UNITED REPUBLIC OF TANZANIA

Technology Needs Assessment
Climate Change Mitigation

Barrier analysis and Enabling Framework for Mitigation

Energy and Forestry Sector

Report II

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DISCLAIMER

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Abbreviations and Acronyms

AfDB	African Development Bank
ARTI	Appropriate Rural Technology Institute
ASDP	Agricultural Sector Development Programme
CARMATECH	Centre For Agriculture Mechanization And Rural Technology
CBO	Community Based Organisation
CBFM	Community-Based Forest Management
CFRs	Catchment Forest Reserves
CIF	Climate Investment Funds
CO_2	Carbon Dioxide
DADPs	District Agricultural Development Plans
ERC	Energy Research Centre
EMEDO	Economic Development Organization
EWURA	Energy and Water Utility Regulatory Authority
FAO	Food and Agricultural Organisation
FBO	Faith Based Organisation
FCC	Fare Competition Commission
FiT	Feed-in-Tariffs
FLR	Forest Landscape Restoration
GEF	Global Environment Facility
Gg	Gigagrams
GHG	Green House Gases
GoT	Government of Tanzania
GWh	Gigawatt hour
HFO	Heavy Fuel Oil
ICRAF	International Center for Research in Agroforestry
ITTO	International Tropical Timber Organization
IUCN	International Union for Conservation of Nature
JFM	Joint Forest Management
kJ/kg	Kilo Joule per Kilogram
LANESO	Lake Nyanza Environmental and Sanitation Organization
LPA	Logical Problem Analysis
LPG	Liquefied Petroleum gas
LV	low voltage
MACEMP	Marine and Coastal Environment Management Project
MDBs	Multilateral Development Banks
MEM	Ministry of Energy and Minerals
MNRT	Ministry of Natural Resources and Tourism
MSW	Municipal Solid Wastes
MSSRF	MS Swaminathan Research Foundation
MTPY	Metric Tonne Per Year
Mt C ha^{-1}	Metric Tonne Carbon per Hectare
MV	Medium Voltage
MW	Mega Watt
MWe	Mega Watt electric
NGOs	Non-Governmental Organisations
NOx	Nitrogen Oxides
NPV	Net Present Value
O&M	Operation and Maintenance

PM	Particulate Matter
PPP	Public-Private-Partnership
PSMP	Power sector Master Plan
PV	Photo Voltaic
RDF	Refuse Driven Fuel
REA	Rural Energy Agency
REDD	Reducing emissions from deforestation and forest degradation
SCF	Strategic Climate Fund
SFM	Sustainable Forest Management
SPP	Small Power producers
SREP	the Scaling-Up Renewable Energy Programme in Low Income Countries
SWER	Single wire earth return
SO_2	Sulphur Dioxide
SUA	Sokoine University of Agriculture
TANESCO	Tanzania Electric Supply Company Ltd.
TaTEDO	Tanzania Traditional Energy Development Organisation
TFCG	Tanzania Forest Conservation Group
TJ	Terra Joule
TMA	Tanzania Metrological Agency
tCO_2/y	Tonne of Carbon Dioxide per year
TNA	Technology Needs Assessment
TBS	Tanzania Bureau of Standards
TOE	Tonne Oil Equivalent
TTSA	Tanzania Tree Seed Agency
t/y	Tonne per Year
TZS	Tanzania Shilling
UDSM	University of Dar es Salaam
UNEP	United Nations Environment Programme
UNFCCC	United Convention on Climate Change
UNGA	United Nations General Assembly
URT	United Republic of Tanzania
USA	United States of America
USD	United Stated Dollar
WB	World Bank
WWF	World Wildlife Foundation

Executive Summary

The Technology Needs Assessment (TNA) for Climate Change mitigation in Tanzania focused on environmentally sound technologies that support Tanzania's economic development in a sustainable manner, in line with the National Development Policy Framework of the country (Vision 2015) and reducing the rate of greenhouse gas (GHG) emissions whilst contributing to low carbon technology investments in the future. The priority sectors identified for mitigation of GHGs are Energy and Forestry. Having identified the potential priority technologies for adoption in each sector, the next step of the TNA process involved analysing barriers that are likely to impact upon successful transfer and diffusion of the prioritised technologies and the corresponding measures to overcome them. The identification and analysis of barriers and enabling measures to overcome these barriers involved wide stakeholder consultations, review of relevant literature and specialist inputs.

Energy Sector

The prioritized technologies for the sector are (1) **Mini and Micro Hydro**power (2) **Sustainable use of biomass fuel (in which there are sub-technologies -** Co-Firing of Biomass with fossil fuels in Cement Industry, Compact Biogas Digester for urban Households, Improved charcoal stoves) and (3) Solar PV (small scale systems and large scale systems).

For the sustainable biomass technologies, Compact Biogas Digesters for Urban Households are aimed at helping the urban households to partially replace imported liquefied Petroleum gas (LPG) or kerosene used for cooking with biogas. The Compact biogas digesters will also minimize charcoal use which is exerting pressure on natural forests. This will in turn conserve the CO_2 sink. Use of a compact biogas digester which could be accommodated in an urban household is recommended for this purpose. The feed stock for the biogas digester would be household domestic waste and/or dried and powdered (energy plant) leaves to be made available in user-friendly packs from the grocery shops.

Co-firing of coal with Municipal Solid Wastes (MSW). This Waste to Energy technology is an attempt to use MSW as a source of energy by converting it into pellets to be used as fuel along with other fossil fuels such as Coal in cement kilns or dedicated power plants. However, this will have to be fitted with air cleaning facilities to handle any dioxins formed from the combustion of halogenated plastics found in MSW.

Use of mini / micro hydropower will be suitable in rural areas where there is no national grid, where majority of people are using wood fuel in inefficient traditional three stone cook stoves.

The following table summarises the barriers that may hinder diffusion of the above technologies and the corresponding measures to solve them.

Barriers to and measures to overcome Barriers to Biomass Waste to Energy		
Barrier Category	Barriers	Measures
Financial Barriers	a) Inadequate awareness on Economic and financial feasibility of the technology	Relevant state institutions should conduct feasibility studies and publicize study results
	b) High capital cost	a) Reduce or eliminate Government taxes on imports and local fabrications and constructions. b) Enhance availability of donor funds on concessionary terms

	c) Difficulty to access finance	a) MEM should establish a levy on fossil fuels or used existing levies b) Establish specific renewable energy Act to promote renewable
Non-Financial Barriers	Private sector not informed of business viability	Strengthen capacity in biogas digester technology to support existing initiatives (e.g. those of CARMATEC)
Technical Barriers	Technology not fully developed (RDF)	The government should take initiatives in demonstrating viability of RDF technologies
Policy, legal and regulatory barriers	Externalities of fossil fuel firing not internalized	Internalise environmental costs in project pricing
Market failure barrier	Adequate supply of waste not established	Involve private sector in the development of RDF from Municipal Solid Wastes (MSW)
Social cultural and behavioural barriers	Convenience to and acceptability by consumers not evaluated (for Compact biogas digester):	a) Relevant government institutions to develop and resolve all technical issues related to compact biogas digester b) Relevant government institutions should develop communication strategy, awareness materials and promotional strategies to ensure public acceptance of compact biogas digesters.

Barriers to and measures to overcome Barriers to Mini / micro hydropower		
Barrier Category	Barriers	Measures
Economical and Financial Barriers	Non-conventional renewable energy options are perceived more expensive as externalities of conventional technologies are not internalized.	Costs of technology options should include the externalities during generation planning
	High investment costs of the equipment, and distribution network	a) Remove Government taxes on local fabrications and constructions b) Donor agencies to consider providing adequate funds on concessionary terms c) The Government should establish a renewable energy development funds to enhance investment in RE d) Encourage Community Based Organisation (CBO) and Faith Based Organisation (FBO) to invest in RE projects
	Difficulty to access finance	a) Offer long term financing and/or risk mitigation. b) Support private-public partnerships. c) Build capacity of commercial banks to lend to renewable energy projects. d) Increase access to long term financing through commercial banks. e) The Government should engage with Development Partners and TANESCO to help solve current operational problems facing TANESCO. f) Use output-based grants to buy-down a portion of the capital cost of off-grid

Barriers to and measures to overcome Barriers to Mini / micro hydropower		
Barrier Category	Barriers	Measures
		services. g) Micro-finance organizations should be encouraged to provide financing, coupled with technical assistance and technology transfer.
	Economic viability not well understood	a) Relevant state institutions should conduct feasibility studies and publicize study results b) Necessary funds should be provided to conduct such studies
	Low purchasing power of the rural communities	Promote credit and/or pay-as-you-go solutions that allow households spread payments of household systems over time
Non-Financial Barriers	a) Limited human and institutional capacity	a) Expanded specialized training aimed at building the capacities. b) Support partnerships with international firms through South-South and North-South exchanges. c) Develop implementation models that can deliver services more efficiently. d) Expand hydro resource characterization for mini-grids. e) Make information easily accessible to developers.
	b) Insufficient information and data	a) Relevant public institutions should generate and share information on mini / Micro hydropower potential in Tanzania. b) Necessary funds should be provided to conduct such studies
	c) Easily accessible and low/no cost supplies of fuel wood	Compute true cost of using forest products.
	d) Inadequate weather related information	TMA should be provided with specific instruments and other resources to provide required weather related information to the energy sector
Technical Barriers	a) Technology not widely available	Provide opportunities to the relevant officials for exposure to functional mini/Micro hydropower plant technologies within and outside Tanzania to lean the challenges experienced by the operators of the technologies.
	b) Poor infrastructure - Electricity grid limitations, telecommunication, road and railway networks	Provide necessary funds to improve relevant infrastructure facilities
	c) Complexity of technology	Provide adequate exposure to relevant officials to get familiarized with these technologies
Policy, legal and regulatory barriers	Inadequate inter agency coordination	Strengthening the inter agency coordination

Barriers to and measures to overcome Barriers to solar PV		
Barrier Category	Barriers	Measures
Economic and financial barriers	a) Non-conventional renewable energy options are perceived more expensive as externalities of conventional technologies are not internalized	Costs of technology options should include the externalities during generation planning
	b) High capital cost	a) Government taxes on importation to be reduced or eliminated b) Donor agencies to consider providing adequate funds on concessionary terms.
	c) Operation and maintenance costs	Put in place cost reduction measures
	d) Difficulty to access finance	a) Ministry of Energy should consider establishing a Fund to provide low interest finances for Renewable Energy and Energy Efficient projects b) Donor agencies to consider providing adequate funds on concessionary terms. c) Access to UNFCCC Mitigation Funds (Climate Funds Update 2016)
	e) *Economic viability not examined*	a) Relevant public institutions should conduct feasibility studies and publicize study results b) Necessary funds should be provided to conduct such studies
Non-Financial Barriers	*Low level awareness of the renewable energy*	Consistent awareness creation
Institutional and organizational capacity barriers	*Poor Financial Position of the Off-taker*	Implement Electricity Supply Industry Reform Strategy (URT, 2014)
Technical barriers	*a) Variability and intermittency of radiation*	a) Apply the Law of Large Numbers b) Enhance the Power of Prediction c) Incentivizing Energy Production at the Right Time and Place d) Develop a Sustainable Electric Grid of the Future
	b) Grid unreliability	Implement Electricity Supply Industry Reform Strategy (URT, 2014)
Policy, legal and regulatory barriers	*a) Government policy and incentives*	Put in place favourable renewable energy policy Mitigate political and regulatory investment risk
	b) Ineffective quality control of products	Establish and enforce quality standards for solar energy equipment
	c) Competition with land uses	The Tanzania Investment Centre should identify suitable sites for solar power projects and acquire such land and register the land under its data bank

Forest Sector

The prioritized forest technologies described in the TNA report are: (i**) sustainable forest management; (ii) agroforestry; (iii) sustainable mangrove conservation, rehabilitation and restoration.**

Sustainable forest management is the management of forest according to principles of sustainable development. It keeps balance between main pillars of sustainable development: i.e. ecological, economic and social cultural. 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

Agroforestry is a land use management system in which trees are grown around or among crops or pasture. It combines trees and agricultural and forestry technologies to create more either positive or adverse effects on productivity, profitability, health, ecologically and sustainable land use system. It provides various ecosystem services and reduces human impacts on natural forests. Agroforestry systems are capable of both raising carbon stocks and producing 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.

Sustainable mangrove conservation entails putting in place measures that ensure that the mangroves are utilized at a rate less than or equal to natural rate of regeneration. This includes mangrove management planning with strong focus 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.

Rehabilitation and restoration – deals with 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. The intention is to restore forest ecosystem as part of a wider landscape improvement. Forest Landscape Restoration (FLR) has multiple benefits, including the increased capacity for carbon sequestration and storage, in addition to other economic and livelihood benefits to communities. If degraded forestlands are restored they can enhance the carbon stock, generating new capacity for carbon capture and storage.

The economic and financial barriers for Sustainable forest management (SFM) include high operational and maintenance cost with relation to forest monitoring, restoration, sustainable harvesting; High dependence on forest products from mangroves as the main livelihood strategy; Low budgetary allocation and disbursement for carrying out forest law enforcement and other SFM activities; and Inadequate investments from private sector into forestry leading to very few privately owned forests. The identified non- financial barriers include Limited awareness on sustainable management of forest resources by local communities and other potential stakeholders; Lack of landscape-scale approaches in forest management; Forest governance institutions have low technical capacity and modern equipment particularly in forest resource assessment and monitoring. There are also optical barriers that need to be overcome, these include: Capture of benefits by the elites and local leaders generates disincentives for local collective action in forest management; Lack of clear benefit sharing mechanisms for communities undermines their

participation in joint forest management; Insufficient institutional ability to enforce forest related laws and regulations aimed at preventing the mismanagement of forest resources; Lack of clear tenure rights negatively impacts on sustainable management of forest resources; Poor sectoral coordination leading to un-harmonized policy actions on sustainable forest management; Limited support and interference from politicians at various levels undermines the implementation and success of SFM measures; Inadequate fines and penalties against offences/ culprits leading to non-compliance to forest related laws. The financial measures proposed to overcome barriers include: Increase financing to carter for higher operational and maintenance on silvicuture, forest monitoring, restoration, sustainable harvesting; Support the promotion and implementation of appropriate nature based livelihood strategies; Advocate for increased allocation and disbursement of funds for forest law enforcement and other SFM activities; Promote private sector investment in the forestry sector through Public-Private-Partnership (PPP). The identified non-financial measures include: Raising community awareness on sustainable forest management through sensitization meetings and distribution of communication products; Enhance the technical capacity of forest managers/ practitioners through training in order to manage forest resources using landscape-scale approaches. The Political, legal and regulatory measures include: Combating corruption in the forestry sector by running anti-corruption campaigns and transparency revenue reporting; Finalize and operationalise JFM cost-benefit mechanism in order to ensure benefit flows to participating communities; Strengthen institutional capacity by increasing budget allocation, skilled human resources and availability of facilities for monitoring/ enforcement; Enhance the enforcement of bylaws through capacity building and provision of required facilities; Addressing insecure land tenure by reviewing the land policy (1997) and the forest policy (1998); Improve sectoral coordination through integrated planning and information sharing amongst key sectors; Carry out advocacy and lobbying campaigns for politicians at various levels to support and further efforts aimed at enhancing the sustainable management of forest resources; and Review forest related laws and regulations to ensure that fines and penalties deter illegal activities in the forestry sector

The economic and financial barriers for the agroforestry technology include: High upfront costs; Limited access to market opportunities for agro-forestry products and services; and Missing or under-developed supply channels of high quality agroforestry germplasm. The none financial barriers include: Limited capacity of institutions at the national and district level to coordinate and implement agroforestry practices; Inadequate knowledge and information on appropriate agroforestry systems and their benefits; Limited experience and low capacity among extension staff on new and appropriate agroforestry technologies including choice of species; Limited ability of agroforestry to produce short term benefits to meet immediate needs of households; Adherence to traditional farming practices by communities limits the widespread use of agroforestry; and Insecure land and tree tenure discourages people from adopting /continuing agroforestry practices. The identified economic and financial measures to mitigate the barriers are Increase access to credit and inputs as incentives for long term investment in agroforestry; Undertake research and develop linkages to improve market opportunities for different agroforestry products and services; Supporting the distribution of high quality agroforestry germplasm through Tanzania Tree Seed Agency (TTSA) and other related institutions. The non-financial measures include: Build the capacity of national and local institutions through training and knowledge sharing events; Carry out awareness raising and sensitization campaigns to enhance the visibility of agro-forestry; Strengthening capacity through events like seminars, short courses and learning visits; Conduct research to enable selection of desired traits of agro-forestry trees such as early maturing and highly productive varieties; Promote the benefits of agro-forestry with demonstration projects; and Undertake reviews of the Forest Policy and Act to address the unclear tenure rights.

The following table summarises the barriers that may hinder diffusion of the above technologies and the corresponding measures to solve them.

Barriers to and measures to overcome Barriers to Mangrove Management		
Barrier Category	**Barriers**	**Measures**
Financial Barriers	Inadequate funding	Improve budgetary allocation and leveraging external funds for financing of mangrove conservation
	Mangrove as the Main livelihood strategy	Promoting appropriate alternative livelihood strategies
Non-Financial Barriers	Inadequate Human resources	Investment in development and placement of skilled human resources to work on mangrove management and restoration.
	Inadequate equipment	Provision of equipment and facilities for management, monitoring and law enforcement
	Weak law enforcement and compliance	Strengthen enforcement of laws and bylaws through capacity building and provision of required facilities
	Prevalence of Corruption	Combating corruption in the mangrove sector by running anti-corruption campaigns;
	Limited expertise in restoration, management and monitoring	Investing in Improving technical capacity of forest managers responsible for mangroves management; Investments in research for mangrove management, protection and restoration. Promote integrated coastal resources management to include mangrove forestry and fisheries resources
	Limited awareness on the true value of sustainable management of mangroves amongst key stakeholders including local communities and decision makers	Raising stakeholders' awareness on the true value of mangroves as well as mangrove rehabilitation and management through sensitization meetings and distribution of communication products
	Ineffectiveness of participatory natural resource management approaches within the Mangrove sub-sector	Revisit the participatory approaches and promote new tactics for increased community participation in mangrove management and restoration initiatives.

Barriers to and measures to overcome Barriers to Sustainable Forest Management		
Barrier Category	**Barriers**	**Measures**
Financial Barriers	Long term nature of SFM investments with high initial cost long term operation and maintenance.	Investing in research and education on benefits of SFM. This should include economic analysis and adopting measure to lower costs of management.
	Low budgetary allocation and disbursement for carrying out forest law enforcement and other SFM activities	**Increase** financing to carter for higher operational and maintenance on silviculture, forest monitoring, restoration, sustainable harvesting **Advocate** for increased allocation and disbursement of funds for forest law enforcement and other SFM activities.

Barriers to and measures to overcome Barriers to Sustainable Forest Management		
Barrier Category	**Barriers**	**Measures**
		Promote private sector investment in the forestry sector through Public-Private-Partnership (PPP). **Strengthen** institutional capacity by increasing budget allocation, skilled human resources and availability of facilities for monitoring/ enforcement
Non-financial Barriers	Limited awareness on sustainable management of forest resources by local communities and other stakeholders	Support the promotion and implementation of appropriate nature based livelihood strategies Raising community awareness on sustainable forest management through sensitization meetings and distribution of communication products.
	Lack of landscape-scale approaches in forest management;	Enhance the technical capacity of forest managers/ practitioners through training in order to manage forest resources using landscape-scale approaches
	Forest governance institutions have low technical capacity and modern equipment particularly in forest resource assessment and monitoring	Advocate for increased allocation and disbursement of funds for forest law enforcement and other SFM activities. Enhance the enforcement of bylaws through capacity building and provision of required facilities
	Capture of benefits by the elites and local leaders generates disincentives for local collective action in forest management	Continuing education to communities on forest governance, including transparency,
	Lack of clear benefit sharing mechanisms for communities undermines their participation in joint forest management;	Finalize and operationalise JFM cost-benefit mechanism in order to ensure benefit flows to participating communities
	Insufficient institutional ability to enforce forest related laws and regulations aimed at preventing the mismanagement of forest resources	The Political, legal and regulatory measures include: Combating corruption in the forestry sector by running anti-corruption campaigns and transparent revenue reporting
	Lack of clear tenure rights negatively impacts on sustainable management of forest resources	Addressing insecure land tenure by reviewing the land policy (1997) and the forest policy (1998)
	Poor sectoral coordination leading to un-harmonized policy actions on sustainable forest management	Improve sectoral coordination through integrated planning and information sharing amongst key sectors
	Limited support and interference from politicians at various levels undermines the implementation and success of SFM measures	Carry out advocacy and lobbying campaigns for politicians at various levels to support efforts aimed at enhancing sustainable management of forest resources
	Inadequate fines and penalties against offences/ culprits leading to non-compliance to forest related laws.	Review forest related laws and regulations to ensure that fines and penalties deter illegal activities in the forestry sector

Barriers to and measures to overcome Barriers to Agroforestry

Barrier Category	Barriers	Measures
Financial Barriers	High upfront costs	Increase access to credit and inputs as incentives for long term investment in agroforestry
	Limited access to market opportunities for agro-forestry products and services	Undertake research and develop linkages to improve market opportunities for different agroforestry products and services
	Missing or under-developed supply channels of high quality agroforestry germplasm	Supporting the distribution of high quality agroforestry germplasm through TTSA and other related institutions
Non-Financial Barriers	Limited capacity of institutions at the national and district level to coordinate and implement agroforestry practices	Build the capacity of national and local institutions through training and knowledge sharing events
	Inadequate knowledge and information on appropriate agroforestry systems and their benefits	Carry out awareness raising and sensitization campaigns to enhance the visibility of agro-forestry
	Limited experience and low capacity among extension staff on new and appropriate agroforestry technologies including choice of species	Strengthening capacity through events like seminars, short courses and learning visits
	Limited ability of agroforestry to produce short term benefits to meet immediate needs of households	Conduct research to enable selection of desired traits of agro-forestry trees such as early maturing and highly productive varieties
	Adherence to traditional farming practices by communities limits the widespread use of agroforestry	Promote the benefits of agro-forestry with demonstration projects
	Insecure land and tree tenure discourages people from adopting /continuing agroforestry practices.	Undertake reviews of the Forest Policy and Act to address the unclear tenure rights.

CHAPTER 1: ENERGY SECTOR

Tanzania consumed a total of 8.42 Million TOE (CEEST, 1998), 19.6 Million TOE (IEA, 2009) and 22 Million TOE in 1990, 2009 and 2010 respectively. Biomass represented 88.6 % 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 %, while petroleum products provided 9.2 % of the total energy consumed in Tanzania. Other energy sources, such as solar represent a small share, see Table 1.

Table 1: Primary energy Source (2010) (IEA, 2011)

Energy Source	Quantity (Million TOE)	%age
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, which has significant both 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 (Kusekwa, 2011). This has significant contribution to climate change.

While the electricity subsector contributes to less than 2 % 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 %) and natural gas (around 35 %), 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 (USEA, 2016).

Demand for electric power is growing and it exceeds supply. In the short to medium term generation expansion plan (up to 2016), the majority (59 %) 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).

The National Green House Gases (GHG) inventory estimated the following GHG emissions from energy sector.

Table 2: GHG Emission in the Energy Sector

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. With the anticipation increase in energy demand this is expected to increase. However, because of the frequent droughts being experienced, majority of new power plants being developed or being planned are focusing on thermal, mainly natural gas and coal.

Process of identifying barriers and development of measures:

Although potential technologies for the energy sector have been identified and prioritized during the Technology Needs Assessment stage, there are barriers which need to be overcome to enable the technology transfer and diffusion. Therefore, a barrier analysis was carried out through stakeholder consultations (see Annex II) supported by literature reviews and specialist inputs. The barriers thus identified have been prioritized and ranked by the stakeholders based on their significance in the deployment of the technologies. Corresponding measures to facilitate the deployment of the technologies were designed.

1.1 Preliminary Targets for Technology Transfer and Diffusion

The mitigation technologies identified and prioritized for the energy sector using Multi Criteria Decision Analysis appear in Table 3. The sustainable use of biomass fuel has sub-technologies as components, namely (a) biomass and/or waste to energy (b) Compact biogas digester for both rural and urban household (c) improved charcoal stove. The categorization of these technologies is shown in Table 3.

Table 3: Categories of the prioritized technologies – Energy Sector

SN	List of Prioritized Technologies	Sub Technologies	Category of the Technology
1	**Mini and Micro Hydro**		Other non-market good
2	**Sustainable use of biomass fuel**	a) Co-firing of MSW to energy	Capital goods
		b) Compact Biogas Digester for urban Households	Consumer
		c) Improved charcoal stove	Consumer
3	**Solar PV**	SHS, Rooftops, large scale power plants	SHS are market, rooftops can be market or capital, large scale can solar can be capital (private sector led) or publicly provided (government led)

The barrier analysis however, will focus on (1) co-firing of MSW with coal (ii) Compact biodigester for urban household and (iii) Solar PV

Table 4 provides the primary targets (URT, 2016) for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of Mini and Micro hydropower technologies.

Table 4: Primary targets of Mini and Micro Hydro power

Technology	Mini and Micro Hydro for off Grid
Primary target	100MW of mini and hydropower plants in the next 10 years[1]
Required investment	Investment cost requirement: USD 130million[2](International Renewable Energy Agency 2012) Additional running costs: USD4.8 million/year[34](International Renewable Energy Agency 2012)
Expected life time	20 years
Expected economic benefits	100 MW Mini and Micro-hydropower Foreign exchange saving by replacing 100MW generated from diesel engine: USD 70.5 million /y. The above is based on the following assumptions: • Calorific Value of diesel: 40,000 kJ/kg • Price of Diesel: USD 917/t • Investment in diesel genset – USD400/kW • O&M diesel genset • Efficiency of diesel genset: .(Alternative Energy 2016) • Annual Plant Load factor of Mini hydropower plants: 62%
Climate Change Mitigation Impacts	100 MW Mini / Micro hydropower Mitigation of 58,391 tCO_2/y based on the following assumptions: i) Emission: 74.1 tCO_2/TJ for diesel ii) Calorific Value of diesel: 40,000 kJ/kg iii) Efficiency of diesel genset: 20%? (Alternative Energy 2016) iv) Annual Plant Load factor of Mini hydropower plants: 62% v) 1 kg of diesel generates 11.42 kWh[5]

Figure 1 shows performance of mini hydro and other types of energy sources over the lifetime of the technology. *T can be seen that th*e diesel based mini-grid is the most expensive solution over the whole lifetime of the project. The fuel costs of diesel, the running costs, and the replacement cost of the genset every 3-4 years (25000 operating hours) offset the low initial investments (Alliance for Rural Electrification (ARE)/USAID. March 2011).

[1] Tanzania has more than 85 mini-hydro power sites with a total potential of about 187 MW (GiZ (2009) Tanzania`s Small-Hydro Energy Market). Assuming about 50% of this potential is developed

[2] The investment costs range for small hydropower projects is between USD 1300/kW and USD8000/kW.

[3] The O&M costs is estimated between 1% and 6% or in some cases even higher for small hydropower plants.

[4] The investment costs range for small hydropower projects is between USD 1300/kW and USD8000/kW.

[5] https://www.epa.gov/.../greenhouse-gases-equivalencies-calculator-calculations-and-re.. (Accessed on 24th March 2017)

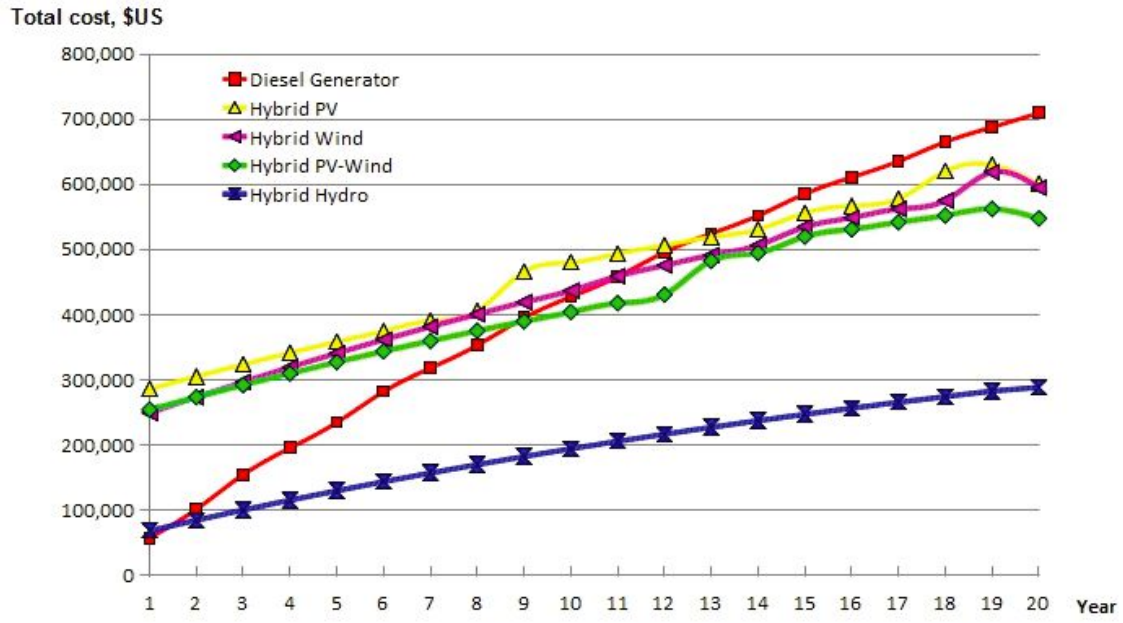

Figure 1: Economic performance of different sources of energy

Table 5 provides the primary targets for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of Biomass to energy technology.

