]

Mini-Hydropower Sources

Out of estimated 315 MW small hydro potential in Tanzania less than 20.5 MW have been exploited by installing four power plants. The Ministry of Energy and Minerals (MEM) through REA has been funding studies for small hydro power plants. Identified potential river sites for small hydro power generation are given in Table 13. TANESCO has already signed Letters of Intent for six small hydro projects with a combined capacity of 29.9 MW.

Table 13: Identified Potential River sites [Source REA-March 2010]

S/No	Site	River	Load Centre	Head[m]	Discharge [m3/sec]	Capacity [kW]
1	Sunda Falls	Ruvuma	Tunduru	13.5	26	2x3,000
2	Kiboigizi	Kitanga	Karagwe	90	3.8	3,200
3	Kenge	Ngono	Bukoba	10	24	2,400
4	Luamfi	Luamfi	Namanyere	40	9	1,200
5	Mkuti	Mkumti	Kigoma Rural	23	3.3	650
6	Nakatuta	Ruvuma	Songea	67.8	50.3	1,500
7	Mtambo	Mtambo	Mpanda	17	13.5	2,000

[20] Mashauri Adam Kusekwa (2011). A Review on the Renewable Energy Resources for Rural Application in Tanzania. Renewable Energy – Trends and Applications

8	Lumeme	Lumeme	Mbinga	301.2	1.31	4,200
9	Ngongi	Ngongi	Ruvuma	270.7	1.09	3,100
10	Luwika	Luwika	Mbamba bay	359.5	1.5	5,800
11	Mngaka	Mngaka	Paradiso	15	7.64	900
12	Songwe	Songwe	Idunda	75	1.5	720
13	Mngaka	Mngaka	lipumba	25	4.42	870
14	Kiwira	Kiwira	Ibililo	20	10	1,350
15	Prison	kiwira	Natural Bridge	30	12	3,000
16	Kitewaka	Kitewaka	Ludewa Township	50	9.88	4,200
17	litumba	Ruhuhu	Litumbaku Hamba	8	59	4,000
18	Mtigalala Falla	Lukose	Kitonga	70	10	5,000
19	Kawa	Kawa	Kasanga/Ngorotwa	65	0.3	130
20	Ijangala	Ijangala	Tandala	80	6	500

Renewable energy exploitation in the country is still at an initial stage. The MEM is currently carrying out small hydro feasibility studies in eight regions of Morogoro, Iringa, Njombe, Mbeya, Ruvuma, Rukwa, Katavi, and Kagera. GVEP International, in partnership with REA is supporting the development of six mini hydro mini-grids with total capacity in the 7.4- 8.8 MW range. EU is financing the Yovi Hydro Power project and Sustainable Community-Based Hydro Power Supply; and UNIDO co-funding the development of six mini-grids based on mini/micro hydropower.

1.6.2. Forestry Sector

Overview of Existing Technologies for forestry

Forests are important for both mitigation and adaptation. This is so in Tanzania as is elsewhere in the world. Thus, new and old, forest technologies, are needed in the efforts to tackling the impacts of climate change and in protecting forest systems against the vagaries of climate change. A number of forest technologies. Ranging from silvicultural practices for management to forest governance for mitigation, have been identified and are expounded here. These include aspects of Agro-forestry, forest (including mangroves) ecosystem or landscape conservation and restoration, sustainable forest management, Tree and Seedlings production (Improvement) technology, Participatory Land and forest management, Reducing Emission from Deforestation and Forest Degradation (REDD) and Sustainable charcoal Production.

Technology Options for Forestry Sector and their Main Mitigation Benefits

A number of technologies suitable for supporting both mitigation and adaptation to climate change have been identified and suggested in this report.

Agro-forestry

As a land use system, agroforestry can be very helpful in addressing various on farm and off farm adaptation needs, as well as various mitigation measures. Among other things Agroforestry, also provides various ecosystem services and reduce human impacts on natural forests (Mbow *et al.*, 2014). Agroforestry can provide these adaptation benefits at local level and contribute significantly to reducing emission from deforestation and forest degradation.

Agroforestry systems are capable of both raising carbon stocks and produce livelihood benefits. The systems can significantly contribute to climate change mitigation by adding carbon sequestering capability of a land unit due to the increased number of trees on farm. Agro forestry increases mitigation capability of land unit by increasing carbon storage while enhancing agricultural productivity, it can also improve the adaptive capability and building resilient agro-ecological systems.

It is important that for agroforestry to succeed as a climate change mitigation and adaptation technology, it should be made to show that it address peoples livelihoods and especially food and water security. This is because majority of Tanzania farmers are smallholder, who are largely subsistent and have food security as their primary objective. Moreover, Agroforestry can enable high production level and economic value of productions system, which can generate income beyond subsistence level. This can be considered as an incentive to encourage practitioners and farmers to invest in Agroforestry while adapting to and mitigating the impact of climate change (Mbow *et al.*, 2014).

Mangrove ecosystems conservation, Rehabilitation and Restoration.

Tanzania is boasting of 158,100 ha of mangrove forests with growing stock of $49m^3ha^{-1}$ (MNRT 2015) Mangroves have multiple social and ecological values to natural systems and societies. As is for other forest ecosystems mangroves can store substantial amount of carbon thus they can be very rich carbon repository. For example there are records that a mangrove forest that had been disturbed for about ten years contained 978.73 Mt C ha^{-1} (128.92 Mt C ha^{-1} above ground biomass and 849.81Mt C ha^{-1} soil carbon stock) (Mang'ora 2015)[21]. The mangroves ecosystems have the attribute of being resilient to change. Given that mangroves are reserved ecosystems in Tanzania this should be an ecosystem that receives substantial investment and attention in management and restoration. Thus their protection is critical.

Unfortunately Mangrove Ecosystems are continuously threatened by conversion and degradation. There are many threats, most of which are anthropogenic, including climate change and its ramifications such as sea level rise. To encourage resilience to climate change, mangroves need to be protected from anthropogenic threats, because mangroves that are healthy will also be better able to adapt to global changes.

If coastal societies are to continue to benefit from mangrove resources then climate change oriented mangroves management and conservation programs need to be instituted. This is because one of the attributes of the mangroves ecosystems is the resilience to cope with changes which can also support societal resilience. It is important that technology in conservation of mangrove ecosystems be adopted. This includes the national mangrove management planning with strong slant towards the climate change mitigation role of the mangroves ecosystems. Building resilience into mangrove conservation plans requires an understanding of how mangroves will respond to climate changes, what factors help them survive these changes, and, consequently, which mangroves are most likely to survive these changes (McLeod and Salm, 2006). Mangrove greenbelts can provide significant coastal protection from erosion and should be established along erosion-prone coastlines and riverbanks and

[21] Mangora, M. M (2015) Biomass and Carbon Stock in the mangrove forest of Wami and Ruvu Estuaries in Tanzania. IMS, University of Dar es Salaam.

in areas which experience significant climate change induced damage from typhoons, tidal surges, cyclones, and geomorphic erosion (Macintosh and Ashton 2004).

Mangrove areas that are degraded can be restored to strengthen and hasten their resilience. In addition to mitigation effect the restoration of mangrove may help create sustainable livelihoods for local communities that depend upon such systems.

Forest Landscape Restoration (FLR) Assessment

Forest landscape restoration is an important process in dealing with forest degradation and deforestation. This process is about strengthening forest ecosystem resilience so as to regain ecological or biological functionality and productivity to enhance human well-being and other benefits from deforested or degraded forest landscapes (Rizvi *et al.,* 2015). The intention is to restore forest ecosystem as part of a wider landscape improvement. FLR has multiple benefits, among them it includes the increased capacity for carbon sequestration and storage, in addition to other economic and livelihood benefits to communities (Rizvi *et al.*, 2015). If degraded forestlands are restored they can enhance the carbon stock, generating new capacity for carbon capture and storage.

Though it focuses on improving broad landscape functionality through forest enhancement, forest landscape restoration can significantly provide climate change mitigation and adaptation benefits. Forest landscape restoration can potentially increase resilience and adaptive capacity of the forest ecosystems and reduce social vulnerability to climate change. Of importance here is that Forest Landscape restoration can provide basis for climate change mitigation.

One FLR assessment instrument is Restoration Assessment Methodology (ROAM). ROAM is an iterative and stepwise application of a series of analyses to identify the best set of FLR opportunities that can be applied to an area of interest. This process identifies feasibility, cost and benefit, incentives needed and stakeholders to be engaged in the process. It does this by using a combination of stakeholder engagement “the best knowledge” and analysis of documented data “best science” to identify and investigate Forest Landscape Restoration Opportunities (Rizvi *et al.,* 2015). This is a technology that needs to be adopted and used in Tanzania when making decisions to restore forest landscapes, both mosaic and wide-scale restoration.

Sustainable forest Management (SFM)

Sustainable forest management contributes to food security, poverty alleviation, economic development, and sustainable land use, in the wider context of sustainable development. Sustainable forest management secures the survival of forest ecosystems and enhances their environmental, socio-cultural and economic functions. It is also, an effective framework for forest based climate change mitigation and adaptation. It can both maximize forests’ contribution to climate change mitigation and help forests and forest-dependent people adapt to new conditions caused by climate change. Improved forest management practices for climate change mitigation and adaptation should be planned and implemented in tandem, as they are closely linked (Barry *et al.*, 2010).

Forests are, of course, managed not only for climate change, but for multiple, usually complementary, objectives which include production of goods, protection of soil, water and other environmental services, conservation of biodiversity, provision of socio-cultural services, livelihood support and poverty alleviation. Accordingly, climate change mitigation and adaptation efforts must provide synergies and be balanced with other national and local forest objectives. For example Carbon offset or Reducing Emissions from Deforestation and Forest Degradation and Sustainable Forest Management (REDD+) schemes can provide an additional benefit and incentive for the creation and protection of sustainably managed multi-purpose forests (Freer Smith et al 2007). The benefits of Sustainable forest management include retention or increase of forest cover over time, thus maximizes carbon capture which is sustaining or increasing carbon stock in forest stands. Sustainable management can help reduce the impacts of pests and forest fire (which can cause significant GHG emissions) by ensuring active risk management (Freer Smith et al 2007, Barry *et al.*, 2010)[22].

Sustainable management, including harvesting, provides economic incentives for local communities to conserve forest cover. The harvesting of sustainably managed forests provides opportunities to store carbon for long periods in manufactured wood products and through the regeneration of forest cover (Barry *et al.*, 2010).

Improved seed and Tree Production Technology

One major input to sustainable forest management and forest restoration is availability of adequate stock of high quality germplasm (seeds, seedlings and clonal material) of indigenous and exotic species. This can be achieved by establishing a network of strategically positioned tree nurseries, and other means of seedling propagation. Tree breeding programme composed of network of progeny and provenance trials. There should also be professionally managed seed orchards and Plus trees. Functional seed protection, storage and distribution (marketing) systems should also be instituted.

It is important to make sure that tree seeds from good quality genetic material are produced, stored and made available to consumers. These will only come from dedicated seed orchards or vegetative propagation material as needed. It is important to develop and implement a long term tree breeding programme. Also use of biotechnology to produce productive clones of various species could also be considered. The Tanzania Tree Seed Agency and Tanzania Forest research Institute should be considered as the main partner in this undertaking.

There are many tree nurseries in Tanzania, but their management and operations leaves a lot to be desired, especially in the control of quality of seedlings produced. It is imperative therefore that investment is made into reviewing the current tree nurseries technologies and in improving the technology such that there is focus in producing high quality seeds and seedlings with minimum resources.

High quality germplasm will produce higher growth rate, survival percentage, quality timber, and potentially resistance to various damaging factors, such as insects and fires. That will be incentive for the forest managers to acquire and plant them. In return the rapid growth will provide for faster sequestration and the higher survival rates will mean higher carbon stock per hectare.

[22] Barry, D., Bray, D., Madrid, S., Merino, L., Zuniga I(2010) Sustainable forest management as a Strategy to Combat climate Change: Lessons from Mexican communities. CCMS and Rights and Resources.

Forest genetic improvement can be an efficient way to adapt forest production material to new environmental conditions assist migration of species and contribute to improving the resilience of forest ecosystem and thus forest dependent communities (tree4future cited 2016)[23]

Sustainable charcoal production models and appropriate techniques

Charcoal, the most extensively used fuel in many households in both urban and rural Tanzania. Charcoal is, thus, one of the major sources of domestic energy in Tanzania. The users prefer it because of its higher energy density, lower transport cost, relative cleanliness, easier access and affordability (Liyama *et al.*, 2014)[24]. It is estimated that over 90% of Tanzania's domestic cooking energy needs are attained by the use of wood fuel. It is estimated that In Dar es Salaam 71% of the Households use charcoal for cooking (World Bank 2009). In other urban areas the share of households using charcoal for cooking is estimated at 53% and that fire-wood is 38% (WB 2009). Total annual charcoal consumption in the country is estimated at one million tonnes.

Charcoal production and consumption is inadequately considered by the energy and forest management policy makers (World Bank 2009). It is generally managed under very unfavourable policy environment and viewed negatively by policy makers and forest practitioners (World Bank 2009). The process of making charcoal using traditional means, also contributes highly to the deforestation and forest degradation, as the recovery rate is estimated at only 8 – 20% of the raw wood used (Liyama *et al.*, 2014)[25]. Since Charcoal remains to be one of the most important components of energy mix in Tanzania, Investment in sustainable charcoal provisioning has to be made. This should include streamlining and harmonization of policies as a prerequisite for an enabling environment for sustainable charcoal production. It should also include, promoting efficiency in production, consumption and sustainable supply in the policy framework. Increasing the production and consumption can be dealt with under energy sector, but these will need to go in tandem with technological decisions in forestry and reform along the entire charcoal value chain. This should include changes in forest and agricultural land management, such that sustainable charcoal supply system is designed and implemented. These could include strengthening agroforestry systems such that more charcoal producing wood is obtained on farm, focusing in harvesting invasive species where they occur.

