The Republic of Uganda

TECHNOLOGY NEEDS ASSESSMENT REPORT FOR CLIMATE CHANGE ADAPTATION

Barrier Analysis and Enabling Framework Report

[December, 2020]

AGRICULTURE, WATER AND FORESTRY SECTORS

Report 2: TNA Report for Climate Change Adaptation in the Agriculture, Water and Forestry Sectors of Uganda

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List of acronyms

ACODE	Advocates Coalition for Development And Environment

AEAS	Agricultural Extension and Advisory Services
BMAU	Budget Monitoring and Accountability Unit
CAADP	Comprehensive Africa Agriculture Development Programme-African Union
CBIS/CIS	Community-Based Irrigation Schemes
CDO	Chief District Officer
CSO	Civil Society Organization
DAES	Directorate of Agricultural Extension Services
DFI	District Farm Institutes
DFS	District Forest Services
DUS	Distinctness, Uniformity and Stability
DWWE	Deep Well Water Extraction
ESAFF	Eastern and Southern Africa Small Scale Farmers' Forum
FAO	Food and Agricultural Organization of The United Nations
FFS	Field Farmers School
FMNR	Farmer Managed Natural Regeneration
FSSD	Forest Sector Support Department
FY	Financial Year
GDP	Gross Domestic Product
GIS	Geographic Information System
GOU	Government of Uganda
HDPE	High Density Polyethylene
ICT /IT	Information and Communications Technology
IDRC	Infectious Diseases Research Collaboration
IPM	Integrated Pest Management
ISSD Plus	Integrated Seed Sector Development Plus
ITK	Indigenous Technical Knowledge
IV	Improved Varieties
IWRM	Integrated Water Resources Management
LG	Local Government

LSB	Local Seed Business
LVB	Lake Victoria Basin
M&E	Monitoring and Evaluation
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
MoFPED	Ministry of Finance, Planning and Economic Development
MPS	Ministerial Policy
MWE	Ministry of Water and Environment
MWLE	Ministry of Water Lands and Environment
NAADS	National Agricultural Advisory Services
NAES	National Agricultural Extension Strategy
NAEP	National Agricultural Extension Policy
NAP-Ag	National Adaptation Plan for Agriculture
NARI	National Agricultural Research Institute
NARO	National Agricultural Research Organization
NDC	Nationally Determined Contribution
NDP	National Development Plan
NFA	National Forestry Authority
NGO	Non-Government Organization
NSA	Non-State Actors
NSCS	National Seed Certification Service
NSS	National Seed Strategy
NTV	Nation Media
NVRC	National Variety Release Committee
OECD	Organization for Economic Co-Operation And Development
OPV	Open Pollinated Varieties
PM&E	Planning, Monitoring and Evaluation
PPP	Public Private Partnership
PPPP	Public Private People Partnership
QDPM	Quality-Controlled Planting Material
REACH Uganda	Resilient Efficient Agribusiness Chains

RWH	Rooftop rainwater Harvesting
SMS	Short Message Service
SPR	Sector Performance Report
SQCC	Seed Quality Control and Certification
SSIP	Sector Strategic Investment Plan
TNA	Technology Needs Assessment
ToR	Terms of Reference
TV	Television
UGGDS	Uganda Green Growth Development Strategy
UGX	Ugandan Shilling
UNESCO	United Nations Educational, Scientific and Cultural Organization
URWA	Uganda Rainwater Association
USAID	The United States Agency for International Development
USD	United States Dollar
VAT	Value Added Tax
VCU	Value for Cultivation and Use
WUA	Water Users Association
WUC	Water Users Committees

Executive Summary

In the first part of the TNA process technologies were prioritized for the key sectors for climate change adaptation (Forestry, Agriculture and Water). The process of technology prioritization involved review of literature and national documents and consultation of stakeholders and experts to ensure that technologies selected were aligned with national development priorities and potentially effective in enabling adaptation to projected vulnerabilities resulting from climate change. The technologies prioritized were:

- For the Agriculture Sector: Community-based irrigation, Crop breeding for climate adaptation, and Responsive agricultural extension;
- For the Water sector: Rooftop rainwater harvesting (RWH), Deep well extraction and Surface runoff harvesting; and
- For the Forestry Sector: Promotion of Farmer Managed Natural Regeneration (FMNR) for forest landscape restoration, Integrated pest management (IPM) in natural forests and forest plantations, and Promotion of Forest based enterprises

In this second part of the TNA process each of these technologies has been analyzed further through literature review, consultation with stakeholders and experts to identify the targets for the technology in the national development process, the barriers to the transfer and diffusion of the technology, and the potential measures to address these barriers. In each sector, the enabling framework for the transfer and diffusion of the technologies was also assessed. In this report, the findings from this analysis are presented. The following tables summarize the barriers and measures to the transfer and diffusion of the technologies in the three sectors.

Water sector

Uganda seeks to increase access to basic safe and affordable water supply for rural households from 69% to 80% (covering 47,349 more villages and 28,780,503 people) by 2030 through establishment of safe sources of water for drinking and irrigation (Ministry of water and Environment Water Sector investment plan 2018). High priority is to be given to water vulnerable hotspots in South Western and Eastern Highlands, Lake Victoria Crescent, the Cattle Corridor, and Eastern and Northern Uganda (UGGDS 2017-2031). The country also seeks to

increase water for production storage capacity from 41.21 million cubic meters (MCM) to 60.3 MCM through dams and valley tanks by 2025 **(**MWE MPS 2020). Rooftop rainwater harvesting is to be increased by establishing 50 rainwater harvesting units for demonstration, 500 units through incentives and 125 institutional units through promoting voluntary establishment by 2031 (MWE SSIP 2018). Deep well extraction is to be enhanced by establishing 855 new units by 2030, improving the functionality of all boreholes, and transitioning from using low yield pumps of $1m^3/h$, to high yield units (> 12 m^3/h), which use solar powered pumps (MWE MPS 2020). The target for surface runoff harvesting is constructing 100 large-scale units for demonstration, promoting 200 units from roads and paths using incentives and motivate 50 voluntary units through advice.

TABLE 1. BARRIERS TO THE TRANSFER AND DIFFUSION OF PRIORITIZED TECHNOLOGIES AND MEASURES TO ADDRESS BARRIERS IN THE WATER SECTOR

Rooftop rain water harvesting		
Barrier category	**Barrier**	**Measure**
Financial	Low private investment in rooftop rainwater harvesting	Enable functional private sector engagement in RWH
		Improve household access to financing for RWH
Non-financial barriers	Inadequate extension advisory capacity for supporting RWH	Develop a catalogue or database of information on RWH technology
		Demonstrate the value of RWH under different climate scenarios
		Strengthen technical capacity in RWH
	Low social cultural culture of RWH	Strengthen community organization for RWH
	Inadequate policy and legal	Strengthen coordination for implementation of RWH policy

	support for RWH	provisions
Deep-well water extraction		
Barrier category	**Barrier**	**Measure**
Financial	High costs especially related to equipment, drilling operation & maintenance and low access to spare parts	Reduce costs of ground water extraction e.g., remove importation duties from drilling equipment, invest in local fabrication of the parts, incentives for business commercial development of groundwater resource, increasing supply of technical service providers, invest in more large-diameter and mechanised boreholes, invest in increasing road access to potential areas for well establishment
Non-financial	Inadequate technical capacity for constructing, operating and maintaining deep wells	Strengthen technical skills for borehole installation and management
	Water Quality concerns	Improve water quality assurance
	Institutional weaknesses	Strengthen institutions for groundwater management
Surface runoff water harvesting		
Barrier category	**Barrier**	**Measure**
Financial	High cost of installation and operation of macro-catchment surface runoff water harvesting	Increase access to capital and equipment
Non-financial	Inadequate skilled personnel to design, install and maintain the technology.	Strengthen the capacity of water officers
	Inadequate information on surface	Create awareness

	runoff water harvesting.	
		Strengthen monitoring and analysis of water runoff data
		Conduct research to increase understanding of the potential for runoff water harvesting
		Strengthen water management stakeholder organizations

Enabling framework for overcoming barriers in the water sector

Common barriers were high cost of installation, inadequate capacity of extension officers, insecurity of land tenure, inadequate community extension support, and low private sector investment. For these, the government has various measures in place including private sector partnerships, subsidising equipment prices, partnering with NGOs in extension, forming and supporting water user associations, processing land titles, investment in construction, and installation of water infrastructure and community organisation.

Agriculture sector

The targets for the technologies prioritised for climate change adaptation in the agriculture sector are as follows:

- Community-based irrigation (CBI): This is going to be a major approach in achieving the national overall objective of increasing irrigated area by 1,500,000 hectares by 2040 (National Irrigation Policy 2017).
- Crop breeding for improved varieties that are climate resilient: the farming population using improved seed was projected to reach to 33-35% by 2020 in the National Seed Strategy and assuming the same rate of growth, should reach 60% by 2030.
- Responsive agricultural extension for climate change adaptation in different contexts: The country seeks to increase the ratio of extension worker to farmer to 1:500 I giving well-coordinated, harmonized, regulated pluralistic service and working with multiple providers to address diverse needs of farmers and other beneficiaries.

TABLE 2. BARRIERS TO THE TRANSFER AND DIFFUSION OF PRIORITIZED TECHNOLOGIES AND MEASURES TO ADDRESS BARRIERS IN THE AGRICULTURE SECTOR

Community Based Irrigation		
Barrier category	**Barrier**	**Measure**
Financial	High cost of establishment, operation and management	Public investment in CBI from direct implementation or contracting private companies
		Legislation against importation of cheap outdated equipment, Reducing taxes on water or energy cost Facilitating farmers to acquire credit on good terms. Conducting studies on the business potential for CBI
Non-financial	Limited farmer capacity in organizing and managing irrigation systems	Map out suitable sites for community-based irrigation scheme
	Inadequate technical capacity of extension officers to support planning, designing and construction of CBI	Develop small-scale irrigation information packages
		Build capacity of extension personnel in irrigation skills
	Potential conflict related to land, water, infrastructure ownership rights	Mitigate and avoid potential conflict related to land, water, infrastructure ownership rights
		Build farmer capacity in organizing and managing irrigation system

Crop breeding for improved varieties that are climate resilient		
Barrier category	**Barrier**	**Measure**
Financial	High cost of production and distribution of climate-adapted seed varieties	Mitigate cost of producing climate-adapted seed varieties by e.g., increasing budget allocation to NARO; investing in precision of equipment and methods for quality control; strengthening regional cooperation in crop improvement, private sector partnership. Increase improved variety affordability through provision of subsidies for farmers, alliances with NGOs to train farmers, providing seed funding for local savings and credit schemes.
Non-financial	Inadequate involvement of farmers and local knowledge variety development	Strengthen community involvement in the development of improved seed
	Inadequate involvement of private sector	Strengthen private sector partnership
	Counterfeit seed in circulation	Strengthen enforcement of regulations to reduce counterfeits
	Insufficient compatibility with smallholder farming contexts	Improve research capacity to generate improved varieties for different contexts
	Research and extension are poorly coordinated	Strengthen research extension linkages and information flow
Responsive agricultural extension for climate change adaptation in different contexts		
Barrier category	**Barrier**	**Measure**

Financial	Inadequate financing and budget allocations	Increase budget allocation, develop partnerships and improve efficiency in agricultural extension including ICT development and research; develop public-private partnerships; provide subsidies; strengthen financial governance and accountability.
Non-financial	Limited human capacity to provide effective extension support for resilient farming in different contexts	Strengthen technical capacity of extension workers to become more responsive to changing needs of farmers
		Strengthen extension-farmer linkages
	Inadequate monitoring and surveillance	Improve monitoring and surveillance
	Weak structures to engage farmers	Coordinate extension service provision

Enabling framework for overcoming barriers in the agriculture sector

Common barriers were high cost of establishment and operation, inadequate farmer involvement in planning and implementation of technology transfer, inadequate tailoring of technology to different contexts, counterfeits and low technical capacity. Various national policies and strategies in place can potentially address these and enable technology transfer and diffusion. These include the key objective in the National Development Plan 3 to increase the rate of growth of the agricultural sector from 3.8% to 7%; a commercialization fund is being piloted under the Agricultural Sector Strategic Plan; Subsidies to support progressive farmers and organized farmer groups; the Intergovernmental Fiscal Transfer Reform Program (IFTRP) supported by the World Bank, direct public investment in water storage and transfer infrastructure, seed variety development and improving extension services, public-private partnerships, regional partnerships in crop breeding, recognizing community land and intellectual

property rights, building social protection in agricultural support programs, recruiting more and training extension officers among others.

Forestry Sector

This is a report of the Phase II of the process of Technology Needs Assessment for the Forestry sector in Uganda. This phase focused on barrier analyses and enabling framework identification for the prioritized technologies for advancing climate change adaptation in the forestry sector in Uganda. The report therefore, presents the key barriers and associated root causes for each of the prioritized technology and related measures/strategies for addressing them.

The objective of the barrier analysis is to analyse the market conditions for each of the prioritized technologies and to identify the barriers to their introduction, use and diffusion. The prioritized technologies are described in Section 2 and include:

- Promotion of Farmer Managed Natural Regeneration (FMNR) for forest landscape restoration;
- Integrated pest management in forest plantations through promoting mixed species plantations; and
- Promoting Forest based enterprises e.g. bee keeping/apiary, butterfly farming, fruit trees production; ecotourism.

The methods, approaches and tools which were applied in the process of barrier analyses and enabling framework identification that was largely based on the publication titled, 'Overcoming Barriers to the Transfer and Diffusion of Climate Technologies,' by Nygaard and Hansen, (2015).

Thus, this largely focused on the following:

a. Identification and prioritization the barriers using the following Barrier Analysis (BA) tools: review of relevant literature (policies, action plans, annual reports, technical reports), informal/bilateral meetings, brainstorming, a site visit, and the Logical

Framework Analysis (LFA), also known as 'Problem Tree' to decompose barriers and complete root cause analysis;

b. Assessment of the possible measures to address the barriers for the transfer and diffusion of each technology; and
c. Identification of the enabling environment and support to enhance the uptake of the technologies.

The following key steps of the barrier analysis were followed:

- Identified all possible barriers for each of the prioritized technologies through review and synthesis of relevant literature and interviews with key informants.
- Screened the long-list of barriers for each prioritized technology to select the most essential ones;
- Classification of the selected essential barriers into a hierarchy of categories including: economic, financial, institutional, legal, technical, social and cultural barriers.
- Develop measures to overcome barriers by translating barriers into solutions;
- Assess the costs and benefits of measures to determine whether they comply with policy objectives;
- Select a set of complementary measures to include in programmes.

Notable is that gender analyses was a key consideration throughout all the phases of the TNA process in Uganda i.e. from inception, through the identification and prioritization of technologies and the barrier analyses and enabling framework identification. This is largely based on the key consideration that climate change impacts on the various gender categories differently and that women and children are more vulnerable to climate change impacts compared to other gender categories (UNFCCC, 2019). Particularly, during the barrier analyses and enabling framework identification phase and gender considerations were integrated during the classification of the identified barriers specifically in the social and cultural categories. Hence, corresponding key strategies for addressing the gender related barriers were identified.

Likewise, representation of gender experts and related presentations and discussion of gender implications for each the prioritized technologies were a key consideration during the

stakeholder's validation workshop. Through the above steps, the consultants applied their own experience, supplemented by published information and learnings of similar processes in other countries. They generated key outputs as barriers for each of the prioritized technology and these were consolidated into the draft barrier analyses report, which was presented, discussed and validated during the national stakeholder's workshop, held on 16-17th March 2020. The workshop involved key stakeholders in the forestry sector including:

Particularly, the stakeholder's representatives reviewed and validated the following, based on stakeholders' knowledge in the area, experience acquired and lessons learned from local implementation (where existing) of the technology:

a. Identified barriers for each of the prioritized technology;
b. Problem and solution tree analyses for each the barriers identified for each prioritized technology.

Furthermore, the stakeholders ranked the major barriers based on relative important attached/perceived i.e. as high, medium or low – by attaching ranks of 1 & 2, respectively. This was as well based on the following criteria:

a. Impact of the barrier on the technology. Thus, is a major or minor barrier? The extent to which the barrier limits technology development and transfer if not addressed. Furthermore, extent to which it promotes technology development and transfer if addressed.
b. Ease of addressing the barrier - estimated cost, social/cultural aspects
c. Existing initiatives by various actors to address the barrier.

For each of the identified barriers, a problem and solution tree analyses were done to better understand the major causes of the barriers and associated strategies for addressing the barrier, respectively. This analysis was as well presented to the stakeholder representatives for validation during the national stakeholder's validation workshop on barrier analyses and enabling framework held on 16-17th March 2020 at the Uganda National Council of Science and Technology offices in Ntinda, Kampala.

As a result, from this process, the identified and prioritized barriers for each of the selected technologies are presented in Table 3.

TABLE 3. BARRIERS TO THE TRANSFER AND DIFFUSION OF PRIORITIZED TECHNOLOGIES AND MEASURES TO ADDRESS BARRIERS IN THE FORESTRY SECTOR.

Farmer Managed Natural Regeneration for forest landscape restoration		
Barrier category	**Critical barrier**	**Measure to address the barrier**
Financial	i) The main benefits of FMNR are realized in the medium term at least five to ten years after establishment; this means that farmers must be prepared to invest in their establishment and management during several years before the main benefits are generated.	a) Promote enterprises with short term benefits with due consideration of preferences of men, women & youth for diversification with farmer managed natural regeneration. b) Provide incentives to support land restoration in the forest landscapes. c) Create targeted awareness to change community mindset/attitude in respect to short-term gains/benefits.
Financial	ii) Limited land available for investment in forest restoration within the landscapes.	a) Development and operationalization of land-use plans b) Provide incentives for land allocation for investment in landscape restoration through FMNR. Some of the incentives could be inform of small grants and or technical support for development of forest management plans.
Non-financial	iii) The bush burning and stray livestock destroy regenerated trees, especially in Northern Uganda, yet the ordinances and byelaws for regulation of wildfires are lacking or inadequately implemented.	a) Enhance knowledge of the community (including men, women & youth) & other key stakeholders about impacts of bush burning and stray livestock. b) Provision of alternative livelihood options for the men and boys involved in

		the hunting of edible rats & mud fish. c) Work with cultural institutions to change mindset, behavior and attitudes linked to bush burning and free-range grazing. d) Advance targeted mass awareness creation on unregulated bush burning e) Promoting alternative gender responsive technology for easing land clearing and opening for agricultural production e.g. use of tractors, oxen ploughs and minimum tillage. f) Provision of improved (e.g. drought resistant, early maturing) pastures as alternatives for grazing of livestock, especially during the dry season. g) Strengthen response for control & regulation of bush fires and stray livestock through implementation of bylaws/ordinances & integrated fire management. g) Update/review of outdated policies-laws – for discouraging bush burning
Non-financial	iv) Limited awareness and appreciation of the technology among policy and decision makers at the national, landscape and local levels.	a) Increased publication of literature quantifying the social, economic & environmental benefits of the technology b) Increased targeted community awareness about the diverse benefits that arise from FMNR.

		c) Increased invested in targeted research, training and development in FMNR to contribute to livelihoods, landscape restoration. d) Support more champions for FMNR through establishment of demonstration sites/centres in the forest landscapes in the country. e) Conducting structured policy dialogues on FMNR with policy and decision makers with the forest landscapes.
Non-financial	v) Long-held beliefs by farmers that trees on farmland will attract pests and/or reduce yields, and so trees should be completely cleared.	a) Increased publication of literature quantifying the social, economic & environmental benefits of the technology b) Targeted training of community & famers (including men, women & youth) to enhance their knowledge and skills for application of FMNR. c) Increased targeted community awareness (including men, women & youth) about the diverse benefits that arise from FMNR. d) Streamlining of priorities and communication from various Government development programs in agriculture, environment and natural resources management to avoid contradictions.

Non-financial	vi) FMNR falls outside the mainstream of agroforestry, agriculture and forestry sub-sectors, thus making it difficult to access structured support for up scaling, but also acceptance by the appropriate research communities	a) Improved access to structured support (e.g. inputs, monitoring/backstopping for up scaling FMNR b) Strengthen extension within the forestry/agriculture sectors to provide responsive advice to community and farmers (including women, youth & men) in respect to application of FMNR. c) Establishment of coordinated research agenda and teams to generate the required evidence for FMNR at different scales.
Non-financial	vii) Land tenure regimes especially the communal land tenure in Northern Uganda and West Nile regions where there are common property rights that compromise effective management and hence survival of the regenerating trees	a) Advancing targeted community awareness creation on information on land policies and laws to guide sustainable land-use and management of communal land through FMNR involving men, women, youth and cultural institutions. b) Strengthen capacity of cultural/customary institutions to deliver on their roles in respect to administration/management of customary land. c) Strengthen institutional capacity for area land committees in providing effective information on land rights & administration.
Non-financial	viii) Limited access, control of resources and decision making in	a) Conduct structured engagements with cultural institutions to influence and

	respect to land use and management by women and youth	change beliefs, attitude and customs that limit women's land ownership. b) Targeted community engagement (including men) to change their attitude for support of women's and youth's access & control of resources. c) Creating targeted awareness on women land rights as provided for in the existing policies and laws. d) Create opportunities for women's and youth's financial and leadership empowerment.
Integrated pest management in forest plantations through promoting mixed species plantations		
Financial	i) The chemical pesticides are expensive and may not be affordable for smallholders.	a) Advance access to chemical pesticides by community and smallholders – including men, women and youth. b) Strengthen institutional organization of smallholders to access chemical pesticides c) Advocate for reduction of taxes and levies charged by Government on the pesticides. d) Strengthen regulation and enforcement of standards for especially chemical pesticides. e) Promote local investment into the manufacture of the chemical pesticides.
Non-financial	ii) Existence of counterfeit especially the chemical pesticides	a) Strengthen enforcement and regulation of standards for chemical

	on the market, which are not effective in the control and treatment of the pests and diseases.	pesticides at all levels. b) Strengthen institutional organization and capacity of consumers to demand for chemical pesticides that meet the acceptable standards and quality. c) Review policies to include strong penalties or deterrent measures to discourage providers of pesticides that do not meet quality and safety standards.
Non-financial	iii) Inadequate knowledge and application of the IPM especially among the private individual commercial tree growers.	a) Strengthen forestry extension system, to provide the required adequate support services to farmers and communities - including men, women and youth. b) Improve access to information about Integrated Pest Management and its application by smallholder farmers including men, women and youth. c) Document targeted simplified Information, Education & Communication materials on application of Integrated Pest Management. d) Promote targeted awareness and information of the farmers (including men, women and youth) about Integrated Pest Management to influence attitude and practice for effective application of IPM. e) Provide adequate training in Integrated Pest Management techniques – especially among smallholders -

		including men, women and youth.
Non-financial	iv) Non-uniformity in pest infestation, thus emerging at different stages of the tree cycle, they evolve over time, some IPM technologies are divisible and rarely do complete 'packages' exist for an entire crop or ecosystem.	a) Strengthen adaptation to Climate variability and change in forest plantations and the landscape through for instance, applying responsive agronomic & pest management practices; planting proven resistant tree varieties. b) Increase investment in research to develop responsive IPM solutions. c) Strengthen monitoring and surveillance of pests and diseases.
Non-financial	v) Limited access, control of resources and decision making in respect to land use by women and youth	a) Conduct structured engagements with cultural institutions to influence and change beliefs, attitude and customs that limit women and youth' access to and ownership of land. b) Conduct targeted community engagement (including men) to change their attitude for support of women's and youth's access and control of resources. c) Create targeted awareness on women land rights as provided for in the existing policies and laws. d) Create opportunities for women and youth's financial empowerment.
Forest based enterprises e.g. bee keeping/apiary, butterfly farming, fruit trees production		
Financial	i) Inability to sell products at	a) Improve access by women, men and

	competitive prices compromises overall revenue and profits from the forest-based enterprises.	youth to transport for their forest-based and agro-forestry enterprises' products and services. to the market. b) Improve access to market infrastructure and information c) Improve organization and coordination capacity by the forest adjacent communities – through bulk production and marketing. d) Support generation of high-quality products on the market through: e) Strengthen the forestry extension services at the local Government levels for effective service delivery to communities; Conduct targeted and responsive trainings, mentoring and backstopping to forest adjacent communities (including men, women & youth) in respect to establishment and management of forest-based enterprises; Strengthen enforcement of guidelines and standards for quality at different scales.
Financial	ii) Limited access to credit services by forest adjacent communities.	a) Promote a saving culture by the forest adjacent communities and their organizations, including men, women and youth. b) Strengthen knowledge of women, youth and men and skills for mobilization and management of

		savings and credit schemes by forest adjacent communities and their organizations. c) Promote access to financial management services, training and advisories by women, men & youth through collaboration with financial institutions and civil society organizations. d) Conduct responsive trainings on organizational development for forest adjacent communities.
Financial	iii) Mismanagement of resources and income by individuals.	a) Support visioning, action and business planning for the collaborative forest management groups and associated forest-based enterprises. b) Strengthen leadership skills of the collaborative forest management group leaders, including men, women and youth. c) Strengthen measures for disciplining or punishment of culprits/wrong doers.
Non-financial	iv) Weak negotiation capacities of collaborative forest management groups/associations.	a) Strengthen organizational and business skills especially among community-based organizations, forest adjacent community organizations or community forest management groups, involving men, women and youth. b) Promote access to structured training, exposure and mentoring- targeting and

		involving men, women and youth. c) Reduce vulnerability of the collaborative forest management groups or associations and their members through provision of various livelihood options and services based on preferences of the various gender categories i.e. men, women & youth. d) Conduct targeted and structured lobbying and advocacy responsive actions to address the needs and concerns of the collaborative forest management groups or associations.
Non-financial	v) Bush burning and stray livestock destroy forest-based enterprises and other properties - especially in Northern Uganda and Wet Nile regions.	a) Enhance knowledge of the community (including men, women, youth) and other key stakeholders about impacts of bush burning and stray livestock. b) Provision of alternative livelihood options for the men and boys involved in the hunting of edible rats and mud fish. c) Work with cultural institutions to change mindset, behavior and attitudes linked to bush burning d) Advance targeted mass awareness creation on unregulated bush burning and stray livestock grazing. e) Promote alternative gender responsive technology for easing land clearing and opening for agricultural production e.g.

		use of tractors, oxen ploughs and minimum tillage. f) Strengthen implementation or enforcement of bush burning bylaws and ordinances where they exist. g) Update or review outdated policies and laws deterring bush burning and grazing by stray livestock.
Non-financial	vi) Insecure tenure and land use rights – especially for the forest adjacent communities.	a) Promote targeted awareness about existing policies and laws, which provide for and protect these rights and obligations. b) Strengthen enforcement of forestry policies, laws and guidelines – through proactive stakeholder engagement and standards for quality at different scales. c) Strengthen institutional capacity community-based institutions including collaborative forest management groups for effective management of forest-based enterprises management groups. For instance, signing collaborative forest management agreements with them. d) Strengthen institutional capacity (limited resources allocation) of mandated institutions (e.g. Local Governments and National Forestry Authority) to effectively support/promote forest-based enterprise value chains.

Non-financial	vii) Limited access, control of resources and decision making in respect to land use by women and youth	a) Conduct structured engagements with cultural institutions to influence and change beliefs, attitude and customs that limit women's land ownership. b) Conduct targeted community engagement (including men) to change their attitude and support women and youth access and control of resources. c) Create targeted awareness on women land rights as provided for in the existing policies and laws. d) Create opportunities for women and youth financial empowerment.

Further details in respect to the related causes of the barriers for each of the prioritized technologies are presented in Tables 6, 7 & 8. In Annexes 1, 2 and 3 – the problem and solution tree analyses for each of the barriers for the prioritized technologies is presented.

Engagements with key stakeholder representatives considered the following as the most important strategies/actions to address the barriers for the selected technologies for advancing adaptation in the forestry sector:

- *Targeted awareness creation;*
- *Responsive/targeted institutional capacity building;*
- *Improving access to inputs and services;*
- *Strengthen policy implementation and enforcement;*
- *Gender mainstreaming during implementation of the measures.*

In Table 9, 10, 11 and 12, the detailed measures for addressing the identified barriers for each of the prioritized technologies is presented. Furthermore, the Enabling framework measures for prioritized technologies in the Forestry sector in Uganda is detailed in Table 12. However, of

note is that effective implementation of the measures for the each of the prioritized technologies as described in Table 12 requires gender mainstreaming during implementation of the measures. This largely because there is limited access, control of resources and decision making in respect to land use by women and youth.