Table 5: Primary targets of Refuse Derived Fuel

Technology	Co-firing RDF with Coal
Primary target	Substituting 100 MW electric of coal with RDF in the 5 to 10 year period.
Required investment	Investment cost requirement for RDF based plant: USD 450 million[6] (International Renewable Energy Agency 2012) Additional O&M costs for biomass plant: (Fixed) USD4.38 million/year and (Variable) 1.5 million/year[7] (International Renewable Energy Agency 2012)
Expected life time	30 years
Expected economic benefits	The annual economic benefit of replacing 100MW Electric of Coal imported with RDF USD 24.48 million per year in terms of foreign exchange savings. This is based on the following assumptions: • Price of Coal: 51.60 /t • Annual operating hours: 7000h/ y • The overall conversion efficiency: 33.44 % • The cost of coal consumed by 100 MW power plant: 3497 $ /hr
Climate Change Mitigation Impacts	Estimated CO_2 reduction about 2,384,200.00 tCO2 per year. This is based on the following assumptions: • Emission factor: 340.6 gCO2/kWh for coal • Annual operating hours: 7000 h/y • Calorific values of RDF: 8-14MJ/kg (use the average) 11MJ/kg[8] (this equivalent to 71,672 tonnes of RDF

[6] The investment cost of circulating fluidized bed boilers range between USD 2 170 and USD 4 500/kW
[7] Fixed O&M costs range from 2% of installed costs per year to 7% for most biomass technologies, with variable O&M costs of around USD 0.005/kWh.

Technology	Co-firing RDF with Coal
	• Gross calorific value (GCV) of coal: 10500 kJ/kg to 25000 kJ/kg

Table 6 provides the primary targets for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of Compact Biogas Digester for Urban Households technology.

Table 6: Primary targets of Compact Biogas Digester for Urban Households

Technology	Compact Biogas Digester for Urban Households
Primary target	100,000 household units each replacing 9,000 tonnes of LPG per year 328,500 t/y of unsustainable charcoal[9] or fire wood per day in 5 to 10 years.
Required investment	Investment cost requirement: USD20 mill[10]
Expected life time	10 years
Expected economic benefits	Savings of foreign exchange (based on LPG USD 15 mill per year) based on the following assumptions: • Normal household consumes 7.5kg of LPG per month • 15kg of LPG costs TZS 55,000 • Exchange Rate: 1 USD = TZS 2180 Based on charcoal – household saves about of USD 277 /y (equivalent to USD 27 mill/year for the 100,000 households)(EUROPAID 2016) based on the following assumptions: Household consumption 9 kg of charcoal per day (Yannick, 2010) • Price of charcoal : TZS. 184 /kg
Climate Change Mitigation Impacts	100,000 household units • Based on LPG replacement 559.8 tCO2e[11] • Based on Charcoal replacement Mitigation of 227,000 t/y based on the following assumptions: • Actual GHG emission reduction = 2,956 mill tCO2e per year[12] (Songela, 2008)

Table 7 provides the primary targets for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of improved charcoal stove technology.

Table 7: Primary targets of improved charcoal stove

Technology	Improved charcoal stove
Primary target	1,000,000 units replacing 1,379,700 t/y of unsustainable charcoal (Lusanbo, 2016)[13] in 5-10 years.

[8] https://en.wikipedia.org/wiki/Refuse-derived_fuel

[9] ***Tanzania burns one million tons of charcoal each year***, *which amounts to clearing more than 300 hectares (about 750 acres) of forest every day to produce charcoal.*

[10] A compact biogas plant (including a biogas stove) costs approximately US $200 to purchase and is run on the discarded food waste of a household.

[11] 1kg of LPG produces 62.2 gCO2e (2009 Atlantic Consulting, LPG's Carbon Footprint Relative to Other Fuels)

[12] Francis Songela (2008) Charcoal as Business and Potential for Carbon Credits (1 ton of charcoal produced and used in Tanzania produces 9 tonnes of CO_2)

Required investment	Investment cost requirement: USD5 mill[14]
Expected life time	5 years
Expected economic benefits	Household savings about USD 632,889.91/y based on the following assumptions: • Household consumption 9 kg per day • Price of charcoal: TZS. 184 /kg • Exchange Rate: 1 USD = TZS 2180 • Fuel savings of 35% to 50% (First Climate 2016)
Climate Change Mitigation Impacts	• 1,000,000 units • Mitigation of 1,million t/y based on the following assumptions: • The technical potential for GHG emission reductions from improved cook stove projects has been estimated at 1 to 3 tonnes of CO2e per stove

Error! Reference source not found. provides the primary targets for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of Waste to Energy technology.

Table 8: Primary targets of Solar PV

Technology	Solar PV
Primary target	100MW of Solar PV in the next 5 years
Expected life time	20 years (7.5 –9.7 hours of solar per day)
Required investment	Investment cost requirement: USD105.5 mill [15]
Expected economic benefits	Annual savings of energy USD 43.8 Million per year (replacing diesel based power); The above is based on the following assumptions: • 100MW of solar power • Average sunlight per day: 9.7 hours. • Average price of electricity: USD 0.125 per kWh • Exchange Rate: 1 USD = TZS 2180
Climate Change Mitigation Impacts	100 MW Solar PV Mitigation of 58,391 tCO_2/y based on the following assumptions: i) Emission: 74.1 tCO_2/TJ for diesel ii) Calorific Value of diesel: 40,000 kJ/kg

[13] Lusambo P. (2016) Household Energy Consumption Patterns in Tanzania. Journal of Ecosystem & Ecography pp (https://www.omicsonline.org/open-access/household-energy-consumption-patterns-in-tanzania-2157-7625-S5-007.pdf (Accessed on 24th March 2017

[14] TZS 13,000 per cook stove (https://energypedia.info/images/a/af/Improved_Cookstoves_in_Tanzania.pdf

[15] cost range is from 935 to 1055 EUR/kWp,(Exchange rate 1USD = 0.946 Euro)

1.2. Barrier Analysis and Possible Enabling Measures for Technology 1: Mini and Micro Hydro Power

1.2.1. General description of the Technology

The potentials for mini and hydropower project is large (315 MW). However, the development of these technologies to meet grid-based electricity generation has not been realized due to various reasons, the major one being the low coverage of the national grid networks which is currently covers on 46% of the electricity users, while mini grids covers 20%.

1.2.2. Identification of barriers for the Technology

A total number of thirteen (13) key barriers which comprised of five (05) economical & financial barriers; four (04) None financial barriers; three (03) Technical barriers; one (01) policy, legal & regulatory barrier have been identified.

1.2.2.1. Economic and financial barriers

Following are the economic and financial barriers identified:

(a) Non-conventional renewable energy options are perceived more expensive as externalities of conventional technologies are not internalized.

While renewable energy projects promise to be attractive for private sector participation because of their size and the availability of renewable energy sources in the area, it is considered that the perceived high costs. The financial analysis looks at the overall Tanzanian Power sector Master Plan (PSMP) from the financial point of view and takes into consideration the financing for the plan, the total amount of required debt and equity, the interest during construction, and inflation (URT, 2012) The PSMP anticipates about 9,000 MW of capacity will have to be added by 2035 to meet demand and to replace generation units that are retired. The majority of capacity additions are expected to be large hydropower and coal (35 and 41 % respectively), while gas and oil (21 %) would supply power, particularly in the early years. Though the potential for other renewable energy is significant, only 3 % is considered in the PSMP 2012 (URT, 2013). Therefore, the projected continue use of fossil based fuels such as coal, Industrial Diesel Oil and natural gas is based on financing models which ignore all externalities such as the effects on human health, damage to the agricultural land etc. If these costs are internalized, the cost of generation of electricity using non-conventional renewable sources may be able to compete with electricity generated using fossil fuels.

b) High investment costs of the equipment, and distribution network

The electricity prospectus (URT, 2014) states that the cost of setting up the initial distribution network: low voltage (LV) and medium voltage (MV) lines, transformers; single wire earth return (SWER) lines for small settlements depend on the number of customers. Off-grid costs include: the costs of the power plants in the case of hydro plants; the costs of network needed to transport the power to the supplied settlements, the costs of the initial distribution network, the customer connection costs. While these projects promise to be attractive for private sector participation because of their size and the availability of renewable energy sources in the area, it is considered that the perceived high costs, as a result of: (i) High pre-investment and transaction costs, high cost of resource assessment and feasibility studies, limited number of projects, lack of competition (ii) Risks: currency depreciation, payment risks, resource uncertainty, Long duration for pre-investment, financial closure and construction, may delay their implementation

c) Difficulty to access finance

Other economic and financial barriers include: Type of financing and financing conditions available domestically is unsuitable for renewable energy projects; Revenues uncertain: Payment delay risk in projects that sell power to TANESCO; Limited ability of rural communities to pay for electricity services; availability of cheap and fuel wood/charcoal also do not encourage rural communities to switch from these cheap fuels to relatively expensive electricity. Another reason for the reluctance of the local banks is that the rate of return from these projects is much lower than some of the other projects such as tourism or trading. Moreover, the bankers appear to have reluctance to consider project itself as the co-lateral for the loan and insist on immovable property such as land or building as co-lateral. A combination of these factors makes access of mini and Micro scale hydropower projects to financing difficult.

Limited financing options coupled with the prevailing off taker's (i.e. TANESCO) delays in paying for electricity procured from Small Power producers (SPP) – [delays may take up to 5 months] is another disincentive to private investors to venture into mini/micro power projects. As SPP are generally smaller companies with loan repayment obligations, the current financial situation from TANESCO's perspective is critical. New SPPs are having difficulties in reaching financial closure as commercial banks are hesitating in providing long-term financing due to "TANESCO-risk". Additionally, many developers have strong technical skills but possess modest entrepreneurial experience, especially in designing and developing bankable projects or corporate finance structures.

d) Economic viability not well understood

The economic viability of Micro hydro power projects is not well understood. This could be attributed to a number of reasons, namely (i) Lack of information and uncertainty on grid extension plans reduces the incentive to develop mini-grid projects, including supply of renewable electricity to TANESCO isolated grids (ii) Although there is already identified potential hydropower sites, there is lack of long term hydrological data for these sites (iii) Lack of data or reliable data and information on quality and duration of the resource exacerbate uncertainty of the resource. Hence the utility and developers have apathy towards investing in these ventures.

e) Low purchasing power of the rural communities

Much of Tanzania does not have access to grid electricity supply. The Rural Electrification Investment Prospectus study which estimated the split of the population by electrification options indicates that about 50 % of the population in rural areas may best be served using mini-grid and off-grid means – if the 2025 goal of electrifying 50% of population is to be achieved. However, distribution to households, which in general terms will be low energy users, is likely to be marginally economic in many circumstances. Therefore the limited ability to pay in rural areas for electricity services is considered to be a major disincentive.

1.2.2.2. Non-financial barriers

Information & awareness barriers

The following 6 barriers have been identified under this barrier category:

a) Limited human and institutional capacity

The alternative energy use, apart from the use of traditional biomass, is a new topic in Tanzania education system. Young professionals entering the power sector do not have sufficient skills to carter for this technology. Therefore, there is limited expertise in Tanzania for undertaking feasibility

studies, detailed design, construction, etc. Furthermore, since mini and micro-hydropower sites are found in rural areas, it is difficult to find qualified staff willing to be posted in remote locations.

b) Insufficient information and data

Although it is often stated that Tanzania has significant hydro potential that could be considered in a least cost expansion plan, there is insufficient information and data to more precisely estimate the true potential. This lack of long term hydrological data blurs attractiveness of mini/micro-hydropower projects development.

c) Easily accessible and low/no cost supplies of fuel wood

As long as the majority of people continue to have access to low/no cost supplies of fuel wood from forests, where extraction enforcement is lacking, incentive to use electricity, particularly for cooking, will remain low. This is a further disincentive to invest in these mini / micro hydropower plants.

d) Inadequate weather related information

The weather related information generated by the Tanzania Metrological Agency (TMA) is aimed at catering to the routine forecasting aspects. Impact of variation weather and climate on mini and Micro hydropower resources cannot be made with needed accuracy. The energy sector needs continuous and very much updated data. Unless the resources of TMA are enhanced such vital information cannot be generated on behalf of the energy sector.

1.2.2.3. Technical barriers

a) Technology not widely available

There is still low number of mini / micro hydropower project commercially operating in Tanzania. As such there is still limited experience on the challenges faced by the operators to run these facilities in the rural setting. Hence decision makers in the energy sector appear to have lack of confidence on this technology as it is not widely practiced, that is why only 3% of renewable (excluding large scale hydropower plants) is considered in PSMP.

b) Poor infrastructure - Electricity grid limitations, telecommunication, road and railway networks

Unfortunately Micro and mini hydropower sources are found in remote areas where infrastructure particularly roads, is not developed. Increasing the share of renewable energy in the system would require the construction and operation of new renewable energy based power projects in the locations where these resources are available. This would involve transporting of heavy machinery to these locations. To facilitate these activities, the road and railway networks need to be enhanced.

c) Complexity of technology

At any given instance the rate of total energy generation in the system should be equal to that of the total energy consumed from the system. If this balance is not maintained, the stability of the system would be seriously affected. As the population served and there might be no entity to off take excess electricity it requires a complex operational procedure to maintain the required stability. Therefore, this aspect needs to be taken into consideration when introducing this technology.

1.2.2.4. Policy, legal and regulatory barriers

a) Inadequate inter agency coordination

Complex and unclear processes for land use decisions, water rights namely poor catchment management and water use conflicts, environmental regulations, physical infrastructure planning, public private partnerships, taxation regimes and business licensing. Experiences show that the issuance of water and land licenses and EIA certificate can take up to 1.5 years (which in most cases is constrained by land acquisition process) - which is considered by many investors to be too long. In addition, import duties related to RE are not clearly defined and clearances are often delayed.

Another crucial issue is what happens when the national grid is extended to the mini-grid served areas; as the mini-grid SPPA is no longer applicable; and the lower tariff main grid SPPA is in force. The government agencies and regulators are already taking commendable steps towards addressing most of these issues although more needs to be done especially in demystifying the regulatory framework from the developers' perspectives. However, more need to be done through enhanced inter agency coordination to facilitate resolving such issues at the appropriate time.

Uncertainty on the future direction of power sector hampers stakeholders' investment planning. Presently, the PSMP baseline plan has limited role for renewable energy other than for large hydro, reflecting the inadequacy of data and unavailability of power planning methods that can more effectively integrate a wide range of renewable energy options, especially distributed generation.

Lack of information and uncertainty on grid extension plans reduces the incentive to develop mini-grid projects, including supply of renewable electricity to TANESCO isolated grids. Also, inadequate coordination and planning information sharing among GoT entities, private sector and development Partners, communities, NGOs, etc. makes the diffusion of mini/micro hydropower difficult.

Renewable energy project preparation and approval process takes considerable time, due to complexities of bureaucratic requirements, and as smaller projects take a disproportionately longer time to bring to financial closure.

The above identified barriers have been used to develop a problem tree and market mapping of the mini and micro hydropower technology see Annex 2.

1.2.3. Identified measures

The identification of required measures to overcome key barriers has been carried out through a stakeholder consultation and by using Logical Problem Analysis (LPA) methodology as described in the TNA Guidebook 'Overcoming Barriers to the Transfer and Diffusion of Climate Technologies' (please see Annex I). The enabling measures thus identified are given below.

1.2.3.1. Economic and financial measures

a) Barrier: Non-conventional renewable energy options are perceived more expensive as externalities of conventional technologies are not internalized

Measure: Costs of technology options should include the externalities during generation planning.

When screening technology options at the planning stage only the direct costs are taken into account. Externalities (indirect costs) such as the impacts on the human health due to particulate emissions, impact on agriculture due to acidification of agricultural land, contribution to climate change etc. are not integrated into the "costs" of generation. Such costs may include costs associated with environmental impacts related to respective fossil fuel use e.g. the impacts of morbidity and mortality from emissions of CO_2, SO_2, NOx and PM; The internalisation may be in form

of Pigouvian tax which is a tax equal to the marginal damage caused by external activity would result in a situation where the marginal damages are equated to the marginal abatement costs.[16]

However, costs of this nature are either borne by the general public or by the government (such as the Ministry of Health, Community Development, Gender, Elderly and Children). As current cost and benefit analysis does not include these costs, electricity generated from fossil fuels appears to be very much cheaper than electricity from renewable sources. Possible instruments to internalise external environmental costs are emission taxes, full costs adders[17] or the trading of emission permits. Because of complexity in computing external costs, some countries have opted to subsidise the renewable energies to make them attractive to investors. This is the approach that may be taken in Tanzania to accelerate the diffusion of this technology.

b) Barrier: High capital cost

Measure (i): Remove Government taxes on local fabrications and constructions.

In order to increase the contribution by Micro hydro projects, the capital costs of these projects needs to be low enough to attract private sector investments in these projects. The following options may be considered:

- The government should consider providing incentives in the form of reduced[18] or no taxes on the imports, construction and fabrication of these power plants.
- Expand REA matching grant support programs. Offer Transaction Advisory Services by "Bundling" provision of transaction services to obtain economies of scale and to incentivize large, more experienced companies to participate. Provide cost shared assistance including possibly converting it to equity/debt on successful financial closure.
- Reduce risks by better resource assessments; bundling transaction advisory services to gain economies of scale; disseminate good practice information; increase access of developers to credible technology information and to low cost methods.

Measure (ii): Donor agencies to consider providing adequate funds on concessionary terms.

Donor agencies having mandate to promote RE technologies in the developing countries need to consider providing required funds on concessionary terms to private sector institutions to enable them to access these technologies. Such funding, if necessary, may be channelled through the government treasury and through commercial banks.

Measure (iii): The Government should establish a renewable energy development funds to enhance investment in RE.

Most of RE projects are being promoted by Donor funds, which are limited in scope and at times, they come with conditions which may not necessarily be appropriate. Such conditions may include clauses that all parts, all contractors, all consultants of the projects should be procured from the donor country; they may contain clauses of personnel to be recruited from donor country at times without capacity building clauses. The implication of such grants is that the project is tied up to the donor country for the remaining life of the project regardless the costs of running the project and

[16] www.plan,be/admin/uploaded/200605091448061.WP9803en.pdf (accessed on 6th February 2017)
[17] Adders act as a surcharge to internalize external costs in the planning of fuels costs. The adder represents a amount per unit of emission that is added hypothetically to the private costs
[18] The level of reduction should be commensurate to the intended purpose of making the mini / micro hydropower attractive to investment

availability of cheaper alternatives from other countries. Another disadvantage this kind of arrangement in that it does not allow countries to build expertise in a particular technology preferred or appropriate for the country.

In order to have a meaningful acceleration of RE, there is a need for the Government to set such a fund which may be used to generate the needed baseline data e.g. hydrology of potential sites, conduct research, build capacity to prepare fundable proposals.

Measure (iv): Encourage Community Based Organisation (CBO) and Faith Based Organisation (FBO) to invest in RE projects. Some of the existing mini / micro hydropower in Tanzania have been constructed and operated by CBOs and FBOs. Using their experience Tanzania can promote more interest.

c) Barrier: Difficulty to access finance

Following Measures should be considered

i. Offer long term financing and/or risk mitigation.
ii. Support private-public partnerships.
iii. Build capacity of commercial banks to lend to renewable energy projects.
iv. Increase access to long term financing through commercial banks. Offer partial risk guarantee instruments to cover off-taker, currency and other commercial risks that foreign equity partners may require.
v. The Government should engage with Development Partners and TANESCO to help solve current operational problems facing TANESCO, such as clearing the outstanding debts of the independent power producers, small power producers; reducing transmission losses etc.
vi. Use output-based grants to buy-down a portion of the capital cost of off-grid services.
vii. Micro-finance organizations could be used to provide financing, coupled with technical assistance and technology transfer.
viii. Measure b(ii) above also apply.

d) Barrier: Economic viability not well understood

Following Measures should be considered:

i. Relevant state institutions should conduct feasibility studies and publicize study results: In order to address this barrier, it is recommended that the relevant state institutions such as TANESCO, REA, and Academia should conduct economic and financial feasibility studies of mini / Micro hydropower projects and make the study findings available to the public and to the decision makers. The task of conducting these studies may be entrusted to competent national officials.
ii. Necessary funds should be provided to conduct such studies: Seek technical and financial assistance from the donor community for these studies which should include all relevant externalities of the technology concerned.

e) Barrier: Low purchasing power of the rural communities

i. Promote credit and/or pay-as-you-go solutions that allow households spread payments of household systems over time. This will address of lack of incentive to switch to hydropower. Currently people high cost fuels which cumulatively they

spend more than what they could have been paid as a result of using low cost hydropower. The money saved from high cost fuel is used to pay for the credit.[19]

1.2.3.2. Non-financial measures

Measures to improve Information and awareness

f) Barrier: Insufficient information and data

i. Relevant state institutions should generate and share information on mini / Micro hydropower potential in Tanzania.
ii. Necessary funds should be provided to conduct such studies: Seek technical and financial assistance from the donor community for these studies which should include all relevant externalities of the technology concerned.

g) Barrier: Easily accessible and low/no cost supplies of fuel wood

Compute true cost of using forest products. This may be used to provide subsidies to communities to switch to low cost and clean hydropower.

h) Inadequate weather related information

Measure: TMA should be provided with specific instruments and other resources to provide required weather related information to the energy sector.
The proper use of water resource for power generation requires accurate weather related information and forecasts on an uninterrupted basis. At present the TMA does not possess the resources required to provide data of this nature. Therefore, TMA needs to be strengthened by providing required hardware, software and skills.

Measures to improve human skills

i) Barrier: Lack of experts in relevant institutions

Measure: Provide required training for officials of relevant institutions.
This measure is identical to measure proposed under barrier (e) and (i) above.
One of the prior requirements for introducing this technology is to provide an adequate exposure to all relevant officials. This could be arranged through bilateral arrangements with selected countries on a Government to Government basis.

j) Barrier: Limited human and institutional capacity

Following measures may be considered:

i. Expanded specialized training aimed at building the capacities. The training should also be extended to Vocational Education Training centres. Support local educational and sector institutions dealing with renewable energy. The training should cover all levels of education starting from vocational training to tertiary education. This is particularly important because of the professionals lack early exposure to such technologies in their carrier. Hence the infusion of required knowledge needs to commence along with the vocational, technical college or university education.

[19] This approach has been used successfully by Mwenga Hydropower in Tanzania to expand its distribution network

ii. Support partnerships with international firms through South-South and North-South exchanges. Develop implementation models that can deliver services more efficiently.
iii. Expand hydro resource characterization for mini-grids. Make information easily accessible to developers.

1.2.3.3. Technical Measures

Measures to address technical barriers

a) Barrier: Technology not commonly available

Measure: Provide opportunities to the relevant officials for exposure to functional mini/Micro hydropower plant technologies within and outside Tanzania to lean the challenges experienced by the operators of the technologies.

This barrier related to lack of awareness and knowledge could be addressed through bilateral arrangements with selected countries on a Government to Government basis. Once these officials are equipped with adequate knowledge on these technologies, these institutions would be in a position to explore potential options to implement these technologies.

b) Barrier: Poor infrastructure – Telecommunication, road and railway network.

Measure: Provide necessary funds to improve relevant infrastructure facilities.
Infrastructure facilities such telecommunication, road and rail network should be adequately improved to support these technologies. This would entail large capital investments. As the financial position of the country is low at present and the government financing is scarce to for such investments, the donor assistance need to be explored.

c) Barrier: Complexity of technology

Measure: Provide adequate exposure to relevant officials to get familiarized with these technologies
This measure is identical to measure proposed under barrier (e) and (i) above.

Since this technology has many different interlinked components it is generally viewed as a complex one. In order to understand the technology involved, it is necessary to identify individual tasks of the process and provide an exposure to the relevant officials on these components.

1.2.3.3. Policy, Legal and Regulatory Measures

a) Barrier: Inadequate inter agency coordination

Measure: Strengthening the inter agency coordination
Since the technology requires interventions and approval from different authorities and government departments e.g. obtaining a water user right, environmental certificate, land title deed etc. strong coordination from these different players will hasten the approval process and consequently implementation of the project.

1.3. Barrier Analysis and Possible Enabling Measures for Technology 2: Conversion of Biomass and Waste to Energy

1.3.1. General description of the technology

Following three sub technologies are considered under this technology: (a) Co-firing Municipal Solid Waste with Coal ; (b) Compact Biogas Digester for urban Households; and (c) Improved Cook stove

1.3.1.1. Co-firing Municipal Solid Waste with Coal

The proposed technology is intended to use MSW as fuels for power generation together with fossil fuels in this case coal. Municipal Solid Wastes (MSW) is shredded, dried and separated into organic, plastic, paper, etc. While recyclable fractions are diverted, the remaining components are blended in appropriate proportions and compacted into pellets known as Residue Derived Fuel (RDF). These pellets could be used along with coal as fuel in cement kilns. The high temperature resulting from the combustion of diesel would crack any dioxins formed from the combustion of halogenated plastics. In addition, the presence of calcium carbonate would absorb any remaining dioxins. It is important to ensure that pellets manufactured in this process are used only in cement manufacture as combustion of these pellets in other applications has the potential of environmental pollution. As such these pellets could replace diesel in the cement manufacturing industry.

1.3.1.2. Compact biogas digester for urban households

Appropriate Rural Technology Institute of Pune, Maharashtra, India (www.arti-india.org) has developed a "Compact Bio Gas Digester" to resolve technical as well as operational challenges of the conventional biogas digester. " The volume of this digester is 0.75 m^3. It essentially consists of two plastic tanks. Through this technology an average household could generate adequate biogas to meet the household requirements for cooking.

The ARTI compact biogas system is made from two cut-down standard high-density polyethylene water tanks and standard plumber piping. The larger tank acts as the container containing the waste material while the smaller one is inverted and telescoped into this larger one. This smaller inverted tank is the floating gas chamber, whose rise is proportional to the produced gas and acts as a storage space for the gas.

The gas can then be used directly for cooking on an adjustable gas stove and the liquid effluent from the digester can be applied as fertilizer in gardens or agriculture.

By specification of ARTI, the CBS of approximate 1 m^3 capacity is designed for treating 1-2 kg (dry weight) of kitchen waste per day (www.howtopedia.org).

The usable gas volume of the 750 l-gasholder is 400 l. The Hydraulic Retention Time (HRT) suggested by ARTI-TZ, which is the ratio of the reactor volume (0.85 m^3) to the flow rate of the inflow substrate (0.02 m^3/day), is 42.5 days. The rather long HRT is designed to compensate for incomplete mixing.

1.3.2. Identification of barriers for the technology

A total number of 8 key barriers have been identified through stakeholder consultations by analysing causal relations using root cause analysis and market mapping for Technology-2. Conversion of biomass / waste to energy, supported by review of literature and specialist inputs. These barriers include three (03) economic & financial barriers, one (01) none-financial barriers, one (01) technical barrier, one (01) policy, legal &regulatory, one (01) social, cultural & behavioural barriers.

1.3.2.1. Economic & financial barriers

Following are the three economic & financial barriers identified:

a) Inadequate awareness on Economic and financial feasibility of the technology

Tanzania uses USD 1.3 – 1.6 billion annually to import fossil based fuels, which is about 25%of total foreign exchange earnings (Mintz-Habib, 2016). Part of this fuel is used to generate power. Currently, the generation equipment in the isolated centres consists of nearly 90 diesel units with capacities of 1500 kW or less (URT, 2012). Furthermore, Tanzania uses about 1 million tonnes of charcoal which is produced using unsustainable practices. 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 %, while petroleum products provided 9.2 % of the total energy consumed in Tanzania. The nearly 1 million tons 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. Biomass/ waste is presently used for centralised power generation (around 18 MW) and the agro-industry generates its own electricity (about 58 MW estimated). There is no known plant that is producing power from Municipal Solid Waste in Tanzania. The potential for modern RDF high, considering that the he amount of municipal solid waste generated, particularly in Dar es Salaam (which is estimated at 900,000 million tonnes per year. However, due to inadequate awareness of economic and financial feasibility of this technology , is used in our energy mix.

b) High capital cost

All equipment and machinery required for the conversion of waste to energy need to be imported on commercial terms. As large sums of money are expected to get involved in the implementation of this technology, required finances have to be raised through commercial lending institutions at commercial rates. Moreover, the Tanzania has no elaborate policy to support initiatives that are aiming at mitigating climate change and relieve the energy cost burden. Whereas fossil fuel based energy conversion projects, such as coal power projects, are implemented by government institutions or private sector with very concessionary terms with guarantees provided by the government.

c) Difficulty to access finance

As indicated in (a) above, the contribution of waste to electricity is not a common practice, as such commercial banks in Tanzania may not be easily attracted to finance them. In respect of hydropower, natural gas power and diesel generation, already there are many existing plants, which provides needed comfort for the lenders. Moreover, most of the wastes are generated as waste as such it is not yet common to many to regard waste as a resource. The waste management is very sporadic; as such there is no guarantee of continuous supply of RDF to the project developers. Furthermore, the current bank lending rates are exorbitantly high on average 23%, which are not user friendly to private lenders. For these reasons, the commercial banks do not have a great enthusiasm in providing required finances for biomass or waste based energy conversion projects and the lenders are not willing to borrow money at such high borrowing rates for the projects that may prove burdensome to sustain.