1.7. Stakeholders' Consultations

1.7.1. Energy Sector

Stakeholder consultations were done through an inception workshop, and direct face to face focussed group discussion. The inception workshop was used to introduce the TNA to the stakeholders. It provided objectives and expected outputs. During the focused group discussion the Consultant

[23] http://www.trees4future.eu/tree-breeding-and-climate-change-resilient-forests-for-the-future.html

[24] Liyama M, Njenga Mary, de Leeuw J, Wagura J, Syano N, Gama B, Kimaro A, Neufeldt H, Dobie P and Jamnadass R (2014). In Treesilience: An assessment of the Resilience provided by trees in the drylands of Eastern Africa (2014) ICRAF.

[25] Liyama M, Njenga Mary, de Leeuw J, Wagura J, Syano N, Gama B, Kimaro A, Neufeldt H, Dobie P and Jamnadass R (2014). In Treesilience: An assessment of the Resilience provided by trees in the drylands of Eastern Africa (2014) ICRAF.

presented the outcomes from literature review highlighting potential areas that have been identified through other processes. Also the Consultant presented the fact sheets for different technologies. This exercise was repeated in Zanzibar. After detailed discussions the following list of technologies was adopted.

a) Solar PV
b) Mini and Micro Hydro
c) Efficient and clean fuel / cooking technologies
d) Sustainable use of biomass fuel
e) Waste to Energy
f) Wind energy (electricity /mechanical power)
g) Geothermal power
h) Natural gas
i) LPG
j) Tidal and wave energies
k) Coal (This was not considered to meet the objectives of TNA, as such was excluded in the future analysis)

1.7.2. Forest Sector

Stakeholder consultations were done through inception workshop, direct face to face focussed group discussion. The inception workshop was used to introduce the TNA to the stakeholders. It provided objectives and expected outputs. During the focused group discussion the Consultant presented the outcomes from literature review highlighting potential areas that have been identified through other processes. Also the Consultant presented the fact sheets for different technologies. This exercise was repeated in Zanzibar. After detailed discussions the following list of technologies was adopted.

a) Sustainable Forest Management
b) Agroforestry
c) Mangrove Conservation Rehabilitation and Restoration
d) Tree and Seed Production Improvement (Improvement of Forest Germplasm)
e) Forest Landscape Restoration
f) Sustainable (Improved) Charcoal Production Methods
g) Efficiency in Biomass Energy Utilization
h) Reducing Emissions from Deforestation and Forest Degradation and Sustainable Forest Management (REDD+)
i) Timber and Non Timber forest Industries Technologies
j) Strengthen National Carbon Monitoring Centres

CHAPTER 2: INSTITUTIONAL ARRANGEMENT FOR THE TNA AND THE STAKEHOLDER INVOLVEMENT

The overall coordination is done by the Vice President's Office (VPO), Division of Environment (DoE). The National TNA Team is responsible for day to day implementation of TNA activities.

The TNA institutional arrangement is comprised of the National TNA Steering Committee, The National TNA Committee, the National TNA Team and Working Groups.

2.1. National Steering Committee

The National Steering Committee is composed of following members:

a) Permanent Secretary Vice Presidents Office
b) Permanent Secretary Ministry of Water and Irrigation
c) Permanent Secretary Ministry of Energy and Minerals
d) Permanent Secretary Ministry Natural Resources and Tourism
e) Permanent Secretary Ministry of Agriculture, livestock and Fisheries
f) Director General, Commission for Science and Technology
g) Director, Institute of Natural Resource Assessment, University of Dar es Salaam

The Steering Committee is responsible for

- Guiding the National TNA team
- Providing political acceptance for the Technology Action Plan

2.2. National TNA Committee

It has eight members from different sectors as follows:

a) Energy
b) Water
c) Agriculture
d) Forest
e) Environment
f) University of Dar es Salaam
g) Commission for Science and Technology
h) The First Vice President Office – Zanzibar

2.3. National TNA Team

The day to day implementation of the TNA is under the responsibility of the National TNA Team, which is comprised of:

a) National TNA Committee,
b) National Consultants /experts,

c) Workgroups, and
d) TNA coordinator.

2.4. Sectoral / Technological Workgroups
It involves technical people from the following four sectors

i. Water
ii. Energy
iii. Agriculture and
iv. Forestry.

2.5. Stakeholder Engagement Process followed in the TNA – Overall assessment

2.5.1. Energy Sector

All stakeholders with an interest in energy, generation, transmission and distribution of energy/electricity and those with interest in renewable energy were identified through literature review, direct contact with institutions that the National Consultant was aware of their involvement in the energy sector. Others were identified through consultations with other stakeholders. The stakeholders include those who make a decision, those who could influence it and those who will be affected by it.

In this context the following groups of stakeholders were identified, see Appendix 1 for details.

1. Government departments with responsibility for policy formulation and regulation of the energy sector;
2. Industries and industry associations, businesses, and distributors that are operating in the energy sector with high GHG emissions or that are vulnerable to climate change impacts;
3. Electric utilities and regulators;
4. Private sector, technology users and/or suppliers who could play a central role in developing/adapting technologies in the country;
5. Organisations involved in the research and development, manufacturing, import, sales, and promotion of energy technologies for mitigation;
6. The financial institutions, which could provide the capital required for technology project development and implementation;
7. Communities, small businesses and farmers that are or will be using the technologies and who would experience the effects of climate change;
8. Non-Governmental Organisations involved with the promotion of environmental and social objectives;
9. Institutions that provide technical support to both government and industry (e.g., universities, research institutions, and consultants);
10. Labour unions, consumer groups, and media;
11. Country divisions of international companies responsible for investments important to climate policy (e.g., agriculture forestry);
12. International organisations, cooperation agencies, and donors; and

13. International agencies, e.g. UN, bilateral, ODA. 14. Other climate change / UNFCCC focal points: UNFCCC, Adaptation fund, NAMAs etc.

2.5.2. Forest Sector

In Tanzania forest stakeholders are many and have varied interest. These include public sector institutions, private business and civil society. These include institutions such as the Division of Forestry and Beekeeping of the Ministry of Natural Resources Tourism which is responsible for forestry policy making and monitoring, the Tanzania Forest Services is responsible for management of forest reserves that include all government owned production forests plantations. The Ministry also has the Tanzania Tree Seed Agency, which is mandated to produce high quality tree seeds. Tanzania Forest research Institute is responsible for planning and implementing forest research programmes in the country. In Zanzibar these responsibilities are under the Department of Forestry and Non-renewable Natural Resources which is under the Ministry of Agriculture and Natural Resources. Other Ministries would include Ministry of Agriculture and Food Security, Ministries that deal with land and Energy for both the URT and GoZ.

A number of academic institutions have programmes that teach and research on forestry, elements of forestry, or natural resources management programmes. The institutions produces personnel qualified in forest resources management and conservation. These include Sokoine University of Agriculture within the department of forestry and nature conservation, the University also has Climate Change Impacts Adaptation and Mitigation (CCIAM) programme. The Olmotonyi Forestry Training Institute. The University of Dar es Salaam has the Institute of Resources Assessment.

In Civil Society Organisations there are a large number of institutions, the few that have prominence include Tanzania Association of Foresters (TAF), Tanzania forest conservation group (TFCG), Tanzania Natural Resources Forum (TNRF), MJUMITA, Mpingo Conservation and Development Initiative (MCDI), and climate Change Forum. Others include International NGO's that have their activities in Tanzania these include the Jane Goodall Institute (JGI), Africa Wildlife Foundation (AWF), World Wide Fund for Nature (WWF), The Nature Conservancy (TNC), International Union for Conservation of Nature (IUCN), World Agroforestry Centre (ICRAF) and CARE Tanzania.

From private sector these include the umbrella organizations such as the Tanzania Private Sector Foundation (TPSF), Tanzania Chambers of Commerce Agriculture and Industries (TCCIA), Tanzania Forest Industries Association (TAFIA), The Forest Development Trust (FDT). These are stimulating policy discussions and communication with the government and other stakeholder and champion the interests of private sector in the dialogue with the government and provide various advocacy and training programmes for their members. Some, including TAFIA and FDT, implement actions on the ground. There are also individual companies that are focused on establishment of forest and some on forest product utilization; examples include Green Resource LLC, New Forest Company

The primary stakeholder group, is very heterogeneous and diverse, that consist, of people living adjacent to forests, users of forest products and beneficiaries to various forest products, this is holistically called community. These are people in villages and in towns, who have interest in or are benefiting from forest resources. These are the investors in land and lead by action in implementation of the forest management and utilization activities, including planting and harvesting.

They are the important part of any forest programme delivery, including adapting to new technologies.

2.5.3 Wide Stakeholder Consultation

For the dates of stakeholder workshops, see section 1.1.1. Stakeholder consultations were aimed at promoting ownership in order to adapt the process to the specific context. Stakeholder consultations were an important source of information that helped the Consultant to identify the priority technologies for further analysis in the TNA process. It is intended that stakeholders will continue to be engaged throughout the project as this will provide continuity. The workshops which were organised on 20th November 2015 and 24th November 2015 provided opportunity to stakeholders to collectively contribute to the TNA process. After the presentation the stakeholders were allowed to work in groups to review the inception report, the list of stakeholders already identified, types of technologies already identified and propose additional stakeholders and technologies.

Through this consultative and participatory process, stakeholders were expected to link elements or steps of the TNA process with local projects e.g. those identified in the SCALING-UP RENEWABLE ENERGY PROGRAMME (SREP) INVESTMENT PLAN FOR TANZANIA (URT,2014), relevant processes and sustainable development programmes and plans. In this sense, it will be possible to generate synergies and avoid duplication of efforts.

2.5.2.1. Level of engagement

The first consultation focussed on technologies identification and where possible prioritisation. This step was crucial to get initial political and technical support. The follow up consultations focused on prioritisation of technologies.

3.0 TECHNOLOGY PRIORITISATION FOR THE ENERGY AND FOREST SECTORS

The technology identification and prioritisation step was intended to establish and rank the most appropriate technologies for low carbon emissions and reduced vulnerability. It involved the identification and classification of technologies for mitigation, starting by generating a comprehensive listing of technologies available, including new or unfamiliar technologies. This extensive analysis was performed using the Multiple- Criteria Decision Analysis, by quantifying the selection process and determining to what extent each potential technology contributes to sustainable development goals, reduces GHG emissions, while being cost effective. The results of this analysis produced a weighted score that was used to prioritise the technologies in the energy and forest sectors.

3.1. Energy Sector

3.1.1. GHG emissions and existing technologies of the energy sector

Large scale hydropower

Hydropower currently contributes about 35 % of electricity generated in Tanzania compared to about 70% in the 1990's.[26] Despite the current difficulty being experienced by hydropower plants because of changing weather patterns in the past few years, there are still some large hydropower being planned as shown in Table 5.

Biomass Energy

Biomass will continue playing a major role in energy mix in Tanzania, particularly for rural use. Although there is no comprehensive study that showing the trend of biomass use, because of its abundance (see section 1.6.1) and renewability efficient biomass energy is seen as a major source of energy in the future.

Solar Energy

Solar energy is a proven technology and various actors have been trying to commercialize the technology in rural areas. As grid electricity reaches about only 1 % of the rural population in Tanzania, the use of solar electricity (particularly for off-grid application) seems to be an attractive option as the country enjoys abundant sunlight.

Wind Energy

As shown in section 1.6.1, there is very limited number of attempts that have been made to harness wind energy in Tanzania. There are two project developers planning to establish 50 MW and 200 MW projects in Makambako and Singida areas respectively. Because of inadequate data on wind regimes this source need to overcome this hurdle.

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26 http://www.undp.org/content/undp/en/home/ourwork/environmentandenergy/strategic_themes/climate_change/carbon_finance/CDM/tanzania.html

Geothermal Energy
As discussed in section 1.6.1 this energy source is still very far from being economically developed.

Mini-Hydropower Sources
As shown in section 1.6.1, Tanzania has an estimated 3,800 MW of economic hydro potential capacity. Only 15% of installed capacity has been developed. It is estimated that 100 GWh/yr could be produced from micro/mini systems. Currently only around 32 GWh/yr is produced from these smaller systems, many of which are private schemes run by religious missionaries. This is an area of interest particularly for areas endowed with rivers, but not close to the national grid.

The growth of GHG emissions is shown in Table 14.

Table 14: GHG emissions trends

	Biomass	Electricity	Fossil Fuel	Natural Gas	Coal
Million TOE (1990)					
	7.66	0.084	0.674	0	0.025
GJ	$320x10^6$	$3\ x10^6$	$28x10^6$		$1x10^6$
Metric Tonne CO2	0	327.07	2201.084		119.32
Million TOE (2000)					
	11.07	0.123	0.984	0	0.123
GJ	$463x10^6$	$5x10^6$	$41x10^6$		$5x10^6$
Metric Tonne CO2	0	478.93	3213.453		587.07
Million TOE (2010)					
	19.8	0.22	1.76	0.63	0.22
GJ	$829x10^6$	$9x10^6$	$73x10^6$	$26x10^6$	$9x10^6$
Metric Tonne CO2	0	856.62	5747.639	1,477.10	1,050.05

3.1.2. Decision context

As it has been shown in section 1.6.1 about 18.4 percent of the country population has access to grid electricity. Electricity demand in the country is increasing rapidly mainly due to accelerated productive investments, increasing population, and increasing access. Demand for electric power is growing and typically exceeds supply. The Power System Master Plan (2010 – 2035) anticipates that Tanzania will increase electrification status from 18.4 percent to at least 75 percent by 2035 while demand from connected customers will increase significantly as Tanzania becomes a middle income country as stipulated in Tanzania Vision 2025. In the short to medium term generation expansion plan (up to 2016), the majority (59 percent) of the planned generation capacity additions are expected to be based on hydropower, coal and natural gas.