This certainly negatively impacts on their participation and full application and adaptation of the technologies. Therefore, the women and youth should be empowered through gender mainstreaming during implementation of the proposed measures described in Table 12. This can be achieved through implementation of the following strategies as part of the process of gender mainstreaming:

a) Conducting structured engagements with cultural institutions to influence and change beliefs, attitude and customs that limit women's land ownership.

b) Organizing targeted community engagement (including men) to change their attitude for support of women's and youth's access & control of resources.

c) Creating targeted awareness on women land rights as provided for in the existing policies and laws.

d) Creating opportunities for women's and youth's financial empowerment.

Overall the 2nd Phase of the TNA process for Uganda i.e. barrier analyses and enabling frameworks identification for the prioritized technologies for advancing adaptation in the forestry sector was successfully completed. It involved active participation of the different key forestry sector stakeholders. With completion of this phase of the Uganda TNA process and guidance and decision made on the priority technologies for advancing adaptation in the forestry sector in Uganda, it's now timely to pursue the third phase of the TNA process. This will focus on the development of the Technology Action Plan.

CHAPTER 1: WATER SECTOR

The water sector is considered to be vulnerable to adverse effects of climate change in Uganda's Nationally Determined Contribution (NDC 2016) and needs special focus for adaptation interventions. Adaptation technologies prioritized in the Technology Needs Assessment include:

- Rooftop rainwater harvesting (RWH)
- Deep well water extraction
- Surface runoff water harvesting

This chapter presents the process followed and the results obtained in the identification and analysis of barriers hindering the acquisition, innovation, and diffusion of these technologies; the measures to overcome these barriers and the enabling framework for transfer and diffusion of these technologies. The respective targets of these technologies according to national aspirations are given below.

1.1 PRELIMINARY TARGETS FOR TECHNOLOGY TRANSFER AND DIFFUSION

The development and utilization of Uganda's water resources gives highest priority to domestic water supply for both human consumption and livestock. Stronger emphasis is on rural areas where 30,967,593 persons (80% of the population) reside (UBOS 2014). Overall, the sector seeks to increase access to basic safe and affordable water supply for rural households from 69% to 80% (28,780,503 people) by 2030 through establishment of safe sources of water for drinking and irrigation in all the villages. By 2030, 47,349 more villages need to be covered (Ministry of Water and Environment Water Sector Strategic Investment Plan 2018). High priority is to be given to the four land degradation hotspots/agro-ecological zones: (i) South Western and Eastern Highlands, (ii) Lake Victoria Crescent Region, (iii) the Cattle Corridor, and (iv) Eastern and Northern Uganda (Uganda Green Growth Development Strategy UGGDS 2017-2031). To increase water for production, storage capacity will be built from 41.21 million cubic meters (MCM) to 60.3 MCM through dams and valley tanks by 2025 **(**MWE MPS 2020**).** Gender concerns are also key as recommended in the Environment and Natural Resources Gender Strategy (2016-2021) and are to be built in the climate change technology transfer process

through training of relevant technical staff, developing and disseminating climate change checklists that are gender responsive. The preliminary targets for transfer and diffusion of the prioritised technologies are as follows.

Rooftop rainwater harvesting (RWH)

Rooftop rainwater harvesting could potentially supply many rural families with water for domestic use, watering of animals and irrigation during drought seasons. Given the endowment with direct rainfall ranging between 500-2800 mm / year with an average of 1180 mm/y (Nsubuga et al 2014), the potential of utilizing this resource is highly under-exploited. Rooftop rainwater harvesting and self-supply constitutes about 0.4% of rural water sources. By 2031, the sector targets to establish 50 rainwater harvesting units for demonstration, 500 units through incentives and 125 institutional units through promoting voluntary establishment (MWE SSIP 2018).

Deep well water extraction

Deep water extraction constitutes about 44% of Uganda's rural water supply sources for domestic use and will be the major technology used in achieving the target of a safe water source for all villages by 2030. Besides installation, the country seeks to improve the functionality of all boreholes by improving human capacity in hydrogeology, borehole set-up and supervision skills (MWE SPR 2018). To improve functionality, the installations will progress from shallow boreholes which use low yield pumps of $1m^3/h$, which are costly to maintain, to high yield units ($> 12\ m^3/h$), which use solar powered pumps to elevated to fill storage tanks that supply at least 5,000 people with drinking water through a piped to a network of at least 2 km radius. By 2023, the sector aims to establish 855 units of which 455 will be solar powered (MWE MPS 2020).

Areas with high refugee population, namely, Yumbe, Adjumani, Arua, Moyo, Kiryandongo and Lamwo, are to be given special priority (MWE 2019). Deep water extraction is likely to be sustainable given that climate change models project an increase in ground water recharge and base flow in the coming 20 to 80 years. However, its potential to supply irrigation and municipal water is uncertain (Nsubuga et al. 2014).

Surface runoff water harvesting

One hundred large-scale units (350m^3 valley tanks or check dams with high density polyethylene (HDPE) dam liners are to be established for demonstration, 200 units are to be promoted using incentives for runoff/ water harvesting from roads and paths and 50 units to be established voluntarily through advice. Special attention will be given to the cattle corridor. In terms of area coverage, demonstration projects are to serve 2000 ha, and those promoted through incentives, 20,000 ha (UGGDS 2017-2031). By 2023, the sector aims to construct 22 dams, 110 community valley tanks and promote 63 individually owned valley tanks (MWE MPS 2020).

1.2 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR ROOFTOP RAINWATER HARVESTING

1.2.1 General description of Rooftop rainwater Harvesting

Rooftop rainwater harvesting is an easily replicable technology which involves collecting water off a roof surface into storage containers for domestic use, livestock watering or irrigation (Danert and Motts 2009). It can enable households that are missed out by formal water supply to have direct control of their own water supply without need for energy and chemicals for water purification. With average rainfall of 500-1200 mm a year, the adoption of RWH to exploit this resource is still under-developed (SPR MWE 2019).

A basic RWH unit includes a roof surface, gutters, pipes, a storage tank, filters, waterproofing agents and tap fittings. Other key accessories are first-flush diverters, a pump, hard or concrete ground below the taps and channels to drain off excess water in ways that minimize creating a muddy conditions and soil erosion. Hard roof surfaces are considered to be the most efficient in rainwater collection and are on about 75% of the houses in Uganda and about 69% of the rural houses (National Population and Housing Census 2018). However, roof sizes vary widely from less than 10 m^2 to more than 80m^2 (Danert and Motts 2009). Rainwater harvesting systems can be developed at small and large scales. Storage tank are ready-made or built in place on the surface, underground or partially buried and can be of plastic, mortar, polyfibre, tarpaulin, interlocking stabilized soil bricks, and corrugated iron. The ideal storage tank capacity for a rural household of 6 people is more than 10m^3 to ensure all-year supply in bimodal rainfall area

with three months of no rainfall, based on an estimated daily per capita water consumption of 20 litres (MWE, 2008). This amount can satisfy a household's domestic, livestock and irrigation needs (Martinson and Thomas 2003).

1.2.2 Identification of barriers for Rooftop rainwater harvesting

1.2.2.1 Economic and financial barriers

a) *Low private investment in rooftop rainwater harvesting.*

Private investment is a key vehicle for wide diffusion of RWH to increase resilience of households to water scarcity as weather events become unpredictable. The potential demand for RWH is high, estimated to be about 1.8 m households, which have hard roof surfaces (Danert amd Motts 2009). However, the development of private business to satisfy this demand is rudimentary. Private investment is low in construction of water storage tanks, or retailing ready-made ones and associated accessories such as guttering, downpipes and associated plumbing fixtures. Therefore, parts and supplies for RWH are not easily available in most locations of the country (Blanchard 2012; Danert and Motts 2009; Thayil-Blanchard & Mihelcic, 2015).

This is mainly attributed to low capacity of rural households to afford built in RWH of sufficient capacity to satisfy their water needs (about 10,000 litres) (Thomas and Rees, 1999; Martinson and Thomas, 2003). The greatest cost is related to the storage tanks where prices vary depending on material and storage capacity. The price of 15,000 litre storage tank ranges from 1.3 million UGX for corrugated iron, to 2 million UGX for polyfibre (inquiry from Kampala suppliers). Costs of tanks in other materials such as Ferro-cement and interlocking bricks are in-between. The 16% value added tax (VAT) on finished tanks partly contributes to the high price (Parker et al 2013).

Retailers in rural areas prefer to stock low storage options of 250 litres capacity or less because they are faster moving. Larger ready-made water storage tanks of 500 litres or more are affordable to more urban consumers and better resourced households usually go up to only 3000 l (Blanchard 2012). The fact that these affordable storage sizes do not satisfy year-round household water needs, demotivates consumers. This is exacerbated by the small roof surface area of many rural houses (Uganda Rainwater Association, 2004).

Many households are not aware of the different RWH options in terms of designs and construction techniques, material, associated accessories, availability of parts, construction services and prices (Uganda Rainwater Association, 2004; Adler et al. 2014). For example, below-ground plastic-lined tanks options are cheaper and could offer rural households larger storage capacity, but this is not widely known (Blanchard 2012). There is little opportunity for improving existing designs to make them more affordable. (Cruddas, 2007). Technology accessories such as first flush diverters for improving water quality and pumps are also not widely known. Creating awareness for RWH as a major safe water supply has been given low emphasis at planning and policy levels (Ntale et al 2005) and low budget allocation (Lehmann et al. 2010).

Tank providers include wholesalers in urban towns, intermediary re-sellers in trading centres and retailers who avail products in 'last mile' distribution points (Danert and Motts 2009). The more distant consumers have lower capacity to afford RWH storage tanks thus resellers do not have opportunity to offer product differentiation or additional value such as delivery or after-sales services for a price mark-up, making the business less attractive. The range of technologies for RWH is very narrow therefore there are very few options to interest the diffusers and end users (Danert and Motts 2009).

Government and other non-state actors provided subsidies to catalyze adoption, covering up to 90% of the costs for communal facilities and 30% for household facilities (Ntale et al 2005). This, however, greatly weakened the demand from a privately driven market and stifled private investment in the technology (Thomas 2010). Given that subsidized programs required just a nominal contribution from the communities, ownership of the setups was low and demand was not catalyzed (Danert and Motts 2009).

1.2.2.2 Non-financial barriers

a) Inadequate extension advisory capacity for supporting RWH

The extension system in Uganda is generally under-staffed and under resourced and personnel are not specially trained in RWH skills. The RWH technology is considered to be too basic to require special skills and is not included in courses offered in regular programs of learning

institutions (Farahbakhsh et al. 2009). Thus, there has been little investment in research and innovation to build it up as a key water supply strategy (Mbogo 2012; Heidhues et. al, 2004). Local artisans are trained to set up RWH by brief NGO and government projects, but they find limited demand for their services. Sometimes, artisans cannot serve a wide area due to limited transport access and inadequate skills in relation to appropriateness and standards (Sendanayake, 2016; Staddon et al, 2018).

The training provided also tends to assume blanket designs without enabling tailoring of different options to the diverse contexts of rural households. For example, the focus on high-storage capacity RWH systems in supported 'demonstrations' makes the system look complex and goes hand in hand with relatively larger brick houses with large roof surface area, which may not be the general context of rural households. Skills are also lacking in motivating private sector uptake for the diffusion of the RWH technology. Government and NGO projects often leave these key players out and then expect them to take over after the project span (Danert and Motts 2009).

b) Low social cultural culture of RWH

Rural houses with hard roof surfaces rarely have proper guttering and pipes to direct the flow of water during rainfall events. Water is harvested using rudimentary methods and the potential of the technology is unknown and regarded casually. They have grown accustomed to cycles of water abundance and scarcity as a way of life. The willingness to invest in RWH is low (Farahbakhsh et al. 2009) because potential users do not consider the range of options it enables nor the alternative costs of labour, time and risks incurred by women and children in supplying domestic water needs.

The use of subsidies by government and NGOs created public expectation of continued access to such support thus limiting their willingness to invest in self-supply. There is also little trust in the longevity of the functionality of water storage options given the scarcity of spare parts and skilled maintenance personnel in rural setting. Concerns about water quality coming from siltation due to lack of awareness of accessories such as first-flush diverters, are not a major hindrance to adoption.

There is limited demand for rainwater harvesting equipment due to a generally low value attached to investment in water availability (Danert & Motts 2009; Staddon et al 2018; Kanyi et al 2017; GWEFFODE 2018). This may partially be due to household investment decisions being mostly led by men who do not have direct roles in ensuring water availability (Ray 2004; Stevenson et al. 2012).

There is also reluctance to be the first in the community to set up built-in RWH (Adler et al. 2014) because there is little opportunity to recoup the investment costs by selling to neighbours as social norms require sharing of water as good social relations and may create tension once it is restricted especially during times of scarcity. People generally lack the technical knowledge of operating a RWH set up (Staddon et al. 2018), increasing the risk of breakdown from poor handling of the fixtures.

c) Inadequate policy/legal support for RWH

The public commitment to supply clean and safe water for all under the national water policy 1999 (Baguma et al. 2012) puts RWH in a special category where government commitment ends at only demonstrating and creating an enabling environment with the assumption that self-supply will ensue where households use their resources (Thayil-Blanchard & Mihelcic 2015). However, this has not taken off and some of the approaches such as use of subsidies have in themselves become obstacles for the diffusion of the technology. Some options such as below ground storage, which are relatively less costly are not widely promoted. Baiyegunhi (2015) found that women whose land rights are insecure were 3.5 times less likely to invest in RWH than men and indicated a positive correlation between land ownership and adoption of RWH technologies.

Structures to promote and monitor conditions of rooftop rainwater harvesting are rudimentary and poorly supported. District water offices, Assistant Water Officers, CDOs are not sufficiently enabled to implement and monitor RWH. All government buildings including offices, schools, hospitals, and prisons are required to have RWH tanks but this is not the case on ground due to weak enforcement. Creating awareness for RWH as a major safe water supply has been given low emphasis at planning and policy levels (Ntale et al. 2005) and low budget allocation (Lehmann et al. 2010).

1.2.3 Identified measures

1.2.3.1 Economic and financial measures

a) Enable functional private sector engagement in RWH

Technology promotion through demonstration needs to be done for different income segments with direct engagement with local communities in order to identify barriers and solutions relevant for each context. The very limited supply of equipment and manpower leading to very high per capita costs of setting up and operating RWH can be overcome through strategic engagement of private sector players in government and NGOs planning of interventions. This will enable identification of ways for promotion ventures to evolve into investment in functional supply chains to sustain the technology diffusion. Some of the key issues to tackle through these engagements include addressing subsidies, using incentives such as removal of tax duties on imported equipment and accessories and identifying business models that can thrive in rural communities. Training of consumers of the benefits of improved access to safe water will generate demand for services and equipment for private installation of RWH (Danert and Motts 2008). Strengthening the capacity for local innovation in fabrication of parts needed and construction of storage tanks using available materials could be some of the avenues (Alford, 2007). Training institutions need to be enabled to provide business skills to artisans within the communities who have been trained by previous projects (URWA, 2009; Baziwe, 2011). These can be employed to train others.

b) Improve household access to financing for RWH

Provide favourable financial support to enable rural households to pay for RWH installation. One way could be through strengthening of local savings and credit schemes and innovations like merry-go-round to enable low-income households to access lumpsums required for upfront investment in RWH. The local economic base and livelihoods of potential RWH users as well as their capacity to invest need to be bolstered through strengthening income generation options including high value crops, value addition (Malesu et al 2010) and product marketing. Gender disparities in access to and control of RWH installations need to be addressed to increase adoption of the technology especially by women.

1.2.3.2 Non-financial measures

a) Develop a catalogue or database of information on RWH technology

The existing rainwater harvesting guideline which shows technical details for construction and design and options for different household sizes, material and associated accessories, needs to be promoted widely and translated into different languages. Communities also need a RWH catalogue to inform them of complementary accessories and equipment for water quality improvement such as first flush diverters and water filtration options, and a data base showing the availability and prices of the different designs, and contacts of service providers (Uganda Rainwater Association, 2004; Adler et al. 2014; Durodola et al 2020). The catalogue can also provide special information for areas with peculiar RWH conditions such as the cattle corridor (Blanchard 2012, Kiggundu et al 2018). The Appropriate Technology Centre can provide this database (Cruddas, 2007).

b) Demonstrate the value of RWH under different climate scenarios

Conduct valuation analyses under projected climate scenarios and create awareness of the potential economic and social benefits of investing in RWH such as reduced cost of moving long distances to provide water and the time freed for children to engage in school and women to participate in other gainful enterprise. More on-site training of community members is needed on the various methods of RWH (Blanchard 2012).

c) Strengthen technical capacity in RWH

Develop a comprehensive course for RWH and a job structure to employ appropriate technical personnel at local government level. Training is also needed for rural masons, households and communities in RWH to increase availability of skills for RWH maintenance (Adler et al. 2014). Train trainers at district and user level in RWH technology installation operation and maintenance. Capacity is also needed in the marketing, accounting, and management skills to develop a thriving private sector.

d) Strengthen coordination for implementation of RWH policy provisions

Government and NGOs working to promote RWH need to be well coordinated to avoid oversupply of some areas while neglecting others. To realize the full potential of obtaining water for domestic use as well as for agricultural production, the water and agricultural sectors need to

work closely and harmonise their planning and regulatory processes (Farahbakhsh et al. 2009; Baguma et al. 2012; Staddon et al. 2018). It is important that the key actors in RWH technologies make gender equality and inclusion a key business goal in their promotion initiatives (Grant et al. 2017).

e) Strengthen community organization for RWH

The potential to build shared storage for adjacent households that individually have small roof surface area needs to be explored to reduce or share the set-up costs. Although farmer groups are rarely organized around water needs, they can be persuaded to include RWH as a key focus area with increased information provision and awareness of the imminent dangers of climate change and the potential enterprises that can be developed from the RWH ventures through radio programs and district environment and water officers. Guidelines need to be developed for local communities to self-organize for RWH. Approaches for promoting RWH should sensitize men on the importance of water provision at household level and involve women in the selection of manageable options (Grant et al. 2017). Participatory RWH investment plans need to be developed with deliberate step-wise advisory support. Low-income households can be handheld by water officers, starting with small volume water storage and building up to sufficient quantity (Blanchard 2012).

1.3 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR DEEP-WELL WATER EXTRACTION

1.3.1 General description of Deep-Well Water Extraction

The average annual groundwater recharge in Uganda is quite high, estimated at 19.1 and 39.9mm (NDP III; UNESCO, NWDR 2006). This resource can be developed for various climate adaptation strategies including water supply for domestic use, irrigation, livestock watering, aquaculture, industry and health (Taylor et al 2009; NDP III; Foster et al 2012). The technology of deep well water extraction (DWWE) involves drilling the ground and drawing water from 30 metres or more underground using containers or pumping it through sunk pipes (Sloots 2010). Inside a vertical borehole, an extraction pipe is placed that has a perforated section (filter) and sand trap, surrounded by a filter gravel. Wells can be hand pumped or co-installed with smart energy technology including solar sources (SPR 2019).

The vertical borehole of most wells in Uganda is drilled to an average depth of 60 m and up to 120 m and about 100 to 600 mm in diameter (Van Steenbergen and Luutu 2012). Alternatively, deep water extraction can be developed for large diameter (1-2 metres) high-yielding projects for municipal water supply. These use an inbuilt mechanised pump supplying water to an elevated reservoir that works as a distribution point to a network of pipes. Large-diameter wells are less costly than multiple small wells in the long run (FAO 1985; Nsubuga et al. 2009; MWE ToR 2019).

1.3.2 Identification of barriers for deep-well water extraction

1.3.2.1 Economic and financial barriers

High costs especially related to equipment, drilling operation & maintenance and low access to spare parts

Direct costs of DWWE construction include siting, drilling and equipment, which is mostly imported from India. Hiring a terrameter for siting deep wells costs UGX 50,000 per day. Personnel costs including hydrogeologists, technicians and casual labor, are quite high (Fagan et al 2015). Daily costs (UGX) are 150,000 to 281,250 for hydrogeologists and 25,000 – 46,875 for technicians.

Other associated costs include energy supply, spare parts and maintenance. Transportation costs at about UGX 750 per kilometer, take a substantial proportion of the DWWE costs in rural areas as drilling companies are few and are mostly based in Kampala (Sloots 2010; Asiimwe and Naiga 2015). The estimated unit cost for small-diameter DWWE construction is about USD 9,000 (MWE 2007). When sites suitable for water drilling are distant from settlements and uneven, steep or bushy, then costs include access development including clearance and maintenance of roads that lead to them (Asaba et al. 2015).

Borehole maintenance is challenging and costly because spare parts and technical skills are difficult to access. The estimated cost is USD 100 per annum, collected as fees from users (Asiimwe and Naiga 2015; Asaba et al. 2015; Mugumya et al. 2015). Usually community members cannot afford these fees (Asaba et al. 2015) and sometimes pay in kind as food stuff or

labour (Sloots 2010; Asaba et al. 2015). The functioning of Water User committees is also constrained with hidden costs of meetings, fee collection, mobilisation and supervision of service providers, which are often not taken into consideration (MWE SPR 2018).

1.3.2.2 Non-financial barriers

a) Inadequate technical capacity for constructing operating and maintaining deep wells

There is inadequate hydrogeological knowledge making estimates of quantity of underground water and physical delineation and dynamics of aquifer systems in relation to precipitation uncertain and not readily available (Tindimugaya, 2005; Van Steenbergen and Luutu 2012; Nsubuga et al. 2014; Denis 2018). Some decisions are based on very imprecise estimates leading to waste of time and other resources in siting and drilling wells. Due to inadequate knowledge, private companies sometimes abstract ground water from restricted less endowed areas (Tindimugaya 2005; Nsubuga et al 2014; Rugumayo et al. 2015) such as the cattle corridor, which tend to dry up during drought conditions (Nsubuga. et al. 2014; Asiimwe. and Naiga 2015). Cases of faulty infrastructure at construction and operation stages are quite common owing to inadequate competence of service providers and lack of means of verifying the genuine from the impostors (Taylor et al. 2009). Limited functionality of boreholes comes from limited access to personnel to do repairs and maintenance (Komives et al. 2008).

Training in deep well extraction is expensive and available only at the National Water Training Institute because it requires specialised equipment. Therefore, only very few people can access it. There are no specific courses on groundwater extraction at the universities although in Makerere University, groundwater development subjects are included in courses for civil engineering, and chemistry and geology (Sloots 2010).

Because of low budget allocation, it is difficult for the sector to motivate and retain expertise (National Water sector Development Report UWDR UNESCO 2006; Denis 2018). At local government level, the water officers are too few and not adequately skilled in deep well extraction and therefore cannot provide sufficient extension advice for community water users (National Water sector Development Report UWDR UNESCO 2006; Denis 2018). Sometimes officers are not sufficiently kitted with means of transportation and fuel, reagents for testing water quality, and equipment such as cameras, GPS and computers to fulfil their duties

(Mugerwa 2007; Rugumayo 2016). Staff working for private companies are more technically grounded while those for NGOs are sometimes under-qualified (Denis 2018).

b) Water Quality concerns

Although Uganda's under-ground water is said to have no chemical pollutant issues (Van Steebbergn and Luutu 2012), water quality concerns are sometimes raised in relation to boreholes. Salinity and flat metallic taste are common complaints especially from women (Asaba et al, 2015; Naiga et al. 2015). Ground water has been reported to contain excess levels of aluminium, chloride, iron, manganese, zinc and hardness associated with corroded borehole casings or natural weathering of the aquifer matrix. (NWDR UNESCO 2006). In urban areas, borehole technology is not trusted because sometimes water is contaminated with high levels of nitrate and chromium especially in case of seepage of sewage waste (Tindimugaya 2005; Taylor et al. 2009; Rugumayo et al. 2015). Contaminants such as cyanotoxins, metals, surfactants, industrial additives and solvents are emerging pollutant threats and Uganda has low capacity to monitor, and minimise their risk to the environment, human and livestock health (SPR MWE 2019).

c) Institutional weaknesses

Ground water is a publicly owned resource with common access, therefore requiring legislation, awareness and motivation to ensure equitable access and good quality while avoiding irresponsible abstraction and conflict. Awareness and implementation of the policies and legislation governing groundwater abstraction is low (Rugumayo et al 2015). Important reference documents such as the Conditional Grant Guidelines, the District Implementation Manual, the Community Handbook, the (operations and maintenance) O&M Framework and guidelines are not readily available at district level (Rugumayo 2016). Drilling and abstraction activities are poorly monitored and some abstraction companies operate without permits or supervision (Tindimugaya 2005).

Various sectors including irrigation, livestock farming, energy, industry and fisheries are potentially key stakeholders, but they are not well coordinated. Deep well drilling projects by government are sometimes poorly coordinated with those of NGOs leading to concentration of wells in some locations, which in turn results in drying up of some wells as they turn into

aquifers for others nearby. Private sector investment in the supply of necessary accessories and spare parts is also inadequate. The functionality of the boreholes depends heavily on the organisational strength of the water user committees to keep up the mobilisation, fee collection and deployment of skilled personnel for ensuring that the equipment and the area around the wells is kept in good repair, yet these committees are not adequately facilitated (Asaba et al. 2015; Naiga et al. 2015). Land tenure insecurity can also be a limitation as the District Implementation Manual (MWE, 2007) states that "communities shall be required to satisfactorily prove (e.g. with written agreements, land titles) that all potential and foreseeable land access and ownership issues have been resolved beforehand".

1.3.3 Identified measures

1.3.3.1 Economic and financial measures

Reduce costs of ground water extraction

Because costs are mainly related to use of imported drilling equipment, the country needs to identify ways of reducing importation costs possibly by removing importation duties in the short term, but also work on a long-term strategy of fabricating the parts locally. This may increase accessibility of spare parts and enable water users to maintain DWWE in functional condition. Partnership with private sector is also needed by creating awareness and business incentives for profitable commercial enterprises related to groundwater resource development including supplying of the required parts and equipment in all districts. Training more technical service providers would enhance their availability and lower costs of hiring them. Emphasis should be shifted to sinking more large-diameter and mechanised boreholes, which are cheaper in the long run and supply many people. To increase road access to potential areas for well establishment, the Water sector and Ministry of Works need to work together.

1.3.3.2 Non financial measures

a) Strengthen technical skills for borehole installation and management

Programs should be developed for up-skilling the existing administrative staff and technical advisors at lower government level, private sector and NGOs to monitor and supervise abstraction and use. Community training is also needed in borehole operation and maintenance

to ensure sustained functionality of existing wells. Hydrogeological courses are also needed at tertiary institutions to enable increase skilled manpower in surveying, delineation and monitoring of ground water sources for deployment to every district (MWLE, National Water Policy 1999; Denis 2018; SPR MWE 2019).

An information catalogue needs to be created on the national hydrogeological status showing the status of groundwater, quantities available, quality, potential opportunities it offers for climate adaptation, farming modernisation and enterprise development. The catalogue can also include laws and guidelines in groundwater abstraction and potential options for groundwater resource development. This needs to be made readily available in digital format to inform and guide issuance of water abstraction permits and supervision. Media including radio, newspapers and television should be engaged in raising awareness and generating dialogue on responsible groundwater abstraction for climate adaptation and its potential benefits for example irrigation and increased access to safe water.

b) Strengthen institutions for groundwater management

Institutional and administrative structures and law enforcement need to be strengthened to build concerns of recharge of ground water and prevention of contamination into water catchment management planning. Sustaining DWWE requires coordination between key government sectors including water, agriculture and energy, also between government and private or non-government entities. Water user association committee members need to be sufficiently facilitated with budgets for management, mobilisation and supervision to ensure efficient fee collection and sustained functionality of installations (Asaba et al. 2015). They also need to be trained in developing and enforcing byelaws to govern groundwater use.

Research in hydrogeology needs to be strengthened to establish the current groundwater status and the potential impact of climate change and water use practices under different scenarios. Feasibility studies for different options for groundwater resource development need to be made and piloted (Taylor et al. 2009). Research also needs to be strengthened in exploring the business potential for local fabrication of equipment for increased access to parts.

Communities also need to be supported with securing and documenting their tenure rights to be able to access government water development programs.

c) Improve water quality assurance

Groundwater from below 30 m requires little or just basic treatment (Taylor et al. 2009). However, with rising urbanisation and threats of pollutants, water treatment technology needs to be installed to ensure safety (SPR MWE 2019). Coordination with other sectors can also lead to developments that reduce water contamination such as legislation and construction guidelines that ensure sewage and wastewater discharge in 'groundwater-friendly' ways (Foster et al. 2012).