1.3.2.2. Non-Financial barriers

Information & awareness barriers

a) Private sector not informed of business viability

In respect of Micro hydro, solar wind, small biomass based power generation, the Energy and Water Utility Regulatory Authority (EWURA) has formulated and published specific Standardized Power Purchase Tariffs for each of these technologies. However, in respect of the large scale waste to energy, tariffs have to be obtained through competitive bidding. Competitive bidding in this technology will take some time to come by as there is no adequate baseline data to support the business viability.

1.3.2.3. Technical barriers

a) Technology not fully developed (RDF)

Similarly, the use of Municipal Solid Wastes (MSW) to manufacture and use Residue Derived Fuel (RDF) is also not a common technology used in Tanzania. As these technologies at the required scale of operation need high investment, potential investors may need to be exposed to such facilities operating in other countries in order to garner confidence.

1.3.2.4. Policy, legal and regulatory barriers

a) Externalities of fossil fuel firing not internalized

Although, Tanzania is phasing out diesel power plants in preference of natural gas, the abundance of coal is also pushing Tanzania to invest in large coal power based power plants. For the companies that are currently using diesel or heavy fuel oil (HFO) to generate electricity, they are expected to switch to coal as Mchuchuma Coal Mine become operational and coal become abundant. To meet the Tanzania electricity demand up 2035, it is forecasted that a total of 3800MW coal based power plants will be installed and 2228MW mainly natural gas power plants will be developed.

According to the PSMP, future energy needs will be met by coal (41%), large hydro (35%), and oil and gas (21%). Much of the early capacity requirements would be met by oil and gas generators; both require shorter lead times than coal and large hydro, which would predominate in later years. Despite the high potential of other renewable energy to provide lower-cost electricity using locally available resources, only 3% is considered in the PSMP. This is due to insufficient resource information needed for investment decisions and inadequate planning and project development.

The decision to use thermal energy sources, particularly coal is based on availability and financial analysis carried out ignoring all externalities such as the effect on climate change, health of the population, damage to the agricultural land etc. If these costs are internalized, then the cost of generation of electricity using biomass would be attractive.

1.3.2.5. Market failure barrier

Adequate supply of waste not established

In respect of Municipal Solid Wastes (MSW), although the national daily production of MSW is around 4,252 tonnes and the daily collection of MSW in the city of Dar es Salaam is about 50%, there is no part of this MSW used for energy generation. Approximately 50–60% of the waste is readily biodegradable (Membe, 2015). Besides the MSW is not segregated as such production of RDF may face a huge challenge. There have been several attempts in the past to establish waste to energy plants, but these have ended at concept stage. There are varied reasons that explain for failure for these projects to take off. Some of the reasons include poorly defined project concepts, lack of well-articulated market segment along the value chain, lack of supporting policies and laws, ill prepared would be investors etc. In view of the above mentioned reasons, the availability of adequate biomass/ waste for energy generation has not been established yet.

1.3.2.6. Social cultural and behavioural barriers

a) Convenience to and acceptability by consumers not evaluated (for Compact biogas digester):

At present, RONGEAD, a French NGO dedicated to poverty alleviation through economic empowerment, in partnership with Environmental Management and Economic Development Organization (EMEDO) and Lake Nyanza Environmental and Sanitation Organization (LANESO) to promote biogas in the Great Lakes Region has been promoting the use of compact biogas digester in Tanzania (Arti Energy, 2016). The compact biogas digester is made up of a pair of plastic vessels to be used at household level by utilizing food residues. Although kitchen wastes such as vegetable peelings also can be used as feed material, the use of such materials causes two difficulties. (a) Need to be first macerated using a device such as hand-operated meat mincer prior to feeding the digester. (b) Fibrous materials are slow to digest and take a longer resident time in the digester slowing down the digestion process and resulting in inadequate gas generation. For the above two reasons, the uptake of this technology is expected to be low if measures to address these barriers are not put in place.

1.3.3. Identified measures

The enabling measures to overcome barriers were identified through stakeholder consultations by using Logical Problem Analysis (LPA) methodology as described in the TNA Guidebook 'Overcoming Barriers to the Transfer and Diffusion of Climate Technologies' (please see Annex I). The measures identified to overcome barriers are given below.

1.3.3.1. Economic and financial measures

a) Barrier: Inadequate awareness on Economic and Financial feasibility of the technology

Measure: Relevant state institutions should conduct feasibility studies and publicize study results.

In order to address the above barrier, it is recommended that the relevant state institutions such as CARMATEC, University of Dar es Salaam, Ardhi University, TaTEDO etc. conduct economic and financial feasibility studies of these technologies and make the study results available to the public and the decision makers. Technical and financial assistance for these studies may be sought from donor agencies. These studies should address all relevant externalities.

b) Barrier: High capital costs

Measure (i): Reduce or eliminate Government taxes on imports and local fabrications and constructions.

The government imposes tax on all local fabrications and constructions. Concessions in the form of tax reduction or waivers would be an incentive for easy diffusion of the compact biogas technology. As demonstrated by the cost benefit analysis, the national economic benefits of introduction and propagation of these technologies offset any government revenue loss due to such concessions.

Measure (ii): Availability of donor funds on concessionary terms for these sectors.

Donor agencies having a mandate to promote these technologies in the developing countries need to consider providing funds to private sector institutions on concessionary terms to access these technologies. For example GiZ has been in fore front to promote renewable energy in Tanzania. Such funding, if necessary, may be channelled through the government treasury and through commercial banks.

Tanzania is one of the pilot countries selected to benefit from the Scaling-Up Renewable Energy Programing Low Income Countries (SREP). SREP operates under the Strategic Climate Fund (SCF), which is part of the Climate Investment Funds (CIF). The objective of the SREP is to pilot and demonstrate the economic, social and environmental viability of low carbon development pathways in the energy sector by creating new economic opportunities and increasing energy access through the use of renewable energy. Multilateral Development Banks (MDBs) provide support to Governments in preparing and implementing their SREP Investment Plan. In the case of the SREP Tanzania, the African Development Bank (AfDB) and the World Bank Group (WBG), including the International Finance Corporation (IFC), jointly provide support to the Government, with the African Development Bank (AfDB) acting as the lead institution (Climate Fund Investments, 2015). Tanzania should take advantage of this opportunity.

c) Barrier: Difficulties to access finance

Measure (i): MEM should establish a levy on fossil fuels or used existing levies (e.g. Rural Electrification levy, Road Toll levy) and use such proceeds to establish a Fund to provide low interest finance for Renewable Energy and Energy Efficiency projects.

Measure (ii): Establish specific renewable energy Act to promote renewable

Currently renewable energies are mentioned in the Electricity Act No. 10 of 2008, the Rural Energy Act 8 of 2005. Provisions of renewable energy are not strong enough to provide the needed impetus to promote renewable energy. Therefore, it is recommended that the MEM should consider establishing a dedicated law that may promote use of renewable technologies including biogas digesters.

1.3.3.2. Non-financial measures

Measures to improve Information & Awareness barriers

a) Barrier: Private sector not informed or invited to participate

Biogas digester technology has been promoted by public institution – CARMATEC for many years. The success of CARMATEC has been limited as they are still working with fixed large designs targeting institutions. For this technology to succeeded, involvement of private sector is essential.

In order to address the above barrier, it is recommended that the relevant state institutions such as CARMATEC, University of Dar es Salaam, Ardhi University, TaTEDO etc. conduct economic and financial feasibility studies of these technologies and make the study results available to the private sector.

1.3.3.3. Policy, legal and regulatory measures

b) Barrier: Externalities of fossil fuel firing not internalized.

Measure: During generation planning costs of technology options should include internalizing the externalities.

Only the direct costs perceived by decision makers during the planning stage and screening of fuel options. Externalities such as the impacts on the human health due to particulate emissions, impact on agriculture due to acidification of agricultural land etc. are not included in the "costs" of

generation. Costs of these externalities are either borne by the general public or by the government (such as the Ministry of Health, Community Development, Gender, Elderly & Children,). As these external costs are not considered, electricity generated from coal/diesel/natural gas appears to be very much cheaper than that of renewable sources.

It is recommended that for comparison purposes, the costs of these externalities be included prior to screening of fuel options.

c) Barrier: Adequate municipal solid waste supply not established

Measure (i): Municipal Solid Wastes (MSW) to be made available for the manufacture of RDF by the private sector

It appears that although there are some waste recycling initiatives in Dar es Salaam, the issue of segregation at source and finally collection of segregated waste, the Dar es Salaam City Council should develop a waste management strategy which will also include use of RDF. As stated in the relevant Technology Fact Sheet, conversion of MSW into RDF is a feasible project. If the government makes appropriate arrangements to ensure adequate and uninterrupted supply of MSW, in a segregated form, it would be possible to promote the waste to energy project.

It is therefore recommended that the government / City Councils create an enabling environment through appropriate policy decisions to ensure availability of specified quantity of MSW for feasible projects to convert MSW into RDF.

1.3.3.3. Technical measures

a) Barrier: Technology not established at the scale envisaged (for RDF)

Measure: The government should take initiatives in demonstrating viability of RDF technologies

As the technologies related to biomass and the conversion of MSW into RDF requires high degree of state support, it is important that the state sector plays a proactive role in promoting these two interventions. In fact, the state sector needs to demonstrate its commitment by announcing its intention to actively take part in these projects while soliciting the private sector collaboration in promoting these technologies.

b) Barrier: Technology not fully developed for compact biogas digester technology to a level of public acceptance

Measure: Relevant government institutions to develop and resolve all technical issues related to compact biogas digester. These may include, inadequate of mixing, optimum resident time, proper sealing of the biodigester, optimum amount of water to be used, pressure regulation etc.[20]

The technology to generate biogas from easily biodegradable biomass has been in Tanzania, particularly CARMATEC Biogas Digesters, for many decades. Biogas digesters of various sizes and shapes have been operating for many years. It is proposed to introduce a compact biogas digester to be used in urban households with suitable feed material to generate adequate biogas to enable

[2020] https://noharm-us Canada.org/…/573-Tech%20Specs-Biogas%20Digesters-final.doc (Accessed on 06th February 2017)

meeting the daily energy demand of an average family for cooking. ARI digester has already been tested at Ardhi University and found that it is a viable for using food leftover in households. But the amount of food left over in an average household is inadequate to generate the required amount of gas. Research is required to identify additional raw materials to supplement the household leftovers.

1.3.3.4. Social, culture and behaviour measures

a) **Barrier: Convenience and acceptability of compact biogas digester by consumers not evaluated:**

Measure: Relevant government institutions should develop communication strategy, awareness materials and promotional strategies to ensure public acceptance of compact biogas digesters.

The use of biogas to cook meals is not different to the use of LPG for the same purpose. The pressure of the gas in biogas generated in a digester is very much lower than the pressure of LPG. A simple adjustment at the burner would solve this problem. Biogas generated from Compact Bio-digester does not give any unpleasant smell. Hence there will be no resistance from the users on these two issues. However, urban dwellers may be reluctant to feed 2 kg of leftovers daily into a digester, particularly, if the digester is kept outside the kitchen. As the price of LPG is continuously increasing, it is very likely that unban community would accept the little hassle of feeding the digester than buying LPG.

This aspect need to be evaluated and appropriate action be taken to ensure that this technology is acceptable to the masses.

1.4. Barrier Analysis and Possible Enabling Measures for Technology 3: Solar PV

1.4.1. General description of the Technology

The potentials for solar PV based electricity generation in Tanzania are very large. It has the capability of generating many times the total electrical energy presently generated in the country. However, the development of this technology to meet grid-based electricity generation has not been implemented in Tanzania due to overdependence of hydropower in the past and natural gas based power currently. Furthermore there has not been any project developed to feed the electricity into the national grid apart from the use of household based solar PV. There is also frequent and rapid variations in the level of outputs of power plants adopting from this technology, as it can only generate power when there is clear sunshine (no dust cover and not in the night). The cost of storing electricity generated by this source to mitigate the fluctuations in outputs is prohibitively expensive. Many developed countries have resolved this problem by adjusting the demand of energy in the system and output levels of hydropower plants to match the variations in the outputs of solar PV power plants. Such adjustments are feasible only by incorporating Smart Grid/ Smart Meter technologies.

1.4.2. Identification of barriers for the Technology

A total number of twelve (12) key barriers which comprised of five (05) economical & financial barriers; one (01) non-financial barrier; one (01) institutional and organizational capacity barrier; two (02) technical barriers; and three (03) policy, legal & regulatory barriers have been identified.

1.4.2.1. Economic and financial barriers

Following are the economic and financial barriers identified:

(a) Non-conventional renewable energy options are perceived more expensive as externalities of conventional technologies are not internalized

The Electricity Supply Industry Reform Strategy 2015 – 2025 (URT, 2014) envisage the contribution from solar will only contribute about 100MW out of 10,798.24MW (by year 2025), with hydropower, natural gas and coal contributing 9,459MW. The decision to use three sources, particularly natural gas and coal, are based only the financial benefits analysis which ignores all externalities such as the effects on human health, damage to the agricultural land, climate change etc. If these costs are internalized, the cost of generation of electricity using non-conventional renewable sources would be in par with the cost of electricity generated using fossil based resources.

(b) High capital cost

A basic barrier to the development of solar energy technology in Tanzania as a developing country lies in the high initial costs, including high installation costs with long payback times. High initial costs may also reflect high-risk perceptions of investors and a general lack of financing instruments as well as financial sectors not being ready to finance projects considered to be risky. Although there some incentives on import or local manufacturing of solar devices in the country e.g., import duty on solar system is only 5%, most of solar projects are being promoted by donors such as World Bank. This challenge further becomes more pronounced in the country because of the high transaction costs since most solar projects are decentralized and within the small scale range. The solar energy projects thus become too costly in the long-run and the local banks in Tanzania consider them too risky business. The banks are always in a haste to recover funds and hence contemplate long-term solar projects too risky to finance. Furthermore, with the view that most of the populace belong to the low-income range, it is thus generally difficult for an average individual to invest in solar energy systems.

(c) Operation and maintenance costs

Solar technologies have been viewed as the energy supply option for the remote and rural poor areas in the country. At the moment, the operation and maintenance costs of rooftop solar systems are appreciably high in the country, due largely to lack of technically skilled personnel. Hence, potential users of the technologies (occupying largely the remote locations) may be prevented from the adoption of solar energy technologies due to fear of failure in the absence of technical supports. Similar barrier may be true for solar power plants.

(d) Difficulty to access finance

Renewable energy based electricity generation projects such as solar require large capital investments. Since there is no large solar power project that is connected to the national grid, local banks may not be easily convinced that such projects area viable. Currently the majority of solar based power projects are based on single household solar PV appear and mainly funded by NGOs and Development organizations. Another reason that may make the banks reluctant to finance such projects the rate of return from such investment is much lower than some of the other projects such as trading. Moreover the difficulty of getting payment of the sold electricity from the monopoly/sole Power distributer (TANESCO) makes the bankers nervous.

(e) Economic viability not examined

The economic viability of integrating solar power projects with the national grid using smart grid technologies with the view to enhance the share of renewable energy in the energy mix has not been carried out in Tanzania. Hence the utility and developers may not having convincing data and information to rely on.

1.4.2.2. Non-financial barriers

Information and awareness barriers

The following two barriers have been identified under this barrier category;

Low level awareness of the renewable energy

The level of awareness about the immense socio-economic and environmental benefits derivable from solar energy among the citizens and decision-makers at different political and administrative levels is relatively low in Tanzania. The majority still look at solar energy in terms of roof top solar systems, currently there is no large scale solar power plant operating in Tanzania. The current flow of information about the development, various applications, dissemination and diffusion of solar energy resources and technologies are also inadequate. This may result in poor confidence of the technology among the public, private and financing sectors on the adoption of solar energy technologies.

1.4.2.3. Institutional and organizational capacity barriers

Poor Financial Position of the Off-taker

TANESCO is the only off-taker for all electricity that has to be fed in the central grid. TANESCO has been dogged by the tendencies of not paying suppliers of electricity in good time. This increases the financial risk of solar energy projects.

1.4.2.4. Technical barriers

(a) Variability and intermittency of radiation

Solar energy is a variable resource and its availability as an energy source fluctuates. Much of Tanzania has a very sunny climate with many places averaging from seven to ten hours of sunshine a day with fewer hours during the rainy season (Tanzania Meteorological Agency, 2015). However, this variability shortcoming can be overcome by the development of appropriate solar energy storage technologies for storage purposes when solar energy is available, and then re-use when the energy is not available.

(b) Grid unreliability

This is an important barrier for grid-connected solar power, considering its intermittence and variability nature of the source. Currently, the transmission grid in Tanzania operates at 66 kV, 132 and 220kV. The current grid coverage is about 20% of the populace that are mostly spread in the urban/semi-urban regions of the country. The transmission network is found to be a weak link in the electricity supply chain in the country (TANESCO, nd.). The current transmission capacity of the national grid is less than 5,700GWh (World Bank Group 2016). Most of the transmission equipment across the country are aged, obsolete, poorly maintained, however currently Tanzania is constructing several new transmission lines of 400 kV, but these efforts are focusing mainly on updating existing transmission lines and some few kilometres of totally new lines. The current transmission losses are reported to be about 6% (World Bank Group 2016). In addition, utility-scale solar power plants are often located more remotely than fossil-fuelled plants due to the requirement for wide land area in rural locations with no grid access. At the moment, the country's national grid is not designed to handle intermittent electricity generating system; therefore, grid connected solar applications will require the construction of new and expensive transmission lines which have hitherto been proving very difficult in Tanzania due to the associated cost. Alternatively

Tanzania will have to introduce a smart grid technology, which will require a through cost benefit analysis before this option is adopted.

1.4.2.4. Policy, legal and regulatory barriers

(a) Government policy and incentives

Policies instituted by the government have not supported the profitable exploitation of renewable energy resources (generally and particularly solar energy) for any intending investors. For example the National Power Master Plan is estimating that the renewable energy will only contribute 3% in the energy mix (URT, 2013). Furthermore, production of electricity in developed countries from solar resources is largely driven by Feed-in-Tariffs (FiT) (France, Germany, Spain, etc.) and government personal income tax credit solar PV-targeted tax incentives (e.g., in the USA and Australia) (Couture, *et al.,* (2010). For instance, the German government in 1991 introduced the Electricity Feed Act in Germany, which regulates the feed-in to the grid of electricity generated from renewable resources. This Act made it mandatory for utility companies in Germany to purchase electricity generated from renewable resources at set rates (feed-in tariffs). Due to this Act, the PV installed capacity has increased from about 90MW in 2000 to 17370 MW in2010 in Germany and similar trend was reported for countries with favourable government policies (Couture, *et al.,* 2010). The proposed FiT incorporated into energy policies in Tanzania of 0.30USD/kWh is considered by investors to be unattractive (Hansen *et al.,* 2014).

(b) Ineffective quality control of products

Absence of national technical standards and effective quality control units in the country were identified as a major institutional challenge to the adoption of renewable energy in households. This absence is due to lack of appropriate training and personnel. Most of the solar products are imported from China. There are no existing standards and specifications regulating these products; products are also without trade mark certificates and certificates of analysis from manufacturers (most of the products in the market have no brand name). These led to the influx of large quantities of substandard/poor quality of solar components; systems and services are also poorly installed by technicians with inadequate expertise. Confidence reposed on the technology has thus been undermined since the high initial cost of investment into these products cannot be justified.

(c) Competition with land uses

Land issues may be very complicated especially when the intending project to be sited on such land, is non-governmental. There may be a major challenge in siting and securing of permits for solar power plants in new locations. Most land in rural communities are for agriculture being the major occupation of the inhabitants; ownership of such piece of land may also belong to families or communities. Since solar projects on a large scale will involve private participation, land acquisition procedures may be a major barrier to solar applications especially solar PV on a large scale.

1.4.3. Identified measures

In order to overcome the above barriers and accelerate the development of solar energy applications in Tanzania, there will be the need for favourable policies and strong political will from the government at all levels (Central and Local Governments). However, the removal of one or more barriers may not be sufficient to encourage and/or increase investment in solar energy as such actions may even be in conflict with other government policies. For instance, some land areas or regions may be designated for large scale farm in order to improve food security in the country and

using such regions for solar energy development can be a threat to food security in such locality. To accelerate solar energy development, the following steps and policies are suggested:

The identification of required measures to overcome key barriers has been carried out through a stakeholder consultation and by using Logical Problem Analysis (LPA) methodology as described in the TNA Guidebook 'Overcoming Barriers to the Transfer and Diffusion of Climate Technologies'(please see Annex I). The enabling measures thus identified are given below.

1.4.3.1 Economic and financial measures

(a) Barrier: Non-conventional renewable energy options are perceived more expensive as externalities of conventional technologies are not internalized

Measure: Costs of technology options should include the externalities during generation planning

When screening technology options only the direct costs are taken into account. Externalities (indirect costs) such as the impacts on the human health due to particulate emissions, impact on agriculture due to acidification of agricultural land, climate change due to release of CO_2 etc. are not integrated into the "costs" of generation. However, costs of this nature are either borne by the general public or by the government. Excluding such costs, electricity generated from coal and natural gas appears to be very much cheaper than electricity from renewable sources such as solar power. Therefore, it is recommended that for comparison purposes, the costs of these externalities should be included prior to screening the options.

(b) Barrier: High capital cost
Measure (i): Government taxes on importation to be reduced or eliminated
In order to increase the contribution solar power projects, the capital costs of these projects needs to be low enough to attract private sector investments in these projects. One option available for reducing the high capital costs would be for the government to consider providing incentives in the form of reduced or no taxes on the imported components. The government may consider increasing the taxes imposed on fossil fuel based power plants in order to offset the loss of revenue.

Measure (ii): Donor agencies to consider providing adequate funds on concessionary terms.
Donor agencies having mandate to promote these technologies in the developing countries need to consider providing required funds on concessionary terms to private sector institutions enable accessing these technologies. Such funding, if necessary, may be channelled through the government treasury and through commercial banks.

Barrier: ***Operation and maintenance costs***

Measure: Cost reduction measures
Solar energy development is economically viable in Tanzania but project finance is not readily available. Financial institutions can be encouraged, through proper incentives such as introduction of financial guarantees, corporate social responsibility, frontloading and debt-based instruments etc.[21], to enable them to offer loans to retailers of solar technologies at rates that are more favourable than commercial terms. Retailers will thus have access to capital needed for procurements of solar

[21] www.snv.org/public/cms/sites/ default/files/explore/download/innovative_finance.pdf (accessed on 06th February 2017)

energy technologies (particularly for mini grids). It may also be essential to provide soft loans with low interest rates for solar energy projects. In addition, micro-lending schemes adopted by microfinance institutions should be encouraged and promoted. Micro-credit linked to micro-enterprise has proven highly successful in promoting renewable energy and reducing poverty in some countries. The government may consider introducing technology based payment differentiation instead having a uniform FiT.

(c) Barrier: Difficulty to access finance

Measure (i): Ministry of Energy should consider establishing a Fund to provide low interest finances for Renewable Energy and Energy Efficient projects. The Fund can be funded through imposing a levy on fossil fuels.

Measure (ii): Donor agencies to consider providing adequate funds on concessionary terms. Donor agencies having a mandate to promote these technologies in the developing countries need to consider providing funds on concessionary terms to private sector institutions to access these technologies. Such funding, if necessary, may be channelled through the government treasury and through commercial banks.

Measure (iii): Access to UNFCCC Mitigation Funds (Climate Funds Update 2016)
The imperative to take action to mitigate climate change impacts has never been more urgent. Despite international efforts, greenhouse gas emissions continue to rise. Climate finance has a crucial role to play in helping developing countries make the transition to more environmentally sustainable systems of energy production and use, while addressing developmental priorities of energy security and energy poverty. This money may be accessed to assist in financing climate friendly technologies such as solar power projects.

d) Barrier: Economic viability not examined
Measure (i): Relevant state institutions should conduct feasibility studies and publicize study results. In order to address this above barrier, it is recommended that the relevant state institutions such as TANESCO, EWURA etc. conduct economic and financial feasibility studies of Solar Technology and make the study findings available to the public and to the decision makers.
Measure (ii): Necessary funds should be provided to conduct such studies. Seek technical and financial assistance from the donor community for these studies which should include all relevant externalities of the technology concerned.

1.4.3.2. Non-financial measures

Measures to improve Information and awareness

Barrier: Low level awareness of the renewable energy

Measure: Consistent awareness creation

Large scale implementation of renewable energy applications can only be undertaken successfully with the understanding and support of the public and private sector. Hence, increased awareness into the benefits and opportunities associated with the development of solar energy technologies and the inherent advantage in general protection of the environment is vital to rapidly and significantly improve the desire and interest among the public and private sector across the country. Although, it may be argued that climate change is not an important issue in developing countries,

frequent blackouts due to frequent droughts that have significantly affected hydropower generation in Tanzania, has changed the way the public perceive the impacts of climate change.

Therefore, continuous awareness is an important ingredient needed to help diffusion solar projects. Awareness can be accomplished through various promotions and dedicated communication efforts primarily through workshops and media (television and advertisement) and community meetings/forums. These meeting and advertisement will need financial support of the government and non-governmental organizations.

Barrier: Poor Financial Position of the Off-taker
Measures: Implement Electricity Supply Industry Reform Strategy (URT, 2014)
This strategy aims at Improving TANESCO's financial position; Attracting private capital investment; Reducing public expenditure on ESI; Increasing availability, reliability, affordability and sustainable quality of electricity supply; Increasing connection and access levels; Diversifying sources of power generation; Improving efficiency and electricity service delivery; and Reducing system losses, both technical and non-technical. The reform will eventually result into unbundled energy generation, transmission and distribution business entities.

1.4.3.3. Technical measures

Barrier: Variability and intermittency of radiation
Measure (i) **The Law of Large Numbers:** This is a probability theorem, which states that the aggregate result of a large number of uncertain processes becomes more predictable as the total number of processes increases. Applied to renewable energy, the Law of Large Numbers dictates that the combined output of every solar power plant connected to the grid is far less volatile than the output of an individual generator. This means the benefits of integrating a solar power plant into the grid will be significant if there are several solar power plants connected to the grid.

Measure (ii) The Power of Prediction: While the law of large numbers and the effect of geographic diversity causes renewable energy to smooth out its own fluctuations on a second-by-second basis, it can still be difficult to predict the expected level of renewable generation during the next hour or two of the day. This will inevitable make modelling and predicting the aggregate renewable power available to the grid very difficult if not impossible. Solar energy depend on natural systems that can be modelled and forecasted with reasonable accuracy.

Measure (iii) Incentivizing Energy Production at the Right Time and Place: While it's possible to manage second-to-second and hour-to-hour fluctuations in renewable energy output through aggregation and prediction, predicting how much renewable energy will be available a day ahead of time is significantly more difficult. Integrating a large share of intermittent renewable energy into daily electricity operations will require a mix of sources that complement each other to roughly match total energy demand over the day. This is technically possible because solar energy peaks at various times over the day, depending on which way it is oriented. Accomplishing this mix will require an efficient and effective electricity market that incentivizes electricity generation at the right time and place. Existing competitive electricity markets already have prices that vary over the day and over a region depending on the local level of electricity supply and demand. Exposing renewable energy to these prices can help encourage a mix of renewable sources that produces just the right amount of energy when we need it, and reduces the need for costly energy storage.

Measure (iv) A Sustainable Electric Grid of the Future: While the challenges posed by the intermittent nature of many renewable energy sources certainly increase the complexity of

effectively operating the grid, they are far from insurmountable. In many ways, they pale in comparison to the enormous challenges that were overcome to develop the current grid. Minimizing the costs associated with renewable variability will be a major challenge of the coming years and decades.

Barrier: ***Grid unreliability***
Measures: Implement Electricity Supply Industry Reform Strategy (URT, 2014)
This strategy aims at Improving TANESCO's financial position; Attracting private capital investment; Reducing public expenditure on ESI; Increasing availability, reliability, affordability and sustainable quality of electricity supply; Increasing connection and access levels; Diversifying sources of power generation.

1.4.3.4. Political, legal and regulatory measures

Barrier: Government policy and incentives
Measure (i): Put in place favourable renewable energy policy
Favourable policies are fundamental to long-term sustainability of solar energy development. The life time and crediting period of large scale solar projects will exceed the democratic duration of any government in Tanzania (i.e. 5 years cycle). Ensuring that laws are stable and enforced is very vital as potential investors will need reasonable certainty that key legislative provisions put in place for solar activities will remain stable, unambiguous and enforced, thus allowing the continuity of investment into the future. In addition, the current electricity tariff is low; the tariff is not market reflective for profitable investment in power generation even with the existing fossil fuel energy sources and hence will not encourage any transactions into solar applications by any potential investor. However, increasing the tariff regime may be counter-productive considering the fact that larger portion of the population belong to the low-income level.

Measure (ii): Mitigate political and regulatory investment risk
The development of essential reform processes in political, economic and societal structures that will be needed to manage corruption, establish standards of transparency in public administration and enforcing established laws are essential in reducing the fundamental barriers of the political and regulatory risk of the country.