However, a particular challenge facing Tanzania is the increasing unpredictability of hydroelectric power in face of changing weather patterns. This problem is exacerbated by having most of the hydropower on two river systems that are now prone to drought. This necessitated the country having to extensively shed load and run expensive thermal power plants as base load. The GoT expects the addition of significant thermal capacity up to 2016, much of it natural gas, to overcome power shortages.

3.1.2.1. What will be the main goals of the analysis in TNA?

In order to meet the needed energy to power the rapidly increasing economy, there is a dire need to diversify energy sources. Tanzania is well endowed with potential for development of a range of sustainable and renewable energy sources; solar power, wind power, wave power, biomass, urban waste and others. The use of renewable energy in Tanzania today is limited to large scale hydropower and an emerging market for small scale solar photovoltaic for domestic and institutional use.

The main goal of TNA therefore is to identify and prioritise low carbon technology needs, which can help Tanzania to meet her energy development needs at the same time mitigating GHG emission. This is possible as Tanzania is blessed with high quality renewable resources, largely untapped. They include hydro, geothermal, solar, wind and biomass. Presently about 4.9 percent of total generation capacity in Tanzania is from renewable energy, including captive generation in sugar, tannin and sisal factories, solar, and small hydro plants, but excluding large hydro. The GoT has a goal to increase the share of renewable energy (excluding large hydro), in the electricity mix to 14 percent by 2015. When large hydropower is included, the total renewable energy generation capacity is about 40 percent.

3.2. Forest Sector

3.2.1. Decision context

The objectives of the Tanzania's forest sector are to conserve and manage forest resources for economic and ecological benefits for the present generation and posterity[27]. This means that sufficient forest land will be managed so as to sustainably produce goods and ecological services. These include management for carbon sequestration. Moreover, this means that forest sector is expected to be a source of employment and a contributor to the national economy.

The sector is faced with a number of challenges, the first being very high rate of deforestation and forest degradation, it is estimated that Tanzania loses 400,000 ha of forest each year (URT 2015). This has resulted in loss of ecological services including biodiversity and carbon sequestration. Other challenges include institutional incapability's to carry out regular forest resources assessment, due to shortage of financial resources. Another challenge is inadequate recognition of the value of forest resources in the national accounts, hence inadequate investment into the sector by the central government. It is estimated that the government of Tanzania spends only 1% of national budget on forestry.

The main goal of this Technological Needs Analysis (TNA) is to determine the technology suitable for strengthening the role of the forest sector in contributing to mitigation and adaption to the impact of climate change.

[27] Tanzania Forest Policy (1997)

The decision on choice and prioritization of forest technology was done through broad consultation with stakeholders, mainly in workshop setting. The stakeholders included government officials, researchers, academics and civil societies that have interest in forest management and conservation in the country. Thus the technology ideas and prioritization criteria were developed in a participatory manner using current knowledge of various experts and reality on the ground. This has made the technologies identified to be credible, legitimate and relevant to Tanzania. It is expected, therefore, that the technologies identified are the real needs of the forest sector in Tanzania and that have potential of being widely accepted and implemented.

3.3. An Overview of Possible Mitigation Technology Options

3.3.1. Energy sector

There are a number of technologies that can help the energy sector to mitigate climate change. These are listed in table below and further details are provided in factsheets (for the priority technologies) in Appendix 1.

Table 15: Energy technology options for Tanzania and how they help in mitigating climate change

No.	Technologies	Mitigation benefit
1.	Solar	The solar energy generates very low GHG compared with fossil based power generation.
2.	Mini and Micro Hydro	Mini hydro do not generate GHG but they could be vulnerable to climate change
3.	Efficient and clean fuel / cooking technologies	The majority of people still use biomass and the situation will remain as such for some time. Hence intervention in this area will have more benefits.
4.	Sustainable use of biomass fuel	Although it is claimed that sustainable biomass fuel is carbon neutral, this has been challenged recently. It is generally accepted that use of sustainable biomass will mitigate GHG as compared to current unsustainable use of biomass
5.	Waste to Energy	Apart from using the waste to generate energy, this will have a co-benefit of cleaning the environment. However, collection, transportation and combustion of waste will generate CO_2
6.	Wind energy (electricity /mechanical power)	Does not generate GHG
7.	Geothermal power	Does not generate GHG
8.	Intensification of Natural gas use	It still generates GHG, though at reduced amount when compared with diesel, kerosene. However, Natural gas is non-renewable energy resource
9.	Intensification of LPG use	It still generates GHG, though at reduced amount when compared with diesel, kerosene. However, LPG is non-renewable energy resource

As indicated in Table 15, these technologies have climate change mitigation benefits and were suggested by stakeholders as they felt these technologies were mature for the experts as well as political endorsement would be received faster for them, since they contribute to rapid acceleration of energy access particularly to the rural communities. Besides the Rural Energy Agency is committed to promote them as they provide opportunity to reach the majority of rural areas, particularly those not covered by the national grid. These technologies have multiple benefits (social, economic and environmental). For example, energy availability is key to improved socioeconomic development, reduction of poverty and protection of forest. These were developed into factsheets and further prioritised during the technology prioritization workshop.

3.4. Criteria and Process of Technology Prioritization for the Energy Sector

Technology prioritization was done at a workshop held between 20, November 2015 where criteria for prioritizing technologies was developed by stakeholders and multi criteria analysis was used to prioritize technologies. The steps for undertaking the MCA were explained to the stakeholders as below:

1. Identify the options
2. Identify the criteria
3. 'Weighting' (Assign weights for each of the criteria to reflect their relative importance to the decision)
4. Combine the weights and scores for each of the options to derive and overall weighted score
5. Prioritise/rank technologies and select the highest priority technologies Examine the results
6. Conduct a sensitivity analysis of the results to any changes in scores or weights.

An important feature of Multi Criteria Analysis (MCA) is its ability to use the expert judgment of the stakeholders e.g., within a sectoral working group in TNA. This includes establishing targets and criteria, estimating relative importance weights and in judging the contribution of each technology to each performance criterion. The stakeholders arrived at a collective decision and prioritized three technologies. The MCA excel based tool provided by UNEP DTU Partnership was used for the MCA exercise.

3.5. Results of Technology Prioritization

3.5.1. Energy sector

Stakeholders went through a process of technology prioritization session where they selected technologies for climate change mitigation. For the energy sector the criteria for ranking technologies were energy efficiency, capital cost, job creation, maturity, sustainability (environmental), social acceptability and gender equity, GHG emission reduction potential, access potential . The weighting was as follows:

a) GHG emission reduction potential (20%)
b) Sustainability (environmental) (20%)
c) Access potential (15%)
d) Maturity (15%)
e) Energy efficiency (10%)
f) Capital cost (10%)
g) Job creation (5%)
h) Social acceptability and gender equity (5%)

Explanation of the criteria as agreed by the experts

a) GHG emission reduction potential: The selected technology should have potential to mitigate GHG
b. Sustainability (environmental): The technology should be resilient to environmental variability
c. Access potential : The technology should be able to reach as many people as possible, particularly those who are living far away from the national grid
d. Maturity: This defines the level of technology in Tanzania, for example are there existing installed facilities similar to the selected technology
e. Energy efficiency: This criterion considered the conversion efficiency. Technologies with low efficiencies means will require high investment for a given power demand
f. Capital cost: this defines the easiness or difficulty to gent interested parties to invest in the technology
g. Job creation: This defines the level of job creation both directly and indirectly
h. Social acceptability and gender equity : This criteria was considered important since there many technologies that have failed because they were not socially acceptable

The weighted averages of the ranks were taken to find the final score and three technologies were chosen which had highest scores. The rankings and weights for each technology during the technology prioritization process are provided in Table 16. The scoring was done individually by each expert, and the averages were adopted after some discussions.

Table 16: Technology rankings for the energy sector

Option/Criterion	GHG emission reduction potential	Environmental sustainability	Access potential	Maturity	Energy efficiency	Capital costs	Job creation	Social acceptability Gender equity
Units	Rank 1-5	Rank 1-5	Rank 1-5	Rank 1-5	Rank 1-5	Rank 1-5	Rank 1-5	Rank 1-5
Preferred value	High	High	High	High	High	Low	High	High
Weights	20%	20%	15%	15%	10%	10%	5%	5%
Solar PV	5	5	5	3	3	2	3	5
Mini and Micro Hydro	5	3	4	4	4	2	4	5
Efficient and clean fuel / cooking technologies	3	3	4	4	3	4	4	5
Sustainable use of biomass fuel	4	3	4	4	3	2	4	5
Waste to Energy	3	2	1	2	3	3	5	4

Option/Criterion	GHG emission reduction potential	Environmental sustainability	Access potential	Maturity	Energy efficiency	Capital costs	Job creation	Social acceptabilit y Gender equity
Wind energy (electricity /mechanical power)	5	5	3	2	3	2	3	5
Geothermal power	5	5	1	1	4	1	3	5
Intensification of Natural gas use	3	3	1	2	5	2	4	5
Intensification of LPG use	3	3	2	3	5	4	3	5

The Table 17 provides final weighted scores and technologies prioritized mini and micro hydropower got the highest score followed by Sustainable use of biomass fuel and solar energy.

Table 17: Prioritized technologies for Energy sector and weighted scores

Rank	Option	Weighted Score
1	**Mini and Micro Hydro**	**78.8**
2	**Sustainable use of biomass fuel**	**63.8**
3	**Solar PV**	**56.7**
4	Efficient and clean fuel / cooking technologies	47.1
5	Wind energy (electricity /mechanical power)	44.2
6	Intensification of Natural gas use	42.5
7	Intensification of LPG use	42.1
8	Geothermal power	40.0
9	Waste to Energy	33.3

The technologies that scored the highest are technologies that Tanzania needs in order to assist the energy sector to effectively mitigate climate change. Stakeholders noted that waste to energy is still constrained by lack of infrastructure for collection, storage and transportation. Besides, the waste to energy is known to pollute environment particularly by releasing dioxins and furans if the facility is not operated and maintained properly. The use of LPG will be constrained by the distribution system and collection of LPG cylinders. The natural gas will face similar situation since the infrastructure for natural gas distribution is still limited. The geothermal is still at infant stage as such not easy to attract investors. The three top prioritised technologies would be developed into technology action plans with further stakeholder engagement at a later stage in the TNA project.

It is worth noting that the prioritized technologies do not deviate from the technologies identified by other CC processes.

3.5.2. Forest sector

The prioritization of the identified technology was aimed at establishing and ranking the most appropriate forestry technologies for both adaptation and mitigation, to contribute in low carbon economy processes and reduce social vulnerability. Sixteen technologies were initially identified and suggested, these are:

1. Agroforestry
2. Mangrove conservation, Rehabilitation and Restoration
3. Urban forest [Green Infrastructure]
4. Sustainable forest Management
5. Sustainable (Improved) Charcoal Production Method
6. Biomass Energy Utilisation
7. Tree Nurseries – Seedlings Production Technology
8. REDD – MRV
9. Harmonisation of forest Classification system
10. LULC classification and detection of forest cover change using remote sensing data
11. Multiple Diagnostic Studies to assess drivers of forest degradation and deforestation to support REDD projects
12. Capacity Building in the carbon Assessment approaches
13. Strengthening Technical capacity in remote sensing, forest inventory data analysis and verification.
14. Establishment of National entity with responsibility and methodologies to coordinate and aggregate MRV activities.
15. Landscape level REDD+ implementation.
16. Establishment of safeguard information system (SIS)

As part of the consultation process the technologies were presented at four forums, these were, stakeholder's workshop, forest working group, Zanzibar Stakeholders workshop and Technology Prioritisation workshop. Some of the technologies were dropped, some were adjusted some were added and recommended for further evaluation. Those that were dropped include:

1. Urban forest [Green Infrastructure]
2. REDD – MRV
3. Harmonisation of forest Classification system
4. LULC classification and detection of forest cover change using remote sensing data
5. Multiple Diagnostic Studies to assess drivers of forest degradation and deforestation to support REDD projects
6. Capacity Building in the carbon Assessment approaches
7. Establishment of National entity with responsibility and methodologies to coordinate and aggregate MRV activities.
8. Landscape level REDD+ implementation.
9. Establishment of safeguard information system (SIS)

The technologies that were added include

- Forest Landscape Landscape Restoration.

- Timber and Non Timber Forest Industries Technology

The technologies that were adjusted include

1. Tree Nurseries – Seedlings Production Technology adjusted to Tree and Seed Production Improvement (Improvement of Forest Germplasm).
2. Biomass Energy Utilisation adjusted to Efficiency in Biomass Energy Utilisation.
3. Reducing Emission from Deforestation and Forest Degradation and Sustainable Forest Management (REDD+) adjusted from three original suggested technologies, these are
   - REDD – MRV
   - Multiple Diagnostic Studies to assess drivers of forest degradation and deforestation to support REDD projects
   - Landscape level REDD+ implementation.
4. Strengthening Technical capacity in remote sensing, forest inventory data analysis and verification was adjusted to Strengthening National Carbon Monitoring Centres

At this stage, the evaluation criteria were developed in collaboration with twelve professionals who formed the forest work group. The criteria included, offering adaptation and mitigation benefits, accessibility, affordability and acceptability, economic viability, sustainability, replicability, and that the technologies are in line with the existing national policy and priorities. The technologies were later evaluated using the Multiple-Criteria Decision Analysis, by quantifying the benefits and costs and determining to what extent each technology meets the established criteria. Through these evaluations the priority criteria were established through ranking, from the most to the least appropriate based on the criteria used. The criteria used are further described below:

1. **Cross cutting adaptation and mitigation benefits:** The technology has to be able to offer mitigation benefits. However, it is realized that many forestry technologies are likely to have both adaptation and mitigation benefits.
2. **Accessible:** The technology needed should be easily reached and distributable to users.
3. **Affordable:** The financial investment cost in technology needed should be affordable at multiple scales so that even small investors can invest in the technology.
4. **Acceptable:** The technology needed should have quality of being, practically, technically preferred and social acceptable by the users of the technology.
5. **Economic value and (Viability):** The technology to be chosen has to have economic viability, meaning the benefit of implementing or using the technology should be higher than the cost.
6. **Sustainable:** The technology has to be sustainable, indicating that once initially supported, it should continue to be used by the adopters of the technology with minimum or no outside support.
7. **Replicable:** It should be possible for the technology to replicable and be used in other geographical or socio-cultural setting.
8. **In line with existing policies and strategies:** The technology should be able to be supported by existing national socio-economic as well as environmental and forest management policies and strategies.
9. **Job creation or Income Generation:** Technology needed should have a potential to generate income or offer employment.