1.4 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR SURFACE RUNOFF WATER HARVESTING

1.4.1 General description of surface runoff water harvesting

Surface runoff water harvesting is the collection, accumulation, treatment or purification, and storing of storm water for its eventual reuse for various purposes such as domestic water supply, livestock watering and irrigation (Hatibu et al. 2006). The system consists of a catchment area (the surface on which runoff is generated), command area (the area where runoff is utilized), runoff transfer infrastructure (channels, gullies, hard surfaces), diversion and storage structures (Mzirai and Tumbo 2010).

Surface runoff water harvesting is done at micro and macro level. Micro-catchment rainwater harvesting systems are designed to guide runoff from a catchment area of 10–500 m^2 into an infiltration-enhancing structure for irrigating plants such as vegetables, coffee and bananas (Kiggundu et al. 2018). Common micro-catchment techniques include pitting, contouring, terracing, furrowing and micro-basins supplemented with mulching and reduced tillage (Biazin et al. 2012).

Macro-catchment rainwater harvesting systems collect runoff or river flow from large areas including manmade surfaces, such as roads, parks, gardens and playing fields into reservoirs of about 10,000 to 15,000 m^3 storage capacity. Sometimes the reservoirs fill 2 or 3 times a year (Sivanappan, FAO 1997). Part of the water seeps into the soil and recharges ground water (Kiggundu et al 2018). Reservoirs include sand dams, earth dams, open ponds, permeable rock dams, cisterns and constructed storage using cement and bricks (Bresci 2008; Temesgen 2012; Kimera 2018; Kiggundu et al. 2018). Bunds or embankments are built around reservoirs

sometimes using the soil excavated from the reservoir. Reservoirs are provided with spillways or weirs to allow controlled overflow (Rusoke et al 2000). They are often fenced around to protect against accidents, vandalism and misuse. Water is abstracted from reservoirs using gravity flow or pumps and channeled where it is needed (MWE 2019). The water quality needs to be monitored regularly and treated for suitability for the different uses (Vikneswaran and Razak 2015). The system can also be used to trap soil from being eroded by water. Surface runoff harvesting is conducted in 121 districts in Uganda with a total of 1300 valley tanks, 34 dams and 53 irrigation schemes and current estimates put the volume of water for production at 124 million cubic meters (SPR MWE 2019). Surface runoff is used mainly for livestock watering, domestic water and to a lesser extent, irrigation (GOU 2005; JWESSP 2013-2018).

1.4.2 Identification of barriers for technology surface runoff water harvesting

1.4.2.1 Economic and financial barriers

High cost of installation and operation of macro-catchment surface runoff water harvesting

Installation of macro-catchment surface runoff water harvesting is expensive (Mugerwa 2007; Kiggundu et al 2018). Capital cost items include purchase or renting of land for siting the reservoir, equipment such as bulldozers, scrapers and tractors for excavation, pipes for inlets and spillways, and rollers for soil compaction or clay lining to minimize permeability of the storage basin, above-ground brickwork to enhance storage capacity, fencing, a system for water abstraction with an energy source (GOU 2005; Sivanappan, FAO 1997; Kiggundu et al 2018; MWE 2019). Reservoir construction costs vary widely depending on soil type, the size of the tank and season of construction. Smaller tanks cost more per cubic meter. In Uganda, per cubic meter cost is US$21.2 for excavation of ponds of 35 m^3 and US$ 99.6 for sub-surface tanks of 11 m^3 (Anyoni et al. 2015). Larger reservoirs such as an 80 000 m^3 earth dam in Mali cost as low as US$ 0.20/m^3. Recurrent costs are repairs, desiltation and cleaning of reservoir, silt traps, gutters, etc. at least once a year, monthly maintenance of pumps abstraction energy bills, and water treatment from contamination (Kiggundu et al 2018).

1.4.2.2 Non-financial barriers

a) Inadequate skilled personnel to design, install and maintain the technology.

Skilled labour is needed for both the micro and macro water harvesting. Macro runoff water harvesting requires specialised hydrogeological skills to determine the appropriate runoff water harvesting areas, test soils, construct earthworks and ensure sustainable operation and maintenance (Kiggundu et al 2018). Large dams holding more than 20,000 m^3 are considered to be hazardous and require a qualified and experienced engineer for certification and design (GOU 2005). However, there are very few such engineers available. Although hydrogeology is taught under water engineering, hydrology and civil engineering courses at Makerere University, National Technical College Elgon, Kampala International University, specialising in Hydrology and Water Resources Engineering attracts the interest of very few young engineers. This is possibly because of limited prospects as the awareness of the technology is not widespread and the demand for their services is low (Rugumayo 2005).

Farmers and extension staff tend to be excluded from processes of construction and maintenance of surface runoff water harvesting structures (De Lange, FAO 1997; Munyao 2014; Kiggundu et al. 2018), leaving limited capacity at community level in dealing with associated challenges including seepage, evaporation, spillway erosion, rill erosion, sinkholes, cracking, embankment settlement; animal-caused damage, and blockage of spillways and out-let pipes (GOU 2005). Well trained extension officers are few and have inadequate budgetary resources to ensure good management of these establishments (Mugerwa 2007; Rugumayo 2016). Constant learning is also needed to enable efficient and equitable water distribution related to crop requirements soil edaphic nature and topography (Rugumayo 2016).

There is inadequate community capacity to sustainably manage (own, operate, and maintain) water facilities (Mugumya et al. 2015; Kiggundu et al. 2018). The introduction of the technology to the farmers often does not give them sufficient time to familiarise with it and understand the logic behind different actions or structures. Community members are not sufficiently trained in implementation processes such as land management system, water management, structure operation and maintenance (Kiggundu et al. 2018; Biazin 2014; Anyoni et al. 2015). Therefore, this uncertainty prevents them from developing a sense of ownership for the water facility (De Lange, FAO 1997; Kiggundu et al 2018).

b) <u>Inadequate information on surface runoff water harvesting.</u>

Technical information and knowledge gaps prevent the realisation of the potential surface runoff harvesting could offer especially in drought prone areas. Various utilisation options have not been explored. Potential areas for surface runoff harvesting are not adequately mapped out and feasibility assessment of such ventures are yet to be made for much of the country. Potential yield of catchments, the nature and level of potential pollutants and the costs needed to make harvested water available for reuse are not known for most catchments. This is due to insufficient instrumentation and technical staff capacity to monitor runoff. Besides, there is limited capacity to match the frequency of monitoring to the changing trends in climatic conditions, land use and cropping patterns. There is therefore insufficient information to guide the development of regulations and by laws to enable the sustainable functioning of the runoff harvesting. The attitude that rainfall and surface water storages are sufficient also makes community planners to give less attention in acquiring knowledge and exploring the potential for surface runoff harvesting. The operation and management of the facilities at the community level is also riddled with unclarity and knowledge gaps leading to very short life functionality life spans and loss of motivation. The functionality of valley dams is at 73% (SPR MWE 2019).

Water user committee (WUC) members are not adequately informed about the technology and do not receive sufficient extension support. The high turnover in membership also drains the institutional memory requiring constant refresher courses and information provision. Community members are not taken on as collaborators who contribute local knowledge in the installation process, but rather, they are brought in at advanced stages of the installation process as receivers and this leaves wide knowledge gaps crippling their capacity to manage the facilities. Hand over processes are done too briefly with many assumptions especially about community organisation and ability to manage the installation and cover the necessary operation and maintenance costs.

Community knowledge is not built to understand the technical logic causing them to get stuck or overwhelmed by very trivial challenges and abandon the set up. Extension officers are often inaccessible, stationed at parish or sub county headquarters which are distant, and are not skilled in methods of engaging and creating ownership among communities (Mugerwa 2007).

Sometimes technical information is not sufficiently backed with social structures to enable communities to manage the system sustainably. Management demands put on the various entities including the WUAs, land owner and fee-paying community members are not sufficiently costed, and rules of engagement are not well thought out leading to dissatisfaction unclarity and conflict. In some cases, land owners deny the community access to the water resource due to poor communication and byelaws to protect other enterprises on the owner's land from getting damaged by community members in accessing water (Kiggundu et al. 2018).

Some individuals may opt out of community managed water resources and refuse to pay user fees, which undermines the community cohesion and limit the capacity to maintain the structures in functional form (Mugumya et al. 2015). Water user associations where community members are mobilised and informed about planning, construction and management of water structures sometimes fail to remain functional (Mugumya et al. 2015; Sivanappan, FAO 1997). Members do not regularly attend meetings and information does not flow between farmers. Community owned initiatives are very rare because of very limited awareness of the technology, highly fragmented land ownership and lack of experience in self-organising to collectively harvest and manage runoff water. Available information on runoff water harvesting methods and best practices is not made easily accessible for potential investors and users. Rarely is such information translated to local languages. It often exists in text and not in easier formats such as audio and video.

1.4.3 Identified measures

1.4.3.1 Economic and financial measures

Increase access to capital and equipment

Runoff water harvesting establishment can be costly, requiring collective action where community members are facilitated to work with credit institutions in the private sector and NGOs to access the necessary capital. Increasing community access to credit will also enable them to develop associated livelihood enterprises such as irrigation, fish farming, and recreation (Sivanappan, FAO 1997; Hartung 2006; Rugumayo 2016). Import duty charged from equipment needed for runoff water harvesting needs to be removed to increase affordability for potential private investors.

Equipment should be made available at all districts especially in areas where the potential for the technology is high and hired out at subsidised rates. Operation and maintenance costs need to be properly estimated for different set-ups and weighed against communities' capacity to cover them using water user fees. Realistic budgetary allocations are needed to support WUCs to do their work. Public grants and soft loans need to be made to community savings and credit schemes to enable enterprise development from the runoff scheme. Larger schemes, which are less costly per cubic meter, should be established by the government with a cost-recovery strategy including supporting development of associated businesses among community beneficiaries.

1.4.3.2 Non financial measures

a) Strengthen the capacity of water officers

There is need to hire more extension workers and equip them with information and mobility to support farmers and train them. New courses for hydrology and engineering need to be introduced at universities and technical school and students motivated to take them (Denis 2018). Research and innovation grants are needed to assist universities to strengthen such programmes through curriculum review to incorporate new knowledge, short-courses and regular awards for best innovation and performance to encourage outreach with industry and farming communities. Short courses could be on target topics like small-dam construction, scheme design, water diversion structures and community organisation for water management etc. (Purcell, FAO 1997). Centres need to be established for demonstrating and testing equipment for runoff water harvesting. This would improve the marketability of the graduates and encourage technical personnel retention (Purcell, FAO 1997; Rugumayo 2005). Local leaders also need to be trained so that they can encourage the uptake of the technology (Mugerwa 2007).

b) Create awareness

Very aggressive awareness creation is needed to address the attitude that production water is and will remain sufficient, the acceptance of the cycle of water abundance and scarcity and the low spread of water storage and irrigation in farming culture. Farmers need to be shown the implication of climate change on rainfall patterns and surface runoff technologies as potential adaptation measures (MWE 2019). Existing information and manuals on the design and

management runoff dams needs to be translated into local languages and disseminated in accessible format. The media needs to be engaged to package and spread the information using TV and radio and social media. Potential enterprises associated with runoff harvesting need to be assessed and information about them made available. Exchange visits are needed to enable farmers to share stories and gain the confidence in implementing runoff water harvesting. Through NGOs, farmers can access information about efficient utilization of the water facilities and on markets, and can facilitate the creation of farmer networks to disseminate and utilize such information (Purcell, FAO 1997).

c) Strengthen monitoring and analysis of water runoff data

Adequate instrumentation is needed to monitor runoff generation. This can be supplemented with documentation of experiences in water harvesting or even establishment of call-in or SMS communication to track storm events or any incidences affecting water quality in the different locations. Collected data needs to be analyzed and disseminated to in usable format to inform planning for water management. Decentralized data analysis capacity needs to be built and this could be achieved through partnerships with research and academic institutions and the national bureau of statistics.

d) Conduct research to increase understanding of the potential for runoff water harvesting

Research is needed to map out catchment areas for potential runoff water harvesting, estimate potential volumes and quality, potential benefits, profitability and risks in different smallholder farmer setups. In consideration of different climate scenarios and market scenarios, feasibility studies are needed to evaluate the potential of rural enterprises that could be developed through RWH. In order for community members to take-up runoff water harvesting as their own, they need to choose technology designs that are appropriate and effective for their particular water needs and are within their financial means while enabling sustainability (Kiggundu et al. 2018). Youth-based enterprises and employment opportunities that could be developed from RWH need to be evaluated and made known to increase motivation and adequate investment in the establishment and management of RWH. Research should use approaches that collaborate with farmers, incorporating local knowledge and more realistic consideration of local context (Temesgen 2012) to increase community cohesion and ownership of the technology (Kiggundu et al 2018).

e) Strengthen water management stakeholder organizations

Coordination of public sectors in agriculture, water and environment needs to be strengthened to enable the establishment and efficient use of runoff water harvesting. Besides national laws and standards, local bylaws are needed to enforce social and environmental safeguards and ensure equitable distribution in times of scarcity.

Organizations related to water management need to be regularly monitored to understand their capacity and operational needs and strengthened to enable equitable representation and participation. Budgets required for institutions to run need to be realistically developed and supported and the sufficiency of user fees needs to be regularly re-evaluated. Sufficient effort should be committed to training and building the capacities of water management entities especially on management i.e. collection, controlling and allocation of water (GOU 2019). Local artisans need to be trained with skills to repair and maintain equipment (Kiggundu et al 2018).

Water technical personnel could establish a water technical support association in various districts so as to improve their performance and efficiency as well as benefit in supporting capacity building initiatives (Rugumayo 2016). This would strengthen their bargaining power for their work, and increase their experience and knowledge.

1.5 Linkages of the barriers identified

Barriers that are common for all technologies include high cost of establishment of infrastructure, inadequate technical capacity, limited facilitation of water user committees and inadequate information. Given that the majority of beneficiaries of these projects are small scale farmers, infrastructure installation costs can be prohibitive, even for seemingly simple technologies like rooftop rainwater harvesting. The bulk of infrastructure development cost is commonly borne by government, but while this enables installation even in remote areas, the functionality of installations remains a challenge due to various reasons. Community involvement as collaborators contributing their resources and local knowledge is not conducted adequately, leaving knowledge and information gaps in operation and maintenance.

Water user committees who are put in charge of these facilities do not have direct access to extension support and information. Information transfer and advisory support through mobile

phone has not been sufficiently developed in the extension system. The affordable access to internet and the culture of browsing available sources for technical information are also yet to develop. This owes to low literacy levels and the language barrier as most information is provided in English. Another related challenge is the low access to spare parts and inadequate skills for local fabrication. Investment in community capacity to mobilize, manage and repair these facilities will increase the efficiency of their operation and maintenance. Private sector engagement needs to be strengthened by identifying avenues that motivate investment in installation, supply of technical services and spare parts.

The low coverage of extension staff is a key barrier in ensuring diffusion of water technologies among small-scale farmers. This is due to inadequate offering of courses covering this subject matter in the learning institutions. There is also inadequate motivation of engineers to specialize in such courses because they perceive limited prospects of demand for such services. The limited ability of small-scale farmers to pay also demotivates private entities from developing technical advisory companies. Existing extension services also require refresher courses to understand these technologies and the skills of social and community engagement to enable community uptake and ownership of facilities.

1.6 Enabling framework for overcoming the barriers in Water Sector

The right to clean and safe water is a key value in the Ugandan constitution. These technologies align well with the Water Policy 1999 objective of "Sustainable provision of safe water within easy reach...” defined as living within 1.5 km (in rural areas) and 0.2 km (in urban areas) of an improved water supply (i.e. protected spring, drilled or dug well, piped system or rainwater harvesting). The diffusion of the technologies is also potentially feasible under the National Development Plan 3 (2021-2025) objective of assuring availability of adequate and good quality water resources for all users and reducing vulnerability to climate change is also supportive of the technologies.

The Sector-Wide Approach Programme (SWAP), where development planning and expenditure is coordinated under Government leadership whether from donor project funding or general budgetary support from government. These technologies fall under the Rural Water Supply and

Sanitation sub-sector and the increased efficiency in channeling of funds from central governments to local governments under SWAP potentially enhances technology transfer and diffusion (Danert and Motts 2009). The enabling framework for addressing barriers common to the three technologies is summarized in the **Table 4.**

TABLE 4. ENABLING FRAMEWORK FOR OVERCOMING THE BARRIERS IN WATER SECTOR

Barrier	**Enabling framework**	**Responsible**
High cost of installation	Developing facilities under public private partnerships (PPP) arrangement where private farmers can acquire technology construction equipment at a subsidised price (GOU 2019, SPR 2019). Increasing access to water including storage and use of rain and storm water is a key objective under the strategy of managing flood waters and drought in the policy for disaster preparedness and management	Ministry of Finance, Planning and Economic Development Minister for disaster preparedness
Inadequate capacity of extension officers	Many NGOs promoting RWH scattered throughout the country can be partnered with to create the necessary training and demonstration (Danert and Motts)	Ministry of local government and Ministry of Water and Environment
	Formation and training of Water user committees **(**NWDR, UNESCO 2006; GOU 2013)	Directorate of Water Development, Ministry of Water and Environment
Insecurity of land tenure and conflicts	Securing land tenure rights through processing of titles, which also enables access to credit.	Ministry of Lands, housing and urban development

Inadequate community and extension support for sustainable operation and maintenance of installed water infrastructure	The Water for Production Strategy and Investment Plan (2010-2035) which emphasizes "A Package Approach" which includes construction and installation of infrastructure, and the software aspects of mobilization, community-based planning and monitoring processes, private sector back-up support, and considerations of efficiency, hygiene, sanitation, environmental awareness, gender responsiveness, and sustainability (SDP 2018-2020)	Directorate of Water Development, Ministry of Water and Environment
Low private sector investment	The strategy for public-private partnerships in all stages of the development of water projects - formulation, implementation, monitoring and evaluation (MWE 2019)	Directorate of Water Development, Ministry of Water and Environment
	The Joint Water and Environment Sector Support Programme 2018-2023 - Phase II is a coordinating several directorates: - Rural Water Supply and Sanitation – RWSS - Water for Production – WFP - Water Resources Management – WRM	

CHAPTER 2: AGRICULTURE SECTOR

2.1 PRELIMINARY TARGETS FOR TECHNOLOGY TRANSFER AND DIFFUSION

The following technologies were prioritized for climate-change adaptation in the agriculture sector in a technology prioritization exercise with national stakeholders:

- Community-based irrigation systems
- Crop breeding for improved varieties that are climate resilient
- Responsive agricultural extension for climate change adaptation in different contexts

This chapter presents the process followed and the results obtained in the identification and analysis of barriers hindering the transfer and diffusion of these technologies; the measures to overcome these barriers and the enabling framework. The respective targets of these technologies according to national aspirations are given below.

Community-based irrigation systems

The Ugandan irrigation potential is 3.03 million hectares (NELSAP 2012), but only 567,000 hectares are equipped in spite of water availability from surface and underground sources. Farmers continue to rely on rainfed agriculture and remain vulnerable to climatic variabilities. The National Irrigation Policy target is to achieve an additional 1,500,000 hectares under irrigated agriculture (constituting 50% of irrigation potential) by 2040. This will include investment in micro, medium and large-scale irrigation systems to reduce vulnerability to effects of climate change by increasing crop yields and minimizing losses. The community irrigation system will fall under the micro-medium scale systems and although no specific target is mentioned for this technology, it is likely to dominate given the large percentage of small-scale farmers. Community-based irrigation schemes are to be established across regions taking into consideration special climatic and social needs. Water stressed areas, marginalized communities and gender-related challenges in farming are key considerations in promoting irrigated agriculture (National Irrigation Policy, 2017).

Crop breeding improved varieties that are climate resilient

Uganda seeks to modernize agriculture by increasing the generation of quality and climate resilient seed varieties for major food and commercial crops and making it available to farmers through a commercially viable system. Desirable traits include drought and flood tolerance, and resistance to pests and diseases. Currently, crop yield is below potential mainly because about 85% of seed planted is of questionable quality and about 30-40% of seed traded in the market is counterfeit. The farming population using improved seed rose from 3.4% in 2010 (Salami 2010) to 20% in 2015 (ISSD Uganda 2015) and was projected to reach to 33-35% by 2020 in the National Seed Strategy. The target for the development transfer and diffusion of climate-tolerant improved seed is to increase the uptake of certified and quality declared seed by farmers. The future targets are not documented, but assuming the same rate of growth, 60% of farmers will use improved seed varieties by 2030.

Responsive agricultural extension for climate change adaptation in different contexts

The current ratio of extension worker to farmer is 1: 1,800 whereas the ideal should be 1:500 under the approved structure of 13 officers at district level and 3 extension staff at sub-county level. Consequently, farmers do not receive enough advisory support and many of their technical needs remain unaddressed. The new strategic direction of the National Agricultural Extension Policy Guidelines and standards for the agricultural extension and advisory services in Uganda (NAEP) 2016) is to transform the agricultural extension and advisory services (AEAS) from a system of parallel institutionally fragmented public and non-state actors (NSAs) to well-coordinated, harmonized, regulated pluralistic service with multiple providers addressing diverse needs of farmers and other beneficiaries. This emphasizes the intention to address the AEAS needs along the agricultural value chains (as opposed to the previous focus on mainly primary production) and synergistic integration with other agricultural support services for optimum return on investment.

2.2 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR COMMUNITY BASED IRRIGATION

2.2.1 General description of Community Based Irrigation

Community-based irrigation (CBI) is the harvesting of rain water in constructed reservoirs or use of existing natural sources (e.g., rivers, lakes and wetlands; ground water) to irrigate farms often covering an area of 200 ha or less. The infrastructure of a CBI consists of a water source, a conveyance system of in-take and discharge pipes, drainage canals, an energy source for pumping water to different points of distribution and a mechanism for controlling the water movement. There are various types of irrigation systems depending on the source type and conveyance methods used. For example:

- Run-of -the-river gravity system: River water can be diverted using a weir to a canal, which supplies it to the farming fields through gravitation flow. Farmers can also raise the water levels on rivers using weirs from local material such as sand bags in order to divert water to channels, which are breached from time to time to allow flow into furrows in their lower-lying fields. This type of system is done informally and is common around Lake Kyoga.
- Reservoir-based gravity-fed system: rainwater is harvested in a reservoir or earth dam and extracted by intake structures into canals which flow into fields by gravity.
- Pressurized gravity harvesting from lakes or springs: Water can also be pumped using fixed or mobile pumps into an intermediate reservoir on a raised platform, which then flows through intakes to canals and to farmers' fields using gravity. Pressurized sprinklers can also be used to sprinkle water into the fields.

In a CBI, the irrigation infrastructure is owned by the community, which is responsible for its operation and management (Wanyama et al. 2017). A CBI scheme can also be a government or public-established irrigation facility, which is delegated to a farmer cooperative or water user association for day-to-day operation (BMAU 2018)

2.2.2 Identification of Barriers of Community Irrigation System

2.2.2.1 Economic and financial barriers

High cost of establishment, operation and management

Costs related to installing, operating and managing a community-based irrigation can be prohibitive for smallholder farmers whose per capita disposable income is only about $100 a year (FAO 2004). Setting up a CBI facility requires installation of the physical infrastructure which may include construction of a reservoir to harvest rainwater or weirs to divert from natural surface water bodies, canals and a pump. Recurrent costs include repairs, desilting and unclogging irrigation canals, energy supply and management costs. Maintenance and repair costs tend to become high due to scarcity of technical experts in rural areas. This leads to delays in servicing and eventual breakage. Related costs include community mobilization, organization and training, feasibility studies with environment and social impact assessment, monitoring and supervision of operations, and safe-guarding the infrastructure from misuse and vandalism. Energy costs from the national grid are relatively lower, but because of limited connectivity in rural areas, only the more expensive off-grid options alternatives such as generators or solar power may be available. These set-ups sometimes fail to remain operational for a period that is economically viable due to high management and operation costs.

2.2.2.2 Non-financial barriers

a) Limited farmer capacity in organizing and managing irrigation system

While many farmers belong to at least one farmer organization, they need new ways of engaging with each other to establish and operate a CBI scheme. Communities in localities with potential resources for CBI often lack champions with sufficient knowledge and confidence to mobilize others and form institutions that can work. Commonly, CBI projects have been initiated by government extension workers, but the handover has not sufficiently prepared local organizations to ensure mechanical functionality of the facility, manage and distribute water as well as ensure equitability among beneficiaries with diverse interests. Water user committees do not have sufficient knowledge on routine servicing, repair and troubleshooting. There are critical knowledge gaps on the water demands of different crops and irrigation regimes that work well in mixed cropping compositions, which are common in smallholder setups (Wamara et al. 2017).

Since irrigation reservoirs tend to become multi-purpose for fish farming, livestock watering and providing domestic water needs, communities need the skills to balance between these enterprises and crop irrigation needs. There is limited knowledge of the business prospects of a CBI investment given the unreliable market conditions for farm commodities (Yuko & Keijiro, 2010; Theis et al, 2018). Communities also have limited capacity to conduct regular supervision, meetings, charging fees for operation and maintenance and ensuring accountability to stakeholders. They are unaware of case studies where CBI has been set up and how it works. The general attitude is that relying on rainfall is sufficient and many rural farmers are unaware of projected climate changes and see no need for exploring irrigation options. Farmers also regard investment in such schemes as a government rather than a locally driven venture. In addition, women are rarely targeted as irrigators (Merry & Bavieska, 1997; Befikadu, 2016) leading to design of CBIs that do not respond to their preferences such as labor saving, multiple purpose water use multiple-season functionality, proximity to homesteads and gardens (Minh et al, 2020).

b) *Inadequate technical capacity of extension officers to support planning, designing and construction of CBI*

Extension officers have limited technical knowledge on installation and management including appropriate timing and quantities of water to release according to seasonal and cropping patterns. There are no university courses on irrigation (Namara et al. 2011). Rarely do extension officers have combined hydrogeological and socio-economic competence, which are both required in providing advisory support for CBI. Few water officers have been trained in gender analysis and including gender in monitoring irrigation projects (Auditor General Report of the Republic of Uganda 2014). Schemes for CBI are not widespread and as such there is limited experiential knowledge in supporting it e.g., where to get good quality equipment at good prices, what parts can be locally fabricated and who to contact, what social organization pitfalls to avoid, what gender-sensitive indicators to monitor, what fees the community can afford and are willing to pay and if this is sufficient to operate and run the system, costs involved in day-to-day operation of the system etc. It is not clear how CBI will link to the national irrigation network proposed in the National Irrigation Plan. There is very limited research focusing on community irrigation. Workplans and budgets of the water and agricultural sectors are developed separately.

c) *Potential conflict related to land, water, infrastructure ownership rights*

Schemes that are publicly funded tend to be regarded as government-owned and even when handed over, communities remain unclear of their ownership rights and responsibilities. Due to this uncertainty, community members are generally unwilling contribute to costs of installation and maintenance. Given the fragmented nature of smallholder farms and the complex crop and livestock mixtures on each unit, it is difficult to get membership to determine how costs and responsibilities will be shared. Elite capture of the system can emerge from the few in the leadership committee when they gain more knowledge and experience than others in installing and managing CBI. People with smaller landholdings or insecure land rights, mostly women, are also likely to get treated inequitably, which may diminish their incentive to engage in irrigation (FAO 2001:6). In Uganda just about 16% of women own agricultural land mainly through marriage and links to male relatives husbands, sons or other male members of the community. Their ownership and control of crops also tends to be stronger if they are used for subsistence rather than commercial value. This may limit their motivation to engage a CBI (Gebregziabher 2012; Befikadu 2016; Bryan and Didi 2019). The sharing of water between upstream and downstream users and between crop, livestock and fish farmers may also become a challenge (Meinzen-Dick and Bakker 1999). In places or times of drought, there may also be tension between water for farm production and water for domestic use.