Barrier: Ineffective quality control of products
Measure: Establish and enforce quality standards for solar energy equipment
A lot of setbacks due to poor-quality solar systems had been suffered with some solar energy projects in this country. The Tanzania Bureau of Standard (TBS) and other government agencies such as Fare Competition Commission (FCC) need to establish suitable manufacturing standards and specifications and to strictly enforce them. Policy instruments and incentives could be introduced to encourage local production of solar devices. The failure of solar energy equipment and associated appliances are due to poor sizing and designs, resulting from lack of quality solar and other meteorological data.

Barrier: Competition with Land use
Measure: The Tanzania Investment Centre should identify suitable sites for solar power projects and acquire such land and register the land under its data bank
Land conflicts have occurred where the developers have gone straight to the villages and individuals and start the length process of acquiring land. In most cases people are not aware of the laws governing land acquisition in Tanzania. In order to avoid this, such land should be owned by TIC and the world be developers should acquire land from TIC.

1.5. Linkages of the Barriers Identified

Although the nature of the technologies varies from one another, some barriers have commonalities irrespective of the type of technology. Such barriers are designated as broader or common barrier. Such linked barriers are discussed below.

1.5.1. High capital cost and difficulties in accessing finance

High capital costs and difficulties in accessing required finance will be the most significant barrier common to all the energy projects in Tanzania. A number of factors that contribute to high capital costs have been identified and these factors include inter alia government taxes on importation and recent steady devaluation of Tanzanian Shilling resulting in escalation of prices of imports. Difficulties in accessing finance for these projects are mainly due to non-commitment of government policies to promote use of renewable energies. Furthermore the current liquidity in the banking sector is forcing the banks to diversifying into other lucrative sectors such as tourism where the return on investment is much higher. The reluctance of the banks to get involved in biomass and wastes based energy projects appears to be due to the uncertainty of fuel supply and price stability.

These two dual barriers could be resolved by appropriate policy interventions including policy reforms and implementation of existing provisions. As Tanzania is projecting to generate over 60% of the electrical energy using fossil fuels, the government is due to benefit in the long term by lowering or removing the taxes as an incentive to promote energy production based on renewable sources for obvious reasons.

Tanzania could assist in generating funds needed for renewable energy development and energy efficient projects by imposing a antipollution fuel tax. Funds so collected could be given for these projects at low interest sans external collaterals. Funds may also be sourced from UNFCC Mitigation fund.

1.5.2. Economic feasibility not properly assessed

This barrier is common to the sub projects of (a) mini and micro hydropower (b) conversion of MSW into RDF (c) use of solar energy. The feasibility studies related to these technologies need to address the issues related to: (1) Externalities of all alternatives (2) Subsidies granted for fossil fuel based electricity generation (this is due to the fact that the fossil fuel based electricity is costing more money per unit cost than the same unit is being sold (3) Cross subsidies built into the tariffs applicable to various consumer types (4) Growth prospects under no subsidy scenario in electricity marketing.
It is recommended that a team of economists/ engineers be assigned to conduct this study in a transparent manner in consultation with relevant stakeholders. The results of the feasibility studies should be made available to the information of the general public

1.5.3. Technology not established at the proposed scale or technology not fully developed.

This barrier is applicable to the technologies of: (a) Mini / Micro hydropower plant (b) Manufacture of RDF from MSW, (c) Solar PV technologies, since they are not common in Tanzania. However, these technologies are being implemented in many parts of the world. In order to build comfort to key stakeholders visiting such operating plants may serve as catalysis to diffusion of these technologies in Tanzania.

1.6. Enabling framework for overcoming the barriers in the Energy Sector

Among prioritized technologies for wider development of energy sector, some of them are already included in different national plans e.g. Updated Power Sector Master Plan (2016). According to this plan Tanzania is expected to increase its energy installed capacity of 1501MW (2015) to 4,912 MW (2020). The energy mix that is anticipated is Natural gas (40%), Coal (35%), Large Scale Hydropower (20%) and renewables (5%). The renewables included Solar PV, Mini Hydropower, Biomass, Geothermal, Wind etc. It can be seen from this anticipated energy mix that renewables are not a priority in the near future. The discussion on enabling frameworks for overcoming barriers to transfer and diffusion of prioritized energy technologies is based on this energy scenario. The enabling framework for the common barriers is given in Table 9.

Table 9: The enabling framework for the common barriers

Type	Common Barrier	Enabling Framework	Responsible
Financial	Limited financial capacity	Strategy to access funds from within the country and outside the country e.g. accessing carbon financing Framework to work with financial institutions providing venture capital	MEM Ministry of Finance and Planning Ministry of Industries and Trade
	High electricity tariff	Strategy to subsidise the electricity intended for those who can afford Provide tax incentives to developers	MEM Ministry of Finance and Planning TANESCO EWURA
	High capital costs	Provide tax incentives to developers	MEM Ministry of Finance and Planning
	Absence of manufacturers or dealers in the country	Legal framework and financial incentives to encourage manufacturers to establish their agencies in the country	Ministry of Finance and Planning Ministry of Justice and Constitutional Affairs Tanzania Investment Centre
Non-Financial	Limited human capacity and expertize	Develop appropriate training modules targeting the needed human resource expertise	Universities Vocational Training Institutions Technical Colleges
	Limited motivation for joint venture companies from small scale producers	Conduct promotional campaigns to relevant stakeholder	MEM TANESCO EWURA
	Limited facilities in R&D and demonstration pilot projects	Establish pilot projects for the renewable energy technologies	Universities Commission for Science and Technology Tanzania Industrial Research and Development

			Organisation CARMATEC
	Resistance to change & limited acceptance of technologies	Conduct promotional campaigns Put in place a policy to assist innovators and front runners Strengthen inter-agency coordination	MEM TIC

1.7. Cost/Benefit Analysis

The following discussion provides an analysis of costs and benefits for the prioritized technologies. It is includes direct costs such as generating costs [in: US dollars or cents per kWh] of each technology [such a parameter is calculated through an adjusted initial capital cost extended to the overall lifetime in this case 20 years, the fixed and variable operation and maintenance costs, the cost of energy fuels (if any) and Government Taxes. The indirect costs [environmental impacts of the technology] are calculated to show the external costs as such they are not included in the Benefit/cost ratio (in Tanzania there is no law in Tanzania requiring internalisation of costs). The benefits include direct benefits [e.g. resulting from selling electricity]; GHG emission credits [in: kg/MWh or g/kWh] are related to the contribution of energy technologies to the GHG mitigation applications (assuming that CO_2 can be sold) and sale of electricity for those technologies that generate electricity. Indirect benefits such as protection of environment, employment creation are not coming directly to the developer as such they are not included in the benefit/cost ratio. The costs and benefits are compared with the incumbent technologies i.e. power production using coal or diesel. Therefore the comparative analysis resulting from the ratio [in: USD/kg or USD/tonnes] between such costs and benefits [for the new and existing technologies]. Annual NPV (net present values) have been calculated for each technology over the lifespan (20 years) for a discount rate of 10 % both the costs and benefits have been discounted. Considering the multi-objectives of the TNA project aiming at fighting "against poverty, against the effects of climate change as interrelated efforts and contribution to sustainable development in general", the prioritized options include the Co-Firing of Biomass / Waste with Diesel; large scale Solar PV, Mini hydropower and the Compact Biogas Digesters.

Within the context of the TNA project and with targets accelerating low emission and low vulnerability pathways. In essence the technologies target are those that will enable the government to meet its energy needs to meets its development needs. The analysis present an alternative of replacing for instance the coal / diesel – fired power technology; and LPG usage by low- carbon biogas technology. As of May 2015, Tanzania's total installed generation capacity was 1,501 MW composed of hydro 525 MW (35 percent), natural gas power plants of 510 MW (34 percent) and liquid fuel power plants of 465 MW (31 percent). It can be seen that liquid fuel still contributes a significant share to the energy mix. Furthermore fossil based (e.g. LPG, Kerosene) and non-sustainable charcoal use is still a major energy sources in many households.

According to the Electricity Supply Industry Reform Strategy Road Map 2014 – 2025, Government's target is to raise the installed capacity from 1,583 MW (April 2014) to at least 10,000 MW by 2025. Thus the Technology Needs Assessment for Mitigation to Climate Change may have a role to play. The calculations below, i.e. Table 10 and Table 12, are therefore based on the scenario of replacing thermal power plant (2,628 GWh) by more clean options. Table 11 and Table 13 are based on replacing about 9,000,000 kg of LPG, however, this will not be associated with electricity generation.

Table 10: Costs and benefits with link to GHG mitigation (replacing diesel)

	Small Hydropower	Large Solar PV	Co-fired RDF (with Coal)	Diesel Based Power plant
Unit CO_2 emission [kg/MWh]	43	48	130	268
Annual CO_2 emission [megatons]	0.378	0.42	1.139	2.35
Avoided CO_2 emission [megatons/year][22]	1.97	1.93	1.21	0
Benefits [10^6 USD/year][23]	3.94	3.86	2.42	0
Benefits for selling electricity [10^6 USD/year]	27[24]	27	27	27
Benefits from employment	These are benefits to the economy not to the investor			
Total benefit (to the developer) [10^6 USD/year]	30.94	30.86	29.42	27
Unit generating cost [USD/MWh]	51.6	24.1	129.59	0.9[25] + 22.83[26]
Annual generating cost [10^6 USD]	11.3	5.28	28.4	5.2
Cost of paying salaries [10^6 USD]	0.11[27]	0.05[28]	0.27[29]	0.11
Government Taxes [10^6 USD/year]	5.86	7.52	0.23	6.51
Total costs to the developer [10^6 USD/year]	17.27	12.85	28.9	11.82
Benefit-to-cost ratio	1.80	2.4	1.02	2.28

NB. Intangible benefits [those associated with environmental protection, job creation, socioeconomic benefits associated with the technologies] are additional consideration. However, because of limited data available these are not evaluated in this report

It can be seen from Table 10 Diesel based power has a high benefit-cost ratio – suggesting that if no political intervention is needed to invest in low carbon technologies, this will remain a preferred option.

Table 11: Costs and benefits with link to GHG mitigation (replacing LPG and unsustainable charcoal)

	Compact Bio	Improved Charcoal

[22] CO2 emission from diesel = 2.68kg/litre
[23] Based on USD 2 per tonne of CO2
[24] Based on 1kWh = 273.89TZS
[25] Fuel cost: 0.9 USD per liter of diesel
[26] Assume – buying a diesel plant with same capacity at about 100Mill USD
[27] 20 people at TZS 1,000,000 per month
[28] 10 people at TZS1,000,000 per month
[29] 50 people at TZS1,000,000 per month

	digester kgCO2/kg biogas	Stove Tonnes / Cook stove (annual)
Unit CO2 emission	1.39	
Annual CO2 emission [megatons]	0.47	
Avoided CO2 emission [megatons/year]	27.65[30]	3
Benefits [10^6 USD/year]	55.3	6
Unit generating cost [USD/kg]	0.54	0.11
Annual generating cost[10^6 USD]	19.71	40
Benefit-to-cost ratio	2.81	0.15*

*The environmental benefits does not justify investment in efficient cook stove as a mitigation, as such it has been dropped from further analysis.

Table 12: Discount Net benefits at 10% discount rate per each technology for a scenario of replacing 876,000 GWh from fossil fuel thermal power plants

Nth Year	Mini Hydropower [10^6 USD/Year]	Co-firing Biomass / waste with Coal [10^6 USD/Year]	Solar PV [10^6 USD/Year]
1.	- 118.18	- 409.09	- 95.91
2.	21.60	19.11	25.38
3.	19.64	17.37	22.96
4.	17.85	15.79	20.87
5.	16.23	14.36	18.98
6.	14.76	13.05	17.25
7.	13.41	11.86	15.68
8.	12.19	10.79	14.26
9.	11.09	9.81	12.96
10.	10.08	8.91	11.78
11.	9.16	8.10	10.71
12.	8.33	7.37	9.74
13.	7.57	6.70	8.85
14.	6.88	6.09	8.05
15.	6.26	5.53	7.32
16.	5.69	5.03	6.65
17.	5.17	4.57	6.05
18.	4.70	4.16	5.50
19.	4.27	3.78	5.00
20.	3.89	3.44	4.54
	NPV = 80.6	NPV = **-233.28**	**NPV = 136.61**

Table 13: Discount Net benefits at 10% discount rate for Compact Biodigester of replacing 9,000,000kg of LPG

[30] LPG emission = 63tCO2/TJ

Nth Year	Compact Biodigester [10^6 USD/Year]
1.	- 18.18
2.	45.70
3.	41.55
4.	37.77
5.	34.34
6.	31.22
7.	28.38
8.	25.80
9.	23.45
10.	21.32
11.	19.38
12.	17.62
13.	16.02
14.	14.56
15.	13.24
16.	12.03
17.	10.94
18.	9.95
19.	9.04
20.	8.22
	NPV = **402.35**

Given that the CO_2 emission by diesel – fired technology is estimated at about 74.1 tCO_2/TJ of diesel replacement of such a technology by any renewable option will result in a significant mitigation. With regard to the above results, the best scenario is the replacement of diesel-based power technologies by alternatives presenting the lowest amount of CO_2 emission. The indicative cost of environmental externalities is varying between 2 and 28 USD per ton of CO2 emissions (IPCCC, 2007). Therefore, In consideration of this minimum 2 USD per ton of CO2 emission; externalities' costs related to the reduction of GHG emission were agreeable in accordance with the literature related to, among other publications, technical and economic assessment of energy technologies (ESMAP, 2007). Furthermore electricity generated from these technologies will be sold at 0.125 USD/kWh.

Solar photovoltaic is also important emitter of CO2. This is due to the process of preparation, treatment and other steps in the overall channel network of fuel production. Thus, it is important to remember that such trends are not affecting the operation process during the lifespan of large solar.

The NPV calculated for each prioritized technology in the sub-sector of electricity and presented above in Table 12 and Table 13 prove that all these technologies, except RDF based, are profitable; therefore their diffusion at large scale in Tanzania is recommended. RDF has shown a negative NPV meaning that it can not be implemented without subsidies.

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CHAPTER 2: FOREST SECTOR

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2.1. Preliminary Targets for Technology Transfer and Diffusion

Barriers and enabling measures are closely related to the technology transfer and diffusion targets to be achieved. Thus this Chapter outlines preliminary targets for the deployment of each selected technology in the forest sector, so that the barrier and enabling measures can be identified.

The prioritized forest technologies described in the TNA report are: sustainable forest management; agroforestry; sustainable mangrove conservation, rehabilitation and restoration.

Targets for Sustainable Forest Management (SFM)
The target group for the transfer and diffusion of this technology is forest users at community level, the government; and non-state actors (NGOs, CBOs, companies) engaged in SFM. These are considered as ideal for the good management and maintenance of SFM approach once put in place.

The preliminary target for the transfer and diffusion of SFM is to bring at least ten percent (10%) of 16,610.581 ha of forestland in central government owned forests, 3,107,351 ha local government managed forests, 21,975,094 ha in villages managed forests, and 3,515,889 ha in private forests under sustainable management by the year 2030. This is expected to benefit around thirty percent (30%) of users of forest products.

The involvement of key stakeholders will be critical towards the achievement of the above targets. The stakeholders include policy makers in the forest, agriculture, livestock and land sectors and relevant Ministries (e.g. Ministry of Natural Resources and Tourism), Departments and Agencies (e.g. Tanzania Forest Services). Others are community forest groups, NGOs (e.g. IUCN, WWF, and TFCG), private sector (e.g. Green Resources), academia (e.g. SUA, UDSM), media, and Development Partners. Stakeholders to be involved in the implementation of the technology include local communities (women and youth inclusive), forest related CBOs and NGOs as well as the Ministry of Natural Resources and Tourism; and the Tanzania Forest Services.

Targets for Agroforestry
The target group for the transfer and diffusion of agroforestry are subsistence farmers and users of agroforestry products.

The preliminary target for the transfer and diffusion of agroforestry is to introduce the technology to 30,000 farmers/ households by the year 2030. The preliminary target for agroforestry is to supply 12,000,000 agroforestry tree seedlings / species to 30,000 households and to establish and maintain 20,000 ha of agroforestry in 5 regions of Tanzania by the year 2025.

The average cost to put in place 1 ha of agroforestry plantation is USD 5,000 covering land preparation, seedling preparation (seeds purchasing, tubing, shade construction, nursery maintenance), installation of plantations and rejuvenation of forests.

The achievement of the above targets will require the active involvement of key stakeholders such as policy makers in the agriculture, forest and land sectors and relevant government ministries (e.g. Ministry of Agriculture, Ministry of Natural Resources and Tourism), Agencies (e.g. Tanzania Tree Seed Agency), and District Authorities. Others are community farmer groups and associations, NGOs

(e.g. ICRAF), private sector, academia (e.g. SUA, Agric. Research Institutes), media, and Development Partners. Stakeholders to be involved in the implementation of the technology include local communities (women and youth inclusive), farmer groups and associations, CBOs and NGOs, as well as the Ministry of Agriculture, Ministry of Natural Resources and Tourism, and District Authorities.

Targets for Mangroves conservation, rehabilitation and restoration

The target group for the transfer and diffusion of mangrove conservation, rehabilitation and restoration is the coastal communities – fishers and users of mangrove products.

The preliminary target for the transfer and diffusion for mangrove conservation, rehabilitation and restoration is to conserve 50,000 ha of mangroves by the year 2030. Also, it is aimed that the undertaking will provide 5,000,000 mangrove seedlings for rehabilitating and restoring 5000 ha of mangroves by the year 2030. This is expected to benefit around 100,000 coastal communities in five districts of Tanzania.

It is estimated that, the cost of rehabilitation and restoration of one hectare of mangrove may vary from USD 225 to USD216,000; and may sometimes go up to USD500,000/ha for individual projects (Lewis, 2001). The above cost is intended to cover for a) planting alone (most inexpensive), b) hydrologic restoration, with and without planting, and c) excavation or fill, with and without planting. Other activities may include conducting frequent awareness campaigns for key stakeholders (e.g. coastal communities), monitoring, security and maintenance cost of replanting sites.

Several stakeholders and actors will be needed to engage to realize the above targets. One of the most important stakeholder group is policy makers in the natural resource, agriculture and land sectors. Other important stakeholders are government Ministries (i.e. Natural Resources and Tourism, Agriculture and Food Security, Land and Human Settlement Development), Departments and Agencies (e.g. Marine Parks). Equally important stakeholders are researchers and experts in mangroves and coastal livelihoods. Implementing groups are coastal communities, CBOs and NGOs dealing with mangroves and coastal livelihoods and District authorities.

2.2. Barrier Analysis and Possible Enabling Measures for Sustainable Forest Management

2.2.1. General Description of Sustainable Forest Management

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 forests 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. The SFM concept encompasses both natural and planted forests in all geographic regions and climatic zones, and all forest functions, managed for conservation, production and 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.

Participatory Forest Management in Tanzania is grouped into two categories: Community-Based Forest Management (CBFM) and Joint Forest Management (JFM).

- CBFM enables local communities to declare – and ultimately gazette – Village, Group or Private Forest Reserves
- JFM - allows communities to sign joint forest management agreements with government and other forest owners.

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).

2.2.1. Description of barriers for Sustainable Forest Management

A total number of 10 barriers to the adoption and scaling up of Sustainable Forest Management (SFM) have been identified. The barriers are categorised into four (4) economic barriers and six (6) non-economic barriers and are discussed below.

2.2.1.1. Economic and financial barriers

a) Long term nature of sustainable forest production and management

Returns from SFM are essentially long term when compared to other economic activities that deliver direct, short term benefits. Globally there are many indications that sustainable forest production can produce acceptable financial results. However, there is evidence that, over short periods, unsustainable practices are viewed to be more profitable. Thus, most investors have little financial incentive to invest in sustainable forest management. Consequently, making sustainable forest management financially attractive becomes a major challenge, that it necessitate SFM strategies to include wood production as a major objective in forest management due to high commercial value of wood in most forests which may lead to oversight to other SFM objectives (FAO, 2005).

b) Inadequate financing in SFM activities

The forest sector is not a high priority in the country development agenda. As such, it receives low budgetary allocation and even lower disbursement of funds for carrying out forest law enforcement and other SFM activities. The forest budget is less than 1% of the national budget and a large share (58.5%) of the sectoral budget is derived from donors (Kiimu, n.d.). On the other hand, unlike other sectors like agriculture, energy and water, the sector experiences inadequate investments from the private sector leading to a limited number of privately owned forests.

c) Under-valuation of forest resources in decision making

Decision makers, often relying on conventional economic approaches, have a tendency of excluding livelihood and environmental benefits generated by forest landscapes. This has resulted into market, policy and management decisions which have a significant adverse impact on forests. Forest resources are undervalued due to low awareness and lack of markets for most forest goods and

services. Forest resources are undervalued in decision making because of the tendency to favour forest management regimes and market development opportunities that focus only on maximizing large-scale, commercial (usually extractive, and often unsustainable) benefits (Emerton, 2012). Income resulting from non-timber forest products for example medicines, provision of soil nutrients, fodder, etc. far exceeds income from commercial logging.

d) Presence of economic disincentives

There exists several economic instruments (e.g. taxes, subsidies, loans, credit arrangements, interest rates) aimed at attracting producers, investors, consumers and at stimulating productivity, employment and income through improving viability and returns (Mogaka et al., 2001). These economic instruments have favoured the provision of lower tax rates, subsidies, preferential credit arrangements and tax relief. As a result, lucrative sectors such as agriculture, industry, mining, water and energy, have benefitted from such instruments, thus catalysing their expansion and intensification at the expense of forests. This also has an implication on the relative desirability of different land and resource uses at the community level, making sustainable forest-based activities appear to be less economically desirable.

2.2.1.2. Non-financial barriers

a) Lack of awareness

Forest stakeholders' particularly local communities have limited awareness on sustainable forest management particularly on forest resource assessment, fire control, nursery management, and appropriate reforestation techniques. This is due to low literacy, inadequate awareness campaigns and limited access to forest extension services. All these lead into unsuccessful conservation efforts and unstainable harvesting of forest resources resulting into deforestation and forest degradation.

b) Limited institutional capacity

The capacity of forest institutions (from the local to the national level) to promote and implement SFM is limited. These institutions have limited skilled staff (most have limited technical expertise) and are financially constrained due to a high dependence on donor funds and relatively lower budgetary allocation. Also, limited availability of facilities and equipment for supporting forest management activities adds up to staffing and financing challenges. It follows that forest institutions are unable to plan and implement priority actions on SFM.

c) Unequitable sharing of benefits

Mechanisms for sharing benefits arising from efforts to conserve forest are either lacking or not implemented. For years, clear guidelines on benefit sharing between the government and local communities have been absent. The government has been quite slow in developing and approving the same casting doubts within the conservation community of its willingness to share the benefits with communities. On the other hand, benefits from forest resource management are captured by the few elites (businessmen and local leaders) thus discouraging community participation in natural resource management. Also, unfaithful forest managers engage in fraudulent acts through accepting bribes at checkpoints and during patrols to evade fines and thus taking away revenues due to the government. These revenues would have been used to support conservation efforts. The underlying cause of rent seeking and fraud is poor governance of natural resources manifested by lack of accountability and transparency.

d) Insufficient enforcement of forest related laws and regulations

The degradation of forest resources in Tanzania is on the rise despite the presence of laws and regulations due to weak enforcement. A combination of factors such as lax attitude, corruption as well as inadequate funds and personnel weaken law enforcement. Another cause is limited political support and sometimes political interference make the enforcement of laws impossible in some areas. Likewise, fines and penalties against offences and culprits stipulated in forest law are inadequate to deter future offences – the law is nearly 20 years old and so needs to be reviewed.

Another related issue is limited awareness amongst magistrates and judges on environmental law. This is not to exclude limited capacity of public investigators to prosecute forest related crimes.

e) Unclear land and tree tenure rights

Communities and private communities find it less appealing to engage in sustainable forest management due to lack of clear and secure land tenure rights. All land in Tanzania is owned by the state and this presents a risk of losing it to the state whenever that part of land is need for national development projects or investments, and such land is not fairly compensated. On the other hand, there exist insecure tree tenure rights arising from Government agencies instituting bans on harvesting of forests or cutting trees. This leaves farmers wondering if they are real owners of the trees.

f) Poor sectoral coordination

A number of Ministries are involved in the management of land-forest-water resources such as Ministry of Natural Resources and Tourism, Ministry of Lands and Human Settlement, Ministry of Agriculture and Food Security, Ministry of Water and the Division of Environment under the Vice President's Office. In several cases, these institutions work in silos leading to un-harmonized policy actions on sustainable forest management. This is caused by lack of inter-sectoral collaboration mechanisms. The outcome of uncoordinated efforts is the duplication of efforts as well as unsustainable initiatives and lack of long term gains.

2.2.2. Identified measures

A total number of 10 measures for enhancing the adoption and scaling up of Sustainable Forest Management (SFM) have been identified. Specifically, there four (4) economic measures and six (6) non-economic measures; and these are discussed below.

2.2.2.1. Economic and financial measures

a) Increase access to financial resources for Sustainable Forest Management

In order to promote and strengthen sustainable forest management for state and privately owned forest resources, there is a pressing need to enhance access to financial resources.

- Lobbying for increased budgetary allocation and disbursement for the forest sector.
- Carrying out fundraising efforts by the civil society and the government for supporting forest conservation projects in several parts of the country.
- Engaging the private sector to invest in forestry through Public-Private Partnerships (PPP)
- Strengthening the capacity to access finance from international financing mechanisms such as REDD+ and PES

b) Improve profitability of sustainable forest production and management

Low profitability of the forest sector has led to its disregard by some decision makers and communities. In order to upscale sustainable forestry management, increasing its profitability is extremely inevitable. Profitability can be enhanced through

- Promoting the adoption of a variety of new production alternatives which are both profitable and conservation oriented. These alternatives include agroforestry, beekeeping, mushroom farming, handicrafts, ecotourism and use of non-timber forest products.
- Addressing market failures for example by helping rural populations to better capture values in existing forest markets and strengthening value-addition in market chains.
- Increase access to emerging economic opportunities and markets for catalysing a shift from unsustainable forestry management practices.
- creating new markets for forest goods and services and using market development to leverage other investments and market flows to the rural poor

c) Addressing under-valuation of forest resources in decision making

It's critical that under-valuation of forest resources be addressed by accounting local level benefits and ecosystem services and addressing links and distribution of values between different users, groups and levels of scale (Emerton, 2012).

- Carrying out advocacy and awareness raising campaigns to inform decision makers of the linkages between forests and rural livelihoods and the economy
- Performing economic analyses on the benefits and costs of SFM in order to inform decision makers from the local to the national level
- Empower communities to participate in decision making regarding forest resources

d) Eliminating economic disincentives

Existing economic incentives have served to discourage stakeholders (farmers and the private sector) from engaging in sustainable management of forest resources. Eliminating or adjusting disincentives to SFM such as, unfair tax rates, subsidies, and loans/credit arrangements is critical to enhancing the adoption of SFM (Emerton, 2012). These will be eliminated by reviewing a number of laws, polices and guidelines. The elimination of such disincentives will help to increase the profitability of sustainable forest management and overcome the barriers to local market participation. Also it will work to discourage people from engaging in environmentally damaging forest resources and the environment in general.

2.2.2.2. Non-financial measures

a) Improve awareness on sustainable management of forest resources.

The fact that limited awareness is a key barrier constraining the adoption of sustainable management of forests, improving stakeholders' awareness particularly local communities is not only necessary but urgent. Relevant measures will include:

- Rolling out awareness raising campaigns through sensitization meetings targeting local communities
- Providing technical training to foresters and land resources managers.
- Disseminating information through community radios
- Distributing communication products

The focus of awareness campaigns may include the benefits of forests in sustaining rural livelihoods and the economy, forest conservation, reforestation, forest assessment, sustainable harvesting. Raising awareness should be the responsibility of the Government, civil society, the academia and the private sector

b) Strengthening the institutional capacity of forest institutions

If sustainable management of forest resources is to be promoted and implemented widely and effectively, the capacity of forest institutions (e.g. Ministry of Natural Resources and Tourism, Tanzania Forest Services, Tanzania Forest Fund and forest department at Local Government Authorities) should be strengthened. Activities to strengthen capacity include:

- Providing tailored technical training to foresters by developing relevant courses and sponsoring them to attend such courses and seminars.
- Recruiting skilled foresters
- Providing institutions with required facilities e.g. vehicles and facilities (e.g. GPS) needed for conservation.
- Increasing financing of the forest sector by accessing public and private funds.

c) Enhancing equitable sharing of benefits

Unequitable sharing of benefits undermines the participation of communities in conservation initiatives. It would be significant to implement the following towards the elimination of inequitable sharing of benefits:

- Putting in place clear benefit sharing mechanisms will ensure that communities' efforts in conservation are fairly rewarded. The major responsibility for finalizing equitable sharing of benefits (between the government and communities) rests with the Government
- Directing a large share of forest revenues to the forestry sector to support conservation efforts.
- Addressing the capture of benefits by the elites by strengthening the capacity of local natural resource governance structures (village natural resource/ environmental committees)
- Strengthening transparency and accountability regarding forest revenues.
- Engaging all key stakeholders in combating corruption in the sector

d) Strengthen forest law enforcement

Weak enforcement of forest laws has resulted into the degradation and deforestation of forests in Tanzania. Factors contributing to weak enforcement - lax attitude, corruption, inadequate resources and political interference, should be addressed. Relevant measures to address the underlying causes of weak enforcement are:

- Providing incentives to law enforcers based on their efforts (better remuneration)
- Combating all forms of corruption at all levels
- Increasing access to resources for patrolling (staff, vehicles and funds)
- Lobbying to mobilize political will and support for law enforcement
- Raising awareness on existing laws to boost compliance amongst communities
- Strengthening the capacity of local natural resource governance structures to participate in the enforcement of existing laws and by laws
- Reviewing fines and penalties for forest related offences to ensure that they deter criminals.
- Raising the awareness of public prosecutors, magistrates and judges to effectively prosecute and try environmental crimes.

e) Unclear land and tree tenure rights

Clear tenure rights are critical incentives for communities to engage in sustainable forest management. The following measures are proposed to address unclear and insecure tenure rights:

- Advocate for the development of policies geared towards land rights formalization
- Develop regulations to protect traditional land rights holders against large scale investments
- Support cost effective and participatory programs aimed at enabling farmers to register and record land rights
- Support the registration and recording of land rights for communities engaged in SFM as a way of increasing assurance and preventing elite capture.
- Promote the design and implementation of flexible mechanisms for temporary and permanent transfers of rights to increase opportunities for capturing the full value of SFM investments
- Provide support to relevant regulatory and policy reforms intended to clarify rights related to land, trees, forest products, water and carbon

f) Poor sectoral coordination

Ministries with a stake in forest resources should work together to promote sustainable management of forest resources.