3.5.2.1. Multiple-Criteria Decision Analysis and Results

The Technologies that were accepted at preliminary discussion between consultant and Project coordinator, were discussed in four stakeholders workshops involving individuals from various organisations, the details of the workshops and the participants are provided in Appendices 1, 4, 5 and 6 of this report. The participants in the technology prioritisation workshops individually evaluated the technology against the established criteria. The score given were used in multi criteria analysis tool. Through the tool the technology were ranked according to the scores attained from the most needed to the least the priority technology. This is presented in Table 18.

Table 18: Forest Technology Ranking

Option/Criterion	Cut across adaptation and mitigation	Accessible affordable and acceptable	Economic Value and Viability	Sustainability	Replicable	In line with Existing Policies and Strategies	Compatible with other socioeconomic activities	Job Creation/ Income generation
Units	Rank 1-5'	Rank 1-5'	Rank 1-5'	Rank 1-5'	Rank 1-5'	Rank 1-5'	Rank 1-5'	Rank 1-5'
Preferred value	High	High	High	High	High	High	High	High
Weights	15%	10%	5%	20%	15%	5%	10%	20%
Agroforestry	4	5	5	4	5	5	5	4
Mangrove Conservation Rehabilitation and Restoration	5	4	5	4	4	5	4	4
Sustainable Forest Management	5	4	5	5	5	5	4	4
Strengthen National Carbon Monitoring Centres	4	3	4	4	4	4	3	3
Sustainable (Improved) Charcoal Production Methods	4	4	4	4	5	4	4	5
Timber and Non Timber forest Industries Technologies	4	4	4	4	4	4	4	4
Efficiency in Biomass Energy Utilisation	5	3	4	4	4	4	4	4
Forest Landscape Restoration	3	4	4	5	5	5	4	4
Tree and Seed Production Improvement (Improvement of Forest Germplasm)	5	4	4	4	4	4	4	4

Table 19: Prioritized technologies for Forest sector and weighted scores

Rank	Option	Weighted Score
1	**Sustainable Forest Management**	**73.3**
2	**Agroforestry**	**70.8**
3	**Mangrove Conservation Rehabilitation and Restoration**	**61.2**
4	Tree and Seed Production Improvement (Improvement of Forest Germplasm)	59.2
5	Forest Landscape Restoration	56.1
6	Sustainable (Improved) Charcoal Production Methods	50.1
7	Efficiency Biomass Energy Utilisation	45.6
8	Timber and Non Timber forest Industries Technologies	38.8
9	Strengthen National Carbon Monitoring Centres	11.9

Based on this analysis the three top, most appropriate or needed forest technologies are, Sustainable forest management (73.3), Agro forestry (70.8) and Mangrove Conservation, Rehabilitation and Restoration (61.2).

CHAPTER 4: SUMMARY AND CONCLUSIONS

4.1 Energy Sector

The TNA process in Tanzania began with an inception workshop to introduce the stakeholder to TNA process and expectation from the process. The sector prioritization process involved brainstorming on country energy development priorities, as discussed in Chapter 1 Tanzania is facing acute shortage of energy, while it has a huge potential of hydropower, particularly micro to mini hydropower. The brainstorming that involved energy experts listed the following technologies having potential to mitigate climate change:

a) Solar
b) Mini and Micro Hydro
c) Efficient and clean fuel / cooking technologies
d) Sustainable use of biomass fuel
e) Waste to Energy
f) Wind energy (electricity /mechanical power)
g) Geothermal power
h) Intensification of Natural gas use
i) Intensification of LPG use

The multi-criteria analysis prioritises development of mini / micro hydropower, sustainable use of biomass fuel and solar, see Table 20. The next step of the TNA process is to undertake a barrier analysis and develop technology action plans.

Table 20: Technologies retained for Technology Action Plans

Technology categories	Specific technologies
Hydropower	Mini and Micro Hydro
Sustainable use of biomass fuel	Fluidised bed boiler
Solar PV	Roof top or solar farm

Stakeholders indicated that in general there is need to build capacity on climate change mitigation in Tanzania and mainstreaming of climate change issues into national development.

4.2 Forest Sector

Based on this assessment process, the technologies that scored the highest are technologies that Tanzania needs in order to make forestry sector contribute to effectively mitigate climate change. It is important to note that, though the focus of this assessment is in mitigation the forest sector dynamics allows that forest technologies provide both mitigation and adaptation benefits. Thus, even with mitigation focus but with the fact that Tanzania is a net sink country; this report recommends that the technologies needed are those that focus on adaptation efforts so as to reduce vulnerability and enhance resilience of its forest ecosystems and people.

Though, based on the MCA assessment process, the three priority technologies are, **Sustainable Forest Management**, **Agroforestry**, **Mangrove Conservation Rehabilitation and Restoration** it should be noted that at least five more technologies among the identified would still be in a position to make significant contribution in mitigation efforts. The methods and approaches have been recommended or used for mitigation elsewhere. For example the entire concept of REDD+ is inclusive of sustainable forest management benefits.

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Annex 1: Technology Factsheets for selected technologies

Energy Sector

Technology 1

Technology: Mini and Micro Hydro	
Introduction	About 75 percent of Tanzanians live in the rural areas, and almost 95 percent of them do not have access to electricity. Lack of access is exacerbated by the fact that majority of these communities are far away from the national grid. To support equitable rural development and to improve economy and quality of life of rural people, the GoT has committed to an aggressive rural electrification program. The 2012 PSMP Update is planning towards 50 percent electricity coverage of the population by 2025 and 78 percent by 2035. Providing electricity to the rural population is challenging compared to electrification of urban areas. It affects many more people, and because of the low population density and dispersed nature of settlements, will come at a high cost, even though these people are the ones least able to afford to pay.
Technology characteristics	Given the dispersed nature of rural populations and low densities, electricity access will have to be accomplished using a combination of grid extension, mini- and micro-grids, and stand-alone systems. A preliminary investigation has mapped the population distribution in relation to the MV grid network and characterized the distribution of population by density and identified the population best served by extending the TANESCO grid, served through mini-grids and those best served through solar PV micro-grids and stand-alone systems. The mini-grids may be powered by a range of energy sources, such as small hydro, biomass, biogas, solar, wind and hybrids.
Costs including	
Cost to implement adaptation options	The financial requirements for implementing renewable energy for rural electrification projects with capacity of about 10MW (which fall in the definition of micro and mini hydropower in Tanzania) are estimated to cost up to 50 million USD.
Operation and maintenance cost over 10 years	Operational and maintenance costs will be around 100,000 USD per year.
Potential development impacts, benefits	
Climate Change Mitigation Benefits	• Reduce the exploitation of non-renewable energy sources; • Reduce GHG emissions due to avoiding the use of fossil fuels;
Economic benefits	• Maximize economic development opportunities: create of new economic activities and jobs related to new technologies, involvement of the private sector etc.
Social and Environmental benefits	• Improve living conditions of people in rural areas through access to electricity for homes and key institutions. • Improve gender equity
Status of Technology in Tanzania	All the technologies that may be used in this project are well known and developed in Tanzania

Barriers	• Project Preparation: Mini-grid project preparation must be scaled up and done so in a shorter time and more cost efficiently if the 2025 goal is to be met. There is also a need to incentivise and encourage local entrepreneurs who will have the best insights into local resources and community needs, but have little experience or knowledge of electrification project development or service delivery. • Technical Capability: Small projects rarely can afford the cost of employing the high quality of design services needed. Even if they could afford it, the skills needed are usually to be found in large firms which have little interest in small projects when they have worldwide opportunities to engage in large projects. Retaining qualified staff in rural areas is difficult and adds to the cost of managing and operating mini-grid services. • Payment Collection Uncertainty: While regulations in Tanzania permit non-utility service providers to supply retail electricity, retail tariff collection is perceived to be risky. Also, companies connected to the grid and also selling power to TANESCO are currently facing significant payment delays. • Administrative Problems: Neither the regulatory environment, nor the bureaucratic environment, is optimised to make it easy for developers to secure all the rights and permits needed to develop a site. The result is that developments may be slowed down or discouraged for reasons that are neither technical nor economic. • Cost and Availability of Capital: Mini-grids will be typically developed and run by small companies whose cost of capital will be higher than larger companies, including TANESCO. Also, retail sales to consumers with limited ability to pay may be seen as highly risky. These factors will both limit the availability of capital and also increases its cost – effectively putting technically and economically viable schemes out of commercial reach.
Acceptability to local stakeholders	It is not expected that this project will face any resistance from the people since
Endorsement by experts	Rural electrification is high on the national agenda as such this project is supported by experts
Timeframe	10 years
Institutional capacity	A number of key capacity building elements are needed to ensure this technology successfully developed: • Human resources: Tanzania have very few experts trained in geothermal resource development and operation and maintenance • Policy and regulatory framework: The Geothermal is covered broadly in the energy policy and under the general renewable energy. It might be important to review the policies and regulatory framework to establish their adequacy in developing the geothermal energy • Institutions: National, regional, and local institutions will likely need to be supported in their efforts to harness this resource • Financing: as discussed earlier, although geothermal energy is cheap to run the risk involved in developing the resource make it expensive to initialize. As such private sector may not be able to participate unless the risk involved are solved. • Participation: Geothermal energy has not been developed in Tanzania, it will be nice to involve as many stakeholders as possible to avoid misinformation and avoid any possible resistance to development of the technology.
Adequacy for current climate	The technology is very suitable for both current variability and future climate change.
Size of beneficiaries group	It estimated that about 2.2 million people will benefit from this project

Technology 2

Technology: Efficient biomass technologies	
Introduction	Tanzania has about 35 million hectares of forests; of which about 38 percent of total land areas (13 million hectares) are protected forest reserves and the remaining 62 percent are forests on public land in village areas that are under pressure from human activities including harvesting for energy. Forest and trees in farmlands contribute to wood fuel supply. However, supply of wood fuel is declining rapidly in the country causing scarcity of energy to rural and semi-urban low-income families and environmental degradation in areas where harvesting of wood fuel exceeds the growing stock potential. Current use of wood fuel is un-sustainable and hence contributes significantly to climate change. Wood waste can be used to generate electricity and supply not into the national grid but also serve the nearby communities.
Technology characteristics	As for the biomass – energy the following are characteristics of the technology, the conventional rankine cycle with biomass burning in a high pressure boiler to generate stem. The stem is passed through a steam turbine to generate electricity. Two types of boilers may be used the Stoker boiler or the fluidised bed boiler may be used the latter being more expensive than the former.
Costs including	
Cost to implement adaptation options	The financial requirements for implementing biomass – electricity is estimated at 3000 USD/kW. As for the energy efficient cook stove the estimated cost is about
Climate Change Mitigation Benefits	• Reduce the exploitation of non-renewable energy sources; • Reduce GHG emissions due to minimizing use of fossil fuels and using sustainable wood products and wastes; • The biomass to electricity will produce 5 – 25 kg of CO_2/GJ (depending on the type of biomass plant and state of biomass, i.e. whether dry wood, wood waste, green biomass etc.). GHG emissions from other fuels are 115 kg CO_2/GJ for coal, 87 kg CO_2/GJ for oil, 63 kg CO_2 / GJ for natural gas.[28]
Potential development impacts, benefits	
Climate Change Mitigation Benefits	• Reduce the exploitation of non-renewable energy sources; • Reduce GHG emissions due to minimising use of fossil fuels;
Economic benefits	• Maximize economic development opportunities: create of new economic activities and jobs related to new technologies, involvement of the private sector etc. • Opportunity for selling excess power to neighbouring countries
Social and Environmental benefits	• Improve living conditions of people in rural areas through access to electricity for homes and key institutions. • Improve gender equity by providing opportunity for small scale business
Status of Technology in Tanzania	Currently, Tanzania has limited number of biomass – electricity. Tanzania has huge potential of biomass resources which can be used to increase access to energy of many rural people.
Barriers	☐ Dispersed form of energy, ☐ Variety of technological solutions ☐ Competition from higher value applications ☐ Not sufficiently mature, therefore, risk to investors ☐ Difficult due to collection in some areas and transportation ☐ In case of Bioenergy, it is land-intensive ☐ Low load factors, hence it tends to increase energy system costs ☐ Minor influence on Tanzanian energy supply ☐ Not modern enough for mass utilization

28 http://www.biomassenergycentre.org.uk/portal/page?_pageid=75%2C163182&_dad=portal&_schema=PORTAL

Acceptability to local stakeholders	It is not expected that this project will face any resistance from the people
Endorsement by experts	Although there are already existing biomass-electricity projects in Tanzania, there still huge unexploited potential. Thus it has been endorsed by experts
Timeframe	15-25 years
Institutional capacity	A number of key capacity building elements are needed to ensure this technology successfully developed: • Human resources: Tanzania have very few experts trained in off grid biomass – electricity plants development and operation and maintenance • Policy and regulatory framework: Already there is standard power purchase agreement, which mill assist in fast tracking the diffusion of technologies. There is also grid codes that can facilitate grid connection. • The Off Grid power is covered broadly in the energy policy and under the general renewable energy. It might be important to review the policies and regulatory framework to establish their adequacy in developing the biomass-electricity • Institutions: National, regional, and local institutions will likely need to be supported in their efforts to large scale harness this resource • Financing: as discussed earlier, although biomass – electricity is cheap in the long run it requires huge initial capital investment costs • Participation: Since there a lot private forest growers, it will be important to involve other stakeholders to maximize the benefit from biomass energy
Adequacy for current climate	The technology is very suitable for both current variability and future climate change.
Size of beneficiaries group	If developed may supply more than 100MW into national grid which benefit many people beyond the borders of the resource itself