2.2.3 Identified measures

2.2.3.1 Economic and financial measures

a) *Public investment in CBI from direct implementation or contracting private companies*

Public financing is needed to rehabilitate existing valley dams with community training and participation in planning, construction and operation to motivate understanding and ownership of the scheme. Support for community construction of reservoirs for rainwater harvesting is also needed as this is more likely to build ownership and confidence in managing the structures. This could be done through direct financing and provision of technical support to rural communities through contracting of private companies to set up CBIs and build local capacity, or through permits to private investors to set up the infrastructure and later contract it to community members.

b) *Facilitate a variety of financing options*

Prices smallholders pay for irrigation equipment can be reduced by removal of import duties and wherever possible, promoting locally available material. Legislation should be enforced against importation of cheap outdated equipment, which becomes costly to maintain and repair. Local fabrication capacity also needs to be built making and customizing equipment to fit users' capabilities. Reducing taxes on water or energy costs will make the operation more affordable (Wanyama et al). Farmer groups or water user associations need to be facilitated to acquire credit on good terms (low interest, no collateral, appropriate and sensitive pay-back period) for irrigation equipment. Conduct studies on the business potential for CBI taking into consideration the gender differences in crop control and ownership, access to input and output markets. Options with benefits that outweigh the costs of installation and maintenance need to be identified.

2.2.3.2 Non financial measures

a) Map out suitable sites for community-based irrigation schemes

Locations need to be identified and mapped where physical conditions are conducive for CBI such as naturally available water sources (e.g., river floodplains and underground water) or potential, low-cost rainwater harvesting, potential gradient for gravitational flow or affordable sources of energy. Socio-economic conditions of potential CBI areas also need to be assessed taking into consideration matters such as level of community organization, crops grown and potential markets, land ownership and gender relations. This analysis of potentially suitable sites needs to be made widely available to guide siting and to also inform communities of the available potential in their locations.

b) *Mitigate and avoid potential conflict related to land, water, and infrastructure ownership rights*

*T*o motivate farmer investment in irrigation infrastructure, farmers need land titles to secure their ownership rights. Communities need to be facilitated to develop equitable rules of engagement, specifying how ownership of irrigation structures (reservoirs, pumps and distribution networks), management responsibilities and benefits are to be shared. Using existing micro- and medium irrigation set-ups, studies should be made on management needs and findings disseminated to

develop realistic expectations of the water user committees and to ensure they are sufficiently supported. Participation of women and men should be ensured recognizing their different needs, inputs, interests and benefits in the irrigation system including land and water use rights. Access and control over land and water is critical in irrigation (FAO, 2018; Theis et al; 2017) and deliberate provisions are needed to ensure inclusion of disadvantaged groups such as women and persons with disabilities in CBI programs.

c) *Build farmer capacity in organizing and managing irrigation system*

Full farmer participation is needed right from conducting feasibility studies, establishing, operating and managing CBI schemes. Farmers need to be made aware of climate risks and the potential role of CBI in helping them to adapt and improve their livelihoods. The capacity of water users' associations needs to be reoriented towards managing an irrigation scheme as an enterprise. This can be done through exposure visits, training and facilitation of discussions of the potential feasibility and business case of a CBI in the farmers' context. Options of increasing profitability of the scheme need to be explored e.g., formation cooperatives to bulk and market produce at good prices. They also need to develop strategic partnerships with those that can provide the necessary support in operating it. Farmers need to be made aware of irrigation equipment including pumps, pipes, sprinklers, channels and drip lines with demonstrations and practical hands-on training. Farmers also need to develop mechanisms of ensuring their membership receive information equitably and in a timely manner. Gender equality should be fostered in all phases of the project including design, implementation and monitoring and evaluation of the irrigation system (FAO, 2018).

d) Develop small-scale irrigation information packages

Information on CBI, which is currently scattered in different places, needs to be consolidated in an easily accessible package for extension workers, support institutions and potential users of the CBI technology. These packages should provide information such as the description of the technology and its potential benefits, equipment required, where to get it from and at what cost, expertise required and contacts of service providers, maps of potentially suitable areas, the legal requirements for setting up CBI etc. Information packages need to be made available at the district level and in electronic form. Information also needs to be made in easy format and in

local languages. Discussions on this technology need to be conducted on media and in farmer-focused events to build the confidence of communities to adopt it.

e) Build capacity of extension personnel in irrigation skills

There is need to review and implement water catchment plans to create resilience at the landscape level. Extension staff and farmers need to be trained in skills of establishing, installing and operating CBI equipment, managing group-owned property and agricultural water management technologies including understanding agronomic needs of crops and timing of water release in appropriate quantities in relation to weather conditions. Local artisans also need to be trained to fabricate irrigation equipment, repair and maintain it because they would be more affordable and accessible when needed. Courses on planning, design and implementation of a CBI set-up are needed for engineering students in tertiary institutions. Skills are also needed to enable farmer groups to analyse the business case, social suitability and enabling conditions of investing in a CBI. Skills are also needed in conducting topographic surveys, assessing social and environmental impact of the scheme, and communicating (including use of ICT).

2.3 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR CROP BREEDING FOR IMPROVED VARIETIES THAT ARE CLIMATE RESILIENT

2.3.1 General Description of Crop breeding for Improved Varieties that are Climate Resilient

Seed breeding is the generation of improved or superior crop varieties with traits desirable for climate-change adaptation. These traits include high productivity, tolerance to high temperature, floods and drought, resistance to pests and diseases, early maturation, and long shelf-life. Seed of the superior product can be any plant part that can be used to propagate new ones. Important steps include collection of germplasm with desirable characteristics, planting and evaluating desired traits, developing new cultivars through controlled pollination or genetic engineering, selection and testing of progeny, multiplication and distribution for wider use. More advanced techniques use molecular markers in selecting individuals with desirable genes, genetic engineering to introduce genes of desired traits, tissue culture for plant multiplication etc.

Improved seed varieties produced by the breeder are evaluated in national performance trials (field experiments in multiple locations). These are then validated by the national certification agencies registered in the national variety catalogue and released by the national variety release committee (NVRC). Released seeds are then multiplied while being inspected for quality control to ensure that the genetic purity is maintained, certified by the national seed certification service (NSCS) and made available to users. Pure seed needs to be available for farmers every year for best results. Alternatively, germplasm with desired traits ready-made from elsewhere can be introduced. Improved seed in use is monitored in the field and through feedback mechanisms, improved further.

2.3.2. Barriers to transfer and diffusion of crop varieties adapted to climate change

2.3.2.1 Economic and financial barriers

High cost of production and distribution of climate-adapted seed varieties

Only 32% of the farmers in Uganda use improved and certified seed mainly because of insufficient availability of affordable high-quality seed and lack of trust in the certified seed available in the market (Naluwairo And Barungi 2014; national seed policy 2018). The process leading to variety release is expensive and lengthy due to use of old methods. Modern technology such as marker-assisted selection, which may potentially cut down time taken and costs, is not yet adopted due to lack of funds to establish the necessary set-ups and inadequate capacity to operate them (Tiwari 2017). The national agricultural research organization (NARO) is the sole provider of improved seed, but due to low budget allocations (Barungi et al. 2016), it is too financially constrained to satisfy the demand (MAAIF 2015). Research receives only 2% of the sector budget (CSBAG 2020). There are not enough varieties produced for drought, pest and disease tolerance. Existing improved varieties within the region are not adequately known, leading to duplication of efforts and unnecessary costs.

The different stages of seed production such as seed inspection, transportation, processing and conditioning, involve costly controls and delays in approvals (MAAIF 2015). For example, inspection for distinctness, uniformity and stability (DUS) costs $100-350 per variety, tests of value for cultivation and use (VCU) costs $220 per variety, and release (creating awareness on seed availability, quality and handling) costs $1200-5000 (FAO 1996; Netherlands 2017 projects integrated seed sector development plus (ISSD Plus) and resilient efficient agribusiness chains (REACH Uganda; Mabaya et al. 2018). Stringent policies governing agricultural seed production leave little room for recuperation of costs for private seed companies (MAAIF 2015).The poor road network also makes it difficult and expensive to distribute seed to most farmers and constrains their access to commodity markets (MAAIF 2015). The pricing of improved seed is not regulated. Given that more than 70% of the soils in Uganda are highly weathered with low phosphorus and nitrogen availability (Bekunda et al, 2002; Kayuki et al, 2015), soil amendment and nutrient addition are prerequisites if farmers are to get the full benefits of improved varieties (Nkonya et al, 2002).

2.3.2.2 Non-financial barriers

a) *Inadequate involvement of farmers and local knowledge variety development*

Breeding programs do not adequately consult or involve farmers in variety development processes, resulting in products that have limited relevance in addressing what farmers want. This misses out on integrating their local technical knowledge and all its advantages of empowering farmers as knowledge co-producers, building trust in the variety generated, building on traits that are widely accepted in traditional food systems, and potentially saving costs. Inadequate participation of farmers in decision making during variety development leads to limited adoption due to uncertainty about how improved varieties fit in farm conditions and interact with other components, taste, labour demands, potential to use saved seed from previous seasons, synchrony with farm seasonal calendar etc. (Grenier 1998 Naluwairo 2006). Farmers have fears and suspicions about improved seed. Programs tend to develop varieties using a generalized, but narrow focus that may not perform well in differentiated natural and economic circumstances appealing to only a limited section of farmers and leading to inequitable usability (Toledano 2017; Esaff 2018). Improved seed information including benefits, instructions for use etc. also tends to be in foreign language. Inadequate inclusion also misses the opportunity for farmers to train and advise one another and use indigenous dissemination methods to widen the demand for improved seeds (Grisley1993). Provisions for motivating and integrating farmers in the research process are poorly developed in the current single-spine extension system where technology is designed by scientists at a research station and then transferred to farmers. Community intellectual property rights are now recognized in the national seed policy (2018), but are yet to be operationalized through relevant legislation so that rights-holders and genetic conservationists are rewarded appropriately.

b) *Inadequate involvement of private sector*

Only 23 seed companies are currently registered in Uganda and these have limited ability to generate sufficient quantities of genuine certified improved seed varieties. About half of these do not have proper production and storage facilities and rely on contracted seed growers around the country. This makes supervision very difficult resulting in production of seed of mixed quality and quantity where supply is not sustained (Joughin 2014). Seeds imported from other countries is also not sufficiently monitored at seed distribution stage.

C) *Counterfeit seed in circulation*

Certified seeds from the genuine companies contribute to only 15% of the seed demand, and an estimated 30-40% of seed traded in the market is substandard or counterfeit (National Seed Policy 2018). Counterfeiting primarily occurs in one of these three forms: mislabeled /diluted seed where open pollinated varieties (OPV) or grains are used to top up contracted orders when companies fail to produce sufficient quantities; label imitation / adulteration where OPV or grains are dyed and repackaged as improved varieties (Bold et al. 2015); and label reuse where bags from reputable companies are filled with grain or fake seeds (De Boef 2014). Counterfeit seed contributes greatly to the annual losses estimated at 60 billion shillings attributed to counterfeit agricultural inputs in Uganda (report by transparency international; NTV 2015; PARM 2015).

The menace of counterfeit seeds in circulation has greatly weakened farmers' trust in the available improved seed on the market (Toro 2014) leading to reliance on home saved seed (National Seed Policy 2018). Surveillance and enforcement of the seeds and plant act 2007 to ensure seed standards are very weak due to limited capacity (De Boef et al. 2014; Bold et al. 2015). Regulations were only recently developed and the process is yet to be cascaded to lower government through development and passing of ordinances and bylaws to control the sale or supply of counterfeit seed (National Seed Policy 2018).

d) *Insufficient compatibility with smallholder farming contexts*

Context variations in biophysical and socio-economic conditions are major limitations as certain traits have limited flexibility in their performance under different conditions. However, while tweaking varieties to address all variations may not be feasible insufficient considerations in context differences lead to focus on a few major crops and one-size fits-all varieties that work in only limited contexts. How different biophysical conditions such as pests, diseases, soils and climate interact in farm situations is also not adequately known (Van Asten et al. 2014) leading to production of varieties with limited conditions in which they can perform. Socio-economic variations also present another dimension of challenges. For example, the returns from improved seed may be too low for farms on very small land sizes, (Tiwari 2017), in remote locations with

poor access to input and output markets and where access to extension advice is limited. Improved seed varieties may be incompatible with cultural entrenched practices such as seasonal use of fire to clear gardens, scattering rather than line planting, intercropping with trees or other components, rotational grazing etc. The performance of improved varieties may also be limited in mixed-crop designs, which dominate subsistence smallholder systems. On the other hand, given that mixed-crop designs are complex and vary between eco-zones, cultural setups and individual farmers, generating improved seed material that is relevant to all contexts may not be feasible.

e) Research and extension are poorly coordinated

Climate change issues are not adequately mainstreamed into the agricultural extension strategies and as such emphasis on promoting and monitoring the adoption of climate-adapted seed varieties is not built into plans and budgets. Extension workers have limited capacity to advise farmers due to insufficient information on the availability and expected performance of climate-adapted varieties. The research-extension system is poorly coordinated, leaving stakeholders including extension workers, private seed companies, NGOS and farmers with information gaps regarding improved varieties. Feedback reporting on performance of varieties is not systematic. There are no structures or platforms for seed stakeholders to convene and share information regularly. Due to low staffing, extension workers are not easily reachable by the wide range of farmers they serve. Extension workers also need training in identifying and addressing differentiated needs of farmers according to gender, wealth and other social categories. The control of counterfeit seeds is sometimes limited due to inadequate facilitation of extension staff and inspectors with means of transport and fuel.

2.3.2 Identified Measures

2.3.2.1 Economic and Financial Measures

Mitigate cost of producing climate-adapted seed varieties

Increasing budget allocation to NARO to train technical staff and install modern technologies such as developing varieties through transgenic transfer into locally adopted varieties, will greatly cut down steps required and costs of developing robust products in the long run. Building human technical capacity and investing in precision of equipment and methods for quality control will also pay dividends in the long run. Data and information resources need to be developed and made available for helping breeders in selection, potentially cutting down on labour and field testing required (Tiwari 2017). Regional cooperation in crop improvement also need to be strengthened to enable co-designing of cost-effective methodologies. Varieties developed from elsewhere can be tested in the local systems and distributed to minimize duplication (IDRC 1983). Increasing the production capacity of the formal seed system will enhance its competitiveness in the local, regional and international seed markets (National Seed Policy 2018).

Affordability of improved varieties can be enhanced through provision of subsidies and enhancing access to credit facilities, but this needs to go hand in hand with supporting output markets to increase profitability. Alliances with NGOS can train farmers to identify models that can be profitable such as aggregation of investment across mane smallholder farms. Such alliances can also support farmers to build relationships with potential consumers of their products along the value chain. These farmer groups can be supported with financial training and seed funding to become savings and credit schemes.

Transaction costs of seed companies can be reduced by adopting international quality control measures such as OECD schemes, which unlike the multiple controls used in the local SQCC classes, only require official field inspection and seed sampling and testing for seed certification (MAAIF 2015). Training farmers and developing functional partnerships with them in seed multiplication distribution is another way that seed companies can be supported to cut down costs. Distribution costs can be further reduced through establishment of seed banks at lower government levels such as parishes.

2.3.3.2 Non Financial Measures

a) Strengthen community involvement in the development of improved seed

Participation of farmers while building indigenous knowledge into crop breeding research and in decision making helps to build products that respond well to contexts and are more likely to be adopted into farming systems (Jogo et al. 2013). A regulation requiring mandatory declaration of the source of germplasm is needed to credit indigenous contribution to knowledge generation and their potential to benefit from it (Naluwairo 2006). Community intellectual property rights in the National Seed Policy (2018) need to be operationalized. Farmers also need to have rights to register their own varieties (Tuhairwe 2017). Traditional knowledge of plant genetic resources needs to be documented to ensure its accessibility and use in crop improvement research (Naluwairo 2006). Farmer recognition can also motivate farmers to engage in research and would strengthen trust amongst other farmers in the improved varieties.

The capacity of research-extension systems needs to be strengthened to nurture farmer engagement and build farmers' voices into breeding processes. Research is needed to understand differences in farmers' seed needs and interest e.g., according to gender, age, wealth status etc. The promotion of improved varieties needs to be customized to different knowledge needs, values, perceptions and traditional beliefs of communities. This can be achieved by cataloguing information on improved seed varieties in local language and training farmers to train others. Community inclusion is also needed in monitoring the performance of varieties in different farming systems and how they interact with other components in the farms.

b) Strengthen enforcement of regulations to reduce counterfeits

Create awareness about the existence of counterfeit seeds and provide simple ways end-users can use to authenticate such as coin-scratch labels or holograms that conceal PIN code etc. This should be provided along with clear phone numbers to report such suspicions. Government can authorize service providers to give unique appearance, special codes and labels to packages of authenticated seed (De Boef et al 2014; Ampurire 2019). Seed companies need to work with government to track and trace their products along the value chain using scanners or smartphones to verify barcodes (De Boef et al 2014). The National Seed Certification Services needs to be sufficiently funded to recruit enough seed inspectors, train and equip them ensure all improved seeds are tested and certified before they are sold to farmers. The ministry of agriculture needs

to coordinate well with the Uganda National Bureau of Standards and with police to ensure strong enforcement to arrest and reprimand those dealing in counterfeits (Ssejjoba 2018; UMC 2019). Regulations need to be operationalized by supporting local governments to develop and pass ordinances and bylaws to control the sale or supply of counterfeit seed (National Seed Policy 2018). Since some fake seed comes from outside the country, border controls also need to be strengthened with sufficient people with the technical skills and equipment to detect and prevent entry. Seed certifying services are needed in all districts and the capacity of district officers needs to be built to detect and prevent the circulation of fake products. Regular surveillance is needed to detect the trends of fake seeds in order to detect their origins and take necessary action. Research is also needed to understand the costs and risks entailed in fake seed distribution. Deliberately linking farmers to genuine seed companies and private sector supplying any support services would also help farmers to avoid fake seed suppliers. Making seed quality standards widely available would also inform people what to look for.

c) Improve the capacity to generate improved varieties for different contexts

Routine studies are needed to map the array of farmer contexts and how these change over time to guide the development of multiple options of improved seed varieties (Asea et al. 2014). Farmer research networks need to be established where farmers collaborate directly with researchers in the development, testing and adaptation of varieties within the contexts where those varieties will be used. Government needs to invest in decentralized programs and laboratories to be able to directly take into consideration ecological and social context variations. Research is also needed to understand the interactions between improved varieties and other ecological processes in the various contexts. Breeding programs need to focus on a wider range of crops in order to foster crop variety which enhances resilience. Direct interaction between farmers, extension workers and researchers is needed in the process of developing improved varieties (Nkonya et al, 2002). Breeding programs also need to be widened to look at multiple wins including poverty reduction, natural resource conservation, productivity and climate adaptation. Improved seed goes hand in hand with considerations of profitability, therefore market linkages also need to be strengthened to support the business prospects for farmers. Mechanisms are needed to enable stakeholders in the various locations to convene and share information regularly to access information on improved seed varieties.

2.4 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR RESPONSIVE AGRICULTURAL EXTENSION FOR CLIMATE CHANGE ADAPTATION IN DIFFERENT CONTEXTS

2.4.1 General description of Responsive Agricultural Extension

The impact of climate change on crops and livestock, the whole agricultural value chain and market trends, requires extension that is agile providing relevant advice, with appropriate incentives. Responsive extension is the provision of advisory support that addresses the changing needs of farmers as well as keeping them updated about the new developments in technology. It involves collaboration with farmers in research where modern knowledge and indigenous knowledge are integrated in developing solutions that are tailored to different farmer contexts. It maintains constant presence and interest in what happens in farming systems with two-way exchange of information and knowledge between the farms, research entities and policy makers in technology development, testing and adaptation.

2.4.2 Barriers of Responsive Agricultural Extension

2.4.2.1 Economic and financial barriers

Inadequate financing and budget allocations

Responsive agricultural extension requires a high proportion of the sector budget allocation as it requires investment in a decentralized system with constant presence throughout the country. Major costs include expansion of the staff establishment and re-training of officers and recruitment of para-extension to maintain functional linkages with farmers. The ongoing single-spine extension system in 2016 was receiving only UGX 265.78 billion (about 12%) of the projected annual estimate of UGX 2,236.95 billion (Barungi, 2016). By FY 2019/20, agricultural extension had a budget gap of UGX 483.4 billion (BMAU Briefing Paper, 2019). Late release of funds poses another challenge as it distorts agricultural extension operations and may lead to poor readiness to implement planned activities, late procurements and asynchrony of advisory services with seasonal cycles (BMAU Briefing Paper, 2019).

2.4.2.2 Non-financial barriers

a) Limited human capacity to provide effective extension support for resilient farming in different contexts

The current number of extension workers countrywide is 3,854, stationed at district and sub-county levels (Ministerial Policy Statement FY 2018/19). The target is 5,000, which gives an extension worker to farmer of only 1: 1,800 whereas the recommended is 1:500. The target of 5000 was estimated for 116 districts, but these have been increased to 132. More extension workers are needed as the approved structure requires 13 officers at district level and 3 extension staff at sub-county level (BMAU Briefing Paper 2019). In the failed National Agricultural Advisory Services (NAADS) approach, which had been premised on privatized extension services supplied on demand by farmers, low emphasis was placed on building the technical capacity of public extension officers whose major role then was to coordinate private service providers (Barungi et al. 2016).

Extension officers do not have adequate skills to respond to variations in farmers' context as driven by climate change and other differences such as market access, culture, information availability etc. Existing curricula for technical expertise do not adequately provide skills for understanding and responding to biophysical and socio-economic diversity and different scenarios. There is no systematic monitoring of changes in environmental or social set-ups aimed at designing continuous refresher and upgrading courses to keep extension officers up to date. Also, there is no motivation for extension officers to be agile in addressing differences in farmers' contexts since this is not considered in their performance evaluations for recognition or promotion.

Extension staff is not adequately facilitated to visit targeted communities as needed due to limited supply, maintenance and fueling of vehicles. For example, of the 4,000 motorcycles planned for district local governments, only 1,061 were procured in FY 2018/19 (BMAU Briefing Paper, 2019). The potential of information technology in making extension responsive is not adequately utilized as staff is not sufficiently supplied with the necessary gadgets or trained in using online platforms or apps for accessing information, interacting with farmers, mapping variations, analyzing and designing relevant responses. Existing extension methods are

not well aligned with the emerging high percentage of youth farmers and do not address their aspirations. On the other hand, farmer organizations are fluid and this complicates transfer and build-up of information. The break-up of farmer cooperatives disempowered local structures into units too fragmented for targeting technologies or building consistent knowledge.

b) Inadequate monitoring and surveillance

Monitoring required for understanding context, the delivery of solutions and how effective these solutions are is not adequately conducted. Context studies are not sufficient. There are no designs in extension system to use existing information on the biophysical and social landscape. Structures put in place especially at district and sub-county level to monitor the process of service delivery and the effectiveness of solutions are not functioning very well (Kuteesa et al. 2018). Lack of farmer empowerment to express themselves freely also limits the extent to which feedback can be provided. A study by ACODE in ten districts (Gulu, Hoima, Kabalore, Kamuli, Luwero, Mbarara, Mukono, Nebbi, Soroti, and Tororo), found that rather than technical officers, farmers preferred to air out their views and concerns to elected leaders whom they trusted to pass them on to higher levels. Farmers get discouraged when governance concerns persist even after they raise them in monitoring and feed-back meetings.

Lack of strategic partnerships for monitoring also leads to incomplete coverage. Monitoring mostly focuses on processes and less so on quantification of impact due to lack of low-cost tools and instrumentation to sample and measure as needed. Remote sensing and information technology options are not adequately utilized possibly due to lack of technical skills to measure, analyses and report to inform planning. Feedback to show observed trends and how these inform planning is not adequately communicated, demoralizing farmers and technical staff operating at lower levels. This sometimes stems from asynchrony and the loose linkage between monitoring information and planning/budget cycles.

c) Weak structures to engage farmers

Agricultural extension is fragmented with no institutional framework for coordinating the different national actors, which include the Directorate of Agricultural Extension Services, Technical Directorates, Agencies (NARO, Knowledge Driven Agricultural Revolution, Coffee Development Authority, Uganda Coffee Development Authority, etc.), local governments and

the non-state actors such as non-government organizations, donor projects; academia and private sector entities (Munyambonera et al, 2012). Operations of the different entities are disjointed sometimes resulting in duplication, redundancy and contradiction. Sometimes the messaging is conflicting, leaving farmers confused (NAES 2016). Extension staff is also poorly distributed across sub-sectors leaving some farmers less supported than others.

Although farmer empowerment is a key principle in the existing extension system, the approved structures do not clearly show how farmers will be involved either in identifying their own needs or in finding and proposing solutions to their problems. Farmers do not perceive themselves to be adequately participating in key decision-making processes. As such, strategies do not adequately attend to persistent concerns of farmers such as support for transitioning from use of a hand hoe to more mechanized approaches, reduced post-harvest loss, better access to good seeds and improved value addition and marketing. There is limited evidence of quality assurance of inputs that farmers receive from extension staff causing loss of trust. Extension service provision remains supply-driven with no system through which farmers can communicate their needs, knowledge or innovation (Suresh et al., 2013, Barungi et al, 2016).

2.4.3 Identified measures

2.4.3.1 Economic and financial measures

a) Increase budget allocation, develop partnerships and improve efficiency

Budget allocation to extension needs to be increased in accordance with CAADP commitments to enable hiring and training of staff, logistical facilitation, monitoring and use of ICT in extending agricultural advice and inputs. Funds are also needed to conduct studies and scenarios analysis for responsive extension aimed at understanding context, identifying appropriate responses and tracking how these increase farmers' potential to adapt to climate change. Private sector partnerships need to be developed to increase investment in some extension processes such as provision of inputs, value addition, post-harvest handling, mechanization and nurturing linkages to markets agricultural insurance and financial services. Targeted subsidies are needed when introducing farmers to new technologies and ensuring that marginal farmers are not excluded. Financial governance and accountability processes need to be strengthened in order to minimize losses and build trust.

2.4.3.2 Non-financial measures

a) Strengthen technical capacity of extension workers to become more responsive to changing needs of farmers

More staff needs to be recruited to fill the established structure and these need to be supplemented with para technical service providers that are motivated and facilitated as required to increase reach and responsiveness to farmer needs. Not only numbers, but building context variations into the mechanism of operation. Officers and technical assistants need to be trained in methods of collaborating with farmers in monitoring and evaluating performance, and building on local knowledge and resources to design appropriate adaptations. Regular information, skills and technology needs assessments are needed to continuously upgrade skills and knowledge of extension workers. Extension programs need to develop active engagements with training institutions to design appropriate courses for enabling adaptation to different scenarios due to climate change or other variations in the curricula for major and short courses. Extension staff and farmers also need to be taken to exposure visits to get insights on what is feasible and potential entry points for transitioning towards responsiveness. Terms of reference and performance evaluations of extension staff also need to be reviewed to motivate them to develop and monitor responsiveness in their work.

Farmers too need to be made aware of their role in ensuring that extension support addresses their felt needs. Existing and new information needs to be made more accessible to farmers using methods such as videos, translation into local language, farmer exchange visits demonstrations, conducting field days, radio talk shows and call centres, etc. Extension using information technology applications and digitalized resources on mobile phones will revolutionalize interaction with farmers and staff needs to develop capacities in this area (NAES 2016; Barungi et al 2017). Extension messages and impact can be strengthened through engagement of enterprises on value addition and local traders or input suppliers (NAES 2016). Farmers' cooperative and marketing organizations need to be strengthened as nuclei for knowledge building and ensuring continuity of information for community development.

b) *Strengthen extension-farmer linkages*

Recognition of farmers' knowledge and contribution to extension processes is needed to motivate farmers to own and actively participate. Annual awards and paid engagement in certain activities should be considered to build farmers' confidence as key participants in the extension work. Farmers should be equipped with knowledge and skills to support one another. They should be included in the development of training manuals and communication materials, consolidation and analysis of data. They should also be credited as co-authors of the products developed with them.

Farmer participation in setting the extension and research agenda needs to be strengthened to enable the system to transition to demand-driven service provision (Suresh et al., 2013, Barungi et al, 2016). Farmers need to be involved at every stage including research design, knowledge generation, technology dissemination, use, monitoring and evaluation. Local leadership needs to be involved in extension systems to build trust with farmers and ensure that their concerns are followed up in future planning. Different groups need to be strategically linked for sharing information and developing value chains and market exchanges.

c) *Improve monitoring and surveillance*

Extension staff needs to be made aware of the importance of monitoring as a basis for responsiveness to farmers' needs. Spatial variations in physical features as well as social and cultural characteristics need to be captured regularly using maps survey and information reviews to lay out the context differences and how these change over time. The impact the technology also needs to be tracked not only at production level, but across the value chain. As such, adequate and up-to-date monitoring equipment and tools are needed for timely gathering and analysis of information. Extension staff need to be trained to use existing data collection tools established by DAES and the Statistics Division for data monitoring and analysis. Extension should also partner with institutions such as academia, research entities or the national bureau of statistics. Information from relevant sources such as meteorological units, disaster preparedness surveillance etc. needs to be integrated with extension monitoring and analysis to strengthen planning. Partnerships need to be developed also with private companies and NGOs to contribute to generation and transfer of information. Monitoring should also aim at scope for potential services for farmers e.g., input and value addition markets, insurance, financial institutions etc.