- Using the National Environmental Advisory Board or establishing a Steering Committee for addressing forest related issues. This organ will bring together the Ministry of Natural Resources and Tourism, Ministry of Lands and Human Settlement, Ministry of Agriculture

and Food Security, Ministry of Water and the Vice President's Office-Division of Environment.

- Strengthening inter-sectoral planning and collaboration through regular meetings and sharing of information.

2.2.3. Cost Benefit Analysis of Sustainable Forest Management

Key activities under Sustainable Forest Management include: institutional development, resource development, sustainable utilization as well as assessment and monitoring of forest resources.

a) Value of the costs of sustainable Forest Management

The cost for sustainably managing one hectare of a tropical forest is USD 12 covering expenses for implementation, management and capacity building (Köthke, 2014). Additional costs include 6.25 USD per hectare. Based on the above data, total costs for sustainably managing one hectare is about USD 18.

Per the preliminary target for the transfer and diffusion of SFM, areas of different forest types to be brought under SFM are at least ten percent (10%) for each of:

- 16,610.581 ha (forest land in central government owned forests),
- 3,107,351 ha (local government managed forests),
- 21,975,094 ha in villages managed forests, and
- 3,515,889 ha in private forests

Using a unit cost of USD 18 per ha, the total cost would be as follows:

Table 14: Costs for implementing Sustainable Forest Management in Tanzania

Forest Type	Forest area under SFM (ha)	Total Cost (USD)
Central Government Forests	1,661	29,899
Local Government Forests	310,735	5,593,232
Village Government Forests	2,197,509	39,555,169
Private Forests	351,589	6,328,600
Total	**2,861,494**	**51,506,900**

b) Value of the benefits of sustainable Forest Management

The Table 15 provides summary economic values (USD/ha/year) (Pearce and Pearce, 2001). Forest ecosystem services with the higher values (Net Present Value) generated in a tropical forest (of which Tanzanian forests are part) come from Existence values (for unique areas) (4,000 USD/ha/year), timber logging - conventional (200 – 4,400 USD/ha/year), genetic information (0-3,000 USD/ha/year), sustainable logging of timber (300 - 2,660 USD/ha/year and climate benefits (360 – 2,200 USD/ha/year) (Pearce and Pearce, 2001)

Table 15: Values of different ecosystem services provided by mangroves (USD/ha/year) (Pearce and Pearce, 2001; Lescuyer, 2007)

Forest ecosystem service	Forest Good or Service (in discounted US$/ha or in US$/ha/year)	
	Global estimates	Estimates based in Cameroon
Timber	200 - 4,400	560
Fuelwood	40	61
NTFPs	0 - 100	41 - 70
Genetic resources	0 - 3,000	7
Recreation	2 - 470	19
Watershed benefits	15 - 850	54 - 270
Climate benefits	360 - 2,200	842 - 2,265
Option values	2.0 - 12	3
Non-use values	4,400	19 - 32
Total Economic Value	4,619 - 15,072	1,606 - 3,287

Based on global estimates, the TEV of forest resources is estimated to range from 4,619 - 15,072 USD/ha/year. No economic valuation of forest resources has been in Tanzania, save alone a study by UNEP (2015) that looked at the benefits of catchment forests. This study found that, the benefits of managing Catchment Forest Reserves (CFRs) on a sustainable basis, extracting timber resources, non-timber forest products, and intermediate services, amount to TZS 1,000,000/= (roughly USD 500) per hectare per year (UNEP, 2015). Unfortunately, the study does not compare these benefits to investment costs in the CFRs. A study by Lescuyer (2007) conducted in Cameroon showed TEV to range from 1,606 to 3,287 USD/ha/year. This is estimations are far below the global estimates derived by Pearce and Pearce (2001). This analysis has opted to apply the global estimates of TEV of sustainable forest management.

The net economic value of SFM calculated as 4,619 - 15,072 USD/ha/year x 2,861,494 ha ranges from 13,217,240,786 to 43,128,437,568 USD/year. The total cost for 2,861,494 ha of community, state and privately owned forests is 51,506,900 USD/year. The benefits of SFM extremely outweigh the costs, thus implementing SFM in Tanzania is justified.

2.3. Barrier Analysis and Possible Enabling Measures for Agroforestry

2.3.1. General description of agroforestry

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”

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. Leguminous trees 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 purposes 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.

2.3.2. Identification of barriers for Agroforestry

A total of twelve (12) barriers to the adoption and use of agroforestry have been identified – whereas four (4) barriers are economic and eight (8) are non-economic. The description of each barrier follows below.

3.1.1. Economic and financial barriers

a) Low financing for agroforestry

There are limited opportunities for accessing financial resources for investing in agroforestry. Financial institutions are not motivated to provide loans and credits to non-commercial investments. Therefore farmers have limited economic means to invest in agroforestry and end up not investing in agroforestry at all. Local government authorities dedicate most of the resources to sectors such as education, health, water and infrastructure and roads. As a result agroforestry receives very little funds as a share from agriculture and forestry funds (Place et al, n.d.)

b) High investment costs

Agroforestry involves high up-front costs emanating from the procurement of inputs such as high quality seeds, herbicides and labour. Most farmers use cheap seeds that are collected locally and these are of low quality and productivity. They take that option because they have limited access to financial resources and very low purchasing capacity to opt for high quality tree seeds. Likewise, the cost of herbicides to control pests and disease is quite expensive and out of reach for most of rural communities who have no regular income. Herbicides are expensive and are not readily available locally and require additional equipment and facilities to apply them. Agroforestry is labour intensive and most of labour used in agricultural activities is family labour. This implies that the family is unable to engage in the production of other crops and non-agricultural goods, and communities are unwilling to invest labour resources into this activity. Apart from incurring high investment and maintenance costs, agroforestry takes time a considerable time (5-10 years) before benefits are realised.

c) Limited access to markets for agroforestry products and services

Agroforestry products and services have a limited market. As a result there is low demand and consequently low markets available for agroforestry products and services. In addition, limited market availability leads to poor viability of the technology. It has been observed that well-developed product markets that could reward small-holder farmers with premium prices for their farm produce is missing in Tanzania (Kitalyi et al, n.d.).

d) Limited access to high quality agroforestry germplasm

Farmers have limited access to high quality agroforestry germplasm due to many reasons including poor seed distribution channels, presence of poor quality seed germplasm in the market, low willingness to pay for high quality seeds, and high cost of high quality agroforestry seeds. High quality seeds are undersupplied because tree seed agencies are centralised and have fewer branches to serve farmers. For example, the Tee Seed Agency has zonal offices combining several regions and these centres are not easily accessible to many farmers. As such there is little institutional structure to ensure that agroforestry seeds are available off-shelf as the case of annual crops which are promoted and distributed by both the public and private sector (Kitalyi et al, n.d.). Local seed markets are flooded with low quality seeds that are collected locally by local entrepreneurs who have limited knowledge on seed selection. Due to high costs of high quality seeds, farmers are not willing to pay for the procurement of those seeds, partly because they have no regular income. As a result, poor quality seeds are used leading to poor performance of agroforestry technology which in turn discourages other farmers from adopting the technology.

3.1.2. Non-financial barriers

a) Inadequate awareness on agroforestry

There is inadequate awareness amongst farmers on different agroforestry approaches including their benefits. Factors behind limited awareness of agroforestry approaches and benefits are inadequate awareness raising campaigns and sensitization meetings as well as limited access to training programmes and lack of agroforestry demonstration plots. At the grass root level, there is inadequate awareness raising campaigns including training due to lack of funds, limited availability of skilled agroforestry extension staff and limited participation by key stakeholders. In several areas where agroforestry is being promoted, demonstration plots for agroforestry are missing partly due to lack of important inputs (land, seeds, herbicides, implements, etc.) and inadequate extension staff. Another critical factor is limited availability of agroforestry communication materials in user friendly languages and low reading culture within the society. All the above factors combine to undermine the adoption of agroforestry, lower the productivity and discourage farmers from engaging in agroforestry.

b) Limited extension services

Agricultural and forest extension services are key to the adoption and effective implementation of agroforestry technologies by farmers. There is limited access to extension service due to several inter-related factors namely inadequate extension staff, limited technical expertise amongst extension staff and inadequate extension visits. In several areas of Tanzania, there are few trained agroforestry extension staff but the so called agricultural and livestock extension staff posted at the ward level. This supports the view that agroforestry is not sufficiently known by extension agents, hence less likely to be disseminated to farmers (Place et al., n.d.). This creates an information bias towards other types of practices, for example convention crop husbandry practices amongst agricultural extension workers and convention tree based approaches for forestry officers.

The number of extension workers is inadequate to serve a whole ward of three to five villages which are usually far apart. These extension staffs are trained either in agriculture or livestock and so have limited knowledge of forestry component of agroforestry. Extension workers do not usually receive technical exposure or tailored agroforestry training, yet are entrusted with assisting farmers with the adoption and implementation of agroforestry. Equally important, inadequate number of extension staff, limited accessibility of some areas (due to lack of transport or remoteness) and low motivation amongst extension staff, often leads to limited field visits. It has been reported that, the low number of extension visits is attributed to the low extension staff–farmer ratio of an average of one extension officer to two thousand (1:2,000) farmers prevalent in Southern Africa (including Tanzania) against the recommended ratio of 1:500 (Masangano and Mthinda, 2010). It is understood that frequent interactions between farmers and extension agents is likely to increase knowledge

acquisition and understanding of agroforestry by farmers by way of demonstration plots on farmers' fields (Mwase et al, 2015).

c) Adherence to traditional farming practices by communities (technological lock-in)

Farmers tend to adhere to traditional farming practices and are resistant to adopting a new technology like agroforestry. Reasons for this include suspicion and misconceptions about agroforestry, limited evidence on the performance and effectiveness of agroforestry, as well as natural tendency to resist change. Farmers' suspicions and misconceptions about agroforestry include- for example some farmers believe that adopting agroforestry implies the loss of a sizeable piece of the farming land to trees or that agroforestry contributes to low yields due to the competition for resources between trees and crops. The suspicions and misconceptions are caused by lack of knowledge resulting from inadequate awareness. This may also be due to inadequate efforts to develop and disseminate communication materials targeting local communities. On the other hand, no evidence has been documented and even disseminated of the performance and effectiveness of various agroforestry technologies. Specifically, for most farmers who must see proof of concept, the absence of demonstration blocks hinders the adoption of the technology. Again, human beings are naturally resistant to change, as this entails risks. Some farmers may view agroforestry as a foreign technology being promoted to compete against and replace their conventional agricultural technologies which have been in place since time immemorial.

d) Limited institutional capacity to promote agroforestry practices

Institutions from the local to the national level have limited capacity to promote agroforestry practices. These institutions are under-resourced – facing challenges of inadequate skilled extension workers, inadequate financial resources and limited means of transport. The presence of insufficient number of skilled extension workers means that only a small proportion of farmers are likely to be reached by the extension services. This implies that only a handful of farmers will have the right knowledge and skills required for the adoption and sustaining of agroforestry practices. Limited access to funds and transport is a major hindrance for furthering agroforestry as extension workers are not able to visit farmers in their fields to offer the required services. Limited access to funds also translates to the inability of respective institutions to carry out activities aimed at promoting agroforestry including awareness and sensitization meetings, establishment of demonstration plots and dissemination of communication materials.

e) Limited access to benefits from agroforestry

Agroforestry has limited ability to deliver direct and short term benefits. Many of the benefits arising from agroforestry are indirect – in terms of ecosystem services that are not easily quantified, valuated or sold. For example, agroforestry helps to enhance soil fertility and control soil erosion – services that are often unrecognized by and easily tradable in markets. On the other hand, the benefits of agroforestry are realized in the medium to the long term i.e. 5 – 10 years. However, farmers are faced with the daily challenge of securing basic needs (e.g. food, shelter, clothing, education, and medication) usually on a daily basis or some short period of time. In this way, many farmers are discouraged from adopting agroforestry technologies.

f) Land and tree tenure

Unclear or insecure land and tree tenure is a key disincentive to the adoption and upscaling of agroforestry. There is evidence that state ownership of land and reallocation programmes undermines long term land investments in places. In addition, current drives by the government to attract large scale foreign investors have worked to increase land tenure insecurity in many rural communities. The Forest policy regulates the harvesting, cutting or sale of tree products and certain tree species thereby inhibiting the planting of trees. Even in the best of intentions, the application of

such regulations has done more harm to discourage farmers from planting and protecting new seedlings that emerge in agricultural landscapes (Place et al., n.d).

g) Presence of subsidies and support for other land uses

In many countries including Tanzania, there exist price floors for food products as well as subsidies for specific inputs like fertilizer (this catalyses higher use of fertilizer and less interest in using agroforestry) and favourable credit terms for certain group of agricultural activities. Most of these measures do not apply to agroforestry and farmers are discouraged to adopt agroforestry.

Despite the fact that fertilizers are needed to improve crop productivity, their promotion at the expense (or exclusion) of agroforestry based fertilizers not only promotes a narrow technological package but also undermines long term soil health. Government support for agriculture exists; unfortunately agroforestry rarely or never features as an agricultural enterprise for support. Low interest credit is available for agriculture but agroforestry is excluded because it is considered to fall under forestry.

Market information systems for agroforestry products, unlike other agricultural commodities, are yet to be improved and tree products are largely ignored. Most mono-specific tree crops benefit from research and development initiatives unlike the case with varieties in more multi-species agroforestry systems (Place et al, n.d.)

h) Poor inter-sectoral planning and coordination

Agroforestry is viewed to have an orphan, because, while it is important to many ministries practically it belongs to none. Agroforestry has passed through from being attached with forestry – which have had comparatively few resources, to agriculture where the practice is known especially when linked to soil fertility benefits.

Generally, agroforestry receives minor attention in forestry and agriculture policy and legal documents – mainly as one of the options for addressing sustainability. Accordingly, in the face of climate change, agroforestry has emerged as a key option for climate change adaptation and mitigation giving it a place in environmental ministries, themselves not implementers but policy coordinators. Unfortunately, there is limited inter-sectoral planning and resource sharing amongst the three ministries.

2.3.3. Identified measures

A total of 12 measures have been identified to address barriers to the adoption and scaling up of Sustainable Forest Management (SFM) –whereby four (4) economic measures and eight (8) are non-economic measures have been described.

2.3.3.1. Financial and economic measures

a) Increasing financing for agroforestry

Unlocking barriers to financing agroforestry requires the identification of innovative measures. These include:

- Relaxing collateral requirements on credits by banks and financial institutions.
- Lowering interest rates on loans and credits
- Increase access to micro-credits
- Tapping opportunities presented by international funding mechanisms e.g. REDD+

b) Addressing high up-front investment costs on agroforestry

High investment costs on agroforestry which often discourages farmers from adopting the technology have to be addressed.

A number of measures that are effective in addressing high investment costs (World Agroforestry Centre, 2011) include:

- Provision of low tax agroforestry inputs such as seeds, herbicides and implements
- Building farmers capacity to access payments for ecosystem services including carbon payments (e.g. Plan Vivo provide activity-based ex-ante payments) for terrestrial carbon sequestration
- Promote the provision of financial instruments such as microcredits or index insurances

c) Increasing access to agroforestry markets

Increasing access to markets for agroforestry goods and services (World Agroforestry Centre, 2011) should be achieved through:

- Adding value to agroforestry products and services
- Undertaking research to understand and develop linkages to improve market opportunities for agroforestry.
- Improving infrastructure.
- Establishing local cooperatives for pooling resources to access markets.

d) Increasing access to high quality agroforestry germplasm

The following measures have been identified as key to increasing farmers' access to high quality seeds:

- Subsidize the cost of high quality tree seeds as the case with annual crop seeds
- Improve distribution of tree seeds to reach the district level
- Develop systems and structures of public and private sectors for managing the multiplication and distribution of tree seeds
- Engage farmers and the private sector in the collection and production of tree seeds
- Creating a demand for new agroforestry systems (e.g. fertilizer trees) to pave way for the private sector engagement.
- Advocate for increased government role in the provision of seeds and seedlings for tree planting campaigns
- Establish and maintain government nurseries and sell the seedlings at subsidized rates
- Increase access to information regarding the quality and source of agroforestry germplasm

2.3.3.2. Non-economic measures

a) Strengthening capacity to promote agroforestry

The capacity of national and local institutions should be strengthened in order to be able to promote agroforestry.

- Increase technical knowledge of foresters, agro-foresters, agronomists and agriculturalists through technical training
- Facilitate learning through study tours and exchange visits
- Recruit more skilled extension workers
- Fundraise for agroforestry
- Increase availability of means of transport

b) Increasing awareness and knowledge on the benefits of agroforestry

Inadequate knowledge on appropriate agroforestry approaches and their values undermines the adoption and use of agroforestry. The following measures are being are critical to improving stakeholders awareness on agroforestry leading to increased adoption rates.

- Supporting the provision of technical training to extension workers to bridge knowledge gaps on agroforestry

- Organize sensitization meetings for the promotion of agroforestry at community level.
- Organizing awareness raising campaigns (e.g. documentaries, columns) in the media (radio, newspapers and TV)
- Promoting learning through study tours and exchange visits amongst extension workers and farmers
- Introduction and improvement of the farmer trainer method in order to reach a wider audience of farmers.
- Develop and disseminate the manual on agroforestry practices and important indigenous tree species.
- Promoting agroforestry through demonstration plots.
- Enhancing interactions between farmers and extension workers through education farm visits

c) Enhancing the provision of extension services

Limited availability of extension services has been identified as a key barrier to the adoption of agroforestry. The following measures are relevant for enhancing extension services.

- Building the capacity of extension workers through technical training
- Recruiting skilled extension workers to fill human resource gaps
- Motivating extension workers by supplying them with required facilities and services
- Sponsoring extension workers to participate in knowledge sharing events e.g. workshops, study tours and site visits.

d) Improve the ability of agroforestry to deliver short term and direct benefits

In tackling agroforest's inability to deliver direct and short term benefits, implementing the following measures will be important to ensure that farmers stay motivated to continue with agroforestry.

- Promoting the production and use of fast maturing varieties
- Promoting high value but short term agroforestry
- Increasing market access for agroforestry products

e) Promote a shift to agroforestry farming practices

To promote the adoption of agroforestry practices in communities, it is critical to implement the following:

- Increase awareness about the benefits of agroforestry to farmers
- Support exchange visits and study tours for farmers to witness the performance and benefits of agroforestry
- Document and disseminate lessons learned and best practices on agroforestry
- Promote the use of agroforestry demonstration plots to help clear out farmers misconceptions about agroforestry.
- Validate local ecological knowledge and integrate into technical knowledge

f) Address insecure land and tree tenure through legal and policy review

In order to positively influence farmers' willingness to invest in their land and improve productivity, there is a need to promote more secure tenure of land and trees. It is known that farmers Investments in agroforestry is comparatively higher on land with secure tenure (World Agroforestry Centre, 2011). Unclear and insecure tenure rights which so often undermine the adoption and investment agroforestry can be addressed by a combination of factors.

Measures to address clarity and security of tenure rights include the following:

- Promote land right formalization (land titling) in the presence of checks against local elites capture of the reform
- Advocate for the development of policies geared towards land rights formalization

- Develop regulations and guidelines to protect traditional land rights holders against large scale investments
- Support cost effective and participatory programs aimed at enabling farmers to register and record land rights
- Support the registration and recording of land rights for communities engaged in agroforestry as a way of increasing assurance and preventing elite capture.
- Promote the design and implementation of flexible mechanism for temporary and permanent transfers of rights to increase opportunities for capturing the full value of agroforestry investments
- Providing support to relevant regulatory and policy reforms intended to clarify rights related to land, trees, forest products, water and carbon

g) Addressing adverse incentives and promoting pro-agroforestry measures

Eliminating existing policy and legal disincentives is necessary if agroforestry has to be adopted and up scaled. Measures to be promoted and implemented include:

- Reduction of national expenditure on nitrogen mineral fertilizers by 25% to 50% annually by exploiting the synergy between fertilizer trees and mineral fertilizer.
- Integration of fertilizer tree seeds as an integral part of the inputs package of the ASDP and DADPS Programme to ensure sustainable soil fertility replenishment.
- Lowering high interest rates for investments in agriculture, agroforestry inclusive
- Expanding access to credit by lowering collateral requirements by banks and financial institutions. Providing subsidies to the private sector for nurseries establishment and germplasm collection campaigns

h) Improve institutional collaboration

Key measures to improve inter-sectoral planning and coordination include:

- Development of a clear policy and legal framework to provide guidance on agroforestry and address existing challenges.
- Establish an independent department of agroforestry at the central and local level
- Institutionalize agroforestry as part of the official programme of activities in the ministries responsible for agriculture; livestock, forestry and environment.
- Enhance communication and information sharing across relevant sectors
- Initiate joint planning and implementation of agroforestry projects.

2.3.4. Cost benefit analysis of Agroforestry

a) Total costs for implementing agroforestry

Total costs have been calculated based on the primary target of establishing and maintain 20,000 ha of agroforestry in Tanzania by the year 2025, and based on the average cost to put in place 1 ha of agroforestry plantation of USD 10,000. The average cost of USD 10,000 covers costs for land preparation, seedling preparation (seeds purchasing, tubing, shade construction, nursery maintenance), installation of plantations and rejuvenation of forests. Specific costs for implementing agroforestry are described below:

i. Awareness and knowledge raising among farmers

This includes the cost of trainers, workshops and training material. In year 1, a starter pack would be made available and be distributed to each of the farming households to improve their understanding about the different agroforestry technologies and their benefits. The cost of a representative pack was estimated at $15 per household including training and information. The total cost was estimated at: $ 15 x 30,000 households= $ 450,000

ii. Provision of subsidies to cover a share of costs on initial investment

It is assumed that each household will be provided with seedlings subsidized by 100%. The cost of seedling will be $ 1.5 per seedling; thus, the total cost of seedlings is estimated to be: $ 1.5 x 12,000,000 = $ 18 million

iii. Other cost

It has been assumed that labor, land and organic fertilizers will be the in-kind contribution of the farmer and hence no costs are estimated here.

Total costs: costs related to awareness and knowledge raising + costs of seedling subsidies

- Total costs (USD) year 1: 450,000 + 18,000,000 = 18,450,000.00
- Total costs (USD) year 2: 1,000,000.00 covering maintenance costs.

c) Benefits from the implementation of agroforestry

No CBA has been conducted for Tanzania; however, the analysis described below is based on a review of the cost benefit analysis of agroforestry from the Rwanda TNA Report (Government of Rwanda, 2012).

Benefits from agroforestry are expected to be realized from year 5 afterwards.

- Building poles
  During year 5, it is estimated that one-fourth of the 12,000,000 trees (per data from the technology target) will be coppiced annually and sold as building poles for USD 1 each.
  Total benefits = 0.25 x 12,000,000 trees x USD 1 = USD 3,000,000.00

- Fruit trees
  Based on assumption that fruit trees will be 50% of the total planted trees and the total number being 6 million it is expected that, from year 7, USD5 worth of fruit will be sold each year from each tree. Fruit sales will be as follows:
  Total benefits = 0.5 x 12,000,000 trees x USD 5 = USD 30,000,000.00

d) Net benefits of agroforestry

The net benefit of agroforestry for a 10 year period is USD 357,000,000.00. Using the discounting rate of 10%, the Net Present Value of agroforestry is USD 153,611,827.75. The descriptions of the benefits and net present values of agroforestry are shown in the table below.

Regarding increases in crop yields, by year 10, maize yields and revenues in the intercropped land will be 22%, which is a gain in yields of 11% against a decline of 11% in the lack of adoption of agroforestry (Government of Rwanda, 2012).

Table 16: Net benefits of agroforestry

Year	Total Benefits (USD)	Total costs (USD)	Net benefits (USD)	Discounted net benefits at 10% (USD)
1		18,450,000.00		

2		1,000,000.00		
3		1,000,000.00		
4		1,000,000.00		
5	3,000,000.00	1,000,000.00	2,000,000.00	1,241,842.65
6	6,000,000.00	1,000,000.00	5,000,000.00	2,822,369.65
7	39,000,000.00	1,000,000.00	38,000,000.00	19,500,008.49
8	72,000,000.00	1,000,000.00	71,000,000.00	33,122,023.99
9	105,000,000.00	1,000,000.00	104,000,000.00	44,106,152.31
10	138,000,000.00	1,000,000.00	137,000,000.00	52,819,430.65
NPV			357,000,000.00	153,611,827.75

2.4. Barrier Analysis and Possible Enabling Measures for Mangrove Conservation Rehabilitation and Restoration

2.4.1. General description of mangrove conservation rehabilitation and restoration

Mangroves are predominantly tropical trees and shrubs growing on sheltered coastlines, mudflats and river banks in several locations of the world. Mangroves grow to reach a maximum height of 30m. Globally, there are about 16 to 24 families and 54 to 75 species of Mangroves covering an estimated 1.5 million hectares. Generally, the majority of mangroves are located between 30° North and South. The equatorial coastal regions are known to host about two thirds of Mangroves.
Tanzania has 158,100 ha of mangrove forests with growing stock of 49m^3ha^{-1} (MNRT 2015). In Tanzania, Mangroves occur along the continental coast and in Zanzibar Islands. The largest mangrove stand is located at the Rufiji River Delta. Other areas with larger areas of Mangroves include Tanga, Kilwa and the estuaries of Ruvu, Wami, Pangani and Ruvuma Rivers. Mangrove species found in the country are *Acrostichum aureum, Avicennia marina, Ceriops tagal, Lumnitzera racemosa* and *Rhizophora mucronata* (FAO, 2005). The mangroves ecosystems have the attribute of being resilient to changes in environmental conditions. According to MSSR Foundation (MSSRF, 2002), Mangroves tolerate high salinity, high temperature as well as tidal extremes and strong wind velocity. They also survive in muddy anaerobic soils. These plants are tough because their roots stand like stilts on the soil, possess salt-excreting leaves and breathing roots; and their typical viviparous germination.

Given that mangroves are protected ecosystems in Tanzania this should be an ecosystem that receives substantial investment and attention in management and restoration. Thus their protection is critical.

The benefits of Mangroves (Lewis, 2001; MSSRF, 2002; UNEP, 2011) include the following:

- High ability to store carbon. E.g. a mangrove forest that had not 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).
- Provision of habitats for marine and terrestrial flora and fauna e.g. migratory birds and estuarine crocodiles.
- Harbouring of a large number of *aquatic species as they possess t*he tangled mass of roots
- Serve as nursery sites for aquatic species and enhance the productivity of fish, shellfish, crustaceans and molluscs by producing significant quantities of nutrients.
- Natural buffers against the adverse impact of storms and cyclones in coastal areas.
- Reduction of coastal erosion.
- Buffering buffer coastal waters from contamination, sedimentation and nutrient enrichment.

- Supply of wood products – firewood, charcoal, timber, poles, fodder, honey, thatching materials, fish, prawns, etc.
- Supply of construction and building materials for houses, bridges and canoes
- Source of materials used for medicine, dyes, insecticides.

Threats to Mangroves are both natural and human induced. However, human activities claim the large share of the damage to mangroves. Threats to Mangroves (Francis and Bryceson, n.d, MSSRF, 2002; Mwansansu, 2016) include:

- Loss of sheltered areas due to conversion for commercial purposes e.g. conversion to agricultural lands including shifting cultivation, clearing of mangroves for rice farms in Rufiji Delta, conversion to salt pans , conversion to aquaculture ponds (prawn farming), charcoal and lime production, fuel wood and harvesting for timber and poles for housing e.g. in Micheweni, seaweed farming especially for Zanzibar
- alteration of the hydrological conditions (dams upstream of rivers)
- shifts in the salt water–fresh water balance that create varying land use opportunities and constraints,
- pollution through using mangrove forests as rubbish dumps

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

Lewis and Marshall (1997) have suggested five critical steps are necessary to achieve successful mangrove restoration.