Technology 3

Technology: Solar Power Technology	
Introduction	Tanzania is situated in the so-called "solar belt" world region, with high levels of solar energy resource ranging between 2,800 to 3,500 hours of sunshine per year (i.e. average of 7.5 –9.7 hrs/day) and an uppermost daily global radiation. Tanzania is thus a suitable country for the development of solar-based technology as a viable alternative to conventional energy sources. Solar energy is the cleanest and the most abundant renewable energy source available.
Technology characteristics	The power plant will consist of the following elements: • PV solar panels/modules (arranged in arrays) • PV module mountings • DC-AC current inverters • Electricity distribution boxes • Cabling • Earthing systems • Electrical substation
Costs including	
Cost to implement adaptation options	The financial requirements for implementing wind - electricity project are estimated at 12,000 – 15,000 USD /MW (depending on local conditions)[29]

[29] https://www.quora.com/How-much-does-it-cost-to-install-a-solar-power-plant-with-10MW-capacity

Climate Change **Mitigation Benefits**	• Reduce the exploitation of non-renewable energy sources; • Reduce GHG emissions due to the avoiding use of fossil fuels; • This will result in reduction 0.69 kg of CO_2 savings per kWh[30]
Potential development impacts, benefits	
Climate Change **Mitigation Benefits**	• Reduce the exploitation of non-renewable energy sources; • Reduce GHG emissions due to the avoiding use of fossil fuels;
Economic benefits	• Maximize economic development opportunities: create of new economic activities and jobs related to new technologies, involvement of the private sector etc. • Opportunity for selling excess power to neighbouring countries
Social and Environmental benefits	• Improve living conditions of people in rural areas through access to electricity for homes and key institutions. • Improve gender equity
Status of Technology **in Tanzania**	Currently, Tanzania has many large scale hydropower projects as such the technology is known
Barriers	• Cost and Availability of Capital: The project require huge amount of money i.e. 200 Million USD • Poor rains: Currently major large hydropower plant are not running because of recurrent draught • Lack of catchment management: this has resulted to poor water resources management which as consequently resulted into lack of enough water to run hydropower projects • Payment Collection Uncertainty: While regulations in Tanzania permit non-utility service providers to supply retail electricity, retail tariff collection is perceived to be risky. Also, companies connected to the grid and also selling power to TANESCO are currently facing significant payment delays. This does not encourage private investor to invest in such large infrastructure • Natural gas barrier: there is a serious belief that discovery of natural gas will solve all our energy problems
Acceptability to local stakeholders	It is not expected that this project will face any resistance from the people since
Endorsement by experts	Although there is no large wind power installation, the wind energy has been used in Tanzania for many years
Timeframe	3 years
Institutional capacity	A number of key capacity building elements are needed to ensure this technology successfully developed: • Human resources: Tanzania have very few experts trained in off grid Solar PV development and operation and maintenance • Policy and regulatory framework: The Off Grid power is covered broadly in the energy policy and under the general renewable energy. It might be important to review the policies and regulatory framework to establish their adequacy in developing the Solar PV based energy • Institutions: National, regional, and local institutions will likely need to be supported in their efforts to harness this resource • Financing: as discussed earlier, although solar energy is cheap it requires

[30] http://www.seia.org/research-resources/cutting-carbon-emissions-under-111d-case-expanding-solar-energy-america

	huge initial capital investment costs • Participation: Since solar energy plant takes huge chunks of land which will belong to individuals it will be important that stakeholders are involved well in advance
Adequacy for current climate	The technology is very suitable for both current variability and future climate change.
Size of beneficiaries group	If developed may supply more than 50MW into national grid which benefit many people beyond the borders of the resource itself

Forest Sector

Agroforestry

Sector: Forestry	
Sub sector: Agroforestry	
Technology characteristics	
Introduction	Agro-forestry is an approach that integrates the production of trees and non-tree crops or animals on the same piece of land. In agro-forestry systems, every part of the land is considered suitable whereby perennial, multiple purpose crops that are planted once but can yield benefits over a long period of time are accorded high priority. The design of agro-forestry systems is based on the beneficial interactions between crops and trees. ICRAF advocates that "agro-forestry is uniquely suited to address both the need for improved food security and increased resources for energy, as well as the need to sustainably manage agricultural landscapes for the critical ecosystem services they provide"
Technology characteristics / highlights	Agro-forestry systems can be categorized into the following major categories: • Agro-silviculture (trees with crops), • Agri-silvipasture (trees with crops and livestock), and • Silvo-pastoral (trees with pasture and livestock) systems. Agro-forestry is viewed to be relevant for different types of land. Legumes have been considered the most important trees in the agro-forestry system due to their ability to fix nitrogen and thus improving the fertility and quality of the soil. This eventually can improve crop growth. Trees in the agro-forestry systems are used for various purpose such as: • Alley cropping: growing annual crops between rows of trees • Hedge rows/ live fences: trees planted along boundaries or property lines • Multi-strata: including home gardens and agro-forests that combine multiple species • Scattered farm trees: increasing a number of trees, shrubs or shaded perennial crops scattered among crops or pastures and along farm boundaries. Criteria considered for the selection of agro-forest crops: • Potential for production • Usefulness as animal feed • Native varieties • Good nutritional content for human consumption

	• Ability to protect the soil • Absence of competition between the trees and crops
Institutional and organizational requirements	• Agro-forestry is implemented at farm level • May require establishment of new and strengthening existing cooperatives in order to improve their negotiating power and access to agro-forestry credit. • Provision of training to farmers on key issues including on marketing agro-forestry products.
Operational and maintenance	Operation and maintenance requires planting, manuring, weeding and harvesting of trees and crops. Training on forestry and also on agronomic, post harvest storage and marketing of agro-forestry products is required for effective implementation of the technology
Endorsement by experts	The adoption of agro-forestry is expanding in many parts of Tanzania and is increasingly being highly recommended by many researchers and experts
Adequacy for current climate	Fits very well in changing climatic conditions – both in the current and future climate
Sale / size of beneficiaries group	Beneficiaries include: • Famers, Pastoralists, Growers of single purpose and multipurpose trees, Fishers
Disadvantages	• Agro-forestry systems require substantial management for addressing the competition for resources and maximizing the ecological and productive benefits. • Comparatively lower yields of cultivated crops than in alternative production systems – though agro-forestry can reduce the risk of harvest failure. • Long time lapse for the occurrence of a breakeven point for some agroforestry systems compelled the farmer to absorb initial net losses before benefitting from their investment.
Capital costs	
Cost to implement adaptation technology	• Initial costs for the agro-forestry system include the establishing community nurseries, plant growing, installation of plantations and rejuventation of regional forests • Costs for the implementation of the technology may be in the range of US$ 4m - 5m annually .
Additional cost to implement adaptation technology, compared to business as usual	Additional costs needed may be consulting services related to the identification of appropriate tree and crop species for the system; capacity building to extension staff and farmers
Long term costs (i.e. 10, 30, or 50 years) without adaptation	
Long term costs (i.e. 10, 30, or 50 years) with adaptation	
Development impacts, direct and indirect benefits	
Direct benefits	• Agro-forestry systems make maximum use of the land and increase land-use efficiency. • Enhancement of land productivity – trees provide forage, firewood and other organic materials that are recycled and used as natural fertilisers. • Leads to increased yields - millet and sorghum may increase their yields by 50 to 100 per cent when planted directly under Acacia albida (FAO, 1991). • Agro-forestry promotes year-round and long-term production.

	• Employment creation • Protection and improvement of soils and water sources. • Livelihood diversification. • Increased access affordable fuel wood and construction materials • Reduces expenditure for industrial fertilizers and pesticides
Reduction of vulnerability to climate change	• Improves the resilience of agricultural production through the use of trees for intensification, diversification and buffering of farming systems. • Increases the socio-economic resilience of smallholder farmers against climate changes by improving access to ecosystem services as well as by improving farm production and household income (Charles et al., 2013).
Economic benefits, indirect growth and investment	• Creation of jobs related to agroforestry • Reduces investment in expensive and environmentally unsustainable agricultural models • Increases access to wood fuel thus reducing dependence on costly energy sources • Agroforestry can diversify income and food sources • Increase crop yields and income from crop sales • Increases livestock productivity and income from livestock sales • High income is obtained from valuable products harvested from agroforestry practices e.g. wood; fruits and nuts; high-value timber products, mushrooms, herbs, medicinal plants and craft materials. • Windbreaks protect crops, livestock and soil and water resources.
Social benefits, indirect income, education and health	• Contributes to improved food security by way of diversifying production systems (Neufeldt *et al.*, 2009) • Increases household income from forest products • Windbreaks help to reduce damage to buildings and settlements from wind impact. • Promote water security by protecting water sources and filtering pollutants thus preventing the pollution of domestic water from agricultural activities. • Increases access to recreation opportunities.
Environmental benefits, indirect	• Improvement of scenic view (visual quality) of the landscape. • Enhancement of air quality by way of absorbing pollutants. • Contributes to CC mitigation as trees act as carbon sinks • Protection of water sources and enhancement of water quality • Reduction of sedimentation • Improvement of soil fertility • Reduction of soil erosion and landslides • Enhances aquatic and wildlife habitat in agricultural landscapes.
Local context	
Opportunities and barriers	Barriers: • Poor access to agro-forestry inputs/resources including land tenure, tree tenure, water, seeds and germplasm, and credit. • High upfront costs versus long-term gains from agroforestry. • Limited access to market opportunities for agro-forestry products and services. • Agricultural policies can discourage farmers from practicing agroforestry – high promotion of other agricultural models (e.g. monoculture systems) and tax exemptions largely target industrial agricultural production (FAO. 2013). • Overdependence on conventional agricultural methods and inadequate knowledge of sustainable approaches restrict the interest of policy-makers in agroforestry development. • Limited experience and low capacity among some extension staff.

	• Lack of knowledge, different labour requirements and less established markets lead to more uncertainties with agro-forestry systems (FAO. 2013). Opportunities: • Emergence of new agroforestry opportunities within the miombo woodlands (savannah) of Tanzania with the hope of diversifying income and alleviating poverty. • The pursue of SFM as well as watershed rehabilitation and soil conservation provides a huge opportunity for the scaling up of agroforestry (FAO, 2013; Binam *et al.*, 2012).
Market potential	The technology has a market potential in most parts of the country.
Status	The adoption of AF in Tanzania is low due to inadequate knowledge and information on its importance (Mbwambo, 2013). By carrying out awareness and sensitization campaigns, there is a high potential for wide scale adoption.
Timeframe	Medium to long term.
Acceptability to local stakeholders	There is low adoption of agro-forestry in Tanzania, however, deliberate awareness raising and sensitization campaigns can increase adoption rates.

Fact Sheet - Forest Landscape Restoration (FLR) Assessment

<table>
<tr><td colspan="2">Sector: Forestry</td></tr>
<tr><td colspan="2">Sub sector: Forest Landscape Restoration (FLR) Assessment</td></tr>
<tr><td colspan="2">Technology characteristics</td></tr>
<tr><td>Introduction</td><td>Forest and landscape restoration (FLR) refers to "an active process that brings people together to identify, negotiate and implement practices that restore an agreed optimal balance of the ecological, social and economic benefits of forests and trees within a broader pattern of land uses" (FAO, 2015).

Unlike conventional approaches to afforestation and reforestation that tend to be limited to increasing tree cover, FLR focuses on restoring the goods, services and ecological processes that forests can provide at the broader landscape level (Barrow et al., 2002). FLR seeks a balance between restoring ecosystem services related to wildlife habitats and biodiversity, water regulation, carbon storage and more, and supporting the productive functions of land for agriculture and other related uses (FAO, 2015).

According to the World Resources Institute (WRI, n.d.), FLR is about:
Forests because it involves increasing the number and/or health of trees or woody plants in an area to a level appropriate for the native ecosystem.
Landscapes because it involves going beyond restoring individual sites to restoring entire watersheds, jurisdictions, or even countries in which many land uses interact and where people live and work.
Restoration because it involves bringing back the ecological functions of an area in order to achieve a wide range of benefits for people and the planet.
A "process" because it typically takes a long time for a forest landscape to recover, although some of the ecological functions and human benefits provided by restoration may appear early on</td></tr>
<tr><td>Technology characteristics / highlights</td><td>Key activities / steps involved in FLR (MINIRENA – Rwanda, 2014) include:
Restore entire landscapes rather than sites to balance a mosaic of interdependent land uses.
A forward looking approach to restore the functionality of the landscape.
Aim to generate a suite of ecosystem goods and services from a range of restoration activities.
Actively engage local stakeholders in decisions regarding restoration goals, implementation methods and trade-offs
Consider a wide range of eligible technical strategies for restoring trees on the landscape
Adapt restoration strategies to fit local social, economic and ecological contexts.
Adapt restoration strategies to changes in human knowledge and societal values.
Address ongoing loss and conversion of primary and secondary natural forest
A successful FLR (WRI, n.d.) demands that:</td></tr>
</table>

	• Mapping where restoration is geographically possible • Identifying candidate landscapes for restoration • Defining the goals of restoration in a candidate landscape • Quantifying the economic, social, and environmental benefits of potential restoration • Developing strategies for restoring landscapes by identifying which key success factors of forest landscape restoration are missing in the candidate landscape and identifying approaches for addressing them • Determining what types of restoration are most appropriate socially and ecologically for a particular area • Involving stakeholders in all of the above
Institutional and organizational requirements	Institutional and organizational requirements for FLR (FAO, 2015) may involve: • Analyzing policies, laws and regulations across different sectors to ascertain how adequacy, complementary or conflicting they are. • Supporting the drafting, revision and/or harmonization of laws/policies/ sectoral programmes and identifying specific support, activities and projects to create a more enabling environment. • The need to support planning processes that are underway (e.g. climate-change national strategy, biodiversity national strategy, national strategy for rural development, etc.). • Increase support on existing mechanisms/platforms that allow different sectors/stakeholders to engage in dialogue. This includes leveraging existing partnerships
Operational and maintenance	FAO (FAO, 2015) highlights some operational and maintenance for FLR to include: • Determining what restoration activities provide the greatest ecological, social and economic benefits in a particular area of degraded land, • Understanding the social, legal and institutional context that will best enable restoration, and • Formulating strategies for moving forward at the national or sub-national level.
Endorsement by experts	Highly recommended by many experts due to the significance of the technology in sustaining the delivery of ecosystem services and supporting livelihoods
Adequacy for current climate	Fits well with current and future climate. Care should be taken to avoid using exotic species in the restoration that are vulnerable to changing climate or that can become invasive.
Sale / size of beneficiaries group	Beneficiaries include: • Forest users / indigenous people • Government agencies at national, sub-national and local level • NGOs, CSOs and the private sector exploring forest landscape restoration. • Landowners and communities, or their representatives, in candidate landscapes. • Development agencies and financial institutions considering financing forest landscape restoration programs and projects. • Forest experts and researchers including Technical advisors or consultants
Disadvantages	Loss of land for other uses to forest related restoration.