Outcomes of monitoring and evaluation need to be synchronized with planning cycles to give coherence.

Farmer structures for conducting monitoring need to be empowered by recognizing their data or working directly with them in data collection and analysis. Setting up community-level monitoring committees will ensure follow up using agreed performance indicators of the technology or knowledge transferred (Buyinza et al, 2015). Monitoring clubs can also be established among young people in schools to help with data gathering.

d) *Coordinate extension service provision*

Improved coordination between sectors and other non-governmental entities will create synergies, avoid redundancy, ensure a common message, standardize successful practices, and leverage resources from the private sector, development partners, and other non-state actors (NAES 2016). It is essential for the agricultural extension services system to have formal and explicit mechanisms for coordination and collaboration established at every level of the extension system. Coordination is also needed between national level entities and local governments (Barungi et al, 2017).

2.5 Linkages of the barriers identified

A key common barrier is the high cost of setting up and implementing the three prioritized technologies. The agricultural sector receives very low budget allocation to conduct its operations and this is often not informed by the need. Private financing institutions can only operate reach a limited number of smallholder farmers due to high costs and risks associated with operating in rural set-ups. Individual farmers often own units that are too small to make viable profit from the technologies yet farmers groups and organizations have developed into robust structures to ensure collective investment. The poor road network and weak connectivity to utility services also increases costs of setting up and operating technologies.

The inadequate number, technical capacity and logistical facilitation of extension workers also features prominently as a key limitation to the transfer and diffusion of technologies. This is connected to low budget allocations and weak systems to assess and address capacity needs. Poor coordination among different public sectors and between government and non-government entities also prevents alignment of extension resources resulting in inefficiency and sometimes

contradiction. The numerous farmer organizations and the fluidity of their memberships limit the extent to which extension workers can reach them for technology and information transfer, training and meaningful engagement. On the other hand, inadequate involvement farmers in planning designing and implementing of the technologies leads to costs and limited reach of all categories of farmers.

The one-size-fits-all approach to technology transfer is also a key barrier as biophysical and socio-economic contexts vary yet systems to analyse and monitor these variations are not adequately developed. This is connected to the inadequate capacity to assess and plan for the different conditions. This may also be due to the inadequate financing.

2.6 Enabling framework for overcoming the barriers in Agriculture Sector

Prioritized actions in different government policies, strategies and plans can potentially support the transfer and diffusion of the prioritized technologies for climate adaptation in the agriculture sector.

The irrigation policy is part of the implementation of the National Water Sector Strategy and Investment Plan (2010-2035), the Agricultural Sector Strategic Plan (ASSP) 2015/16-2019/20 and the National Agricultural Policy (2013). This policy provides for Farmers' Organizations which include community groups, associations and cooperatives among others to operate and maintain irrigation facilities sustainably.

Since 2015, the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) is rolling out the Single Spine extension service delivery system, which can be further improved to become responsive to enable adaptation to climate change in different farmers' contexts.

The goal of the National Seed Policy (2018) is to guide, promote, develop and regulate the seed subsector in order to ensure availability and access to safe and high-quality seed to all stakeholders for increased food and nutrition security, household income, wealth creation and export earnings. Development of a new seed varieties is a key pillar in achieving the 6% annual growth in agriculture under the Comprehensive Africa Agriculture Development Programme-AU (CAADP). Vision 2040 highlighted government's plans to reform the extension system to increase information access, knowledge and technologies to farmers; collect adequate

agricultural statistics; improve weather information and its dissemination; intensify environmental control measures to halt the decline in soil fertility and ensure that land fragmentation is reversed to secure land for mechanization (GOU 2010). The common barriers identified and the potential enabling frameworks are summarized in **Table 5.**

TABLE 5. ENABLING FRAMEWORK FOR OVERCOMING THE BARRIERS IN AGRICULTURE SECTOR

Barrier	**Enabling framework**	**Responsible institution**
High cost of establishment and operation	Higher budgetary allocation to the agriculture sector can be lobbied under the National Development Plan III (2021-2026) which seeks to increase the rate of growth of the agricultural sector from 3.8% to 7%.	Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF).
	A commercialization fund is being piloted under the Agricultural Sector Strategic Plan to enable individual farmers or farmer groups to acquire necessary production equipment, (Francis & James, 2003).	
High cost of establishment and operation of community-based irrigation schemes	Subsidies to support progressive farmers and organized farmer groups to set up micro irrigation schemes (National Irrigation Plan)	Directorate of Water in Ministry of Water and Environment; MAAIF.
	The Intergovernmental Fiscal Transfer Reform Program (IFTRP) supported by the World Bank includes support for micro-scale Irrigation (National Irrigation Policy 2018).	Department of Agricultural Infrastructure Mechanization and Water for Agricultural Production, MAAIF.

	Public support for Sustainable Water for Production Management Systems through the private sector arrangement	MAAIF
High cost of seed production and low affordability to farmers	A regional variety catalogue that is already underway will also help avoid unnecessary costs of duplication and make information on ready-made varieties available for users.	MAAIF
	Public investment in generating appropriate, safe, climatic change resilient and cost-effective agricultural technologies, innovations and management practices (TIMPS (Agricultural Sector Strategic Plan)	MAAIF
	Competitive Research Grants (CRG) Scheme were established in each district (ASSP)	MAAIF
	The government of Uganda through Operation Wealth Creation (OWC) programme, distributes subsidized improved seed	
Inadequate farmer involvement	Community intellectual property rights are now recognized in the National Seed Policy (2018).	
	The Uganda National Seed Strategy 2014/15 – 2019/20 will use public private people partnership (PPPP) in new variety	Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF).

	development and dissemination**.**	
	In implementing the irrigation plan, government will work with non-state actors (NSAs) including farmer organizations, civil society networks etc.	Directorate of Water
	Farmer Field Schools (FFS) supported by FAO (Fris-Hansen et al. 2014).	
Inadequate tailoring of technology to different contexts	Social protection and pertinent needs of women, youth, persons with disabilities and those living with HIV/AIDS are prioritized (Water and Sanitation Subsector Gender Strategy)	Directorate of Water
	A national food and agricultural statistics system has been created to produce annual and spatially disaggregated estimates of agricultural production	Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF).
Counterfeit seeds	The Agricultural Sector Strategic Plan seeks to Strengthen policies, laws and regulations for seeds and planting materials supply and use Up-scaling use of improved and climate change resilient seeds Strengthen the national certification and regulation system Increase availability and access to quality	National Seed Certification Services (NSCS), MAAIF

	seeds/ planting materials	
	Promotion of development of new plant varieties and their protection, and rewards through granting plant breeders' rights (Plant Variety Protection Act (2014).	Plant Variety Protection Committee MAAIF
Low technical capacity	Increased staff establishment for agricultural extension (NDP 3).	Directorate of agricultural extension services, Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF).
	A comprehensive sector capacity building programme to capture knowledge and skills gaps; implementing the capacity building plans for extension staff, the NARs and private sector; periodic reviews of achievement. Institutional strengthening of extension systems including farmer institutions Building BTVET into agricultural extension system Partnership with development partners, non-state actors and private sector (The Agricultural Sector Strategic Plan (ASSP).	Directorate of agricultural extension services, Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF).
	Multi-stakeholder Innovation Platforms (MSIPs) were also established as the main drivers of knowledge sharing, learning,	

	joint demand-driven needs assessments and implementation. NARO supported staff for long-term training, short-term training, professional courses, workshops, seminars and conferences	

CHAPTER 3: FORESTRY SECTOR

The prioritized technologies for climate change adaptation in the Forestry Sector were:

- Promotion of Farmer Managed Natural Regeneration (FMNR) for forest landscape restoration
- Integrated pest management (IPM) in natural forests and forest plantations
- Promoting Forest based enterprises e.g. bee keeping/apiary; butterfly farming, fruit trees production; ecotourism

This chapter presents the process followed and the results obtained in the identification and analysis of barriers hindering the transfer and diffusion of these technologies; the measures to overcome these barriers and the enabling framework.

3.1 PRELIMINARY TARGETS FOR TECHNOLOGY TRANSFER AND DIFFUSION

Promotion of Farmer Managed Natural Regeneration (FMNR) for forest landscape restoration

In Uganda FMNR has been promoted by International (e.g. the International Union for Conservation of Nature, World Agroforestry Centre) and local Non-Governmental Organizations through pilots to advance forest landscape restoration.

The technology is applicable nationwide across the 7 forest landscapes and results in the generation of several timber forest and non-timber forest products that have a huge market potential at the local, sub-regional and national levels.

Overall, the preliminary targets for transfer and diffusion of the technology are to directly benefit 300,000 households (i.e. 1,800,000 people) directly, of which at-least 30% should be women and youth. Furthermore, the promotion of or investment in the technology will contribute towards restoration of 569,403 Ha across the selected forest landscapes. This is 20% of the available land available for restoration across the 7 forest landscapes in Uganda through FMNR (MWE,2016).

Integrated pest management (IPM) in natural forests and forest plantations

Integrated pest management in forest plantations in Uganda is promoted by both Government and Private Institutions. The responsible Government Institutions for the research and development of plausible integrated pests and diseases management techniques in forestry include: National Forest Resources Research Institute – NARO and Makerere University School of Forestry, Environmental and Geographical Sciences, College of Agricultural and Environmental Sciences (CAES).

On the other hand, the private sector institutions responsible for promoting the application of the integrated pest and disease management techniques in forest plantations are by large the Uganda Timber Growers Association, community and private forest owners.

The technology has a national wide potential, thus, it's applicable across the 7 forest landscapes in the country and in both natural and plantation forests. The various actors who are applying the technology at different scales, include: National Forest Authority, Uganda Wildlife Authority, Community Forest Association, Private commercial forest companies.

Overall, the preliminary target for transfer and diffusion of the technology is to directly benefit 400,000 households (i.e. 1,400,000 people) directly, of which at-least 30% should be women and youth. Furthermore, the promotion or investment in the technology will contribute towards restoration of 365,956 Ha of forests across the 7 forest landscapes under integrated pest management technology. This is 20% of the total land covered by forests under the various forest tenures in Uganda (MWE,2016b).

Promoting Forest based enterprises e.g. bee keeping/apiary; butterfly farming, fruit trees production; ecotourism

In Uganda over the years since the forestry reforms in 2001-2003, various forest responsible bodies have promoted forest-based enterprises. Some these are enlisted as follows:

National Forestry Authority – has promoted the enterprises in collaboration with the civil society (both local and international) and local governments. This is within the framework and guidelines of collaborative forest management targeting forest adjacent communities living near the central forest reserves

Uganda Wildlife Authority has promoted the forest-based enterprises targeting communities living adjacent to the national parks in various parts of the country. Commercial Tree Companies, Private tree growers/members of the Uganda Timber Growers Association have promoted forest-based enterprises within the forest plantation and also targeting participation of the surrounding communities.

The technology is applicable nationwide across the 7 forest landscapes and results in the generation of several timber forest and non-timber forest products that have a huge market potential at the local, sub-regional and national levels.

Overall, the preliminary targets for transfer and diffusion of the technology are to directly benefit 200,000 households (i.e. 1,200,000 people) directly, of which at-least 30% should be women and youth. Furthermore, the promotion/investment in the technology will contribute towards restoration of 838,740 Ha across the selected forest landscapes. This is 20% of the available land available for restoration across the 7 forest landscapes in Uganda through FMNR (MWE,2016).

3.2 ANALYSES OF THE ROOT CAUSES OF THE CRITICAL BARRIERS FOR THE PRIORITIZED TECHNOLOGIES

The analyses of the root causes of the critical barriers for each of the prioritized technologies are presented in **Tables 6, 7 & 8** as follows.

3.2.1 *Promotion of Farmer Managed Natural Regeneration (FMNR) for forest landscape restoration*

TABLE 6. CRITICAL BARRIERS AND ASSOCIATED KEY ROOT CAUSES

Critical barrier	Key root causes
i) Bush burning and stray livestock destroy regenerated trees, especially in Northern Uganda, yet the ordinances and byelaws for regulation of wildfires are lacking or inadequately implemented.	a) Cultural beliefs by pastoralists that bush burning allows re-generation of new grass for livestock. As stipulated in most cultures and customs, this practice is usually done by men and boys. b) Hunting edible rats, mud fish – especially men and boys are involved as expected and stipulated by most cultures in northern and eastern parts of the country. c) Ignorance of the community about impacts of bush burning

Critical barrier	Key root causes
	d) Careless smokers (especially men – as its common in most cultures in Uganda) who throw burning cigarettes in the forest and bush e) Bush burning makes land clearing and opening for agricultural expansion a simple task. But it's very wasteful and destructive! f) Free range grazing of livestock in the forest landscape. g) Weak response for control & regulation of bush fires and stray livestock through implementation of bylaws/ordinances where they exist. h) Outdated policies-laws, which cannot effectively discourage bush burning. Penalty is five hundred shillings or imprisonment for a period not exceeding three months or both.
ii) The main benefits of FMNR are realized in the medium term at least five to ten years after establishment; this means that farmers must be prepared to invest in their establishment and management during several years before the main benefits are generated.	a) Trees take long to mature. b) Degraded landscapes (soil, arable land,) take long to be restored. c) Community mindset/attitude for short-term gains/benefits.
iii) Limited land available for investment in forest restoration within the landscapes.	a) Lack of land-use plans b) Investment in other competing enterprises c) Increased population growth with several competing demands for land-use
iv) Limited awareness and appreciation of the technology among policy and decision makers at the national, landscape and local	a) Limited published literature quantifying the social, economic & environmental benefits of the technology. *b)* Low levels of sensitization among community (including men, women & youth) and other key stakeholders about the diverse

Critical barrier	Key root causes
levels.	benefits that arise from FMNR. c) Community's mentality that tree-planting is a better solution than protecting existing systems. d) Few champions for FMNR in the forest landscapes in the country. e) FMNR is a new discipline/concept that is not known by many stakeholders for effective application. f) Low level of local knowledge and awareness of how quickly trees (once protected) will reach useful size and begin producing valuable products is a barrier.
v) Long-held beliefs/attitudes by farmers that trees on farmland will attract pests and/or reduce yields, and so trees should be completely cleared.	a) Limited published literature quantifying the social, economic and environmental benefits of the technology. b) Limited knowledge and skills for application of FMNR by the community and farmers – including men, women & youth. c) Contradictions in Government priorities and programs in agriculture, environment and natural resources management sectors and how they are communicated. d) Low levels of community awareness about the diverse benefits that arise from FMNR.
vi) FMNR falls outside the mainstream of agroforestry, agriculture and forestry sub-sectors, thus making it difficult to access structured support for up scaling, but also acceptance by the appropriate research communities	a) Limited access to structured support for up scaling FMNR b) Weak forestry/agriculture extension system, thus not providing the required, responsive and adequate extension support services to farmers (i.e. women, youth & men) and communities c) Lack of a coordinated research agenda for generation of the required evidence for FMNR at different scales.
vii) Land tenure regimes especially the communal land tenure in Northern Uganda and West Nile regions where there are common	a) Limited access to information on land policies and laws to guide sustainable land-use and management of communal land by the community, including men, women and youth. b) Weak implementation of roles and responsibilities in respect to

Critical barrier	Key root causes
property rights that compromise effective management and hence survival of the regenerating trees	administration and management of customary land by cultural/customary institutions. c) Weak institutional capacity for area land committees in providing effective information on land rights and administration
viii) Limited access, control of resources and decision making in respect to land use and management by women and youth.	a) Some cultures and customs limit land ownership by women and youth. b) Ignorance about existing land policies and laws. c) Wrong perception (by community especially men) that that women and girls should not own and or control resources such as land. d) Limited opportunities for women's and youth's empowerment. e) Lack of capital to buy land especially by the women and youth.

3.2.2 *Integrated pest management in forest plantations through promoting mixed species plantations.*

TABLE 7. CRITICAL BARRIERS AND ASSOCIATED KEY ROOT CAUSES

Critical barrier	Key root causes
i) The chemical pesticides are expensive and may not be affordable for smallholders.	a) Limited access to chemical pesticides by community and smallholders, including men, women and youth. b) Weak institutional organization of smallholders to access chemical pesticides. *c)* High taxes and levies charged by Government on the pesticides limit access especially for women & youth. d) Most of the pesticides are imported from outside. e) Weak regulation and enforcement of standards – especially for chemical pesticides.
ii) Existence of counterfeit especially the chemical pesticides on the market, which are not effective in the control	a) Weak enforcement and regulation of standards for chemical pesticides. b) Weak institutional organization of consumers to demand for

Critical barrier	Key root causes
and treatment of the pests and diseases.	chemical pesticides that meet the acceptable standards and quality. c) Weak penalties /non-deterrent measures to discourage perpetuators.
iii) Inadequate knowledge and application of the IPM especially among the private individual commercial tree growers.	a) Weak forestry extension system, that fails to provide appropriate services to farmers and communities – including men, women and youth. b) Limited awareness about Integrated Pest Management among smallholder tree farmers including men, women and youth. c) Lack of simplified Information, Education & Communication materials on application of Integrated Pest Management. d) Limited access to information about IPM and its application by farmers including men, women and youth. e) Inadequate training in Integrated Pest Management techniques – especially among smallholders including men, women and youth.
iv) Non-uniformity in pest infestation, thus emerging at different stages of the tree cycle, they evolve over time, some IPM technologies are divisible and rarely do complete 'packages' exist for an entire crop or ecosystem.	a) Weak adaptation to Climate variability and change in forest plantations and the landscape. b) Limited investment in research to develop responsive IPM solutions. *c)* Weak regular monitoring and surveillance of pests and diseases.
v) Limited access, control of resources and decision making in respect to land use by women and youth.	a) Some cultural and customs limit land ownership by women and youth. b) Ignorance about existing land policies and laws. c) Wrong attitude (by community/men) that attitude that women and girls should not own and or control resources. d) Limited opportunities for women's and youth's empowerment.

3.2.3 *Promoting Forest based enterprises e.g. bee keeping/apiary; butterfly farming; fruit trees production; ecotourism.*

TABLE 8. CRITICAL BARRIERS AND ASSOCIATED KEY ROOT CAUSES

Critical barrier	**Key root causes**
i) Inability to sell products at competitive prices compromises overall revenue and profits from the forest-based enterprises.	a) Limited access to transport by the community especially by women and youth, which hinders the marketing of forest-based enterprises and agro-forestry products and services. b) Limited access to market infrastructure and information by forest adjacent communities comprising of men, women and youth. c) Weak organization & coordination by the forest adjacent communities comprising men, women and youth. d) Low quality products and services from forest-based enterprises due to: • Weak forestry extension, resulting in provision of inadequate training and guidance to the forest adjacent communities comprising of men, women and youth; • Inadequate knowledge and skills for handling, value addition, processing and packaging skills for various gender categories i.e. men, women & youth; • Weak enforcement of guidelines and standards for quality at different scales.
ii) Limited access to credit services by forest adjacent communities.	a) Poor saving culture by the forest adjacent communities and their organizations, including men, women and youth.

Critical barrier	Key root causes
	b) Inadequate knowledge and skills of the community (including men, women and youth) for mobilization and management of savings and credit schemes. c) Limited access to financial management services, training and advisories especially by women and youth. d) Weak organizational development (i.e. in respect to leadership and governance) of the forest dependent communities and their organizations, thus lack of rules and regulation, not registered.
iii) Mismanagement of resources and income by individuals.	a) Lack of a clear vision, action and business plans for the collaborative forest management groups and associated forest-based enterprises. b) Weak leadership skills of the collaborative forest management group leaders, including men, women and youth. c) Weak measures for disciplining or reprimanding offenders.
iv) Weak negotiation capacities of collaborative forest management groups/associations.	a) Inadequate organizational and business skills especially among community-based organizations and forest adjacent community organizations or community forest management groups. b) Limited access to structured training, exposure and mentoring. c) The collaborative forest management groups/associations & their members are highly vulnerable due to limited livelihood options and services.
v) Bush burning and stray livestock destroy forest-based enterprises and other properties -	a) Cultural beliefs by pastoralists that bush burning allows re-generation of new grass for livestock. As

Critical barrier	Key root causes
especially in Northern Uganda and Wet Nile regions.	stipulated in most cultures and customs, this practice is usually done by men and boys. b) Hunting edible rats, mud fish – especially men and boys are involved as expected and stipulated by most cultures in northern and eastern parts of the country. c) Ignorance of the community about impacts of bush burning. d) Careless smokers (especially men – as its common in most cultures in Uganda) who throw burning cigarettes in the forest and bush. e) Bush burning makes land clearing and opening for agricultural expansion a simple task. But it's very wasteful and destructive! f) Free range grazing of livestock in the forest landscape. g) Weak implementation of bush burning bylaws and ordinances where they exist. g) Outdated policies-laws, which cannot effectively discourage bush burning. Penalty is five hundred shillings or imprisonment for a period not exceeding three months or both.
vi) Insecure tenure and land use rights – especially for the forest adjacent communities.	a) Limited knowledge about existing policies and laws (which provide for and protect these rights and obligations) among the forest adjacent communities – including men, women and youth. b) Weak enforcement of forestry policies, laws and guidelines – through proactive stakeholder engagement and standards for quality at different scales
vii) Limited access, control of resources and	a) Some cultures and customs limit land ownership by

Critical barrier	Key root causes
decision making in respect to land use by women and youth.	women and youth. b) Limited awareness about existing land policies and laws among the community, including men, women and youth. c) Wrong perceptions by community especially men, that women and girls should not own and or control resources. d) Limited opportunities for women and youth empowerment.

3.3 MEASURES FOR OVERCOMING BARRIERS

The measures for addressing the root causes of the critical barriers for each of the prioritized technologies are presented in **Tables 9, 10 & 11** as follows.

TABLE 9. MEASURES FOR OVERCOMING BARRIERS TO FARMER MANAGED NATURAL REGENERATION FOR FOREST LANDSCAPE RESTORATION

Critical barrier	Measure to address the barrier
i) The bush burning and stray livestock destroy regenerated trees, especially in Northern Uganda, yet the ordinances and byelaws for regulation of wildfires are lacking or inadequately implemented.	a) Enhance knowledge of the community (including men, women, youth) and other key stakeholders about impacts of bush burning and stray livestock. b) Provide alternative livelihood options for the men and boys involved in the hunting of edible rats and mud fish. c) Work with cultural institutions to change mindset, behavior and attitudes linked to bush burning and free-range grazing. d) Advance targeted mass awareness creation on unregulated bush burning. e) Promote alternative gender responsive technology for easing clearing and opening up land for agricultural production, such as: use of tractors, oxen ploughs and minimum tillage.

	f) Provide improved (e.g. drought resistant, early maturing) pastures as alternatives for grazing of livestock, especially during the dry season. g) Strengthen response for control and regulation of bush fires and stray livestock through implementation of bylaws or ordinances and integrated fire management. h) Update or review of outdated policies-laws – for discouraging bush burning.
ii) The main benefits of FMNR are realized in the medium term at least five to ten years after establishment; this means that farmers must be prepared to invest in their establishment and management during several years before the main benefits are generated.	a) Promote enterprises with short term benefits with due consideration of preferences of men, women and youth for diversification with farmer managed natural regeneration. b) Provide incentives to support land restoration in the forest landscapes. c) Create targeted awareness to change community mindset/attitude in respect to short-term gains/benefits.
iii) Limited land available for investment in forest restoration within the landscapes.	a) Develop and operationalize land-use plans. b) Provide incentives for land allocation for investment in landscape restoration through FMNR. Some of the incentives could be inform of small grants and or technical support for development of forest management plans.
iv) Limited awareness and appreciation of the technology among policy and decision makers at the national, landscape and local levels.	a) Increase publication of literature quantifying the social, economic & environmental benefits of the technology b) Increased targeted community awareness about the diverse benefits that arise from FMNR. c) Increased invested in targeted research, training and development in FMNR to contribute to livelihoods, landscape restoration. d) Support more champions for FMNR through establishment of demonstration sites/centres in the forest landscapes in the

	country. e) Conducting structured policy dialogues on FMNR with policy and decision makers with the forest landscapes.
v) Long-held beliefs by farmers that trees on farmland will attract pests and/or reduce yields, and so trees should be completely cleared.	a) Scale up simplified and targeted publications on quantification of the social, economic and environmental benefits of the technology b) Conduct targeted training of community and farmers (including men, women and youth) to enhance their knowledge and skills for application of FMNR. c) Increase targeted community awareness programmes for men, women and youth, about the diverse benefits that arise from FMNR. d) Streamline priorities and communication from various Government development programs in agriculture, environment and natural resources management to avoid contradictions.
vi) FMNR falls outside the mainstream of agroforestry, agriculture and forestry sub-sectors, thus making it difficult to access structured support for up scaling, but also acceptance by the appropriate research communities	a) Improve access to structured support (e.g. inputs, monitoring or backstopping for up scaling FMNR b) Strengthen extension within the forestry/agriculture sectors to provide responsive advice to community and farmers (including women, youth and men) in respect to application of FMNR. c) Establish coordinated research agenda and teams to generate the required evidence for FMNR at different scales.
vii) Land tenure regimes especially the communal land tenure in Northern Uganda and West Nile regions where there are common property rights that compromise effective management and hence survival of the regenerating trees	a) Advance targeted community awareness creation on information on land policies and laws to guide sustainable land-use and management of communal land through FMNR involving men, women, youth and cultural institutions. b) Strengthen capacity of cultural/customary institutions to deliver on their roles in respect to administration/management

	of customary land. c) Strengthen institutional capacity for area land committees in providing effective information on land rights & administration.
viii) Limited access, control of resources and decision making in respect to land use and management by women and youth	a) Conduct structured engagements with cultural institutions to influence and change beliefs, attitude and customs that limit women's land ownership. b) Conduct targeted community engagement (including men) to change their attitude and support women and youth access to and control of resources. c) Create targeted awareness on women land rights as provided for in the existing policies and laws. d) Create opportunities for women's and youth's financial and leadership empowerment.

TABLE 10. MEASURES FOR OVERCOMING BARRIERS TO PROMOTION OF INTEGRATED PEST MANAGEMENT IN FOREST PLANTATIONS THROUGH PROMOTING MIXED SPECIES PLANTATIONS

Critical barrier	**Measure to address the barrier**
i) The chemical pesticides are expensive and may not be affordable for smallholders.	a) Advance access to chemical pesticides by community and smallholders – including men, women and youth. b) Strengthen institutional organization of smallholders to access chemical pesticides c) Advocate for reduction of taxes and levies charged by Government on the pesticides. d) Strengthen regulation and enforcement of standards for especially chemical pesticides. e) Promote local investment into the manufacture of the chemical pesticides.
ii) Existence of counterfeit especially	a) Strengthen enforcement and regulation of standards for

the chemical pesticides on the market, which are not effective in the control and treatment of the pests and diseases.	chemical pesticides at all levels. b) Strengthen institutional organization and capacity of consumers to demand for chemical pesticides that meet the acceptable standards and quality. c) Review policies to include strong penalties or deterrent measures to discourage providers of pesticides that do not meet quality and safety standards.
iii) Inadequate knowledge and application of the IPM especially among the private individual commercial tree growers.	a) Strengthen forestry extension system, to provide the required adequate support services to farmers and communities - including men, women and youth. b) Improve access to information about Integrated Pest Management and its application by smallholder farmers including men, women and youth. c) Document targeted simplified Information, Education & Communication materials on application of Integrated Pest Management. d) Promote targeted awareness and information of the farmers (including men, women and youth) about Integrated Pest Management to influence attitude and practice for effective application of IPM. e) Provide adequate training in Integrated Pest Management techniques – especially among smallholders - including men, women and youth.
iv) Non-uniformity in pest infestation, thus emerging at different stages of the tree cycle, they evolve over time, some IPM technologies are divisible and rarely do complete 'packages' exist for an entire crop or ecosystem.	a) Strengthen adaptation to Climate variability and change in forest plantations and the landscape through for instance, applying responsive agronomic & pest management practices; planting proven resistant tree varieties. b) Increase investment in research to develop responsive IPM solutions. c) Strengthen monitoring and surveillance of pests and diseases.

v) Limited access, control of resources and decision making in respect to land use by women and youth	a) Conduct structured engagements with cultural institutions to influence and change beliefs, attitude and customs that limit women and youth' access to and ownership of land. b) Conduct targeted community engagement (including men) to change their attitude for support of women's and youth's access and control of resources. c) Create targeted awareness on women land rights as provided for in the existing policies and laws. d) Create opportunities for women and youth's financial empowerment.