1. Understand the autecology (individual species ecology) of the mangrove species at the site, in particular the patterns of reproduction, propagule distribution and successful seedling establishment
2. Understand the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species
3. Assess the modifications of the previous mangrove environment that occurred that currently prevents natural secondary succession
4. Design the restoration program to initially restore the appropriate hydrology and utilize natural volunteer mangrove propagule recruitment for plant establishment
5. Only utilize actual planting of propagules, collected seedlings or cultivated seedlings after determining through Steps 1-4 that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization, or rate of growth of saplings established as goals for the restoration project.

2.4.2. Identification of barriers for Mangrove Conservation, Rehabilitation and Restoration

A total of eight (8) barriers to the adoption of Sustainable Mangroves Management have been identified – whereas three (3) barriers are economic and five (5) are non-economic. The description of each barrier follows below.

2.4.2.1. Economic and financial barriers

a) Limited access to alternative economic opportunities

There is high dependence on mangrove forest products for meeting basic needs amongst residents of coastal areas as a result of limited economic opportunities. As a result most of community members engage in destructive activities such as shifting cultivation, unsustainable extraction of timber and wood fuels, uncontrolled salt mining and prawn farming – leading to the degradation of mangrove resources. For example, shifting agriculture for flood irrigated rice farming has caused the clearance of mangroves in Rufiji Delta. Salt mining, occurring widely along the coast as a key livelihood strategy, has adverse impacts on mangroves particularly young mangrove. Prawn farming by investors has threatened the integrity and functioning of mangroves as large areas are cleared to pave way for aquaculture ponds. In the Micheweni area of Zanzibar, for example, lime production, fuel wood extraction, timber harvesting, extraction of poles for housing and seaweed farming are seriously threatening mangroves. Efforts to discourage coastal communities from engaging in the above activities are fruitless given the absence of alternative economic opportunities.

b) Limited access to financial resources

In spite of being legally protected Mangrove forests, are not accorded high recognition by decision makers. The low budget that is allocated for forestry, 1% of the national budget, is split to finance conservation activities in all types of forests including mangroves. On the other hand, financing from the private sector for sustainable management of mangroves has not been realized. Finance mechanisms such as payments have not been accessed to support the management of mangroves. Limited financing of mangroves sub-sector limits the planning and the implementation of priority actions to conserve, rehabilitate and restore mangroves. Consequently, only a limited number of activities (e.g. mangrove assessments, patrolling and reforestation) are initiated or completed.

c) Limited access to benefits from mangrove resources.

Traditionally, mangroves in the coastal areas of Tanzania have been used for poles (domestic and export), timber for fences, houses, boats, fish traps and fuelwood. They have been the source of employment and income for coastal communities (Mang'ora, 2011). However, due to their legal status as reserved forests, mangroves are out of reach for most communities. As a result, communities are legally restricted to access benefits accruing from mangroves. This protection status pushes communities into illegal activities that are destructive to mangrove's integrity and functioning. Elites reap the benefits from resources management while exacerbating the degradation of natural resources. People feel that there are no incentives or benefits to conserve mangroves under such management scenarios (Mang'ora, 2011).

2.4.2.2. Non-financial barriers

a) Conflicting and overlapping jurisdiction

Mangrove management is Tanzania is one of the sub-sectors which have experienced conflicting and overlapping management due to sectoral approaches. Each of the responsible (Land, Natural Resources, Mining, Trade) is required to develop its own strategy and guidelines to implement existing laws. However, lack of funds implies these strategies are missing. Examples of conflicting and overlapping situations as pointed out by Francis and Bryceson (n.d.) and Mang'ora (2011) are:

- Salt mining licences in mangrove reserves is issued by the Commissioner of Minerals while land titles are issues by the Commissioner of Lands.
- The ministry responsible for industries and trade issues permits for salt extraction in designated mangrove forest reserves
- Mangrove forests are designated as reserves by the Forest and Bee Keeping Division, however, the Fisheries Division issues permits for development of prawn farms

On the other hand, unilateral translation of laws and sectoral disintegration leads into conflicts (Mang'ora, 2011). The prevalence of conflicting mandates frustrates and demotivates conservation

institutions and practitioners leading to poor planning and implementation of conservation, rehabilitation and restoration programmes.

b) Inadequate information

For better planning and management of mangroves, availability and access to adequate and reliable information is critical. Traditionally, planning for mangrove management has relied upon historic data - historic flood and storm intensity and frequency, which is insufficient in the face of climate change. Historic data alone is inadequate to guide the planning for mangrove management; hence the need to factor in the scenarios of future development, climate change projections and environmental degradation. Unfortunately, however, sustainable management of mangroves suffers from lack of baseline information necessary for informing planning and management actions (Macintosh and Ashton, 2003). In addition, inadequate information prevails on the trends and patterns in resource use and economic development, land use and ownership and infrastructure (Mang'ora, 2011).

c) Limited community participation in the conservation of mangroves

The status of mangroves as reserved forests implies that the major responsibility for their conservation, rehabilitation and restoration rests with the Government. This means that community participation in sustainable management of mangroves is quite limited. This is exemplified by the absence of participatory natural resource management approaches (Community Based Forest Management and Joint Forest Management) in the mangrove sub-sector unlike other coastal and terrestrial forests. Given weak institutional capacity, and in the absence of effective community participation, government institutions at all level have insufficient capacity to ensure sustainable management of mangroves. Mangrove forests are cleared and degraded in the sight of adjacent communities – who lack power and mandates to intervene in the reserved forests. Without adequate participation of adjacent communities through CBFM or JFM or other approaches, mangrove forests will continue to disappear at high rates.

d) Limited awareness

Different groups of stakeholders, including communities and practitioners, have limited awareness and understanding regarding key factors to be considered for successful conservation, rehabilitation and restoration of mangroves. The factors include autecology (individual species ecology) of the mangrove species at the site, normal hydrologic patterns controlling the distribution and successful establishment and growth of targeted mangrove species, environmental changes affecting natural secondary succession, design of the restoration programme and utilization of the right type of mangrove seedlings (Lewis and Marshall, 1997). Limited awareness on the above is caused by inadequate awareness raising campaigns. On the other hand, practitioners have limited awareness on the assessment of mangrove status, mainly due to lack of technical training. Decision makers; also have limited understanding on the linkages between mangrove ecosystems and resources (and coastal livelihoods) such as fish/fishing (Mang'ora, 2011)

e) Weak enforcement of laws and regulations on mangrove protection.

Laws and regulations for managing mangroves are poorly enforced in several mangrove rich areas of the Tanzanian coast. This paves ways for continued illegal and unsustainable activities to take place in mangrove reserves include harvesting for timber, poles, wood fuel as well as salt mining and fishing in nursery sites. As a result thereof, mangroves are cleared and become degraded hence compromising their ability to deliver a bundle of ecosystem services required for sustaining life and coastal livelihoods. Major factors behind weak enforcement include lax attitude amongst law enforcers, corruption, inadequate skilled staff, limited availability of funds for patrols and related law enforcement activities and limited accessibility due to remoteness and inadequate vehicles (Mang'ora, 2011; Francis and Bryceson, n.d.). Other factors include insufficient political support (and

political interference) from politicians in technical matters (Mang'ora, 2011; Francis and Bryceson, n.d.). Most government authorities concentrate on the collection of revenues rather than the management of forest resources (Mang'ora, 2011). Understanding on existing laws and regulations defining the management of mangroves is also limited particularly in coastal communities.

2.4.3. Identified measures

A total of eight (8) measures for enhancing to the adoption of Sustainable Mangroves Management have been identified – whereas three (3) measures are economic and five (5) are non-economic. The description of each measure follows below.

2.4.3.1. Economic and financial measures

a) Increasing access to alternative economic opportunities

To ensure that coastal communities have access to alternative economic opportunities, it is recommended that:

- Conduct training on sustainable livelihood approaches focusing on existing livelihood strategies e.g. fishing, crop production, salt mining and prawn farming.
- Supporting value addition to products
- Expanding markets to include other town and cities
- Improving marketing strategies of products and commodities produced by locals
- Promote environmentally friendly initiatives such as ecotourism

b) Enhancing access to financial resources for mangrove management

Proposed activities to increase access to financial resources for managing mangroves are:

- Lobby for increased budgetary allocation
- Pioneer PES schemes amongst industries and institutions discharging wastes into wetlands in coastal areas
- Scale up REDD+ in mangrove areas to generate funds for mangrove conservation
- Promote tourism in marine parks and reserves to increase revenues to be used for the management of marine ecosystems including mangroves

c) Increasing access to benefits from mangrove resources.

Ensuring access to benefits from mangroves amongst adjacent communities works to inject a sense of ownership and motivates local communities to participate in conservation activities. Actions to enhance access to benefits are:

- Controlling corruption and elite capture in the mangroves sub-sector
- Creating incentives for community based management of mangroves such as payments based on patrols.
- Investing in the development of infrastructure for facilitating ecotourism in collaboration with local communities
- Renegotiating access rights to mangrove resources between the government and adjacent communities

2.4.3.2. Non-financial measures

a) Addressing conflicting and overlapping jurisdiction

Key actions to be carried out to address conflicting and overlapping jurisdiction include:

- Promote integrated approach for managing mangrove resources (forests, fisheries and minerals)

- Review with a view of harmonizing conflicting laws and regulations on mangrove management
- Harmonize the issuance of permits and licences (land and mining licences and prawn farming permit) in mangrove areas in such a way they are centrally issued by one authority
- Establish an inter-sectoral steering committee that will oversee the planning, implementation and monitoring of conservation and development projects in mangrove areas.
- Develop a stand-alone Mangrove policy to adequately address mangrove related priorities, challenges and opportunities

b) Enhancing community participation in the conservation of mangroves

Increased and effective community participation, without which sustainable management of mangroves cannot be achieved, will be enhanced by the introduction of the following measures:

- Engage adjacent communities in carrying out patrols in reserved mangroves
- Pilot the implementation of participatory forest management approaches (e.g. JFM and CBNRM) and/or co-management (shared governance) in the management of mangroves
- Initiate and support community initiatives for the conservation, rehabilitation and restoration of degraded mangrove sites
- Engage communities in the planning, implementation and monitoring of mangrove conservation
- Strengthen and engage natural resource governance structure at the community level.

c) Improve access to information

To achieve effective and sustainable management of mangrove forests, there is a need to increase access to information by:

- Carry out widespread assessment and research to acquire baseline data (e.g. growth rate, standing biomass/volume, phenology, etc.) needed to support the formulation of mangrove management plans.
- Undertake research to develop local and national scenarios of future development, climate change and environmental degradation.
- Documenting, assessing and integrating indigenous knowledge and traditional management practices into mangrove conservation, rehabilitation and restoration
- Identifying reference mangrove sites for providing long-term data on mangrove growth and development.

d) Improve awareness and understanding

Relevant measures for enhancing awareness of local communities, decision makers and practitioners on the sustainable management of mangroves include:

- Conducting sensitization meetings targeting adjacent communities on the unique features and the values of mangroves, the linkages with local livelihoods and potential consequences of the loss of mangroves on communities' wellbeing and livelihoods.
- Distributing communication products on a range of issues including the benefits of mangroves, drivers of mangrove degradation, and the conservation and protection of mangroves.

- Providing technical training to practitioners on approaches and tools for the assessment of mangroves status
- Organizing workshops to raise decision makers on relevant aspects such as the benefits of mangroves, the linkages with rural livelihoods and the role of mangroves as green infrastructures
- Incorporating mangrove conservation, rehabilitation and restoration in education curricula
- Facilitating dissemination of information to the public through the print and audio-visual media.
- Develop learning platforms involving the scientific community, the public and the media for sharing information about mangroves
- Develop and promote the dissemination of publications and apps (e.g. "World Mangrove iD" App) on mangroves in order to reach the wider audience

e) Strengthening the enforcement of laws and regulations on mangrove protection.

Strengthening the enforcement of laws and regulations for managing and protecting mangroves will require the implementation of the following measures:

- Increase communities understanding on policy, legal and institutional frameworks for the management of mangroves
- Addressing the lax attitude amongst law enforcers by providing them with appropriate incentives
- Fighting corruption in the forest sector
- Enhancing human resource capacity by training and recruiting skilled staff.
- Increasing access to required facilities for patrols e.g. vehicles
- Mobilizing political support and eliminating political interference
- Advocating for increased community participation in the management of mangroves

2.4.4. Cost and Benefit Analysis of sustainable management of mangroves

Critical activities to be performed for sustainable management of mangroves include:

- Dredging where necessary to improve water flows
- Replanting of resilient and appropriate species
- Fencing
- Capacity building for local organizations to enforce no-take zones and buffer zones using community-based mangrove management systems.

Estimations on the costs and benefits of mangrove management have been estimated based on past mangrove projects (e.g. MACEMP and TCMP) implemented in the country.

a. Value of the costs of sustainable management of mangroves

A proposal for Tanzania developed by UNEP to the Adaptation Fund Board (2011) attempted to estimate the costs and the benefits of mangrove management. The proposal shows that, the direct costs of mangrove rehabilitation (covering equipment, biomass and labour but excluding the costs for land purchase) are estimated at 200 USD per hectare. Additional costs are included to cover training for local communities on sustainable mangrove management and use.

Based on the target to conserve 50,000 ha of mangroves, the total costs would be calculated as follows:

Total costs = 50,000 ha x USD 200 / ha = USD 10,000,000.00

b. Value of the benefits of sustainable management of mangroves

The UNEP proposal to the Adaptation Fund Board (2011) showed that, the combined value of mangroves benefits amount to 9,270 USD/ha/year including waste treatment services (6,696 USD/ha/year), food production (466 USD/ha/year), coastal disturbances protection (1,839 USD/ha/year). Given the absence of a specific study on the economic benefits of mangroves management in Tanzania, it is justified to apply the findings of two studies (on the costs and benefits of mangrove management) conducted in the neighbouring country of Kenya.
Benefits of mangroves are described below:

- The value of mangroves on fisheries ranges from USD 44/ha/year (UNEP, 2011) to USD 113.09/ha/year (Kairo *et al.,* 2009).
- Mangrove benefits on building poles and fuel wood is valued from USD 16.8/ha/year (UNEP, 2011) to USD 18.5/ha/year (Kairo *et al.,* 2009).
- Eco-tourism is valued from USD 6.5/ha/year (UNEP, 2011) to USD 9.3/ha/year (Kairo *et al.,* 2009)
- The value of the contribution of mangroves to research and education is estimated to range from USD 184.4/ha/year (UNEP, 2011) to USD 770.23/ha/year (Kairo *et al.,* 2009)
- Mangrove's shoreline protection is valued from USD 91.7/ha/year (UNEP 2011) to USD 1,586.66/ha/year (Kairo *et al.,* 2009)
- Carbon sequestration by mangroves is estimated to value USD 126/ha/year (UNEP, 2011)
- Biodiversity value of mangroves is USD 5/ha/year (UNEP, 2011).
- The Existence Value of mangrove is valued at USD 1,092/ha/year (UNEP, 2011).

Table G1: Economic valuations of mangroves in Africa (all values in US$ / hectare / year)

Product / Service	This study (2011)	Kairo *et al.* (2009)	Lower Volta Mangrove project (1996)	Spurgeon (2002)
	Kenya: Gazi	Kenya: Gazi (Replantation)	Ghana	Egypt
Extent of mangroves (ha)	**620**	**7**	**?**	**500**
Direct use				
Fishery	44.00	113.09	254.00	18,150
Wood	20.80	379.17	251.00	-
Apiculture	14.70	-	-	0.8-1
Aquaculture	4.80	-	-	-
Education & Research	184.40	770.23	-	-
Tourism / Recreation	6.50	9.30	-	130,000
Indirect use				
Carbon sequestration	126.00	44.42	-	-
Shoreline protection	91.70	1586.66	-	1050
Biodiversity value	5.00	-	-	-
Non-use value				
Existence value	594.40	-	-	-
Total Economic Value	1,092.30	2902.87	505.00	~149,200

Sources: Kairo et al. (2009); GWD (1996); Spurgeon (2002)

The total economic value (TEV) of mangroves is estimated to be USD 2,902.7/ha/year (Kairo et al (2009) which is within the global estimates of USD 1,000/ha/year to USD 22,000/ha/year (Spalding

et al., 2010). The TEV of USD 1,092.30/ha/year has not been adopted in this analysis because it is comparatively lower and was carried out in an infant mangrove forest (UNEP, 2011). The lifetime of mangroves is 22 years (Tuan and Tinh, 2013). Lewis (2001) estimates the lifetime to range from 15 to 30 years (the average is roughly 22 years). Provided that the rehabilitation and restoration of mangroves is completed within four years, 25% of TEV accrue in Year 3, 50% of TEV in Year 4 and the total benefit (100% of TEV) is accrued from Year 5 to Year 22 (Tuan and Tinh, 2013).

Total benefits are calculated as:

- Total benefits = TEV x total number of hectares x life time of mangroves
- Total benefits = USD 2,902.87/ha/year x 50,000 ha x 22 year

Therefore, the total benefits are USD 3,193,157,000 for the lifetime of planted mangroves

c. Net benefits

Net benefits are calculated as deductions of total costs from total benefits as shown below:

- Net benefits = Total benefits - Total costs
- Net benefits = USD 3,193,157,000 - USD 10,000,000

Net benefits from sustainable management of mangroves are USD 3,183,157,000 for the whole period of 22 years.

2.5. Linkages of the Barriers Identified

Linkages between barriers of forest technologies were identified during the barrier analysis process so as to maximize synergies and optimize the effects of recommended measures. Common barriers identified for forest technologies include limited access to financial resources (credits/loans), limited awareness amongst stakeholders, weak institutional capacity, weak enforcement of laws and regulations, insecure tenure right, limited access to short term and direct benefits.

a) Weak institutional capacity

There is weak institutional capacity for national level and local institutions with roles in sustainable forest management, agroforestry and sustainable management of mangroves. This is due to inadequate skilled staff, limited availability of facilities and equipment (e.g. vehicles, boats, GPS), limited access to funds for the implementation of priority actions. This barrier can be addressed by building the capacity of extension staff (foresters, agro-foresters, agricultural officers, etc) through training and short courses, fundraising for the forestry sector, and procurement of required facilities and equipment.

b) Weak enforcement of relevant legislations, regulations and guidelines

Weak enforcement of relevant legislations, regulations and guidelines prevails from the local to the national level. Reasons behind this include limited resources (e.g. human and financial) to undertake patrols, corruption amongst law enforcers, inadequate political support (political interference, limited awareness on existing laws amongst communities, and inadequate fines and penalties for forest related offences. Measures needed to unlock this barrier include strengthening institutional capacity, enhancing natural resource governance, combating corruption in all forms at all levels, incentivizing extension workers (better remuneration), raising awareness on existing forest related laws and regulations to enhance compliance and advocating for increased political support

c) Limited awareness amongst key stakeholders and actors

There is limited awareness on the benefits and approaches to sustainable forest management, agroforestry and sustainable mangrove management. This results from high illiteracy levels amongst rural communities, inadequate coverage of environmental content in educational curricula, inadequate awareness campaigns and sensitization meetings and also poor promotion in the media.

Addressing this barrier will require carrying out of training activities, sensitization meetings, mainstreaming of environmental conservation in education curricula, and promoting selected forest technologies through the media (especially community radios).

d) Lack of direct and short term benefits

In countries like Tanzania, low investment in forest resources management and conservation is largely due to Inability of sustainable forest management as well as agroforestry and mangrove conservation, rehabilitation and restoration to generate short term and direct benefits. Faced with the challenges of meeting needs of food, clothing, shelter, healthcare, education and others, communities rely on strategies that can deliver short term and direct benefits, unfortunately, SFM, agroforestry and sustainable mangroves management are not part of such strategies. Lack of direct benefits is aggravated by lack of economic valuation of ecosystem benefits and limited markets for forestry and agroforestry products and services. To address this barrier, it will be critical to enhance access to markets of forestry/ agroforestry products and to promote sustainable livelihood strategies with direct and short term benefits such as bee keeping.

e) Insecure tenure right

An insecure tenure right is a barrier common to SFM, agroforestry and sustainable management of mangrove. Local communities are only occupiers and users but not owners of land. This discourages community members from engaging in sustainable management of forest resources and continued involved in agroforestry. Key measures to be promoted to address the barrier include drafting policies for formalizing land rights, developing regulations to protect traditional land rights holders against large scale investments, carrying out cost effective and participatory programs aimed at registering and recording land rights and introducing flexible mechanism for temporary and permanent transfers of rights to increase opportunities for capturing the full value of investments in the forestry sector. In addition, it is crucial to undertake regulatory and policy reforms intended to clarify rights related to land, trees, forest products, water and carbon

f) Limited access to financial resources

Limited access to finance (credits and loans) is a common barrier limiting the adoption and wide use of SFM, agroforestry and sustainable management of mangroves. This is due to high interest rates (18%), limited availability of loans for non-commercial investments as well as low budgetary allocation and limited involvement of the private sector to finance forestry activities. Because forestry is not a high priority sector in the national development, the government does not allocate and disburse funds which addresses the requirements of the sector. Addressing this barrier will require a combination of measures such as lowering interest rates, relaxing collateral requirements for accessing credits and loans as well as unlocking international finance mechanisms (e.g. REDD+ PES schemes) and promoting Public-Private Partnerships for investing in the sustainable forest management, agroforestry and sustainable management of mangroves.

2.6. Selection of Priority Measures

Out of the requirement to selected two priority measures from each technology, the measures identified above were assessed based on five criteria namely:

- Effectiveness of the measure
- Efficiency of the measure
- Interactions of the measure with other measures
- Suitability of the measure within country/sector
- Benefits and costs of the measure

2.6.1. Sustainable forest management

Measures identified further consideration and inclusion in the TAP A are:

- Strengthen legal and regulatory enforcement
- Improve profitability of the forest sector

The two measures have been assessed as shown in the table below:

Table 17: Justification of the selected measures on SFM

Measure	Assessment	Remarks
Strengthening legal and regulatory enforcement	• Strengthening legal and regulatory enforcement is necessary for protecting forest resources from illegal harvesting, encroachment and related activities. Effectiveness of this measure is enhanced when communities collaborate in the enforcement of forest related laws • It is relatively cheap as it requires using existing law enforcement personnel and resources, with minimum addition of resources • The measure has some positive interactions with other measures (e.g. improving mangrove's policy, legal and regulatory framework). • There are no suitability issues within country/ sector • Benefits to technology implementation are direct – the measure will ensure that forest resources are sustainably harvested.	Strengthening legal and regulatory enforcement is definitely a cost-effective measure and contributes to enhanced forest resources. In comparison with the rest of measures, it is ranked higher given its impact on actual implementation at the household level is largely indirect, depending on the household's knowledge on forest laws- and bylaws and the willingness to enforce those laws and regulations
Improve profitability of the forest sector	• Improving the profitability of the forest sector is crucial for ensuring that communities adopt and continue with SFM in the face of competing land uses. • Effectiveness of this measure is enhanced when communities are trained in undertaking profitable and conservation oriented initiatives, value addition of forest products and accessing new markets • The measure is somewhat cheap as it requires a few capacity building events and may make use of available local entrepreneurship trainers. • The measure has some positive interactions with other measures (e.g. increasing access to benefits from agroforestry and mangrove resources). • There are no suitability issues within country/ sector; the measure is locally acceptable • Benefits to technology implementation are indirect – the measure will incentivize communities to adopt SFM	Improving the profitability of the forest sector is a relatively cost-effective measure and contributes to high rates of adoption and use of SFM. In comparison with the rest of measures, it is ranked higher given its influence on communities willingness to adopt SFM at the household level, albeit depending on the selected profitable forest dependent enterprise

2.6.2. Agroforestry

The two measures selected to be include in the TAP are:

- Eliminate adverse incentives on agro-forestry practices
- Organize information and awareness campaigns on agroforestry

The two measures have been assessed as shown in the table below:

Table 18: Justification of the selected measures on Agroforestry

Measure	Assessment	Remarks
Eliminate adverse incentives on agro-forestry practices	• Eliminating adverse incentives on agroforestry is critical for improving the adoption and wide scale use of agroforestry practices. Effectiveness of this measure is enhanced when pro-agroforestry practices are promoted. • It is comparatively expensive because its associated with, for example removal of subsidies on conventional agriculture and lowering interest rates • The measure has no interactions with other measures, nonetheless does not negatively impact them. • There are no suitability issues within country/ sector • Benefits to technology implementation are direct – the measure will enable many households to adopt, continue using and benefit from agroforestry.	Eliminating adverse incentives on agro-forestry practices is relatively a cost-effective measure that promises wide scale adoption of the technology. In comparison with other measures, it is accorded the highest ranking in relation to the adoption and implementation at the household level. However, this is subject to the success of the removal of adverse subsidies
Organize information and awareness campaigns on agroforestry	• Organizing information and awareness campaigns on agroforestry is extremely important for ensuring that communities adopt and continue using agroforestry practices. • Effectiveness of this measure is enhanced when communities are aware of different agroforestry approaches and their associated benefits as well as value addition and access to markets. • The measure is relatively cheap requiring information dissemination and awareness raising campaigns using local extension workers. • The measure has no direct interactions with other measures, but does not have negative impacts on other measures • There are no suitability issues within country/ sector; the measure is locally acceptable • Benefits to technology implementation are direct – the measure will incentivize communities to adopt and implement agroforestry	Organizing information and awareness campaigns is a relatively cost-effective measure and contributes to high rates of adoption and use of agroforestry. Compared to other measures, it is ranked higher given its influence on communities willingness to adopt agroforestry at the household level, but, may depend on the extent to which communities are willing to give up conventional farming practices

2.6.3. Sustainable management of mangroves

Under Sustainable Management of Mangroves, the selected measures are:

- Improve mangrove's policy, legal and regulatory frameworks
- Increase access to alternative economic opportunities

The two measures have been assessed as shown in the table below:

Table 19: Justification of the selected measures on Sustainable Management of Mangroves

Measure	Assessment	Remarks
Improve mangrove's policy, legal and regulatory frameworks	• Improving mangrove's policy, legal and regulatory frameworks is centrally important for addressing conflicting and overlapping jurisdiction and ensuring community participation in the sustainable management of mangrove resources. Effectiveness of this measure is enhanced when an inter-sectoral approach is applied in the management of mangrove resources. • It is relatively expensive because a lot of consultations have to be undertaken in reviewing existing legal frameworks or instituting a standalone mangroves policy. • The measure has no interactions with other measures, nonetheless does not negatively impact them. • There are no suitability issues within country/ sector • Benefits to technology implementation are direct – the measure will enhance inter-sectoral planning and collaboration in the management of mangrove resources.	Improving mangrove's policy, legal and regulatory frameworks is relatively a cost-effective aimed at enhancing inter-sectoral planning and coordination of conservation efforts. In comparison with other measures, it is ranks high and has a great potential for propelling the implementation of collaborative initiatives. To be successful, it depends on stakeholder involvement in the process.
Increase access to alternative economic opportunities	• Increasing access to alternative economic opportunities is so important in reducing the dependence on mangrove resources amongst coastal communities, thus enhancing the integrity of mangrove ecosystems. • Effectiveness of this measure is enhanced when communities have increased access to benefits associated with the management of mangroves. • The measure is relatively cheap requiring training on sustainable approaches on fishing, crop production, salt mining and prawn farming. • The measure has direct interactions with other measures particularly increased access to benefits on SFM and agroforestry through eco-tourism, bee keeping, etc. Thus, the measure has positive impacts on other measures • There are no suitability issues within country/ sector; the measure is locally acceptable • Benefits to technology implementation are direct; the measure will motivate communities to actively engage in mangrove conservation, rehabilitation and restoration.	Increasing access to alternative economic opportunities is a relatively cost-effective measure and contributes the maintenance of mangrove ecosystems through the adoption of conservation oriented economic opportunities. Compared to other measures, it is ranked higher because reduces the pressure on mangrove resources exerted by adjacent communities. But this largely depends on the type and effectiveness of such livelihood activities.

2.7. Enabling Framework For Overcoming The Barriers In The Forest Sector

The enabling framework (environment) includes institutional, regulatory and political framework conditions that are conducive to the adoption and widespread use of technologies (IPCC, 2000). This includes the country-specific circumstances that encompass existing market and technological conditions, institutions, resources and practices, which can be subject to changes in response to government actions.
Common barriers identified for forest technologies include limited access to funds/financial resources, limited awareness, weak institutional capacity, weak enforcement of laws and regulations, insecure tenure rights, lack of direct and short term benefits.

The enabling framework to address the common barriers include investment in research and development, training and human and organizational capacity building, information and education, awareness raising, strengthening of institutional collaboration and infrastructure, setting of appropriate policies (incentives or disincentives), enforcement, relevant policy support, financial services and promotion of public-private partnership.

Table 15 summarises the enabling measures for the adoption and wide scale use of forest mitigation technologies. The measures address both economic and non-economic barriers.