Capital costs	
Cost to implement adaptation technology	Restoration costs are about US$ 2,390 to 5,000 per hectare, for implementation and for monitoring depending on the extent of degradation/ status of forest resources (FAO & Global Mechanism of the UNCCD, 2015)
Additional cost to implement adaptation technology, compared to business as usual	The FLR costs (as the case with and benefits) are subject to site- and ecosystem-specific conditions and hence very variable.
Long term costs (i.e. 10, 30, or 50 years) without adaptation	
Long term costs (i.e. 10, 30, or 50 years) with adaptation	
Development impacts, direct and indirect benefits	
Direct benefits	• The direct benefits of forest resources include supporting the livelihoods of 90% of the 1.2 billion people living in extreme poverty most of them living in the developing world (Barrow et al., 2002). • According to IUCN (2012), at the global level, the net annual benefits of FLR (million USD/year) is as follows: wood products (64,000); NTFPs (8,000), additional crop yields (6,000); carbon sequestration (5,000); and cultural benefits (467).
Reduction of vulnerability to climate change	Contributes to the reduction of the impacts of climate change and non-climatic hazards by creating natural barriers and enhancing the flow of ecosystem services critical for sustaining livelihoods and ecosystem functioning. FLR is viewed as a solution for ecosystem-based adaptation in addressing adverse impacts of climate change (WRI, n.d., Barrow et al., 2002; MINIRENA Rwanda, 2014; FAO & Global Mechanism of the UNCCD, 2015)
Economic benefits, indirect growth and investment	• Contributes to the diversification of economic activities for households, rural communities, and national economies (e.g., timber, NTFPs, agroforestry, eco-tourism, payments for ecosystem services) • Maintains the supply of fuel wood, construction poles, timber and NTFPs
Social benefits, indirect income, education and health	Social benefits, indirect income, education and health (WRI, n.d., Barrow et al., 2002; MINIRENA Rwanda, 2014) are: • Improves crop yields / food productivity (through through enhanced soil fertility and moisture conservation) • Increases availability and access to wild food (e.g., fruit, nuts) and animal feed or fodder • Provides the opportunity for increasing and diversifying smallholder income through production of timber, NTFPs, etc. • Creates new jobs e.g., seed collection, nursery management, tree planting, extension services, forest products production, ecotourism) (WRI, n.d.)

	• Promotes sustainable livelihoods
Environmental benefits, indirect	Environmental benefits of FLR (WRI, n.d., Barrow et al., 2002; MINIRENA Rwanda, 2014): • Improves the provision of ecosystem services (Barrow et al., 2002) • Reduces habitat fragmentation and creates new wildlife habitat • Promotes animal movement, seasonal migrations and conserves endangered species • Increases presence of pollinators • Increases presence of natural predators of crop pests. • Supports fish and other aquatic life • Reduces topsoil erosion, improves soil nutrients and reduces silting of reservoirs • Recharges groundwater supplies and stabilize water flows • Ensures clean, stable supplies of freshwater for downstream water users, including cities • Enhances carbon sequestration and ameliorates local temperatures due to cooling effect of forest cover
Local context	
Opportunities and barriers	Opportunities for FLR: • The availability of degraded forest landscapes as well as higher cost of restoration and higher risk of investment (FAO, 2015) presents a great opportunity for undertaking FLR assessment in Tanzania. • Results from the NAFORMA process can be used to guide FLR interventions in the country. Barriers towards FLR: • Policy and governance issues (land tenure rights, incentives, public rights over forest resources and their administration) • Natural resource conflicts and the elite capture • Limited access to resources and to management rights • Use of natural vs. exotic species • Lack of affordable but appropriate monitoring and evaluation instruments. • Lack of policy dialogues on economic push and pull mechanisms between government representatives, the private sector and the poorest. • Weak law enforcement
Market potential	The technology has a market potential national wide
Status	The NAFORMA has been carried out throughout the country and does provide a great chance for the implementation of this technology.
Timeframe	Medium to long term
Acceptability to local stakeholders	Easily acceptable to the majority (if not all) stakeholders

Fact Sheet - Mangrove ecosystems conservation, Rehabilitation and Restoration

Sector: Forestry	
Sub sector: Mangrove ecosystems conservation, Rehabilitation and Restoration	
Technology characteristics	
Introduction	Mangroves are predominantly tropical trees and shrubs growing on sheltered coastlines, mudflats and river banks in many parts of the world. The common characteristic possessed by all is tolerance to salt and brackish waters. Mangroves are trees and shrubs from different plant families, up to 30m in height. About 16 to 24 families and 54 to 75 species are found worldwide. There about 1.5 million hectares of mangroves globally. The majority of mangroves occur between the latitudes of 30° North and South. Mangrove wetland ecosystems are found in many tropical and sub-tropical regions of the world. Two thirds of the equatorial coastal regions are home to Mangroves.
Technology characteristics / highlights	Mangrove conservation and restoration involve the following activities: • Collection of plant propagules from a sustainable source • Preparation of the restoration site for planting • Direct planting of plant propagules at regular intervals at an appropriate time of year • Establishment of nurseries to stockpile seedlings for future planting • Planting dune grasses that have a high potential to provide a stable, protective substrate for mangroves to establish their root systems
Institutional and organizational requirements	• Strict enforcement of laws and regulations with respect to establishing prawn farms in mangrove areas, which has been the cause for mass destruction of mangroves in some parts of the world. • Increased commitment by the government for the restoration, management and sustainable development of mangrove ecosystems and enhancing stakeholders' participation.
Operational and maintenance	Operational and maintenance of mangroves (Kairo *et al.*, 2001) include: • Monitoring mangrove species that develop • Monitoring growth as a function of time • Monitoring growth characteristics • Recording level of failure of saplings • Recording levels of rubbish accumulation • Adjusting density of seedlings and saplings to an optimum level • Estimating cost of restoration project • Monitoring impact of any harvesting project • Monitoring characteristics of the rehabilitated mangrove ecosystem
Endorsement by experts	Conservation and restoration of mangroves is a widely a highly recommended technology in Tanzania.
Adequacy for current climate	Mangroves are extremely sensitive to current rising sea levels caused by global warming and climate change. However, well conserved / protected mangroves have the ability to adapt to changing climatic conditions.
Sale / size of beneficiaries group	Beneficiaries to mangrove conservation and restoration include: • Fisher communities • Users of mangrove products. • Tourists (Ecotourism) • Research & educational institutes
Disadvantages	Examples of mangrove conservation and rehabilitation are: • Competing land uses: Space requirement for mangrove conservation and

	restoration takes place in locations which are often of high development potential. • Costly due to higher requirement of expertise in restoration particularly in locations where re-colonization has to be encouraged by transplanting wetland plants.
Capital costs	
Cost to implement adaptation technology	The costs to successfully restore both the vegetative cover and ecological functions of a Mangrove forest have been reported to vary from US$ 225/ha to US$216,000/ha; although gray literature shows that such costs could go up to US$500,000/ha for individual projects. Costs vary depending the type of the project such as a) planting alone (most inexpensive), b) hydrologic restoration, with and without planting, and c) excavation or fill, with and without planting (Lewis III, 2001).
Additional cost to implement adaptation technology, compared to business as usual	These include conducting frequent awareness campaigns for coastal communities, hoteliers, industrialists and other groups. Other additional costs include costs for monitoring, security and maintenance cost of replanting sites.
Long term costs (i.e. 10, 30, or 50 years) without adaptation	
Long term costs (i.e. 10, 30, or 50 years) with adaptation	
Development impacts, direct and indirect benefits	
Direct benefits	Mangroves provide direct benefits on the local and national economy by supporting tourism, fisheries and by reducing property / infrastructure damage through natural the protection of natural protection of coasts;
Reduction of vulnerability to climate change	Mangroves protect coastal areas and communities from storm surges, waves, tidal currents and typhoons by acting as a buffer against wave energy. In this way, they reduce vulnerability to climate change.
Economic benefits, indirect growth and investment	Direct economic benefits from mangroves arise from tourism, fisheries and natural protection of coasts; with one square kilometre of mangrove forest creating a value of US$ 200 to US$ 900 annually (Wells, 2006). One study reported by IUCN (IUCN, 2006) showed that the value of the shoreline protection function of mangroves stood at US$ 392.5 per hectare of mangrove (IUCN, 2006).
Social benefits, indirect income, education and health	Social benefits provided by mangroves (IUCN, 2006; Barua *et al.,* 2010) include: • Supporting coastal livelihoods – e.g. fishing • Access to timber and firewood • Access to food • Supply food and feed for fisheries and aquaculture • Access to natural dyes / tannins • Herbal medicines • Enhancing recreational / cultural value
Environmental benefits, indirect	Various environmental benefits (IUCN, 2006; Barua et al., 2010)are provided by mangroves such as: • Diverse habitat for many species such as fish, birds, reptiles, amphibians,

	mollusks, crustaceans and many others. • Breeding grounds and feeding grounds for many coastal fish species and crustaceans • Nutrients to the coastal water bodies and maintenance of ecological balance of the coastal ecosystems. • Protection of vital coral reefs and sea grass beds from damaging siltation. • Protection of shoreline erosion from wave action, currents, winds • Natural water treatment plant by retaining heavy metals and trapping sediments. • Valuable resource for research and education.
Local context	
Opportunities and barriers	Barriers to mangrove restoration and rehabilitation (Dale *et al.*, 2014; Ngongolo *et al.*, 2015) include: • Competing land uses that threaten mangroves constrain rehabilitation efforts. • The effects of climate change on mangroves. • Limited local capacity for mangrove management • Inadequate funding for mangrove restoration • Weak enforcement of laws and regulations on mangrove protection. • problems arise from overlapping jurisdictions • Inconsistencies between agencies. Opportunities for mangrove restoration (Ngongolo *et al.*, 2015) include: • Local communities and institutions are available to participate and support restoration programs. • Availability of international organizations (e.g. IUCN, WWF) with an interest in funding and providing technical backstopping in the restoration project
Market potential	The technology has a market potential in the coastal strip of the country endowed with mangrove forests.
Status	Technology for mangrove restoration has been successfully implemented in some parts of the country.
Timeframe	Medium to long term
Acceptability to local stakeholders	Acceptable by local communities, but need to address salt mining and shrimp farming

Fact Sheet - Reducing Emissions from Deforestation and Forest Degradation (REDD+)

<table>
<tr><td colspan="2">Sector: Forestry</td></tr>
<tr><td colspan="2">Sub sector: Reducing Emissions from Deforestation and Forest Degradation (REDD+)</td></tr>
<tr><td colspan="2">Technology characteristics</td></tr>
<tr><td>Introduction</td><td>REDD+ is a forest carbon initiative aimed at addressing GHG emissions contributing to climate change. Whereas REDD is an acronym for “Reducing Emissions from Deforestation and Forest Degradation, the (+) stands for conservation, sustainable management of forests, and enhancement of forest carbon stocks.

REDD+ is a rewards based payment mechanism by the United Nations Framework Convention on Climate Change (UNFCCC) designed to provide incentives for the implementation of activities aimed at mitigating forest related contribution to climate change (Kweka et al., 2015).</td></tr>
<tr><td>Technology characteristics / highlights</td><td>• Tanzania was one of the few countries that piloted REDD+ projects as a way for generating lessons and best practices that would inform and guide full scale implementation of REDD+.

• Four ways have been identified in which REDD+ can be implemented (Burgess et al, 2010; Meshack et al., 2006) in Tanzania:
o State-owned protected areas (avoiding and reducing deforestation and, especially, degradation in reserves.
o Community forestry through PFM
o Promotion of agroforestry and conservation agriculture
o State-owned tree plantations and private forestry.