TABLE 11. MEASURES FOR OVERCOMING BARRIERS TO PROMOTION OF FOREST BASED ENTERPRISES E.G. BEE KEEPING/APIARY; BUTTERFLY FARMING, FRUIT TREES PRODUCTION, ECOTOURISM

Critical barrier	Measure to address the barrier
i) Inability to sell products at competitive prices compromises overall revenue and profits from the forest-based enterprises.	a) Improve access by women, men and youth to transport for their forest-based and agro-forestry enterprises' products and services. to the market. b) Improve access to market infrastructure and information c) Improve organization and coordination capacity by the forest adjacent communities – through bulk production and marketing. d) Support generation of high-quality products on the market through: e) Strengthen the forestry extension services at the local Government levels for effective service delivery to communities; Conduct targeted and responsive trainings, mentoring and backstopping to forest adjacent communities (including men, women & youth) in respect to establishment and management of forest-based enterprises; Strengthen enforcement of guidelines and standards for quality at different scales.

ii) Limited access to credit services by forest adjacent communities.	a) Promote a saving culture by the forest adjacent communities and their organizations, including men, women and youth. b) Strengthen knowledge of women, youth and men and skills for mobilization and management of savings and credit schemes by forest adjacent communities and their organizations. c) Promote access to financial management services, training and advisories by women, men & youth through collaboration with financial institutions and civil society organizations. d) Conduct responsive trainings on organizational development for forest adjacent communities.
iii) Mismanagement of resources and income by individuals.	a) Support visioning, action and business planning for the collaborative forest management groups and associated forest-based enterprises. b) Strengthen leadership skills of the collaborative forest management group leaders, including men, women and youth. c) Strengthen measures for disciplining or punishment of culprits/wrong doers.
iv) Weak negotiation capacities of collaborative forest management groups/associations.	a) Strengthen organizational and business skills especially among community-based organizations, forest adjacent community organizations or community forest management groups, involving men, women and youth. b) Promote access to structured training, exposure and mentoring-targeting and involving men, women and youth. c) Reduce vulnerability of the collaborative forest management groups or associations and their members through provision of various livelihood options and services based on preferences of the various gender categories i.e. men, women & youth. d) Conduct targeted and structured lobbying and advocacy responsive actions to address the needs and concerns of the collaborative forest management groups or associations.

v) Bush burning and stray livestock destroy forest-based enterprises and other properties - especially in Northern Uganda and Wet Nile regions.	a) Enhance knowledge of the community (including men, women, youth) and other key stakeholders about impacts of bush burning and stray livestock. b) Provision of alternative livelihood options for the men and boys involved in the hunting of edible rats and mud fish. c) Work with cultural institutions to change mindset, behavior and attitudes linked to bush burning d) Advance targeted mass awareness creation on unregulated bush burning and stray livestock grazing. e) Promote alternative gender responsive technology for easing land clearing and opening for agricultural production e.g. use of tractors, oxen ploughs and minimum tillage. f) Strengthen implementation or enforcement of bush burning bylaws and ordinances where they exist. g) Update or review outdated policies and laws deterring bush burning and grazing by stray livestock.
vi) Insecure tenure and land use rights – especially for the forest adjacent communities.	a) Promote targeted awareness about existing policies and laws, which provide for and protect these rights and obligations. b) Strengthen enforcement of forestry policies, laws and guidelines – through proactive stakeholder engagement and standards for quality at different scales. c) Strengthen institutional capacity community-based institutions including collaborative forest management groups for effective management of forest-based enterprises management groups. For instance, signing collaborative forest management agreements with them. d) Strengthen institutional capacity (limited resources allocation) of mandated institutions (e.g. Local Governments and National Forestry Authority) to effectively support/promote forest-based enterprise value chains.

vii) Limited access, control of resources and decision making in respect to land use by women and youth	a) Conduct structured engagements with cultural institutions to influence and change beliefs, attitude and customs that limit women's land ownership. b) Conduct targeted community engagement (including men) to change their attitude and support women and youth access and control of resources. c) Create targeted awareness on women land rights as provided for in the existing policies and laws. d) Create opportunities for women and youth financial empowerment.

3.4 Linkages of the Barriers Identified

Overall, the barriers for the three prioritized technologies in the forestry sector were related to the following themes:

a) Access to inputs and services;
b) Limited knowledge and awareness;
c) Inadequate policy implementation and enforcement;
d) Weak institutional capacity building;
e) Gender considerations in respect to women and youth access to, control of resources and decision making on land use and management.

3.5 Enabling framework for overcoming the Barriers in the Forestry Sector

The forestry sector in Uganda comprised of the following tenure categories as described in the National Forestry Policy, (2001) (MWLE, 2001): Central Forest reserves (constitute 15% of the total forest cover); Forests in wildlife and national parks (constitute 15% of the total forest cover); Forests on private and community forests (constitute 70% of the total forest cover).

As stipulated in the National Forestry Policy, (2001) (MWLE, 2001), the National Forestry Authority (NFA), the District Forest Services (DFS) are responsible for management of the central forest reserves and the community & private forests, respectively. The Forest Sector

Support Department is by large responsible for policy formulation, implementation and enforcement. Besides, FSSD also supervises the NFA and the DFS among other responsibilities.

Addressing the key barriers described (in **Tables 6, 7 and 8**) for each of the prioritized technology requires a responsive enabling framework in place. The FSSD, NFA and the Local Governments working in collaboration with other key stakeholders (including: forest adjacent communities, research institutions, Civil Society, Private sector, Cultural and religious institutions) have a key role to play based on their mandates and responsibilities as stipulated in the existing national forest policy (2001) (MWLE, 2001) and National Forestry and Tree Planting Act (2003).

The ongoing forestry policy and legislation review coordinated by the FSSD presents a great opportunity for addressing some of the barriers by integrating appropriate strategies as responses and commitments as part of the policy review. This will require structured engagements with the policy and decision makers to appreciate the barriers and the associated strategies for addressing them.

In **Table 12**, the possible enabling measures for overcoming the critical barriers identified across all of the prioritized technologies for the sector are presented and validated during the stakeholders' workshop held on 16-17th March 2020.

Notable is that, the implementation of the identified strategies for addressing the barriers of the prioritized technologies should be anchored within the existing initiatives (i.e. policies and programs implementation) in the forest landscape by different actors (i.e. Central Government, Local Government, line ministries and authorities, private sector, research & academic institutions and the civil society organizations) at different levels by tapping into synergies thereby building into overall sustainability.

Furthermore, the key forestry sector stakeholder representatives were engaged during the breakout sessions of the national validation workshop for barrier analyses and enabling framework to prioritize the strategies for addressing the barriers. This was based on agreed criteria with the following key considerations:

i) Cost associated with the implementation the strategy/action/response;

ii) Acceptability and practicability;

iii) Ongoing initiatives in support of implementation of the strategy/action/response for addressing the barriers for the prioritized technology.

Subsequently, the stakeholder representatives considered the following as the most important strategies/actions:

a) *Targeted awareness creation;*
b) *Responsive/targeted institutional capacity building;*
c) *Improving access to inputs and services;*
d) *Strengthen policy implementation and enforcement;*
e) *Gender mainstreaming during implementation of the measures.*

TABLE 12. ENABLING FRAMEWORK MEASURES FOR PRIORITIZED TECHNOLOGIES IN THE FORESTRY SECTOR IN UGANDA.

Prioritized Technology	**Enabling measures**
i) Promotion of Farmer Managed Natural Regeneration (FMNR) for forest landscape restoration	*Improving access to inputs and services* a) Provide alternative livelihood options for the men and boys involved in the hunting of edible rats & mud fish. b) Provide incentives for land allocation for investment in landscape restoration through FMNR. c) Provide incentives to support land restoration for instance, small grants and or technical support for development of forest management plans. d) Provide of improved (e.g. drought resistant, early maturing) pastures as alternatives for grazing of livestock, especially during the dry season. e) Promote enterprises with short term benefits (based on preferences of various gender categories i.e. men, women & youth) for diversification with farmer managed natural regeneration. f) Promote alternative gender responsive technology for easing land clearing and opening for agricultural production e.g. use of tractors, oxen ploughs and minimum tillage. g) Improve access to structured support (e.g. inputs, monitoring/backstopping) for up scaling FMNR. *Targeted awareness creation* a) Advance targeted community and mass awareness creation on impacts of bush burning & stray livestock grazing. b) Scale up targeted awareness activities about the diverse and immediate benefits that arise from FMNR. c) Advance targeted community awareness creation on information about land policies and laws to guide sustainable land-use and management of communal land through FMNR involving men, women, youth and cultural institutions. d) Increase publication of literature quantifying the social, economic and

	environmental benefits of the FMNR technology e) Scale up targeted awareness activities about the diverse and immediate benefits that arise from FMNR. g) Work with cultural institutions to change mindset, behavior and attitudes linked to bush burning grazing by stray livestock. *Strengthen policy implementation and enforcement* a) Update or review outdated policies-laws deterring bush burning and grazing by stray livestock. b) Strengthen implementation and enforcement of bush burning bylaws and ordinances where they exist. c) Developand operationalize land-use plans within the forest landscapes. d) Strengthen extension within the forestry and agriculture sectors to provide responsive advice to address community and farmer's (including women, youth andmen) needs in respect to application of FMNR. e) Conduct structured policy dialogues on FMNR with policy and decision makers within the forest landscapes. *Responsive/targeted institutional capacity building* a) Enhance knowledge about impacts of unregulated bush burning on livelihoods, environment and biodiversity. b) Strengthen capacity of cultural or customary institutions to deliver on their roles in respect to administration/management of customary land. c) Strengthen institutional capacity for area land committees in providing effective information on land rights & administration d) Conduct targeted training of community and famers (including men, women, youth) to enhance their knowledge and skills for application of FMNR. e) Establish coordinated research agenda and teams to generate the required evidence for FMNR at different scales.

ii) Promotion of integrated pest management in forest plantations through promoting mixed species plantations.	*Improving access to inputs and services* a) Advance access to chemical pesticides by community and smallholders – including men, women and youth. b) Improve access to information about IPM and its application by farmers – including men, women & youth. *Responsive/targeted institutional capacity building* a) Strengthen institutional organization (leadership, governance & business) of smallholders (including men, women & youth) to access chemical pesticides. b) Advocate for reduction of taxes and levies charged by Government on the pesticides. c) Strengthen the forestry extension services at the Local Government levels for effective service delivery to farmers and communities. d) Provide adequate training in IPM techniques and their application – especially among smallholders – including men, women and youth. e) Strengthen adaptation to climate variability and change in natural forests and plantations in the landscape. f) Increase investment in research to develop responsive IPM solutions. g) Strengthen regular monitoring and surveillance of pests and diseases. *Targeted awareness creation* a) Promote targeted awareness and information about IPM to influence attitude and practice compete for scarce funds.
iii) Promotion of Forest based enterprises e.g. bee keeping/apiary; butterfly farming, fruit trees production;	*Improving access to inputs and services* a) Improve access by men, women and youth to market infrastructure and information. b) Improve access by women and men, youth to transport forest and agro-based enterprises' products and services to the market. c) Promote a saving culture by the forest adjacent communities and their organizations, including men, women and youth. e) Promote access to financial management trainings by women, youth and advisories, through collaboration with financial institutions and civil society organizations.

ecotourism	f) Provide various alternative livelihood options and services based on preferences of the various gender categories i.e. men, women and youth. g) Provide and establish improved pastures within the community. h) Promote alternative gender responsive technology for easing land clearing and opening for agricultural production e.g. use of tractors, oxen ploughs and minimum tillage. *Responsive/targeted institutional capacity building* a) Strengthen institutional capacity community-based institutions including collaborative forest for effectiveness of forest-based enterprises management groups by for instance, signing collaborative forest management agreements with them. b) Strengthen institutional capacity (limited resources allocation) of mandated institutions (e.g. Local Governments, National Forestry Authority and Uganda Wildlife Authority) to effectively support/promote forest-based enterprise value chains. c) Support visioning, action and business planning for the collaborative forest management groups and associated forest-based enterprises. d) Strengthen leadership skills of the collaborative forest management group leaders. e) Strengthen organizational and business skills especially among community-based organizations and forest adjacent community organizations or community forest management groups, involving men, women and youth. f) Promote access to structured training, exposure and mentoring- targeting and involving men, women and youth. g) Improve organization and coordination capacity by the forest adjacent communities through bulk production and marketing. h) Conduct targeted and responsive trainings, mentoring and backstopping to forest adjacent communities (including men, women and youth) in respect to establishment and management of forest-based enterprises. i) Strengthen knowledge of women youth and men and skills for mobilization and management of savings and credit schemes by forest adjacent communities and their organizations.

	Strengthen policy implementation and enforcement a) Update or review outdated policies or laws that deter bush burning and stray livestock grazing. c) Strengthen enforcement of forestry and land policies, laws and guidelines through proactive stakeholder engagement and standards for quality at different scales. d) Strengthen the agriculture and forestry extension services at the local Government levels for effective service delivery, to address the needs of the communities and farmers (including women, youth and men) as applied to management of forest-based enterprises. f) Strengthen enforcement of guidelines and standards for quality at different scales. g) Strengthen implementation or enforcement of bush burning & livestock grazing by-laws and ordinances where they exist. *Targeted awareness creation* a) Advance targeted community and mass awareness creation on impacts of bush burning and grazing by stray livestock. b) Work with cultural institutions to change mindset, behavior and attitudes linked to bush burning and stray livestock grazing. c) Promote targeted awareness about existing policies and laws, which provide for and protect these rights and obligations.

Notable is that effective implementation of the measures for the each of the prioritized technologies as described in **Table 12** requires gender mainstreaming during implementation of the measures. This largely because there is limited access, control of resources and decision making in respect to land use by women and youth. This certainly negatively impacts on their participation and full application and adaptation of the technologies. Therefore, the women and youth should be empowered through gender mainstreaming during implementation of the proposed measures described in **Table 12**. This can be achieved through implementation of the following strategies as part of the process of gender mainstreaming:

a) Conducting structured engagements with cultural institutions to influence and change beliefs, attitude and customs that limit women's land ownership.

b) Organizing targeted community engagement (including men) to change their attitude for support of women's and youth's access & control of resources.
c) Creating targeted awareness on women land rights as provided for in the existing policies and laws.
d) Creating opportunities for women's and youth's financial empowerment.

SUMMARY AND CONCLUSIONS

Common barriers to the transfer and diffusion of climate adaptation technologies in the Water, Agriculture and Forestry Sectors in Uganda were high cost of establishment, operation and maintenance, low technical capacity, weak extension support, poor coordination of institutions, poor governance and weak implementation of existing policies. The weak involvement of local communities and the private sector in the development and transfer of technologies is also notable barriers. The diffusion of all technologies will also entail adaptation of the technologies to different contexts and building capacity for local fabrication and ownership. The policy and institutional framework is majorly supportive of technology transfer and diffusion and logical roadmaps have already been laid out in national documents. However, the infrastructure and financial support needs to be strengthened for this to be realized. Institutions also need to be strengthened and coordinated amongst government sectors and the interaction with non-government entities. The business angle of these adaptation technologies is unlikely to develop strongly and it is safer to assume they will be operated mainly as public establishments requiring national budgets with community user fees. However, opportunities for private enterprise development should be supported. The challenge in Uganda may not just be technology transfer and diffusion, but developing technology ownership to ensure sustained operation. Therefore, investment in building social relations and change in attitudes and values is a critical component in the process.

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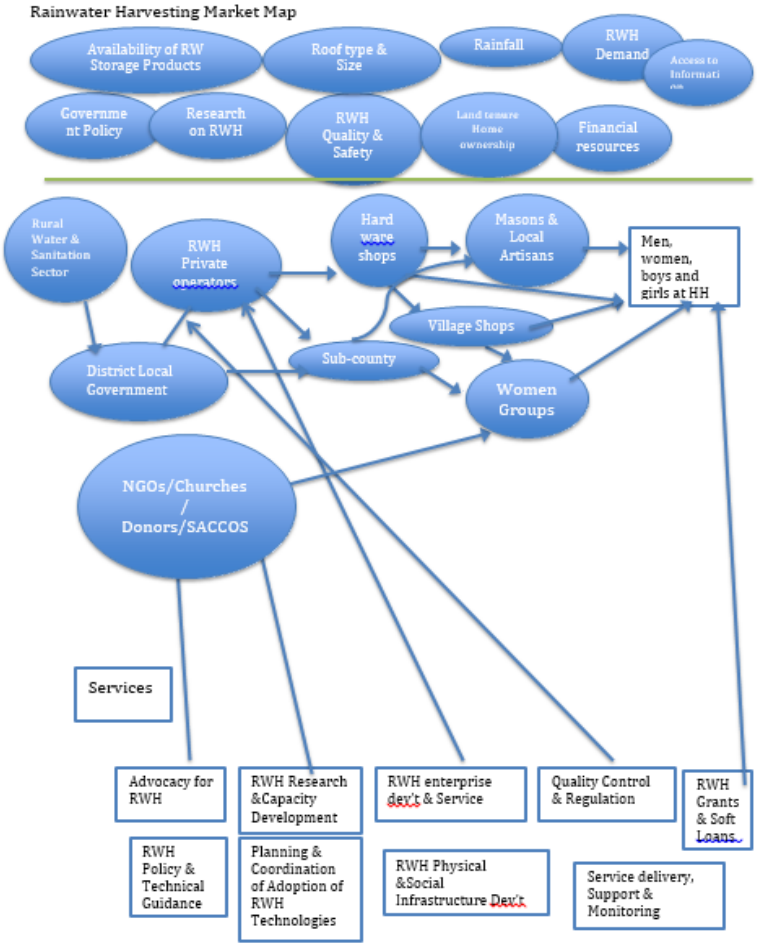
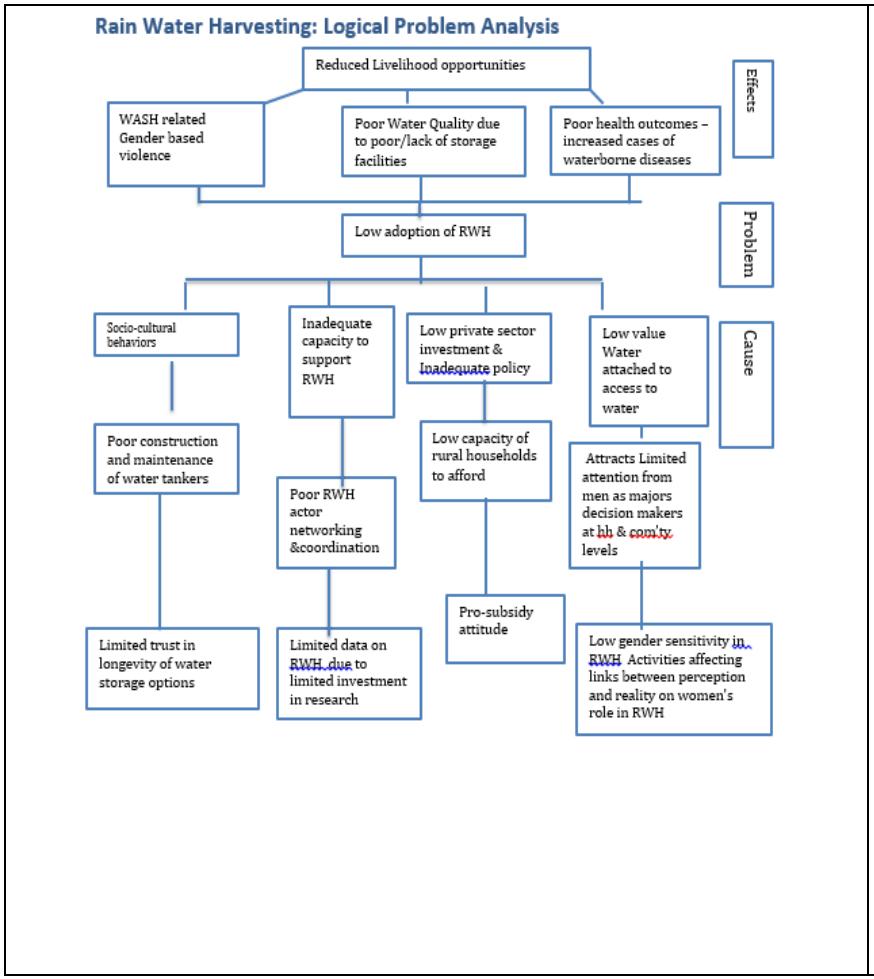
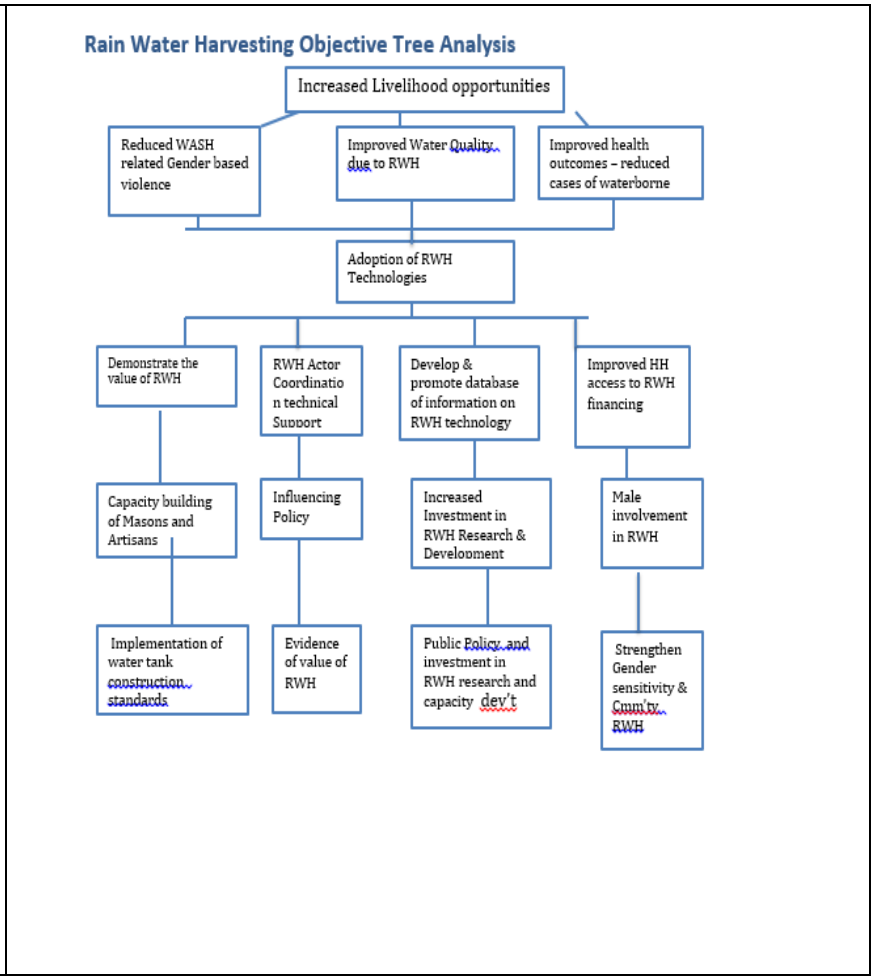
Annex I: Market maps and problem trees

WATER SECTOR

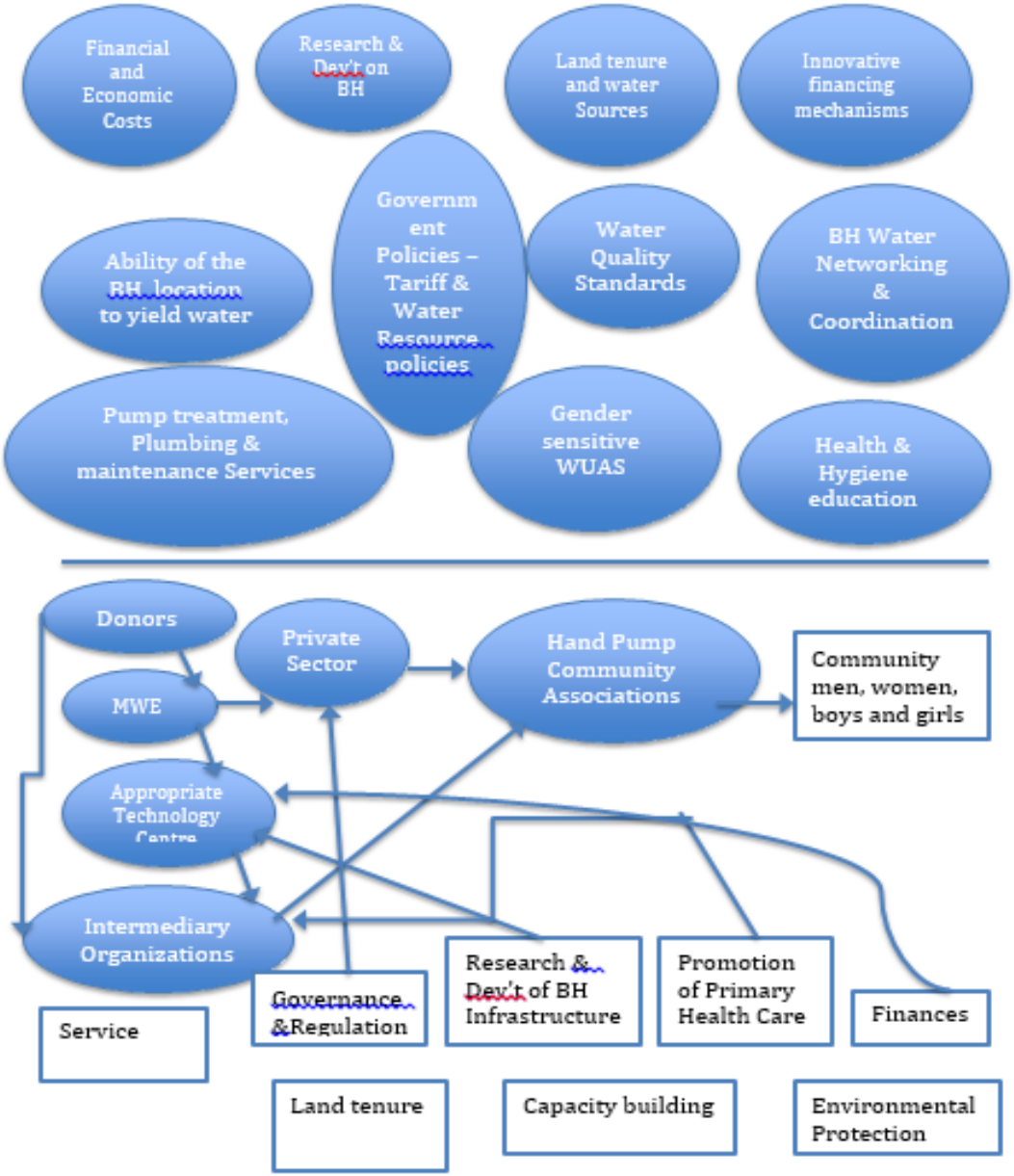


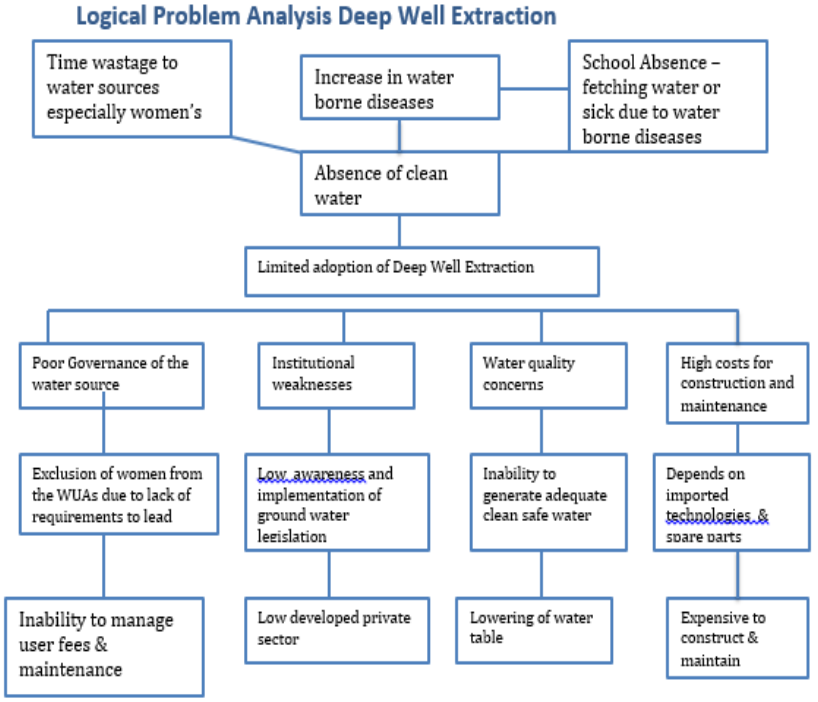

Rain Water Harvesting: Logical Problem Analysis
Reduced Livelihood opportunities
WASH related Gender based violence
Poor Water Quality due to poor/lack of storage facilities
Poor health outcomes – increased cases of waterborne diseases
Effects
Low adoption of RWH
Problem
Socio-cultural behaviors
Inadequate capacity to support RWH
Low private sector investment & Inadequate policy
Low value Water attached to access to water
Cause
Poor construction and maintenance of water tankers
Poor RWH actor networking &coordination
Low capacity of rural households to afford
Attracts Limited attention from men as majors decision makers at hh & com'ty levels
Limited trust in longevity of water storage options
Limited data on RWH due to limited investment in research
Pro-subsidy attitude
Low gender sensitivity in RWH Activities affecting links between perception and reality on women's role in RWH