Table 20: Enabling measures for the adoption and scaling up the selected forest technologies

Barrier Category	Enabling measures
Economic and financial	• Provision of adequate financial resources including grants and loans • Reduction of interest rates on credit and loans • Promotion of Public-Private Partnerships in the forestry sector • Developing public investment policies to direct financing to SFM, agroforestry and sustainable mangroves management • Capacity building to access international financing mechanisms e.g. REDD+, CDM, etc
Technical	• Provision of adequate training to enhance capacity and skills for farmers, extension agents and practitioners • Promotion of publicly funded research and development for and training programmes • Supporting testing and demonstration facilities for SFM, agroforestry and sustainable mangroves management • Conducting training programs to improve technical capacity • Enhancing capacity monitoring programmes to address insufficient capacity to plan, implement and monitor technology
Information and awareness	• Carrying out information dissemination, outreach and awareness raising • Promotion of PPPs to raise awareness and acceptance of technologies within the public and private sector. • Creation of sufficient awareness on the existence and use of technologies • Promotion of effective extension services
Institutional and organizational capacity	• Carrying out capacity building programmes for local, regional and national organizations and institutions • Provision of required facilities (vehicle, GPS, etc.) for facilitating the enforcement of relevant laws and for implementing activities related to SFM, agroforestry and sustainable management of mangroves. • Increasing financing for the selected forest technologies

Barrier Category	Enabling measures
	• Strengthen enforcement of laws and regulations
Policy, legal and regulatory	• Promotion of forestry, agroforestry and mangroves associations, networks, organizations and alliances to resolve barriers related to lack of stakeholder/ community participation. • Provide policy support to implement sustainable forest management, agroforestry and sustainable management of mangroves

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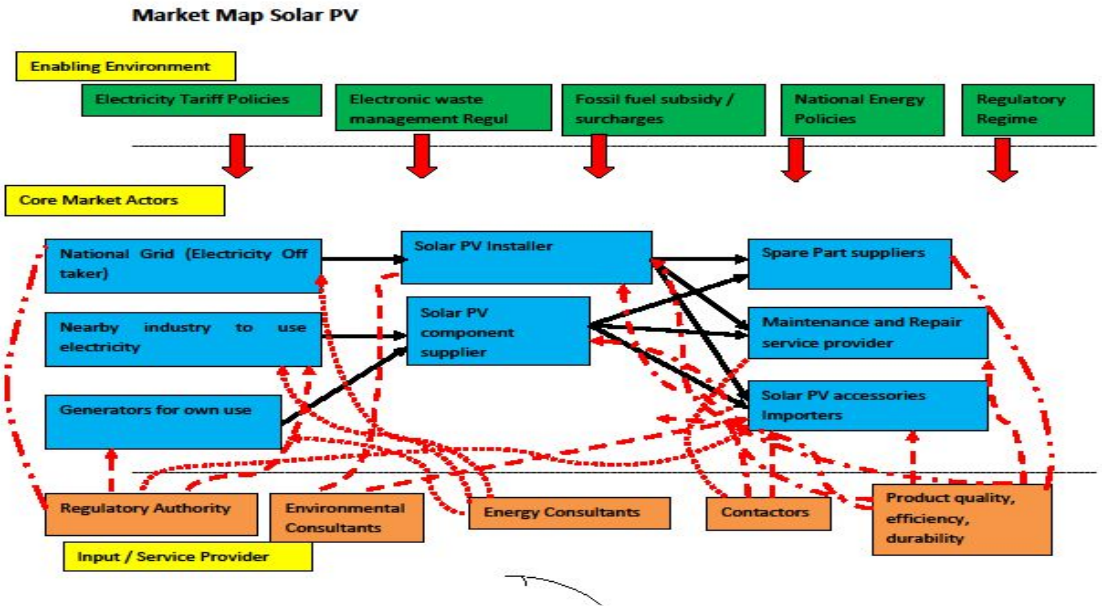
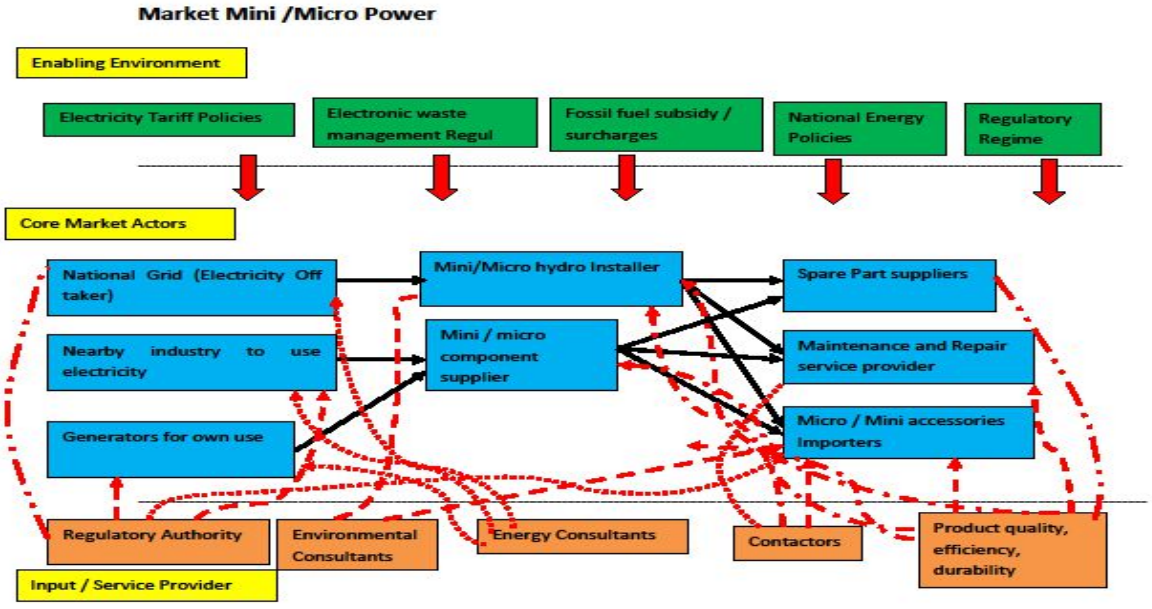
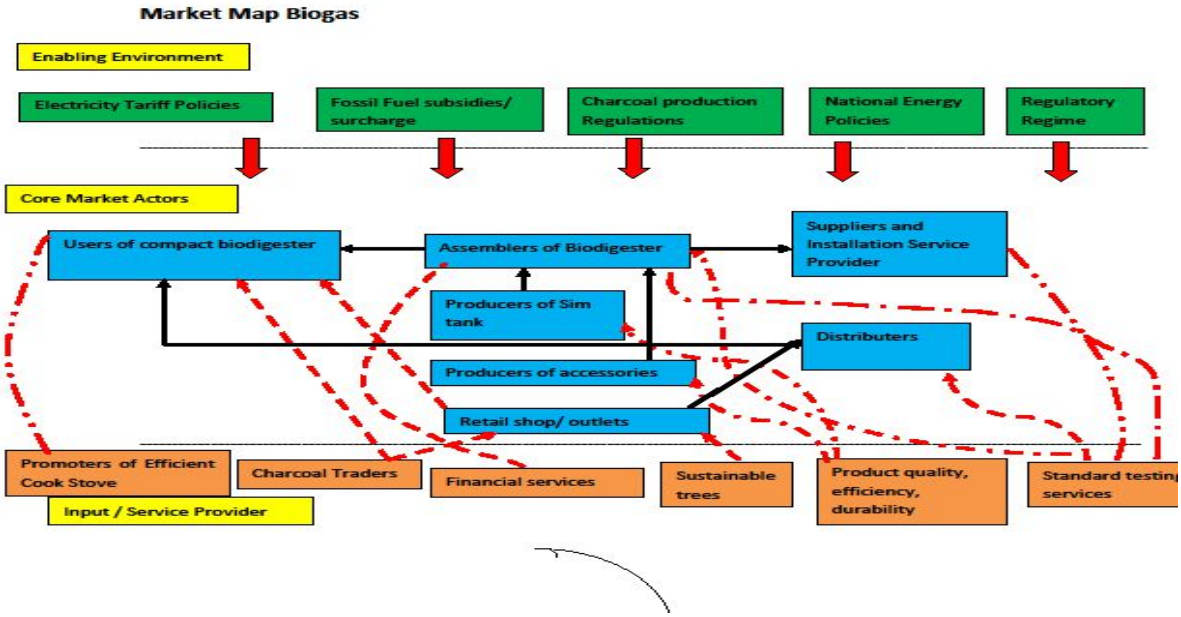
Annex 1: Market map – Solar PV



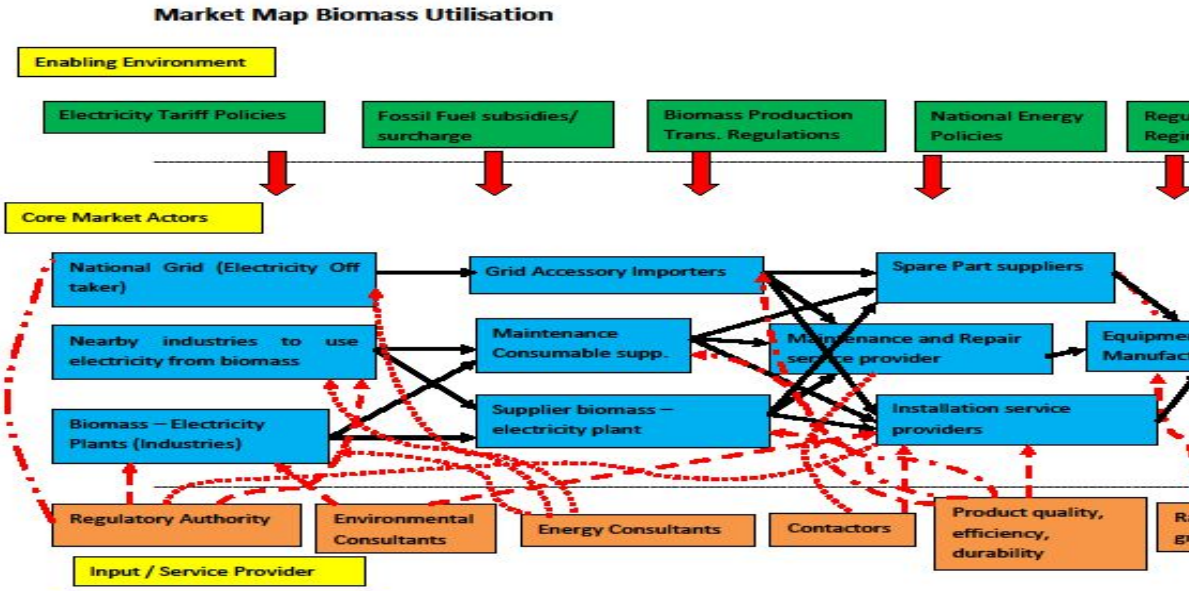
Annex 2: Market map – Mini Hydropower



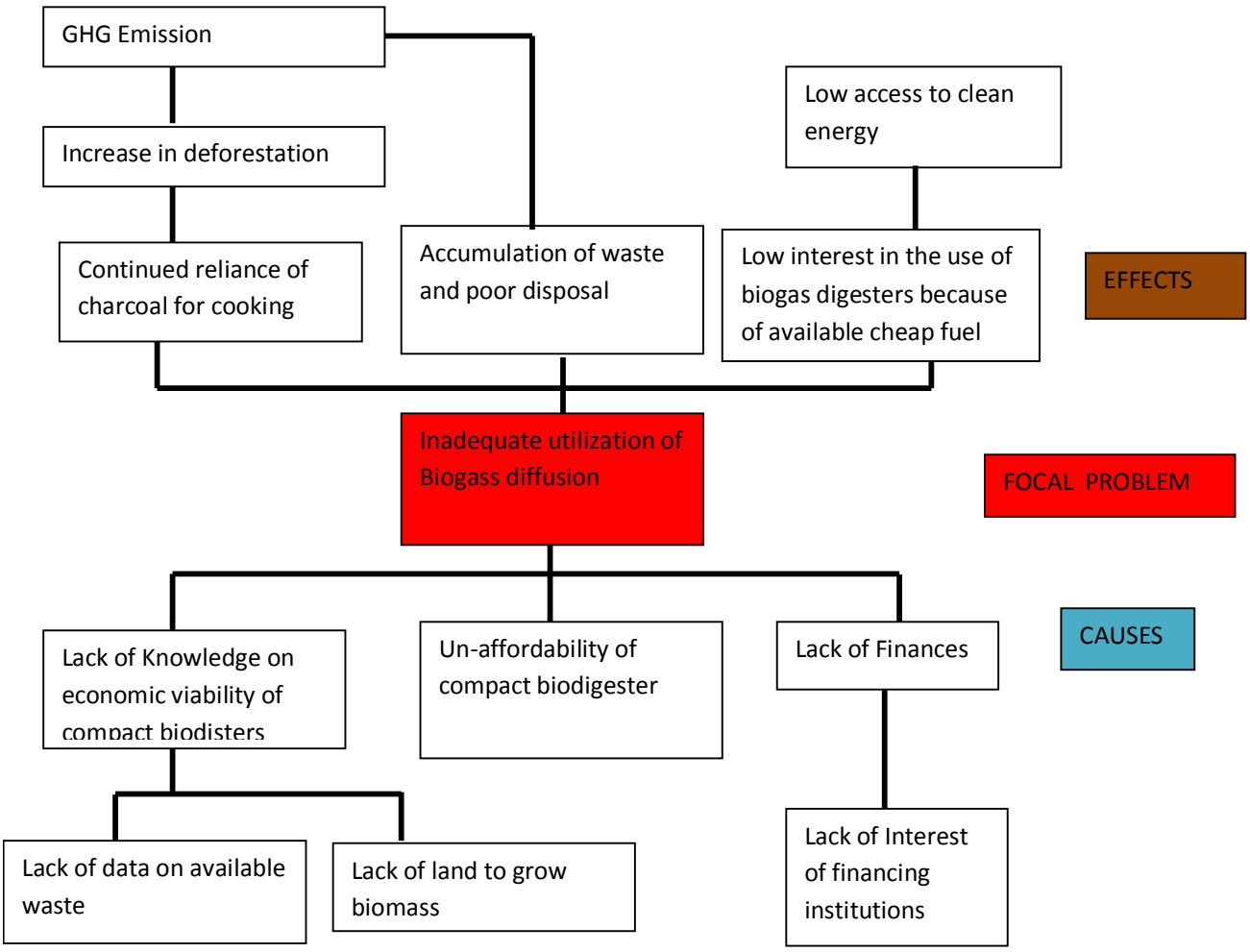
Annex 3: Market map – Biogas Digesters



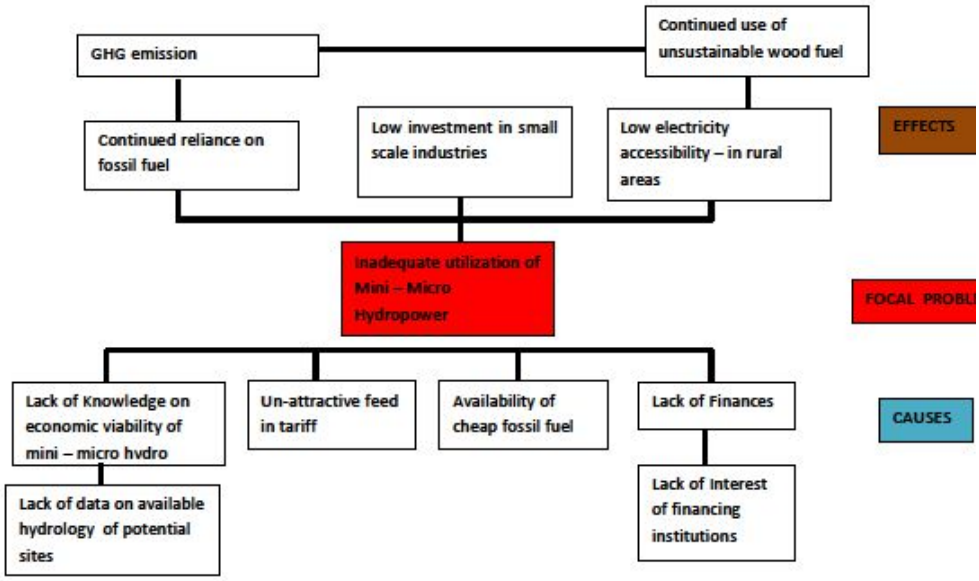
Annex 4: Market map – RDF



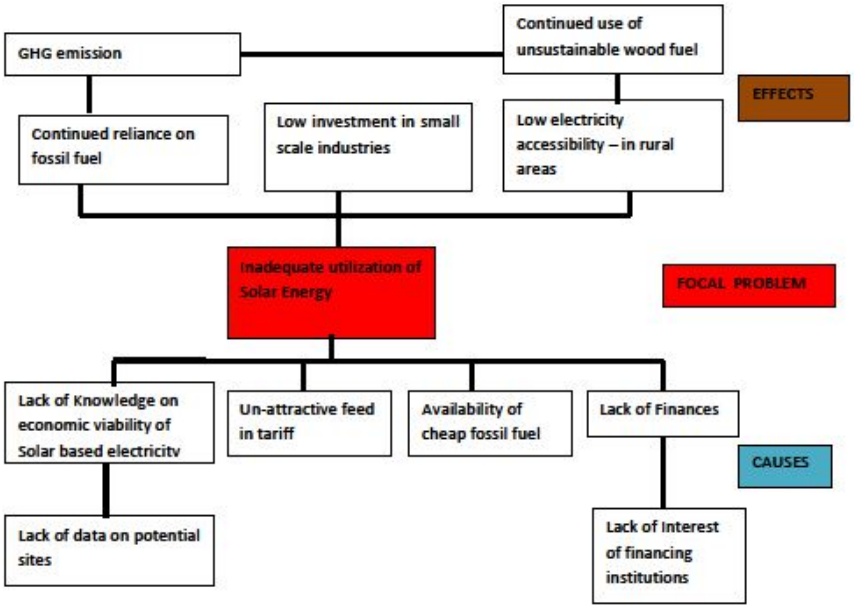
Annex 5: Problem trees – Biogas Digester



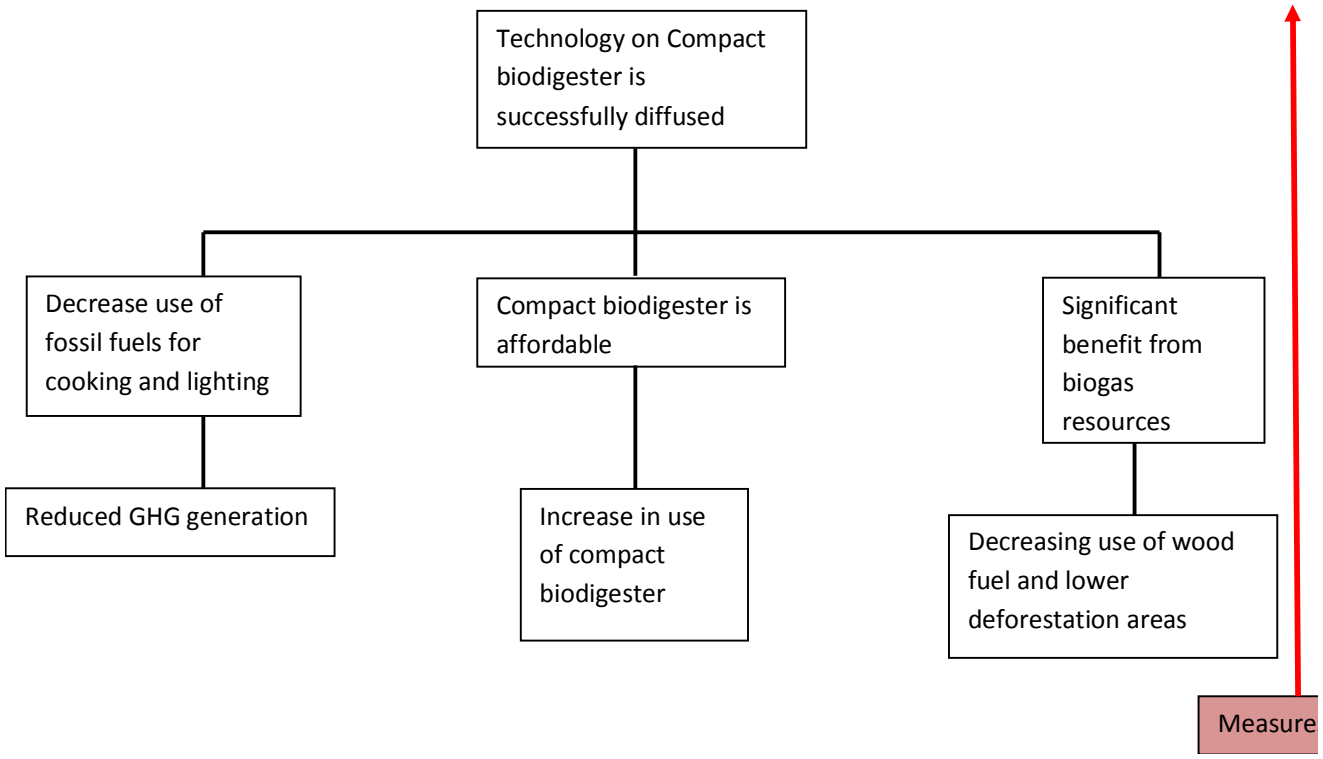
Annex 6: Problem trees – Mini Hydropower



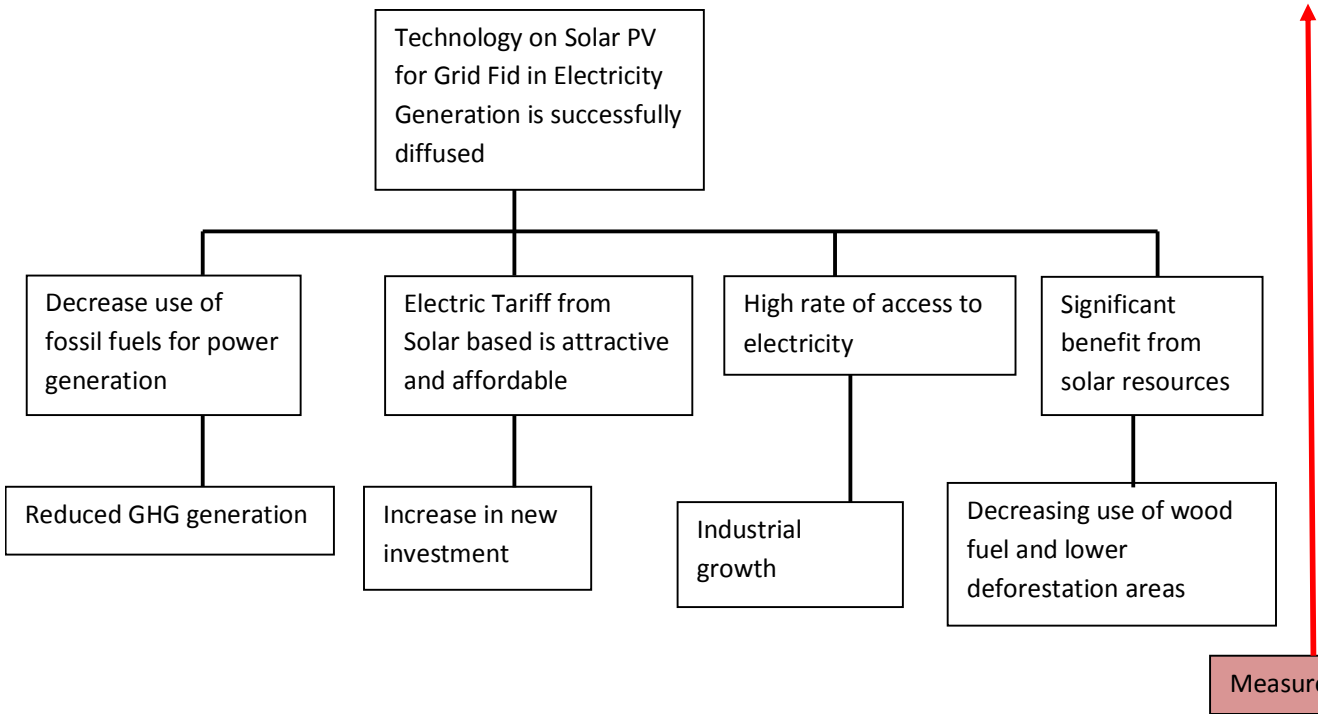
Annex 7: Problem trees – Solar PV



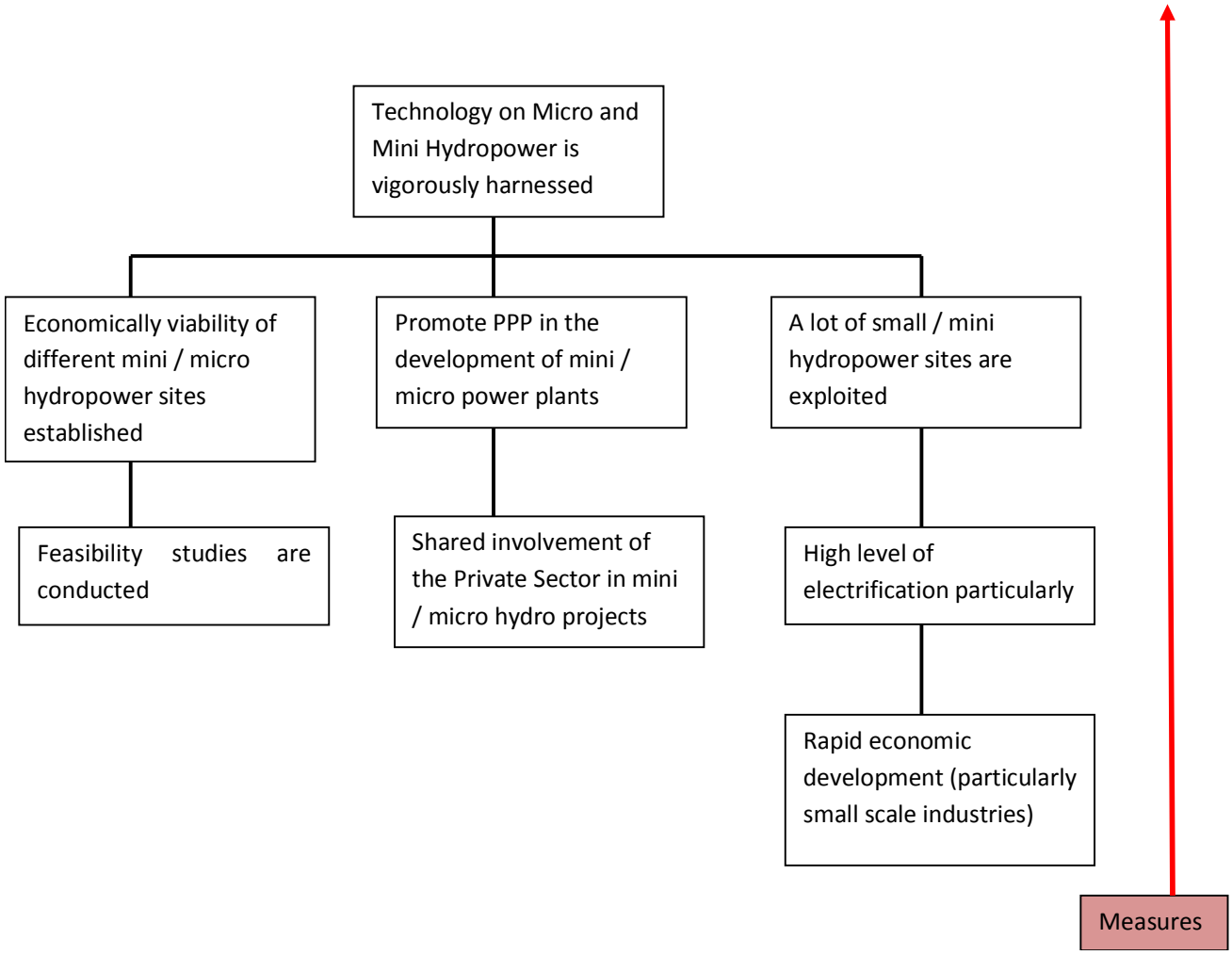
Annex 8: Objective – Biodigesters


Technology on Compact biodigester is successfully diffused
Decrease use of fossil fuels for cooking and lighting
Compact biodigester is affordable
Significant benefit from biogas resources
Reduced GHG generation
Increase in use of compact biodigester
Decreasing use of wood fuel and lower deforestation areas
Measure