• The most preferred financial mechanism for receiving and dispersing REDD+ incentive payments by the Government of Tanzania is the fund based approach (Burgess et al, 2010).</td></tr>
<tr><td>Institutional and organizational requirements</td><td>• REDD+ National Strategy and Action Plan, REDD+ Safeguards – already in place
• Carbon Monitoring Centre – under way</td></tr>
<tr><td>Operational and maintenance</td><td>The operation of REDD+ requires preparation of Land Use Plans, bylaws as well as Monitoring, Reporting and Verification,</td></tr>
<tr><td>Endorsement by experts</td><td>The initiative has been endorsed by many experts, but attention should be directed to loss of tenure rights, land grabbing, forced evictions, benefit sharing, and loss of livelihoods for marginalized communities.</td></tr>
<tr><td>Adequacy for current climate</td><td>Fits well with the current and future climate.</td></tr>
<tr><td>Sale / size of beneficiaries group</td><td>REDD+ beneficiaries include: Forest users, indigenous people, construction industry, Government authorities, Conservation NGOs, private sector, Development Partners, Funders.</td></tr>
<tr><td>Disadvantages</td><td>Some disadvantages of REDD+ are:
• Loss of forest dependent livelihoods
• Exacerbation of gender inequalities in benefit sharing
• Land grabbing and forced evictions</td></tr>
<tr><td>Capital costs</td><td></td></tr>
<tr><td>Cost to implement adaptation</td><td>Based on experience from pilot projects, costs to implement REDD+ (Merger et al., 2012; Kabura John et al., 2014) include:
• The implementation costs for three projects of the three pilot projects range</td></tr>
</table>

technology	between US$ 3.7 - 7.9 ha/year (US$ 4.5 - 12.2tCO_2) over a period of 30 years • Costs incurred by managing the forest in relation to tCO_2 stored were USD 1.0485 tCO_2e$-^1$ha^{-1}.
Additional cost to implement adaptation technology, compared to business as usual	Evidence from pilot projects (Merger et al, 2012) show that: • Transaction costs for measurement, reporting and verification (MRV) and other carbon market related compliance costs ranges from US$ 0.2 ha/year to US$ 0.9 ha/year. • Institutional costs are estimated at US$ 0.05 – 0.07 ha/year.
Long term costs (i.e. 10, 30, or 50 years) without adaptation	
Long term costs (i.e. 10, 30, or 50 years) with adaptation	
Development impacts, direct and indirect benefits	
Direct benefits	Subject to price volatility, the estimated carbon credit payments usually range between $5 and $10 /tCO2e; but can be as low as $10 /t$CO_2$e (TNRF, 2012)
Reduction of vulnerability to climate change	Adaptation benefits of REDD+ include: • REDD+ supports adaptation by enhancing availability of ecosystem services required for adaptation. • REDD+ payments have the potential to improve adaptive capacity by improving access to assets required for adaptation; and that can recovery following occurrence of climatic shocks (Monroe and Mant, 2014). • Conserved mangroves reduce the magnitude of climate change in coastal communities • Capacity building on sustainable management of forests may build human capital for adapting forest use to climate change.
Economic benefits, indirect growth and investment	Economic benefits of REDD+ (TNRF, 2012) include: • Contribution to GDP via sale of carbon credits. • Incentive payments from carbon credits sales and household income ☐ • Multiplier effects derived from spending of REDD+ revenues in local markets • Financial savings from improved environmental services, like flood control • Improved physical infrastructure
Social benefits, indirect income, education and health	Social benefits of REDD+ (TNRF, 2012)include: • Governance and institutional strengthening, e.g., improved tenure security, PFM expansion, monitoring systems in place, enhanced accountability of national institutions • Income from employment in REDD+ schemes, establishing PFM and generating related revenues. • Enhanced livelihood, health benefits arising from local environmental services • Improved/ enhanced availability of natural resource based materials, e.g. food, building materials, fodder, fuel wood, medicinal products, and timber supply • More secure land/ forest tenure • Enhanced local governance – e.g. accountability, transparency, law enforcement, conflict resolution, and participation • Enhanced capacity (institutional capacity, human resources) and knowledge

Environmental benefits, indirect	Environmental benefits of REDD+ (TNRF, 2012) include • Maintaining and enhancing national forest coverage • Enhancing national and local forest ecosystems and associated systems (water, soil, etc) • Maintaining and improving local and national biodiversity • Improved natural resource base
Local context	
Opportunities and barriers	Some of the barriers to REDD+ implementation in Tanzania (Burgess et al, 2010; Kweka et al., 2015) include: • Weak forest governance an unclear mechanism for benefit sharing (e.g.in the cases of Joint Forest Management (JFM). • Poor enforcement of forest laws and regulations remain challenges likely to affect REDD+ implementation • Lack of data and technical capacity The following are key opportunities of REDD+ in Tanzania (Yanda, n.d.): • Extensive forest cover • Alarming deforestation rates • Policy reforms in forestry management (mainly the National Forest Policy in 1998 and the subsequent Forest Act of 2002) that facilitated engagement of communities in forest management. • Good practices and lessons from PFM
Market potential	The technology has market potential in forested parts of the country.
Status	The technology has been piloted in eight representative forest ecosystems by NGOs in collaboration with Central, local government, academic institutions, and private sectors (Kabura John et al, 2014). Lessons generated will help to inform and guide full-scale implementation.
Timeframe	
Acceptability to local stakeholders	There is medium to high acceptance of REDD+ amongst local communities (Mnguni *et al.*, 2013; Jeremiah *et al.*, 2014).

Sector: Forestry	
Sub sector: Sustainable charcoal production models and appropriate techniques	
Technology characteristics	
Introduction	About 30,000,000m^3 of wood is needed annually for the production of about 1 million tons of charcoal consumed in Tanzania annually. The production of this much charcoal requires the use of 160,000 earth kilns yearly and the loss of forest area estimated at 100,000 – 125,000 ha (World Bank, 2009). Statistics show that, the percentage of households using charcoal stood at 90 in 2013 from less than 50% in 2002. In Dar es Salaam, the largest urban centre in Tanzania, the proportion of households using charcoal as their primary energy source increased from 47% to 71% between 2001 and 2007 respectively. Factors like the hike in electricity prices (3-4 times in 2013 compared to the 2008 prices), limited access to LPGs together with increased demand on energy due to urbanization has contributed to rising percentages of charcoal users in urban areas of Tanzania (CAMCO, 2013).
Technology characteristics / highlights	Traditionally, charcoal is unsustainably harvested from dry woodlands and/or miombo woodlands within a catchment area as far as 200 kilometres from the energy markets in urban centres. The charcoal sector has the following characteristics: • Ecologically unsustainable: Although charcoal helps to meet urban energy demands and supports livelihoods of people across the value chain, this is done at the cost of many functions of rural landscapes. Charcoal is largely obtained from rural areas which have limited alternative economic opportunities (CAMCO, 2013). • There is a rising charcoal market trend attributed by the complementary nature of charcoal as a commodity. In order to use charcoal, one should posses a metal / ceramic stoves which happen to be comparatively cheap, affordable and readily available in the market unlike electric and LPG cookers (Luoga, 20009). • The charcoal business provides producers with positive profits as a result of very low capital outlays to fell trees and construct earth mound kilns, using their own free labour, using free wood, and lack of concern about associated external costs (Luoga et al., 2000). • Informal and sometimes illegal: Charcoal production and utilization activities that are unregulated and unregistered contribute to loss of revenues estimated at US$100 million per year (World Bank, 2009).
Institutional and organizational requirements	• Requires the development and implementation of regulations that will both formalize and facilitate the modernization of charcoal production (Kifukwe, 2013) • Adoption and implementation of the Biomass Energy Strategy (BEST); and reviewing the national energy policy in order to support sustainable charcoal throughout Tanzania (CAMCO, 2013) • Introduction of effective pricing and licensing policies aimed at providing incentives for the adoption of improved charcoal production technologies (World Bank, 2009).
Operational and maintenance	Operation and maintenance required for charcoal sector include acquiring wood, construction of kilns, labours for wood cutting, burning and packing charcoal into bags. Transportation of charcoal lies in the hands of buyers. Permits /licenses are required for wood harvesting, transporting and selling in urban centres.
Endorsement by experts	Current production and marketing models are denounced by many experts and researchers, majority calling for the recognition, regularization and legalization that would eventually promote sustainable production technologies.

Adequacy for current climate	Fits well with current and future climatic conditions, but should minimize rates of deforestation and degradation in order to avoid exacerbation of ecological and human vulnerability.
Sale / size of beneficiaries group	Beneficiaries of charcoal business include: Tree growers, artisans for the construction of improved kilns, casual labourers, transporters, consumers, Government authorities (village to national level).
Disadvantages	The disadvantages of charcoal include the following: • Deforestation and degradation of closed and open woodland catchment areas. Charcoal is the second largest cause of deforestation in Tanzania claiming between 100,000 and 125,000 hectares of forest annually (World Bank, 2009). • Contributes to global warming due to the emission of significant quantities of carbon dioxide and methane as a result of unsustainable harvesting and incomplete combustion (Iiyama *et al.*, 2015). • Changes in the composition of forests/woodlands due to selective harvesting of trees beyond natural regeneration. • Depletion of forests leading to poor ecosystem functions and low resilience hence increased communities' exposure to extreme events (Luoga et al., 2000; Iiyama *et al.*, 2015).
Capital costs	
Cost to implement adaptation technology	These costs relate to transportation, charcoal royalty paid to village government, transport permit, registration of charcoal business, and registration of charcoal store in the market
Additional cost to implement adaptation technology, compared to business as usual	Following the regularization and legalization of charcoal business, additional costs are likely to include costs for packaging, labelling and monitoring (Malimbwi and Zahabu, n.d)
Long term costs (i.e. 10, 30, or 50 years) without adaptation	
Long term costs (i.e. 10, 30, or 50 years) with adaptation	
Development impacts, direct and indirect benefits	
Direct benefits	• Though poorly governed, the charcoal sector contributed over US$ 650 million annually to the Tanzanian economy in 2009 • Increased income: A 90kg bag of charcoal could be sold in the excess of TZS 60,000/= in Dar es Salaam and much less in other urban centres. • Access to employment opportunities for rural and urban residents.
Reduction of vulnerability to climate	Sustainable charcoal production can diversify rural livelihoods (income) and thereby increase resilience to climate change.

change	
Economic benefits, indirect growth and investment	• Reduction of oil imports that would eventually result into foreign exchange savings (Kifukwe, 2013)
Social benefits, indirect income, education and health	Sustainable charcoal production can result into: • Creation of employment • Energy access and security • Increased income
Environmental benefits, indirect	Sustainably produced and marketed charcoal has the following environmental benefits (Iiyama et al., 2015): • Reduction of GHG emissions • Increased access to renewable energy • Enhanced flow of ecosystem services
Local context	
Opportunities and barriers	Opportunities for sustainable charcoal industry: • A broader range of socio-economic strata still use and will continue using charcoal as the main or as a backup fuel for the decades to come (Iiyama et al., 2015). This partly due to urbanization and changes in consumer behaviour whereby high-income consumers are shifting from electricity and LPGs to charcoal. (CAMCO, 2013). • Efforts by NGOs and the private sector to pilot sustainable technologies and model for charcoal production and marketing is posed to regularize and legalize charcoal sector in the country. Barriers towards sustainable charcoal industry (Mwampamba *et al.*, 2013; Malimbwi and Zahabu, n.d): • Prevalence of negative perceptions by policy makers and forest authorities on charcoal – industry viewed as informal, even illegal, highly associated with rural poverty and as a problem rather than as a solution to the current energy access challenges • There is a high likelihood that certified charcoal is going to be more expensive • Lack of evidence whether or not people are willing to buy the clean charcoal at the new price
Market potential	There is a market potential for charcoal national wide. Accordingly, charcoal consumption is set to increase in the future due to: a) rapid population growth; b) continued urbanization; and c) relative price increases of fossil fuel-based alternative energy sources (World Bank, 2009).
Status	Charcoal is available and being used in different areas of the country particularly urban areas.
Timeframe	Short term
Acceptability to local stakeholders	Charcoal is highly acceptable particularly in urban areas due to its simplicity in production, transport, use as well as accessibility and affordability (Kifukwe, 2013).

Fact Sheet - Sustainable Forest Management

Sector: Forestry	
Sub sector: Sustainable Forest Management (SFM)	
Technology characteristics	
Introduction	The United Nations General Assembly (UNGA, 2008) defines "Sustainable forest

	management as a dynamic and evolving concept aims to maintain and enhance the economic, social and environmental value of all types of forests, for the benefit of present and future generations." Another definition, by the ITTO (ITTO, n.d.), defines sustainable forest management (SFM) as "the process of managing forest to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment" It is acknowledged that SFM aims to maintain and enhance the economic, social and environmental value of all types of forests, for the benefit of present and future generations.
Technology characteristics / highlights	SFM is applicable in all types of forests in all geographic regions and embraces management for different purposes such as production, protection, conservation, or a combination of multiple objectives (multipurpose forest management). The SFM concept encompasses both natural and planted forests in all geographic regions and climatic zones, and all forest functions, managed for conservation, production or multiple purposes, to provide a range of forest ecosystem goods and services at the local, national, regional and global levels (CPF, 2012) Seven elements have been identified as major characteristics of SFM (UNGA, 2008) namely: • Extent of forest resources; • Forest biological diversity; • Forest health and vitality; • Productive functions of forest resources; • Protective functions of forest resources; • Socio-economic functions of forests; and • Legal, policy and institutional framework. SFM in Tanzania is decentralized and is known as Participatory Forest Management and is grouped into can be grouped into two types: Community-Based Forest Management (CBFM) and Joint Forest Management (JFM). • Community Based Forest Management (CBFM) enables local communities to declare – and ultimately gazette – Village, Group or Private Forest Reserves • Joint Forest Management (JFM) - allows communities to sign joint forest management agreements with government and other forest owners. While the implementation of Community Based Forest Management has moved forward relatively rapidly. Unlike CBFM, Joint Forest Management is performing somewhat poorly due to the failure to formalize the majority of Joint Management Agreements through signing by government, and the failure of government to agree and move forward with legally binding agreements for the sharing of forest management costs and benefits in jointly managed forests (FBD, 2012)
Institutional and organizational requirements	• SFM is applied at the landscape level and does involve protection, conservation and sustainable use by individuals, community groups, NGOs, state agencies and the private sector. Requires strengthening technical and infrastructural capacity.