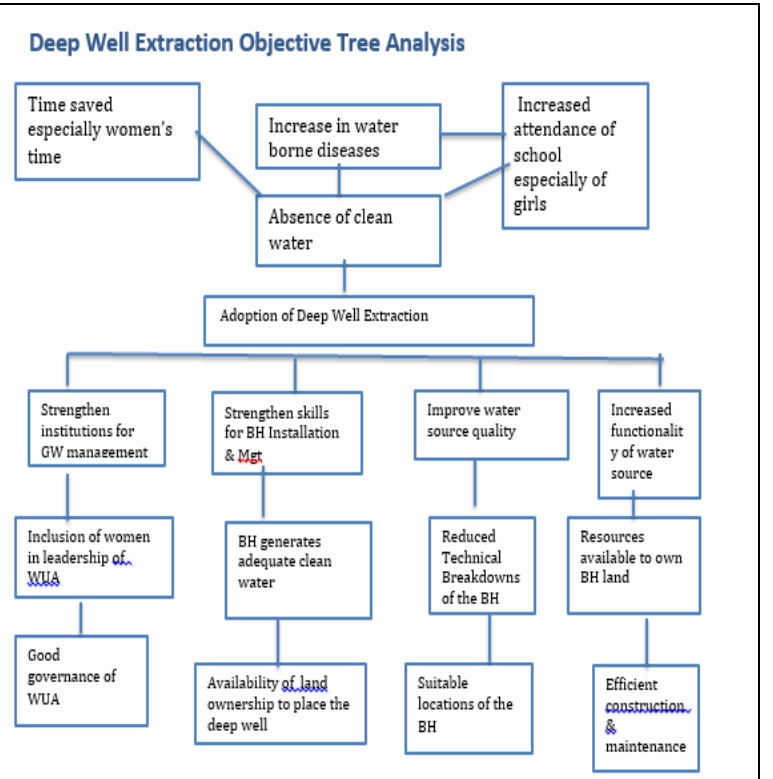

Rain Water Harvesting Objective Tree Analysis
Increased Livelihood opportunities
Reduced WASH related Gender based violence
Improved Water Quality due to RWH
Improved health outcomes – reduced cases of waterborne
Adoption of RWH Technologies
Demonstrate the value of RWH
RWH Actor Coordination technical Support
Develop & promote database of information on RWH technology
Improved HH access to RWH financing
Capacity building of Masons and Artisans
Influencing Policy
Increased Investment in RWH Research & Development
Male involvement in RWH
Implementation of water tank construction standards
Evidence of value of RWH
Public Policy and investment in RWH research and capacity dev't
Strengthen Gender sensitivity & Cmm'ty RWH

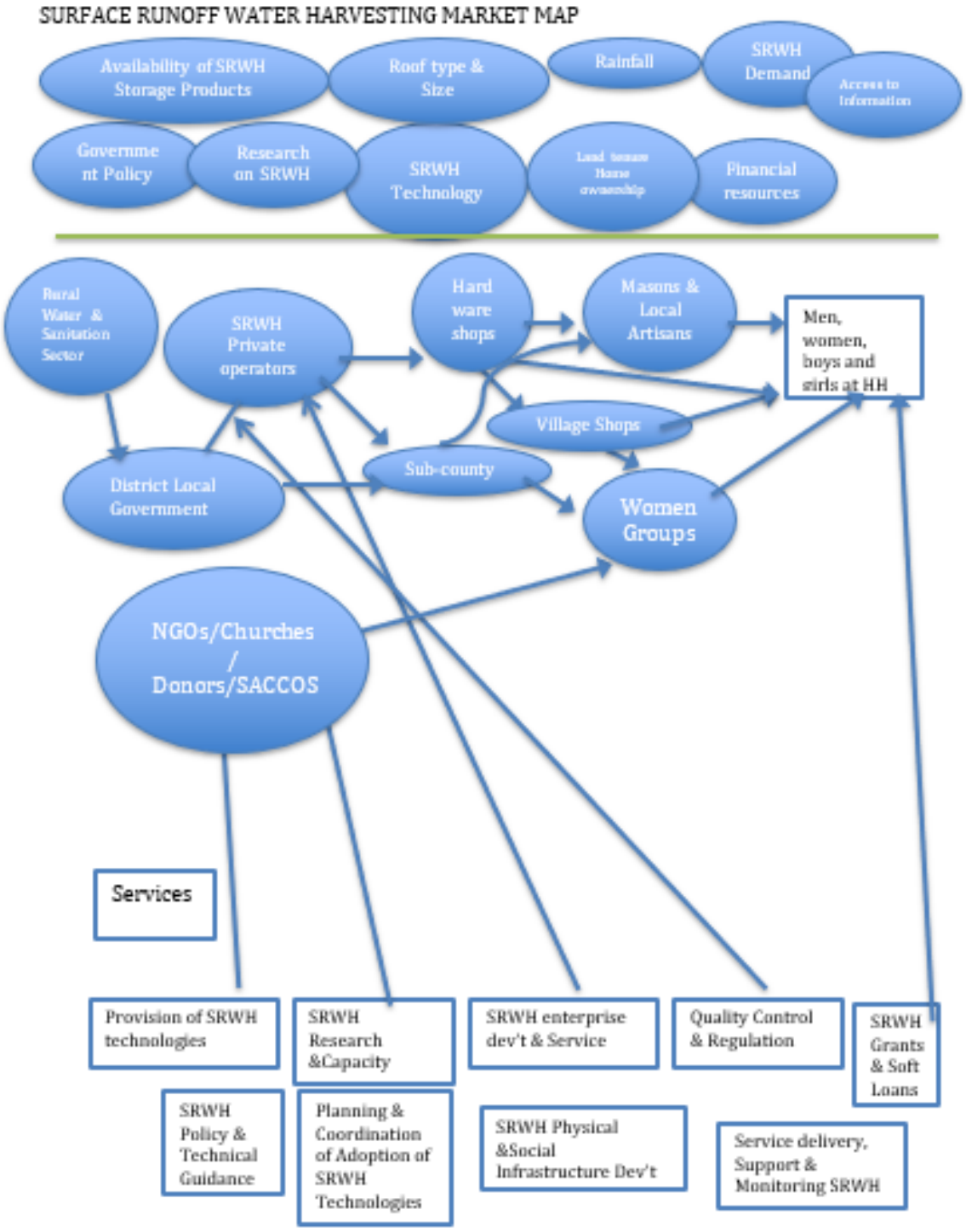
Deep Well Extraction Market Maps

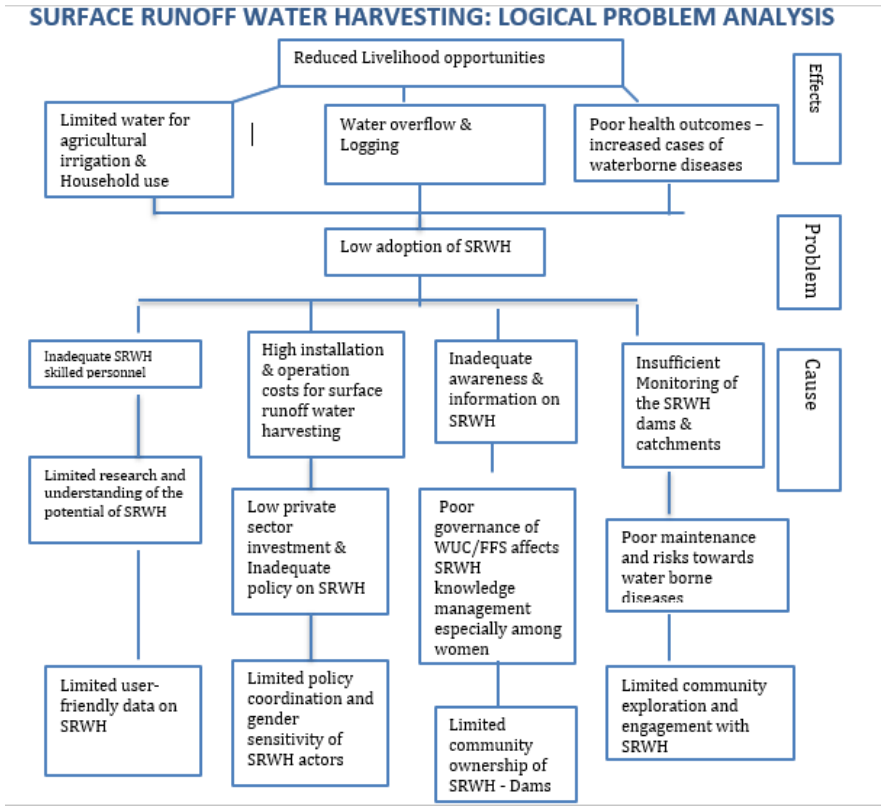
ENABLING ENVIRONMENT

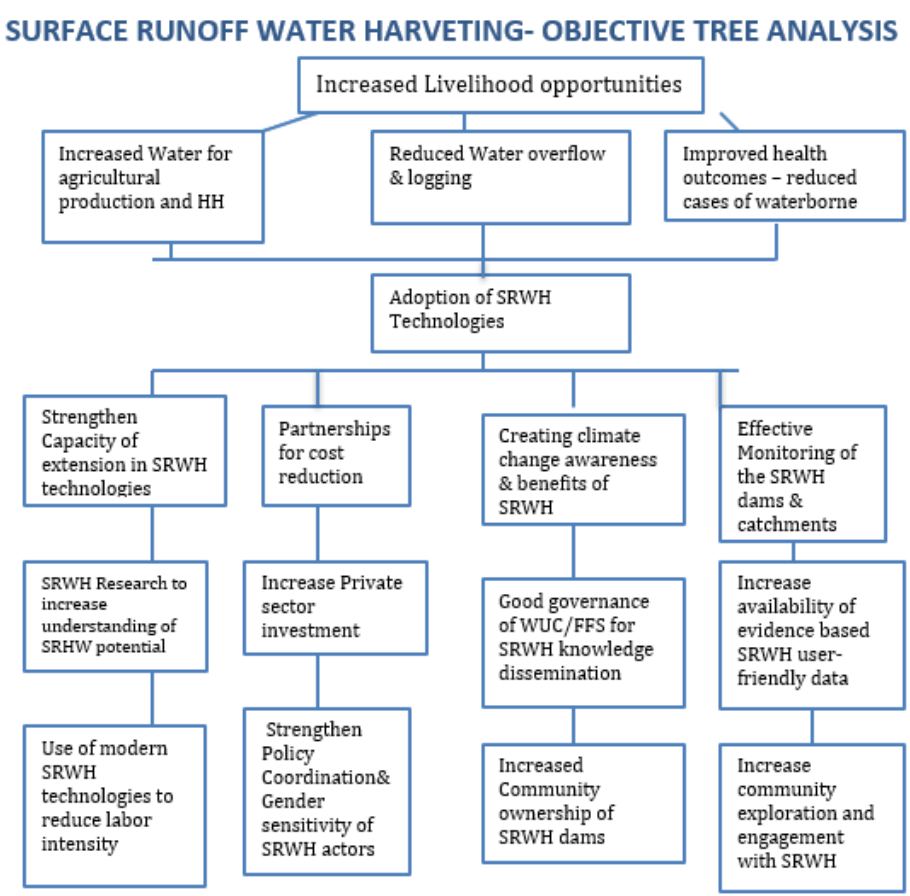



Logical Problem Analysis Deep Well Extraction
Time wastage to water sources especially women's
Increase in water borne diseases
School Absence – fetching water or sick due to water borne diseases
Absence of clean water
Limited adoption of Deep Well Extraction
Poor Governance of the water source
Institutional weaknesses
Water quality concerns
High costs for construction and maintenance
Exclusion of women from the WUAs due to lack of requirements to lead
Low awareness and implementation of ground water legislation
Inability to generate adequate clean safe water
Depends on imported technologies & spare parts
Inability to manage user fees & maintenance
Low developed private sector
Lowering of water table
Expensive to construct & maintain

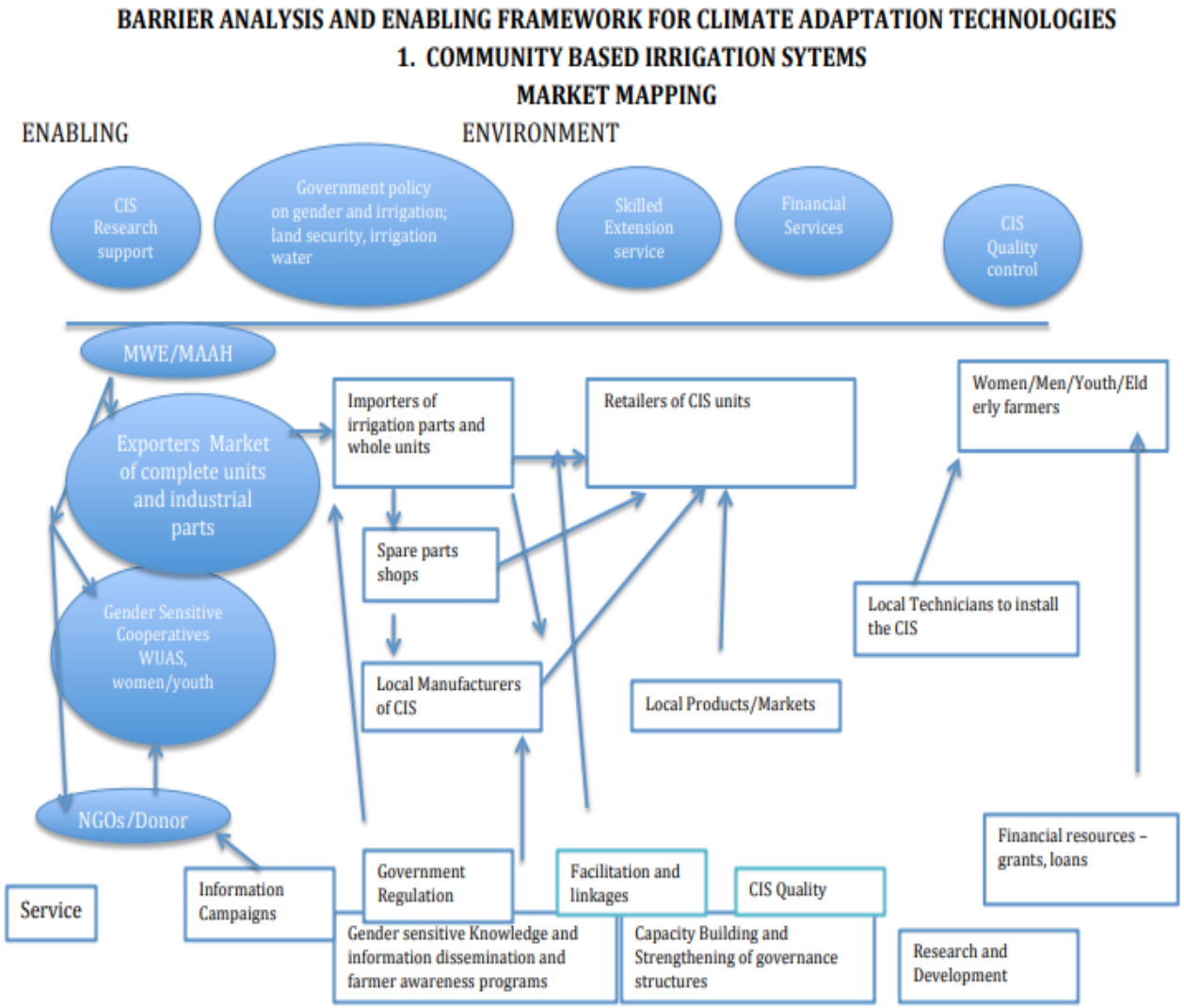

Deep Well Extraction Objective Tree Analysis
Time saved especially women's time
Increase in water borne diseases
Increased attendance of school especially of girls
Absence of clean water
Adoption of Deep Well Extraction
Strengthen institutions for GW management
Strengthen skills for BH Installation & Mgt
Improve water source quality
Increased functionality of water source
Inclusion of women in leadership of WUA
BH generates adequate clean water
Reduced Technical Breakdowns of the BH
Resources available to own BH land
Good governance of WUA
Availability of land ownership to place the deep well
Suitable locations of the BH
Efficient construction & maintenance

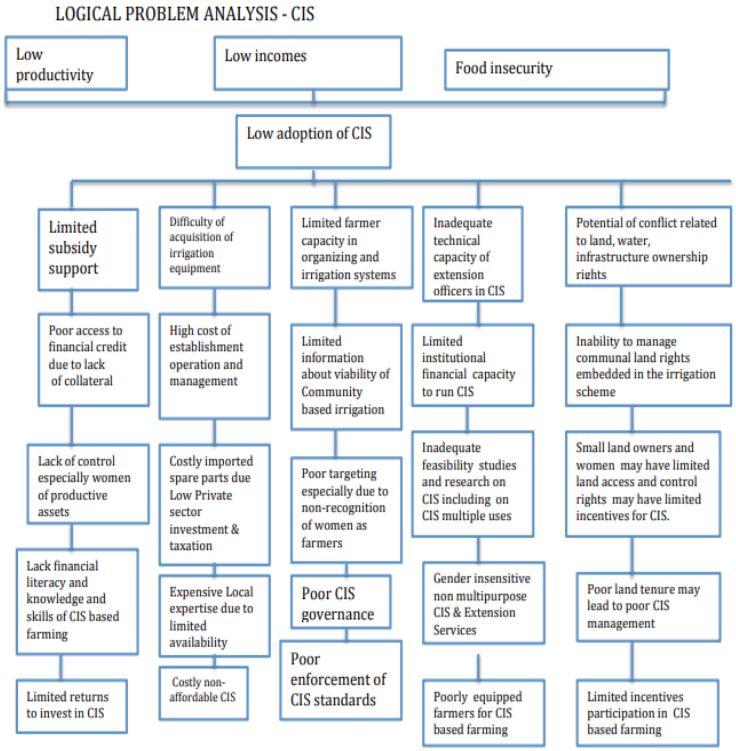

SURFACE RUNOFF WATER HARVESTING MARKET MAP
Availability of SRWH Storage Products
Roof type & Size
Rainfall
SRWH Demand
Access to Information
Governme nt Policy
Research on SRWH
SRWH Technology
Land tenure Home ownership
Financial resources
Rural Water & Sanitation Sector
SRWH Private operators
Hard ware shops
Masons & Local Artisans
Men, women, boys and girls at HH
Village Shops
Sub-county
District Local Government
Women Groups
NGOs/Churches / Donors/SACCOS
Services
Provision of SRWH technologies
SRWH Research &Capacity
SRWH enterprise dev't & Service
Quality Control & Regulation
SRWH Grants & Soft Loans
SRWH Policy & Technical Guidance
Planning & Coordination of Adoption of SRWH Technologies
SRWH Physical &Social Infrastructure Dev't
Service delivery, Support & Monitoring SRWH

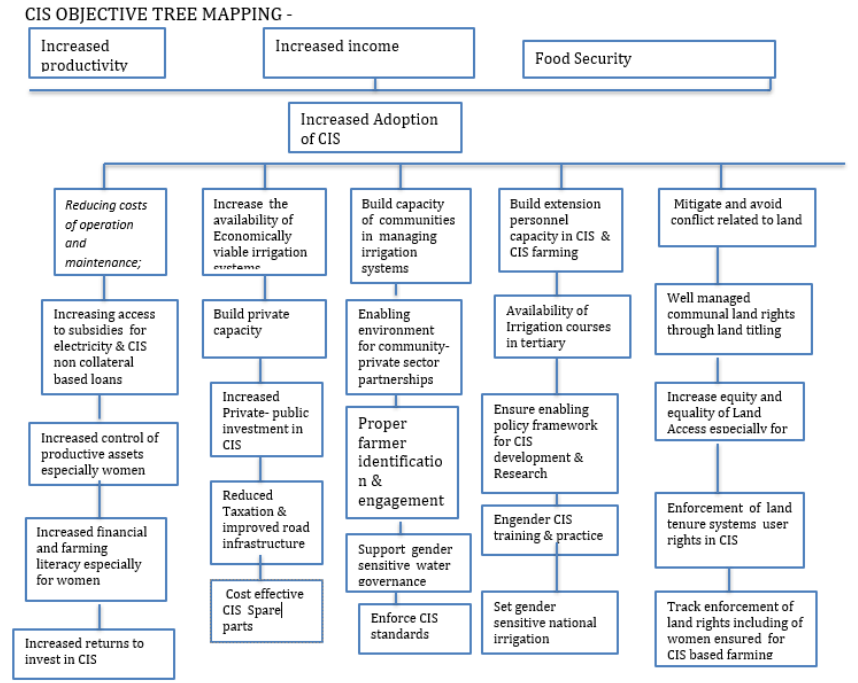

SURFACE RUNOFF WATER HARVESTING: LOGICAL PROBLEM ANALYSIS
Reduced Livelihood opportunities
Limited water for agricultural irrigation & Household use
Water overflow & Logging
Poor health outcomes – increased cases of waterborne diseases
Effects
Low adoption of SRWH
Problem
Inadequate SRWH skilled personnel
High installation & operation costs for surface runoff water harvesting
Inadequate awareness & information on SRWH
Insufficient Monitoring of the SRWH dams & catchments
Cause
Limited research and understanding of the potential of SRWH
Low private sector investment & Inadequate policy on SRWH
Poor governance of WUC/FFS affects SRWH knowledge management especially among women
Poor maintenance and risks towards water borne diseases
Limited user-friendly data on SRWH
Limited policy coordination and gender sensitivity of SRWH actors
Limited community ownership of SRWH - Dams
Limited community exploration and engagement with SRWH

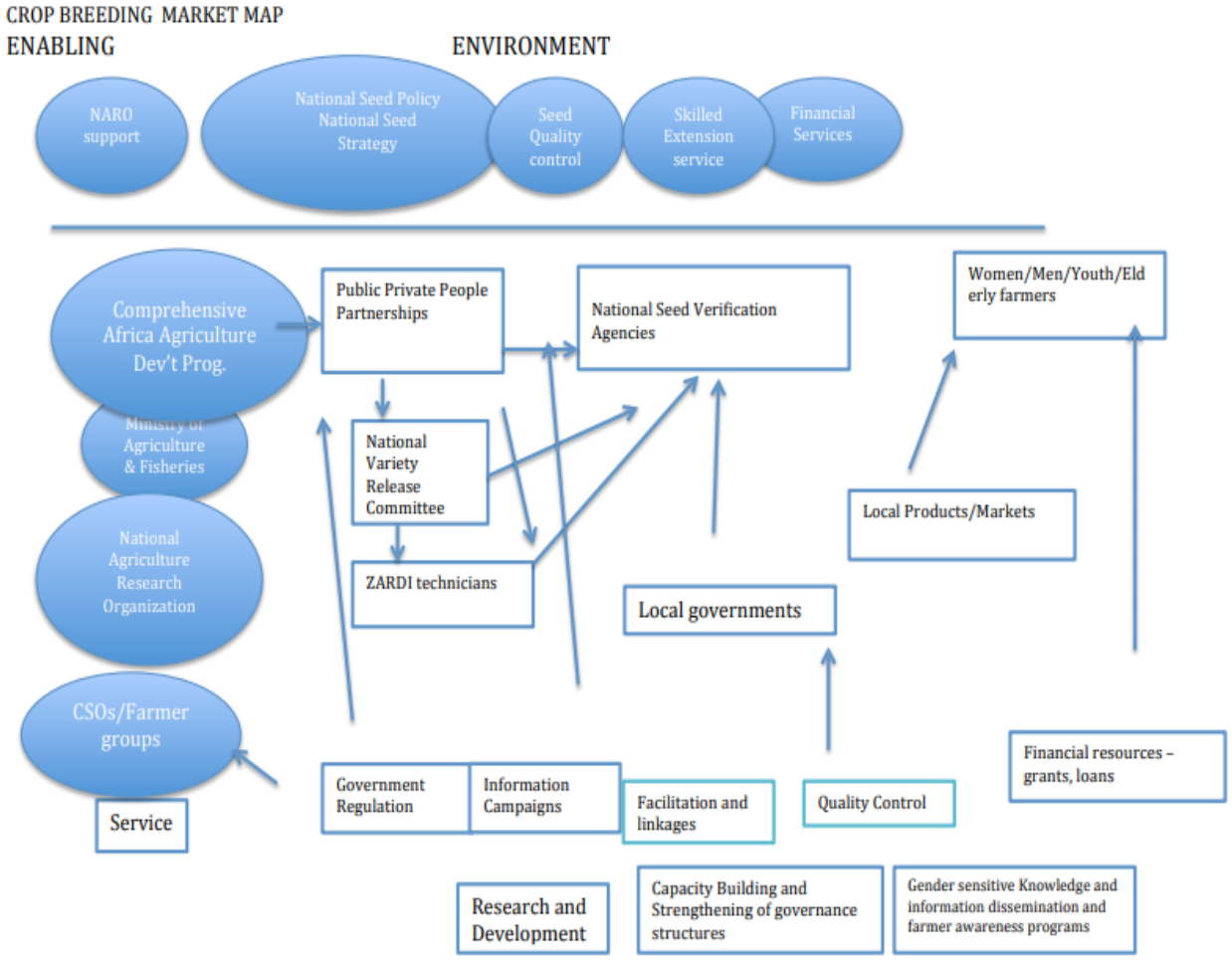

SURFACE RUNOFF WATER HARVETING- OBJECTIVE TREE ANALYSIS
Increased Livelihood opportunities
Increased Water for agricultural production and HH
Reduced Water overflow & logging
Improved health outcomes – reduced cases of waterborne
Adoption of SRWH Technologies
Strengthen Capacity of extension in SRWH technologies
Partnerships for cost reduction
Creating climate change awareness & benefits of SRWH
Effective Monitoring of the SRWH dams & catchments
SRWH Research to increase understanding of SRHW potential
Increase Private sector investment
Good governance of WUC/FFS for SRWH knowledge dissemination
Increase availability of evidence based SRWH user-friendly data
Use of modern SRWH technologies to reduce labor intensity
Strengthen Policy Coordination& Gender sensitivity of SRWH actors
Increased Community ownership of SRWH dams
Increase community exploration and engagement with SRWH