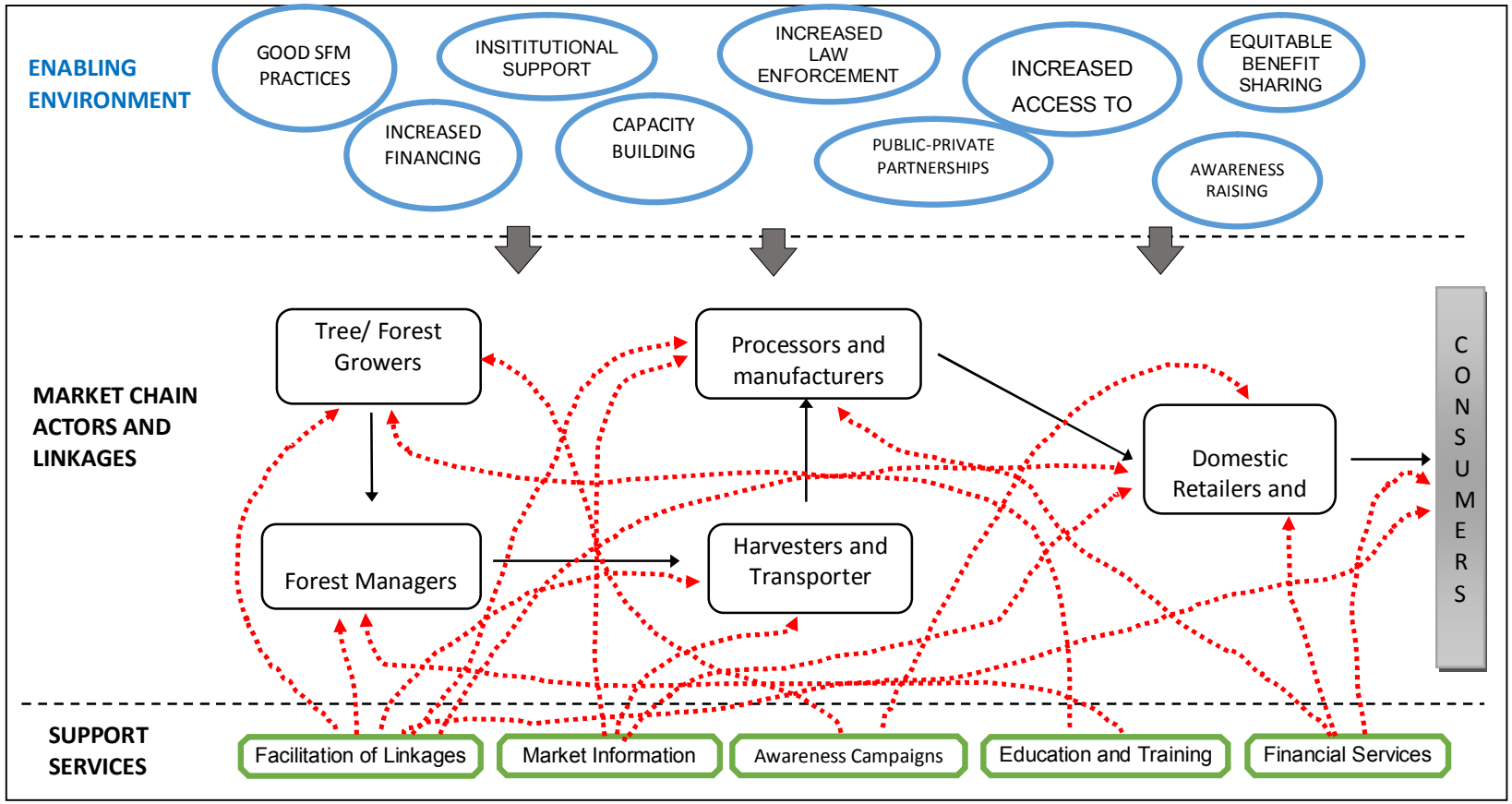
Annex 9: Objective – Solar PV



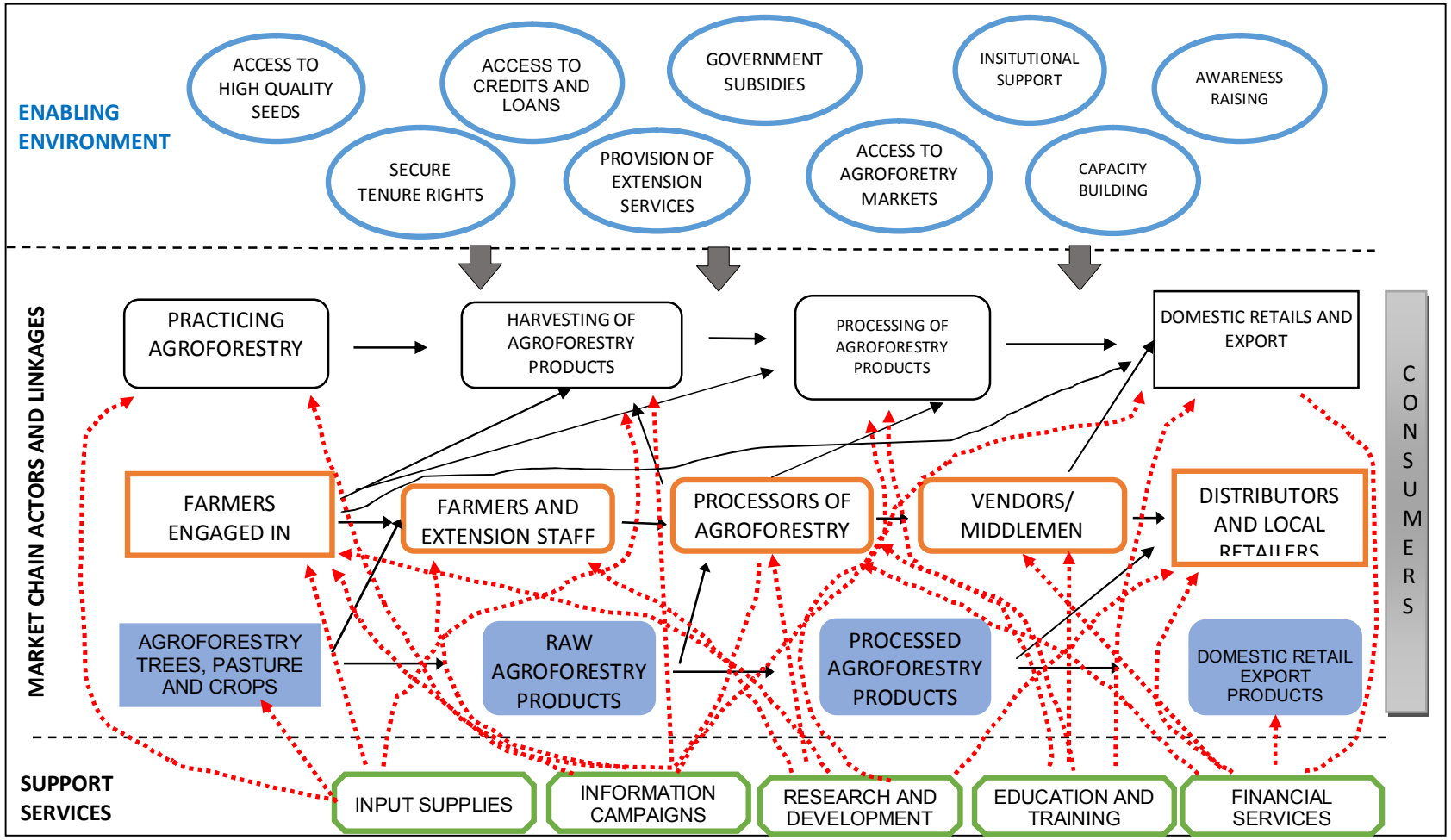
Annex 10: Objective – Mini Hydropower



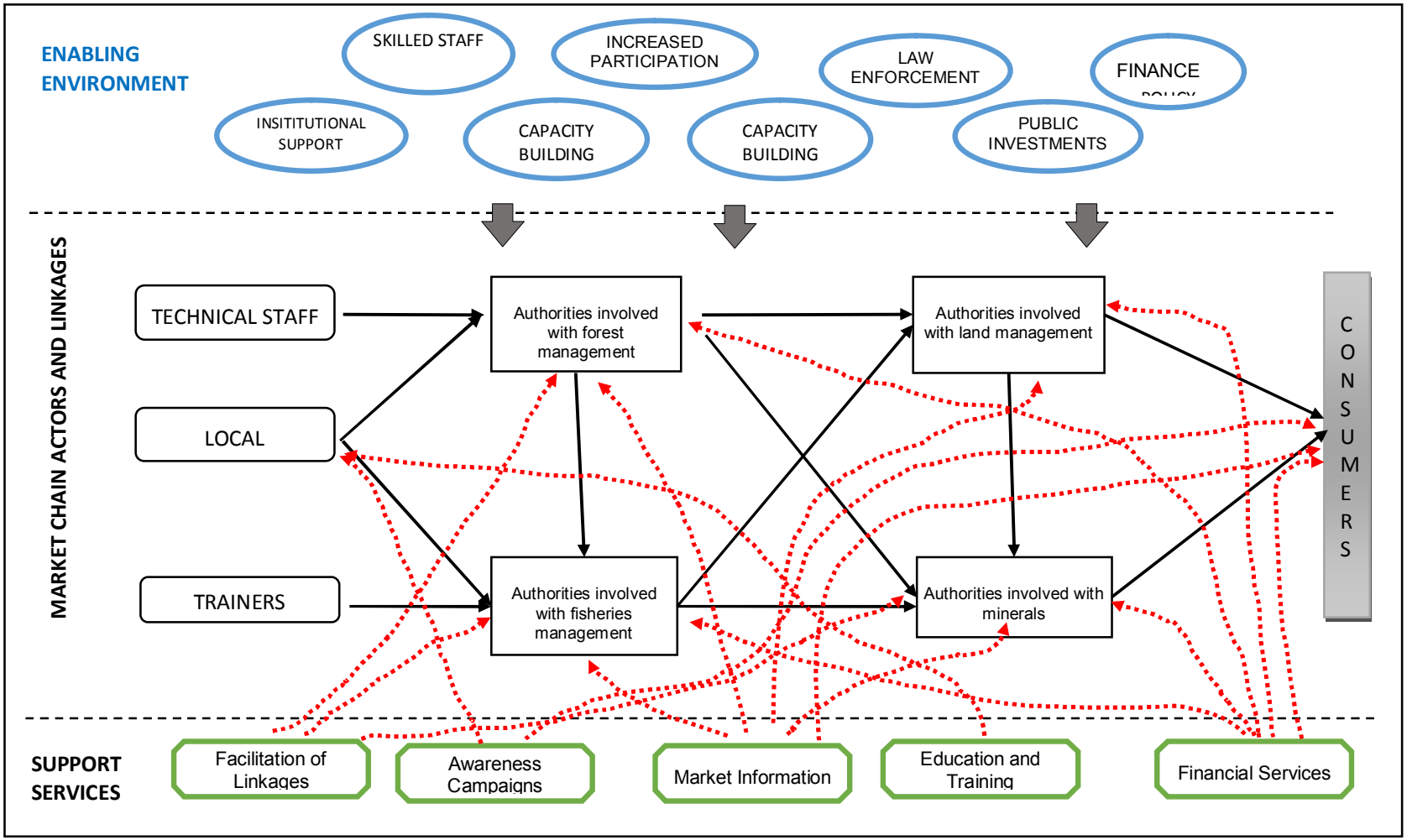
Annex 11: Sustainable Forest Management



Annex 12: Agroforest

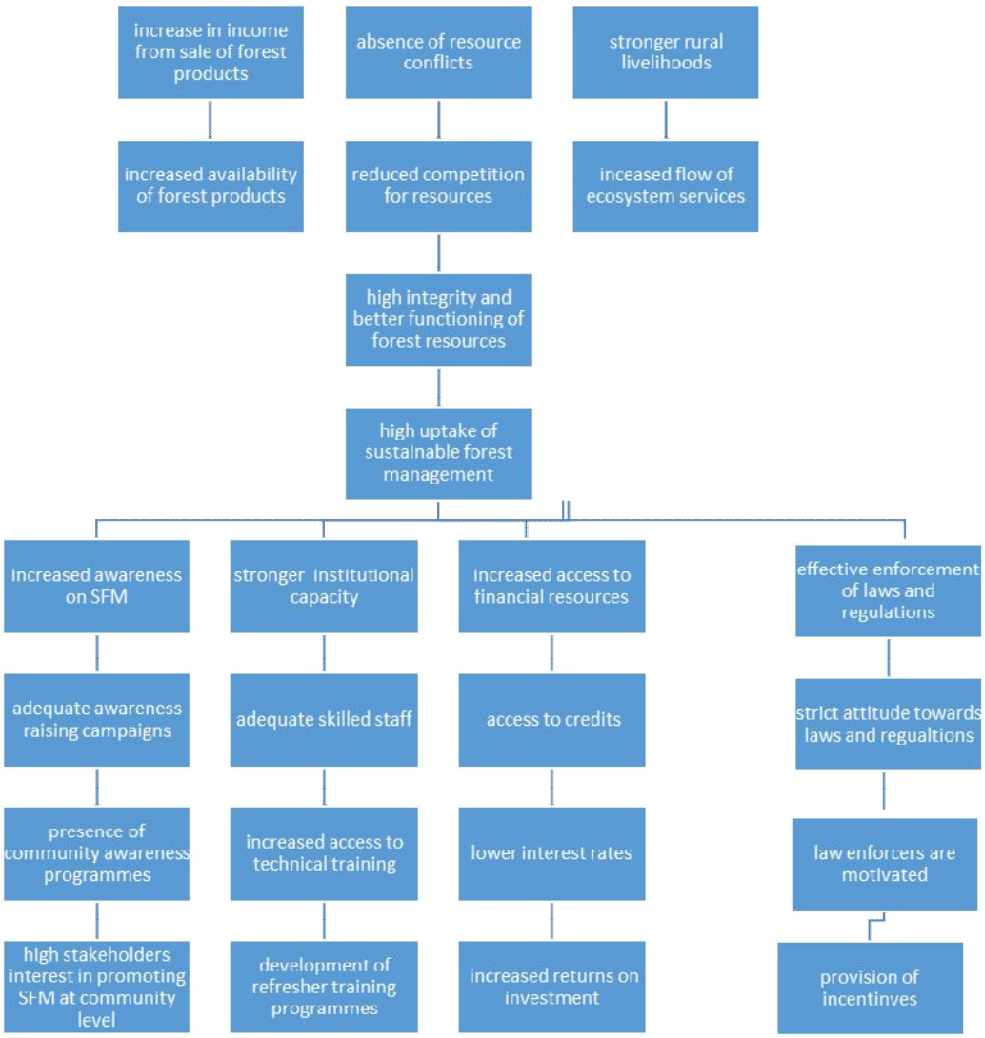


Annex 13: Sustainable management of Mangrove

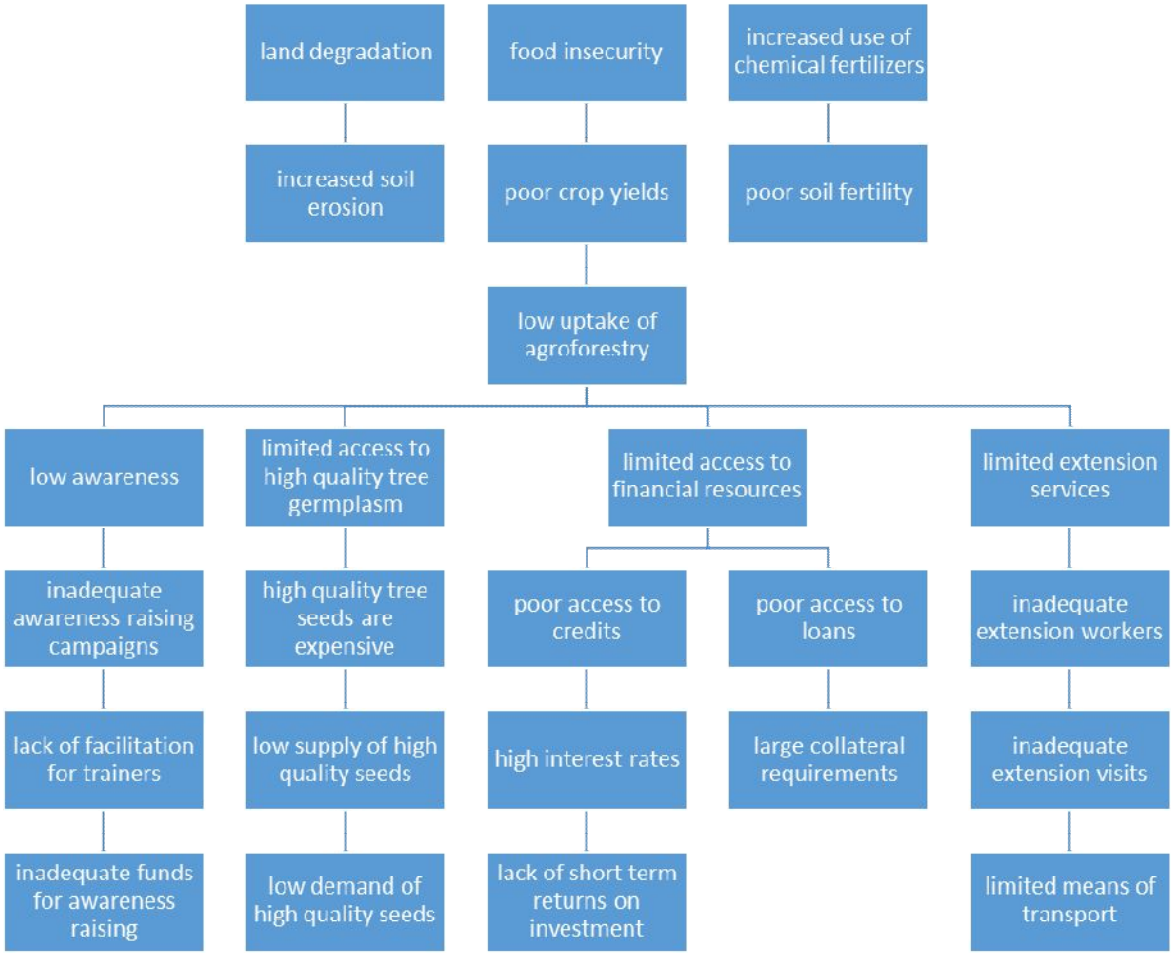


Annex 14: Problem Tree - SFM

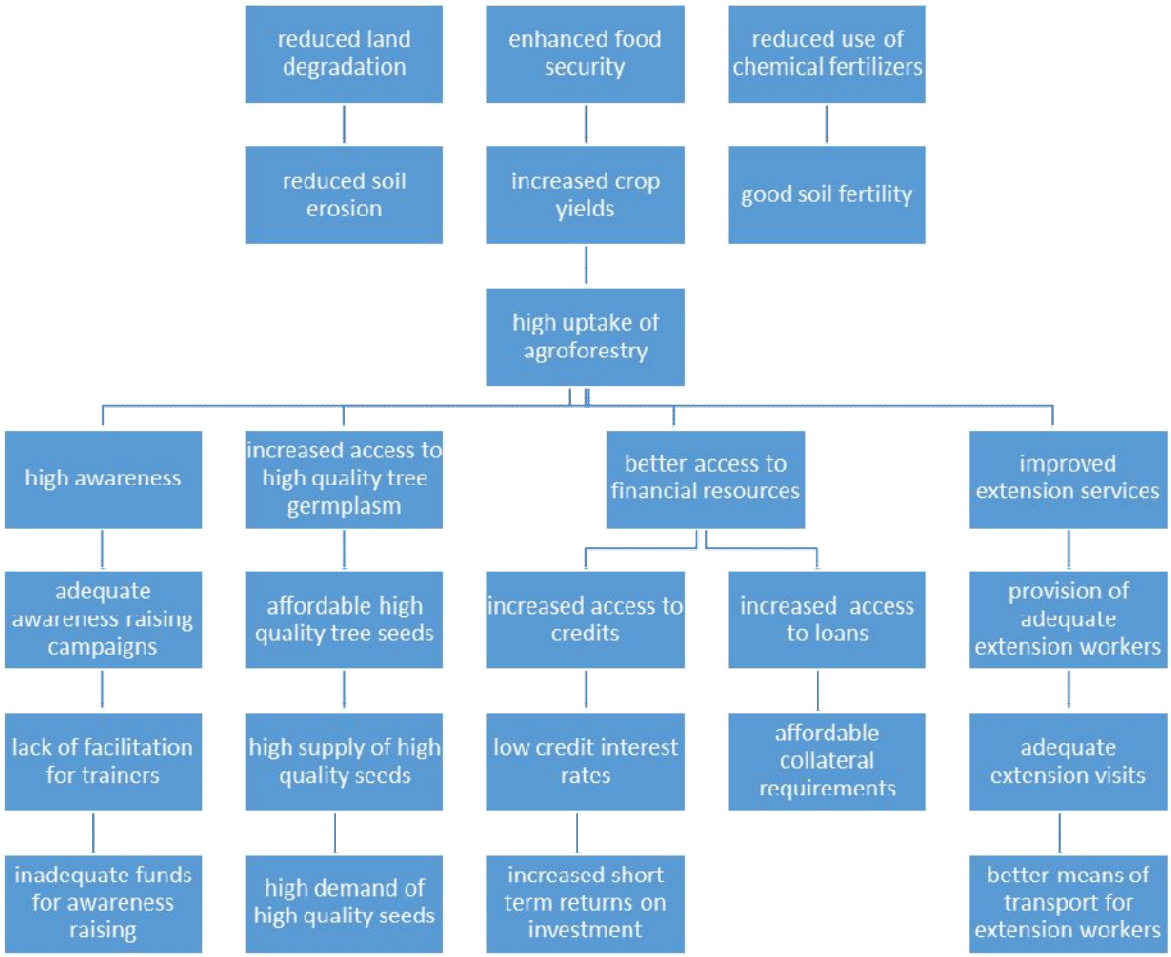
Annex 15: Solution Tree - SFM



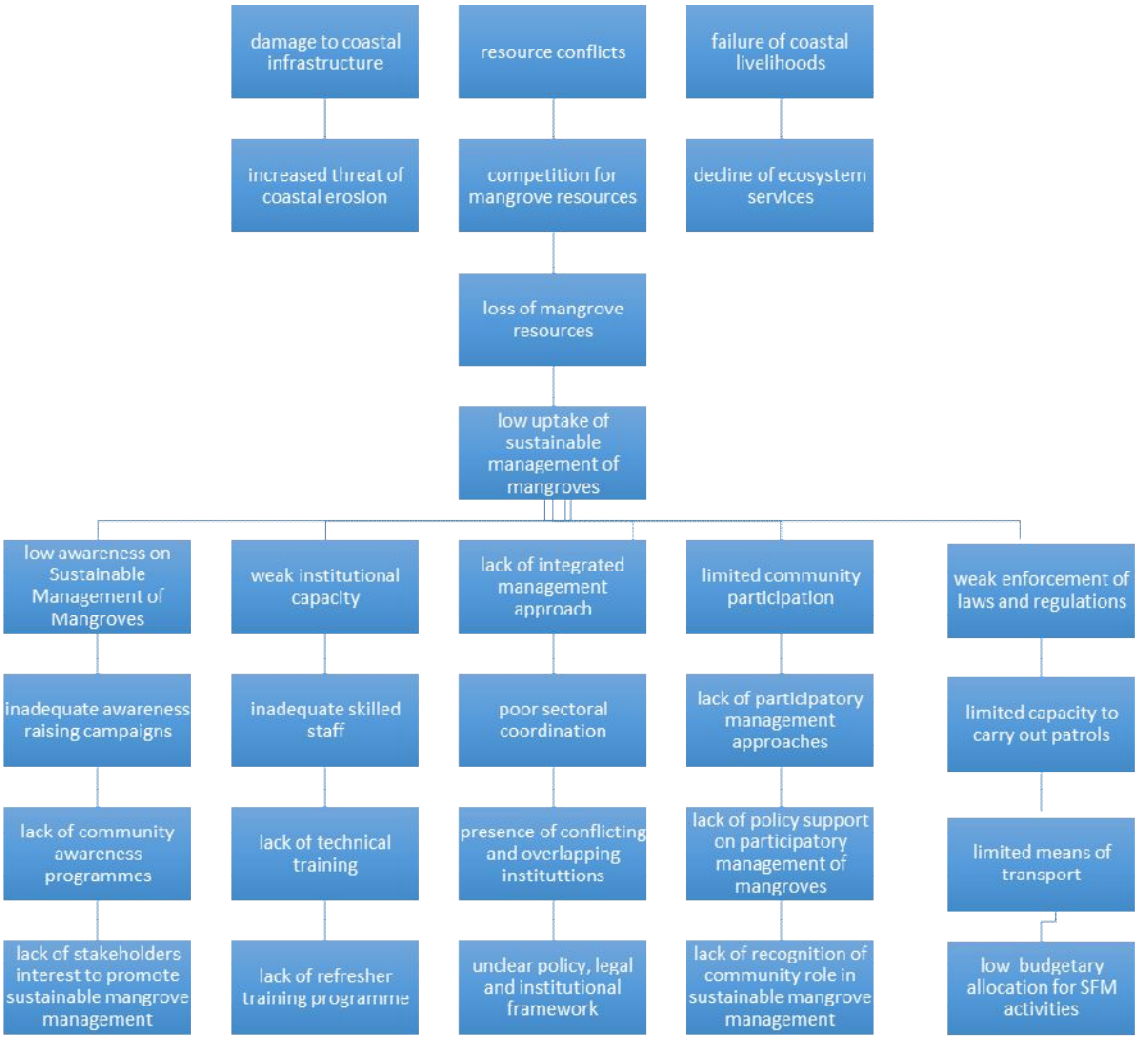
Annex 16: Problem Tree Agroforest



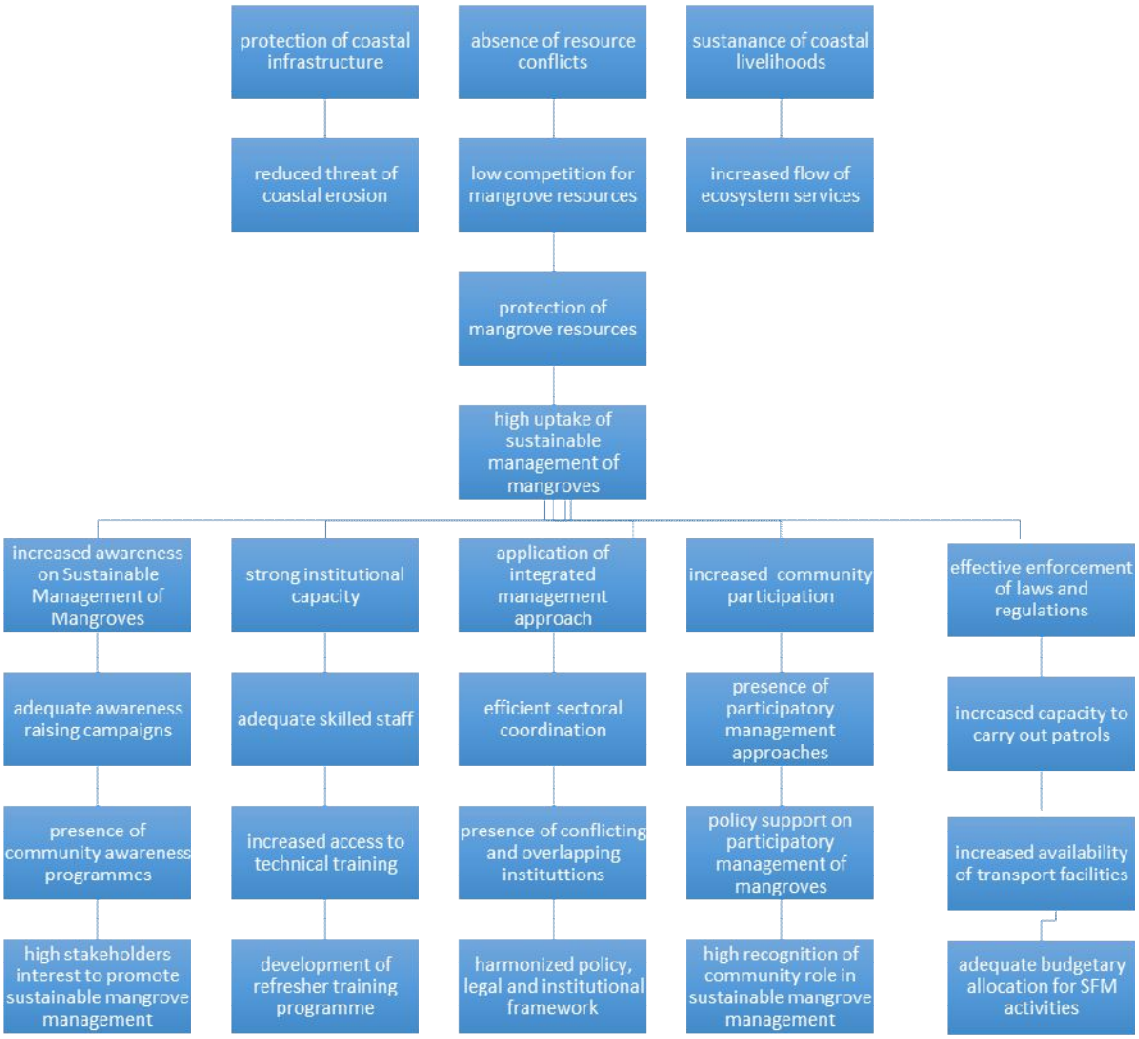
Annex 17: Solution Tree - Agroforest



Annex 18: Problem Tree – Sustainable Mangrove Management


damage to coastal infrastructure
resource conflicts
failure of coastal livelihoods
increased threat of coastal erosion
competition for mangrove resources
decline of ecosystem services
loss of mangrove resources
low uptake of sustainable management of mangroves
low awareness on Sustainable Management of Mangroves
weak institutional capacity
lack of integrated management approach
limited community participation
weak enforcement of laws and regulations
inadequate awareness raising campaigns
inadequate skilled staff
poor sectoral coordination
lack of participatory management approaches
limited capacity to carry out patrols
lack of community awareness programmes
lack of technical training
presence of conflicting and overlapping instituttions
lack of policy support on participatory management of mangroves
limited means of transport
lack of stakeholders interest to promote sustainable mangrove management
lack of refresher training programme
unclear policy, legal and institutional framework
lack of recognition of community role in sustainable mangrove management
low budgetary allocation for SFM activities

Annex 19: Solution Tree – Sustainable Mangrove Management



Annex 20:List of Stakeholders

List of stakeholders involved in the identification of barriers and development of enabling framework, including their names, organisation, approach of consultation (e.g. interview, meeting discussion, questionnaire, etc.), time, and topics.

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