	• Organizational requirements could be through community forest groups, timber and NTFP traders • There is urgent need to finalize and operationalize JFM cost-benefit mechanism in order to ensure benefit flows to participating communities; this would ensure that JFM has a bright future (Blomley and Iddi, 2009).This includes undertaking reviews of forest policy, law and regulations to include benefit sharing as an incentive for SFM and clarify user rights on forest land to enhance investment opportunities
Operational and maintenance	Operational and maintenance basically consist of forest monitoring, restoration, sustainable harvesting. In addition, capacity building to forest staff and forest conservation groups is crucial for sustainable management of forest resources.
Endorsement by experts	SFM has been recommended by many researchers and experts worldwide.
Adequacy for current climate	SFM can be deployed to improve ecological resilience and the adaptation of forest ecosystems to environmental change, for example through the selection of tree species, management regimes and stand structures that suit anticipated changes in soils, water, disturbance regimes and site productivity. However, unmitigated climate change is still likely to exceed the adaptive capacity of some forests during this century (CPF, 2012).
Sale / size of beneficiaries group	Beneficiaries include: • Forest users / indigenous people • Government agencies at national, sub-national and local level • NGOs, CSOs and the private sector undertaking SFM. • Development agencies and financial institutions considering financing SFM programs and projects. • Forest experts and researchers including Technical advisors or consultants
Disadvantages	• In the absence of clear guidelines, there is inequitable sharing of costs and benefits • Requires high technical capacity and modern equipment particularly in forest resource assessment and monitoring
Capital costs	
Cost to implement adaptation technology	Costs to implement the technology include forest resource assessment and monitoring, nursery management, tree reforestation, etc.
Additional cost to implement adaptation technology, compared to business as usual	
Long term costs (i.e. 10, 30, or 50 years) without adaptation	
Long term costs (i.e. 10, 30, or 50 years) with adaptation	
Development impacts, direct and indirect benefits	
Direct benefits	Forests maintain the delivery of ecosystem benefits; provide income for communities and countries and supply food, construction materials and food.

Reduction of vulnerability to climate change	SFM supports community adaptation through ecosystem-based adaptation strategies practices such as landscape management, conservation and restoration and agroforestry (CPF, 2012; Campbell et al., n.d.)
Economic benefits, indirect growth and investment	• Forests provide household income and revenues for the government through the sale of timber and NTFPs. • Reduce dependence on expensive and imported energy sources.
Social benefits, indirect income, education and health	Social benefits of forests (CBD, 2009; Campbell et al., n.d.) include: • Provision of basic needs (food, shelter, clothing and heating) for the poor and rural populations • Spiritual fulfilment and aesthetic enjoyment. • Source of livelihoods and income – e.g. gathering building materials, fruits, honey, medicinal plants. • Sources of genetic material for horticultural crops and trees. • Source of employment, e.g. in forest industries.
Environmental benefits, indirect	Environmental benefits of sustainably managed forests (CBD, 2009) are: • Prevention of land degradation and desertification by stabilizing soil, reducing water and wind erosion, and maintaining water and nutrient cycling in the soil. • Maintaining the productivity by stabilizing soils, reducing water and wind erosion, enhancing soil productivity, • Supporting the restoration of degraded lands and prevents desertification • Habitat for biodiversity • Water storage and purification • Mitigation of natural disasters such as droughts and floods, • Carbon storage and climate regulation • Enhanced rainfall formation
Local context	
Opportunities and barriers	Among others, key barriers to SFM (Campbell et al., n.d.; CPF, 2012) are: • Deforestation and forest Degradation due to agriculture, forest fires, charcoal production. • Climate change • Unsustainable wood harvesting • Lack of landscape-scale approaches in forest management • Financial constraints to SFM including management and transaction costs; • Weak local and institutional capacity. • Weak enforcement of laws and regulations Opportunities to SFM in Tanzania (FBD, 2008; Campbell et al., n.d.): • Forests are still a valuable resource. • Resource rights are shifting to local people • Emerging new approaches to integrating conservation and development, e.g. REDD+ • Emerging and expanding forest markets within and outside the country. • Building from the success of PFM offers exciting prospects for SFM • Economic incentives for communities towards SFM – e.g. through financing from REDD+
Market potential	The technology has a market potential in many parts of the country that are endowed with

	forests.
Status	Tanzania has over 20 years of SFM under PFM with CBFM delivering better results compared to JFM. As much as 4 million ha of forests and woodlands across the mainland are covered under PFM.
Timeframe	Medium term to long term
Acceptability to local stakeholders	Easily acceptable by many stakeholders. Awareness and sensitization campaigns will increase acceptance levels.

Fact Sheet - Tree Nurseries / Seedlings Production Technology

Sector: Forestry	
Sub sector: **Tree** Seedlings Production (Improvement)Technology	
Technology characteristics	
Introduction	Woodlots are small plantings or clumps of trees near villages, as well as larger plantings which are intended for firewood, building materials, poles, laths and droppers for local villages, but not for industrial purposes, such as production of sawn timber, mining timber or pulpwood. These woodlots are usually associated with a community (Chidumayo and Gumbo, 2010).
Technology characteristics / highlights	In Tanzania, initial efforts of tree nurseries focused on highland areas that have comparatively fertile soils and adequate water availability (Chamshama and Nshubemuki, 2011). Later on nurseries were introduced into drier areas but by using a combination of techniques to increase survival rates and growth. Such techniques included: adoption of right and timely dosages of fertilizers (especially nitrogen (N) and potassium (K)), root/top pruning and decreasing watering regimes towards planting out (Singunda, 2010) Evidence from research (e.g. Singunda, 2010) indicate that, the purpose for tree planting include: • Timber production (e.g. pines, cypress and *Grevillea)* • Building poles, firewood and charcoal production (e.g. eucalyptus, black wattle and *Cussonia spp)* • Fruit trees (e.g. mangoes, oranges, etc) • Trees planted for shade and water sources protection (e.g. *Cussonia*, *Ficus*, *Syzygium*, *Albizia spp*) • Trees for other purposes (e.g. land improvement, hedges and boundary
Institutional and organizational requirements	• Tree nurseries are established and managed at farm level • May require establishment of tree nursery associations to effective management of the tree nurseries.
Operational and maintenance	Operation and maintenance requires storage of seeds and maintenance of seedlings at the nursery – watering, thinning, fertilizer application as well as pests and disease control.
Endorsement by experts	Highly recommended by experts and researchers – but focus should be on the use of native tree species that have comparatively higher survival rates and are resilient to changing climatic conditions.
Adequacy for current climate	Fits well with current and future climate particularly when natural species are used.
Sale / size of	Famers, tree growers, timber industries, NGOs, Government agencies

beneficiaries group	
Disadvantages	• There is a likelihood to increase the spread of exotic species replacing indigenous trees leading to loss of native species • Loss of diversity may result due monoculture tree plantations that prefer to focus on a single tree species. • Uncertified seeds could result into vulnerable and poor quality trees and associated products.
Capital costs	
Cost to implement adaptation technology	Cost to implement technology relates to the purchase of seedlings, nursery preparation and maintenance, land preparation, labour for planting and maintenance, replacement of seedlings, weed and pest/insect control.
Additional cost to implement adaptation technology, compared to business as usual	
Long term costs (i.e. 10, 30, or 50 years) without adaptation	
Long term costs (i.e. 10, 30, or 50 years) with adaptation	
Development impacts, direct and indirect benefits	
Direct benefits	• Increase access to planting materials for reforestation, afforestation and tree plantations • Creates employment opportunities • Access to income accruing from the sale of tree seedlings
Reduction of vulnerability to climate change	Reduces vulnerability in two ways: • Diversifying livelihoods (income and food access), • Enhancing the provision of ecosystem services in rehabilitated forests. Ecosystem services are required for adaptation by communities.
Economic benefits, indirect growth and investment	• Source of income from the sale of tree seeds and seedlings, timber, poles, fruits and other NTFPs • Helps to meet demand on wood/timber, fuel-wood
Social benefits, indirect income, education and health	Trees on farm serve as a safety net - providing income and affordable sources of food, fuel, fodder and housing materials (Singunda, 2010)
Environmental benefits, indirect	Environmental benefits include: • Enhances landscape greening • Rehabilitation / restoration of degraded areas • Enhances the integrity of ecosystem services • Woodlots lowers pressure on natural forests and rangelands
Local context	
Opportunities and barriers	Opportunities for tree nurseries and seed production include: • Government policy supports tree planting, with a national day declared for tree planting by each region, district, institution and organization. • Growing demand for timber and NTFPs products provides a market for tree seedlings • Access to comparatively high income by persons with tree nurseries or woodlots has attracted many to get into the nursery business.

	• The Tanzania Tree Seed Agency is available to provide high quality tree seeds. The Agency can position itself and undertake capacity building on seed production and the tree nurseries management. Barriers facing tree nurseries and seed production: • Lack of sufficient knowledge on tree selection, growing and harvesting • Limited access to appropriate inputs (seeds and tools) • Lack of market information, marketing and bargaining power • Inadequate technical and institutional capacities
Market potential	The technology has a market potential in most parts of the country.
Status	Widely practiced in different parts of the country.
Timeframe	Short term
Acceptability to local stakeholders	There is high acceptance of the technology throughout Tanzania

Appendix 1: List of Stakeholders Workshop on Climate Change Technology Needs Assessment held at Giraffe Ocean View Hotel, Dar es Salaam on 29th – 30th September, 2015.

S/NO	Names	Institution	Contact
1	Dr. Julius Ningu	Vice President's Office	jningu@gmail.com
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37	Abudallah Shah	Forest - Consultant	abdallasha62@yahoo.com

Appendix 2: List of Stakeholders Workshop on Climate Change Technology Needs Assessment held at Giraffe Ocean View Hotel, Dar es Salaam on 20th November, 2015**.**

<u>Energy Work - Group</u>

S/No.	Names	Institutions	Contact
1	Maxmilian Mahangila	Vice President's Office	mahangila@yahoo.com
2	Prof. Jamidu Katima	Energy - Consultant	jkatima@katima.org
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4	Fokas Daniel	Tanzania Electrical and Supply Company Ltd (TANESCO)	fokas.daniel@tanesco.co.tz
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7	Sospeter Kerefu	National Development Corporation	sbjkerefu@hotmail.com
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Appendix 3: List of Stakeholders Workshop on Climate Change Technology Needs Assessment held at Giraffe Ocean View Hotel, Dar es salaam on 25th September, 2015**.**

Forest Work – Group

S/No.	Names	Institutions	Contact
1	Mariam Mrutu	Tanzania Forest Services	mariam.mrutu@tfs.go.tz
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11	Twaha Twaibu	Ministry of Natural Resources and Tourism	twaibu1965@yahoo.com
12	Abdallah Shah	Forest - Consultant	abdallasha62@yahoo.com

Appendix 4: List of Stakeholders Workshop on Climate Change Technology Needs Assessment held at MACEMP House, Zanzibar on 24 November, 2015.

Agriculture, Forest, Energy and Water Work - Groups

S/No.	Names	Institutions	Contact
1	Maxmilian Mahangila	Vice President's Office	mahangila@yahoo.com
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19	Khatib M. Khatib	Department of Environment - Zanzibar	
20	Juma B. Alawi	Department of Environment - Zanzibar	jbalawi@yahoo.com

Appendix 5: List of Stakeholders involved in technology prioritization held at the Vice President's Office, Dar es Salaam on 3 – 4 March 2016.

Agriculture, Water, Energy and Forest sectors.

S/No.	Names	Institutions	Contact
1	Euster Kibona	Consultant – Watera and Agriculture	euster79@gmail.com
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		Services	
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13	Dr. Julius Ningu	Vice President’s Office	jningu@gmail.com
14	Joseph Kihaule	Vice President’s Office	kihaule@gmail.com

Appendix 6: Stakeholders Workshop on Climate Change Technology Needs Assessment (TNA) and Climate Technology Centre & Network(CTCN), to be held at Giraffe Ocean View Hotel, Dar es Salaam on Tuesday 29th - 30th September 2015.

Tentative Agenda

DAY ONE		
Time	Activity	Responsible
08.30-9.00	Registration	All
09.00-9.10	Welcome Remarks and Introductions	Director of Environment - VPO
09.10-9.25	Opening Speech	Permanent Secretary - VPO
09.25-9.40	Group photo	All
09.40 - 10.00	Tea- break	All
10.05 - 10:15	Introduction of Technology Needs Assessment (TNA)	VPO
10.15-10.45	Presentation: TNA Assessment - Forest	TNA Consultant - Forest
10.45 - 11:55	Discussion	All
11.55 - 12.25	Presentation: TNA Assessment - Agriculture	TNA Consultant - Agriculture
12.25 - 13.25	Lunch	All
13. 25 - 14.35	Discussion	All
14.35 – 15.05	Presentation: TNA Assessment - Water	TNA Consultant - Water
15.05 – 16.15	Discussion	All
16.15 – 16.45	Coffee - Break	All
End of Day One		

DAY TWO		
Time	Activity	Responsible
8.30-9.00	Registration	All
9.00-9.10	Recap of Day One	VPO
09.10 – 09.40	Introduction of Climate Technology Centre and Network (CTCN)	Thando Ndarana (CSIR)
9.40 – 10.00	The NDE and Incubator programme in Tanzania	COSTECH
10.00 -10.30	Tea – Break	All
10.30 – 11.00	Group work 1: Idea generation for project concept	COSTECH/ Thando Ndarana (CSIR)
11.00 – 11.30	Group work 2: Stakeholder mapping for project concepts	COSTECH/ Thando Ndarana (CSIR)
11.30 – 12.00	Group work 3: Actions/ mechanisms for project implementation	COSTECH/ ThandoNdarana (CSIR)
12.00 – 13.00	Feedback from groups and discussion	
13.00-14.00	Lunch	All
14.00 – 15.00	Discussion: Fine tuning of project concepts	Thando Ndarana (CSIR)/ All
16.00-16.15	Coffee - Break	All
16.15-16.30	Way Forward	Dr Flora (COSTECH)
16.30 – 16.40	Closing Remarks	ADEA - VPO
End of Day Two		