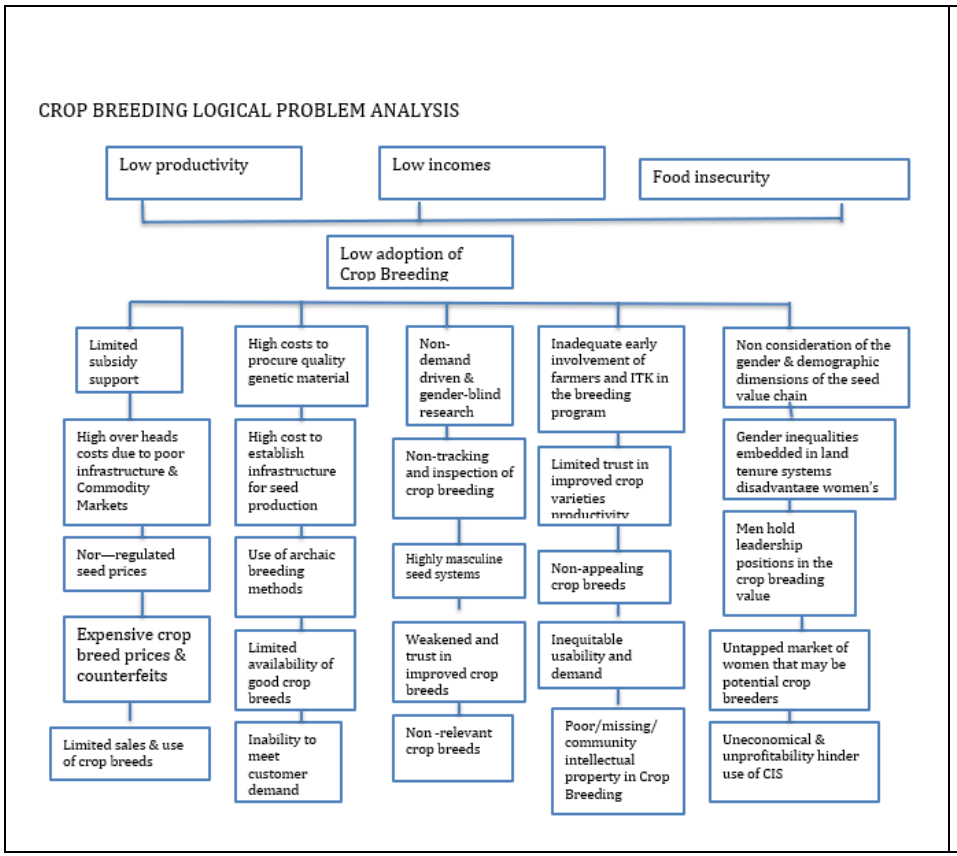
AGRICULTURE SECTOR

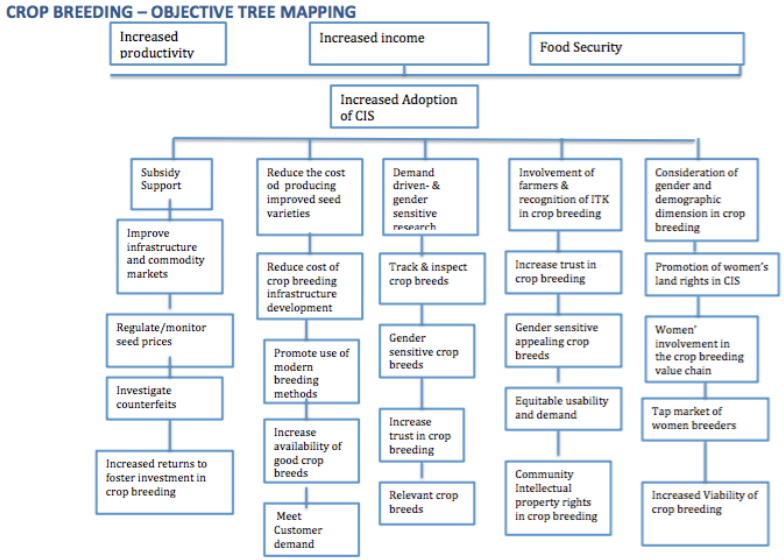


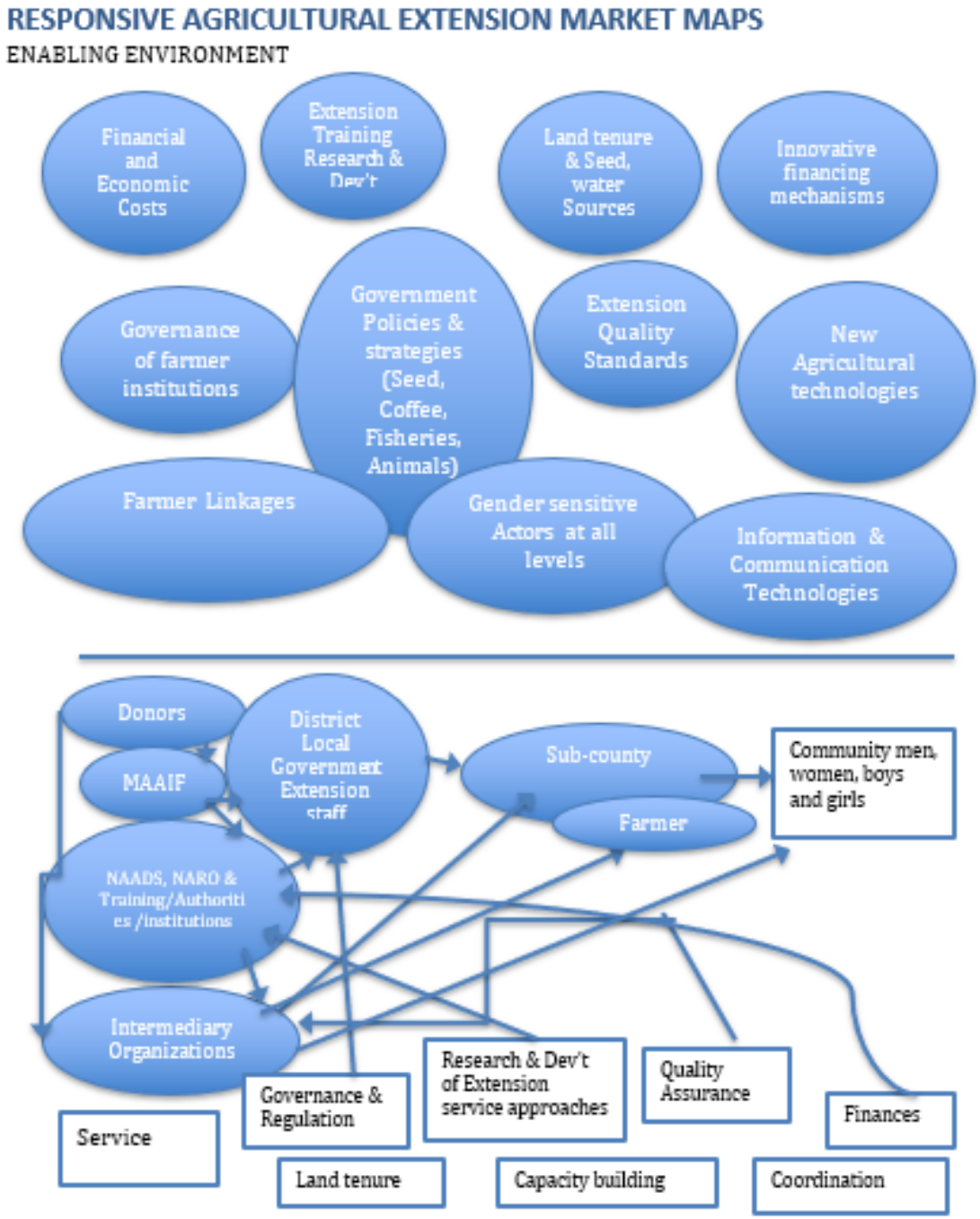

LOGICAL PROBLEM ANALYSIS - CIS
Low productivity
Low incomes
Food insecurity
Low adoption of CIS
Limited subsidy support
Difficulty of acquisition of irrigation equipment
Limited farmer capacity in organizing and irrigation systems
Inadequate technical capacity of extension officers in CIS
Potential of conflict related to land, water, infrastructure ownership rights
Poor access to financial credit due to lack of collateral
High cost of establishment operation and management
Limited information about viability of Community based irrigation
Limited institutional financial capacity to run CIS
Inability to manage communal land rights embedded in the irrigation scheme
Lack of control especially women of productive assets
Costly imported spare parts due Low Private sector investment & taxation
Poor targeting especially due to non-recognition of women as farmers
Inadequate feasibility studies and research on CIS including on CIS multiple uses
Small land owners and women may have limited land access and control rights may have limited incentives for CIS.
Lack financial literacy and knowledge and skills of CIS based farming
Expensive Local expertise due to limited availability
Poor CIS governance
Gender insensitive non multipurpose CIS & Extension Services
Poor land tenure may lead to poor CIS management
Limited returns to invest in CIS
Costly non-affordable CIS
Poor enforcement of CIS standards
Poorly equipped farmers for CIS based farming
Limited incentives participation in CIS based farming

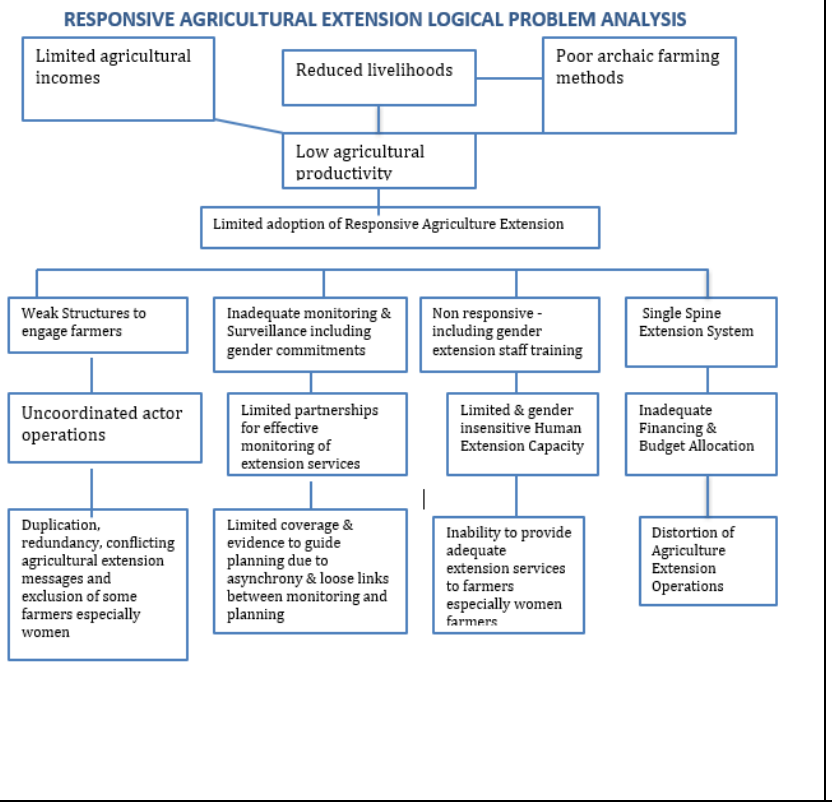

CIS OBJECTIVE TREE MAPPING -
Increased productivity
Increased income
Food Security
Increased Adoption of CIS
Reducing costs of operation and maintenance;
Increase the availability of Economically viable irrigation
Build capacity of communities in managing irrigation systems
Build extension personnel capacity in CIS & CIS farming
Mitigate and avoid conflict related to land
Increasing access to subsidies for electricity & CIS non collateral based loans
Build private capacity
Enabling environment for community-private sector partnerships
Availability of Irrigation courses in tertiary
Well managed communal land rights through land titling
Increased control of productive assets especially women
Increased Private- public investment in CIS
Proper farmer identification & engagement
Ensure enabling policy framework for CIS development & Research
Increase equity and equality of Land Access especially for
Increased financial and farming literacy especially for women
Reduced Taxation & improved road infrastructure
Support gender sensitive water governance
Engender CIS training & practice
Enforcement of land tenure systems user rights in CIS
Increased returns to invest in CIS
Cost effective CIS Spare parts
Enforce CIS standards
Set gender sensitive national irrigation
Track enforcement of land rights including of women ensured for CIS based farming

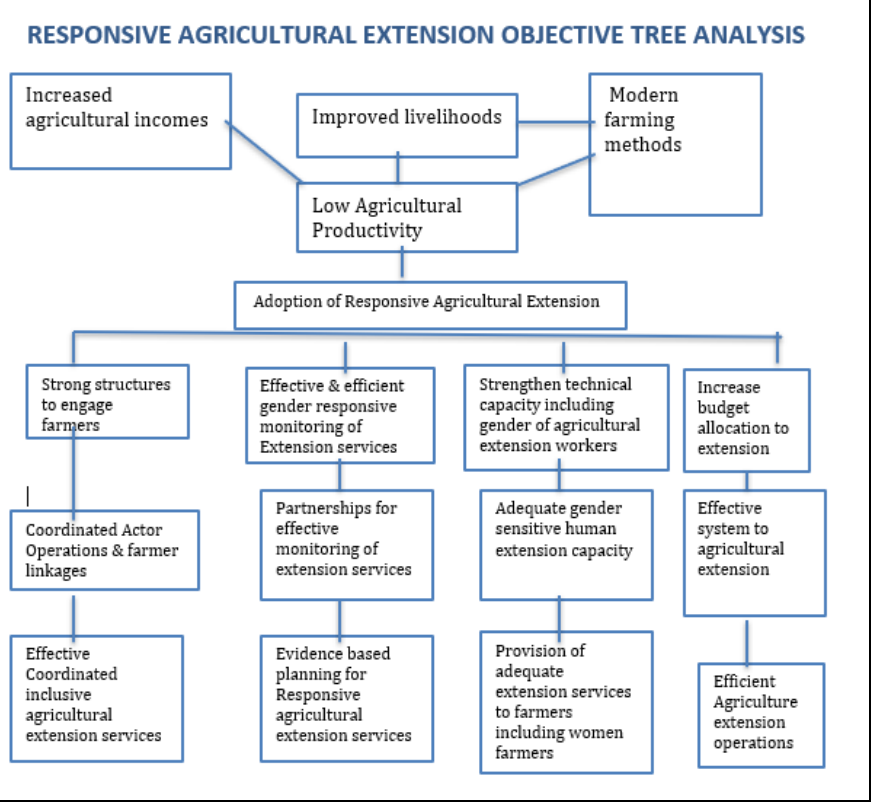

CROP BREEDING MARKET MAP
ENABLING ENVIRONMENT
NARO support
National Seed Policy National Seed Strategy
Seed Quality control
Skilled Extension service
Financial Services
Comprehensive Africa Agriculture Dev't Prog.
Ministry of Agriculture & Fisheries
National Agriculture Research Organization
CSOs/Farmer groups
Service
Public Private People Partnerships
National Seed Verification Agencies
National Variety Release Committee
ZARDI technicians
Women/Men/Youth/Elderly farmers
Local Products/Markets
Local governments
Financial resources – grants, loans
Government Regulation
Information Campaigns
Facilitation and linkages
Quality Control
Research and Development
Capacity Building and Strengthening of governance structures
Gender sensitive Knowledge and information dissemination and farmer awareness programs


CROP BREEDING LOGICAL PROBLEM ANALYSIS
Low productivity
Low incomes
Food insecurity
Low adoption of Crop Breeding
Limited subsidy support
High over heads costs due to poor infrastructure & Commodity Markets
Nor—regulated seed prices
Expensive crop breed prices & counterfeits
Limited sales & use of crop breeds
High costs to procure quality genetic material
High cost to establish infrastructure for seed production
Use of archaic breeding methods
Limited availability of good crop breeds
Inability to meet customer demand
Non-demand driven & gender-blind research
Non-tracking and inspection of crop breeding
Highly masculine seed systems
Weakened and trust in improved crop breeds
Non -relevant crop breeds
Inadequate early involvement of farmers and ITK in the breeding program
Limited trust in improved crop varieties productivity
Non-appealing crop breeds
Inequitable usability and demand
Poor/missing/ community intellectual property in Crop Breeding
Non consideration of the gender & demographic dimensions of the seed value chain
Gender inequalities embedded in land tenure systems disadvantage women's
Men hold leadership positions in the crop breading value
Untapped market of women that may be potential crop breeders
Uneconomical & unprofitability hinder use of CIS


CROP BREEDING – OBJECTIVE TREE MAPPING
Increased productivity
Increased income
Food Security
Increased Adoption of CIS
Subsidy Support
Improve infrastructure and commodity markets
Regulate/monitor seed prices
Investigate counterfeits
Increased returns to foster investment in crop breeding
Reduce the cost od producing improved seed varieties
Reduce cost of crop breeding infrastructure development
Promote use of modern breeding methods
Increase availability of good crop breeds
Meet Customer demand
Demand driven- & gender sensitive
Track & inspect crop breeds
Gender sensitive crop breeds
Increase trust in crop breeding
Relevant crop breeds
Involvement of farmers & recognition of ITK in crop breeding
Increase trust in crop breeding
Gender sensitive appealing crop breeds
Equitable usability and demand
Community Intellectual property rights in crop breeding
Consideration of gender and demographic dimension in crop breeding
Promotion of women's land rights in CIS
Women' involvement in the crop breeding value chain
Tap market of women breeders
Increased Viability of crop breeding


RESPONSIVE AGRICULTURAL EXTENSION MARKET MAPS
ENABLING ENVIRONMENT
Financial and Economic Costs
Extension Training Research & Dev't
Land tenure & Seed, water Sources
Innovative financing mechanisms
Governance of farmer institutions
Government Policies & strategies (Seed, Coffee, Fisheries, Animals)
Extension Quality Standards
New Agricultural technologies
Farmer Linkages
Gender sensitive Actors at all levels
Information & Communication Technologies
Donors
MAAIF
District Local Government Extension staff
Sub-county
Farmer
Community men, women, boys and girls
NAADS, NARO & Training/Authorities /institutions
Intermediary Organizations
Service
Governance & Regulation
Research & Dev't of Extension service approaches
Quality Assurance
Finances
Land tenure
Capacity building
Coordination


RESPONSIVE AGRICULTURAL EXTENSION LOGICAL PROBLEM ANALYSIS
Limited agricultural incomes
Reduced livelihoods
Poor archaic farming methods
Low agricultural productivity
Limited adoption of Responsive Agriculture Extension
Weak Structures to engage farmers
Inadequate monitoring & Surveillance including gender commitments
Non responsive - including gender extension staff training
Single Spine Extension System
Uncoordinated actor operations
Limited partnerships for effective monitoring of extension services
Limited & gender insensitive Human Extension Capacity
Inadequate Financing & Budget Allocation
Duplication, redundancy, conflicting agricultural extension messages and exclusion of some farmers especially women
Limited coverage & evidence to guide planning due to asynchrony & loose links between monitoring and planning
Inability to provide adequate extension services to farmers especially women
Distortion of Agriculture Extension Operations

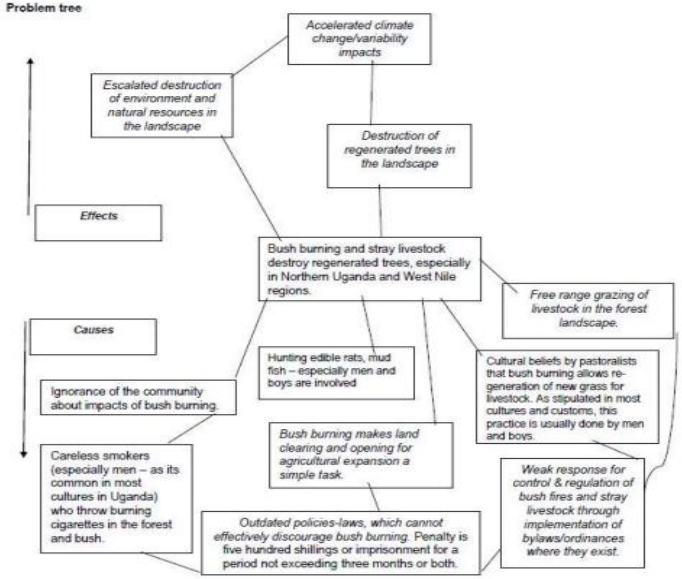

RESPONSIVE AGRICULTURAL EXTENSION OBJECTIVE TREE ANALYSIS
Increased agricultural incomes
Improved livelihoods
Modern farming methods
Low Agricultural Productivity
Adoption of Responsive Agricultural Extension
Strong structures to engage farmers
Effective & efficient gender responsive monitoring of Extension services
Strengthen technical capacity including gender of agricultural extension workers
Increase budget allocation to extension
Coordinated Actor Operations & farmer linkages
Partnerships for effective monitoring of extension services
Adequate gender sensitive human extension capacity
Effective system to agricultural extension
Effective Coordinated inclusive agricultural extension services
Evidence based planning for Responsive agricultural extension services
Provision of adequate extension services to farmers including women farmers
Efficient Agriculture extension operations

FORESTRY SECTOR

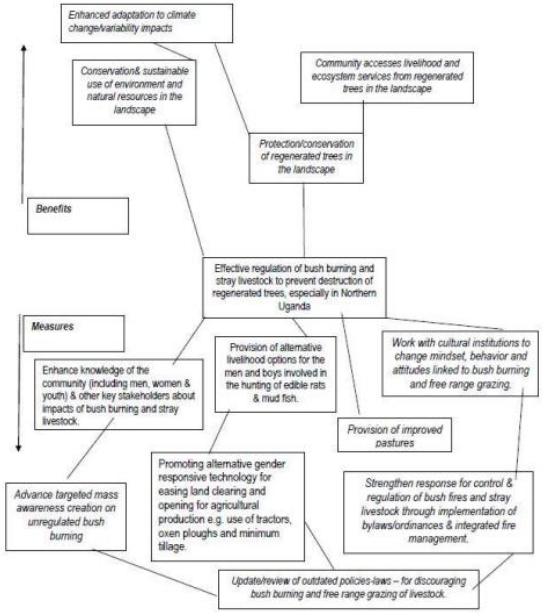
Annex 1: Technology 1 - *Promotion of Farmer Managed Natural Regeneration (FMNR) for forest landscape restoration.*

Barrier #1: Bush burning and stray livestock destroy regenerated trees, especially in Northern Uganda

Problem tree

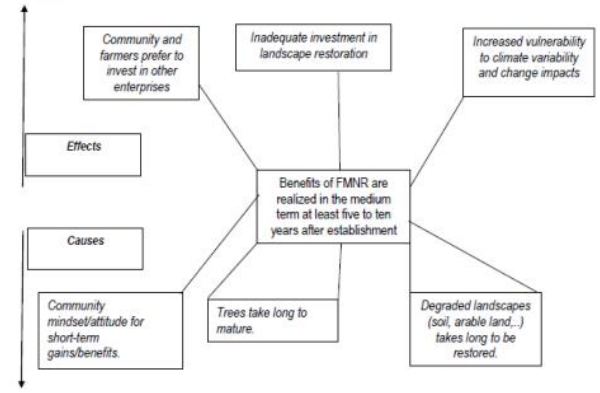


Objective/Solution tree

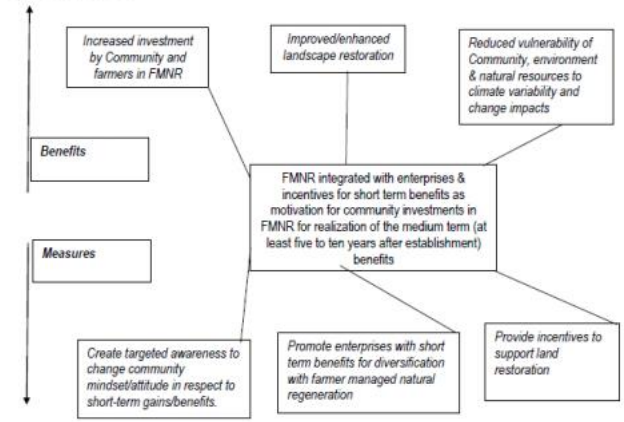


Barrier #2: Benefits of FMNR are realized in the medium term at least five to ten years after establishment.

Problem tree

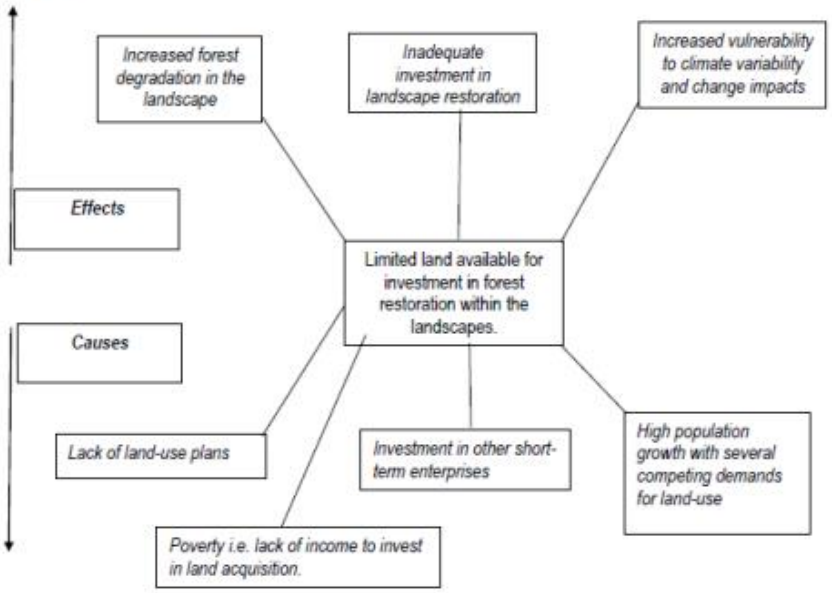


Objective/solution tree

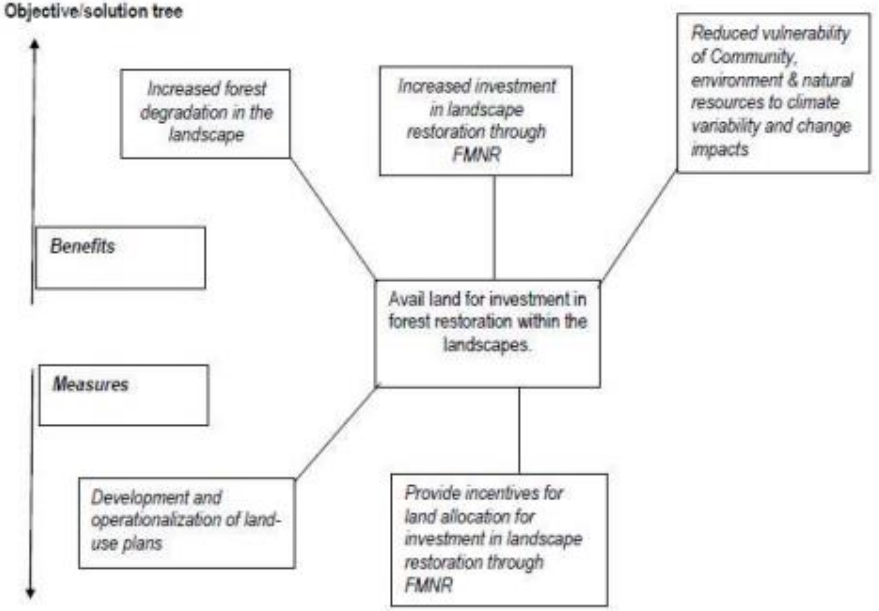


Barrier #3: Limited land available for investment in forest restoration within the landscapes

Problem tree

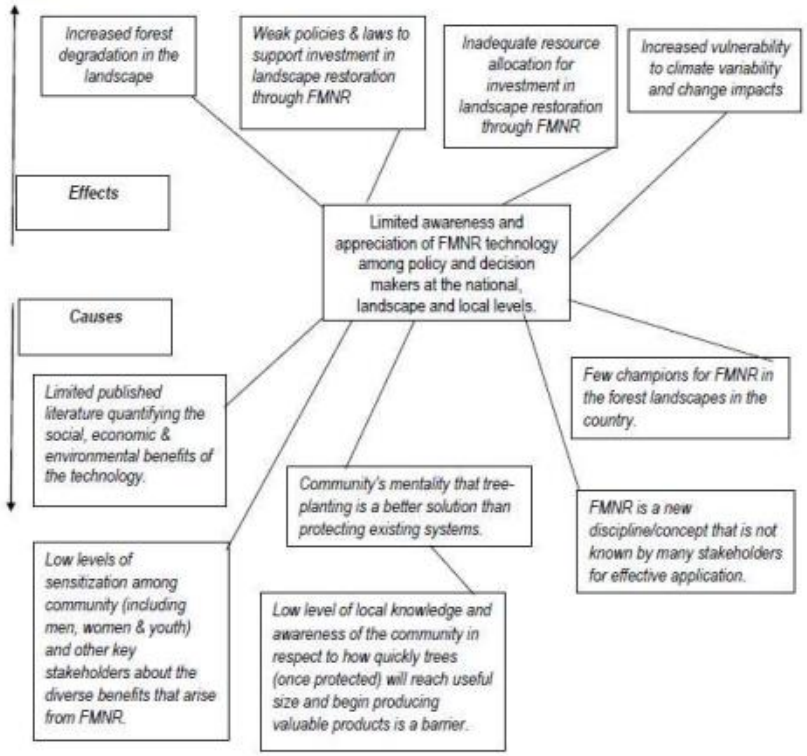


Objective/solution tree

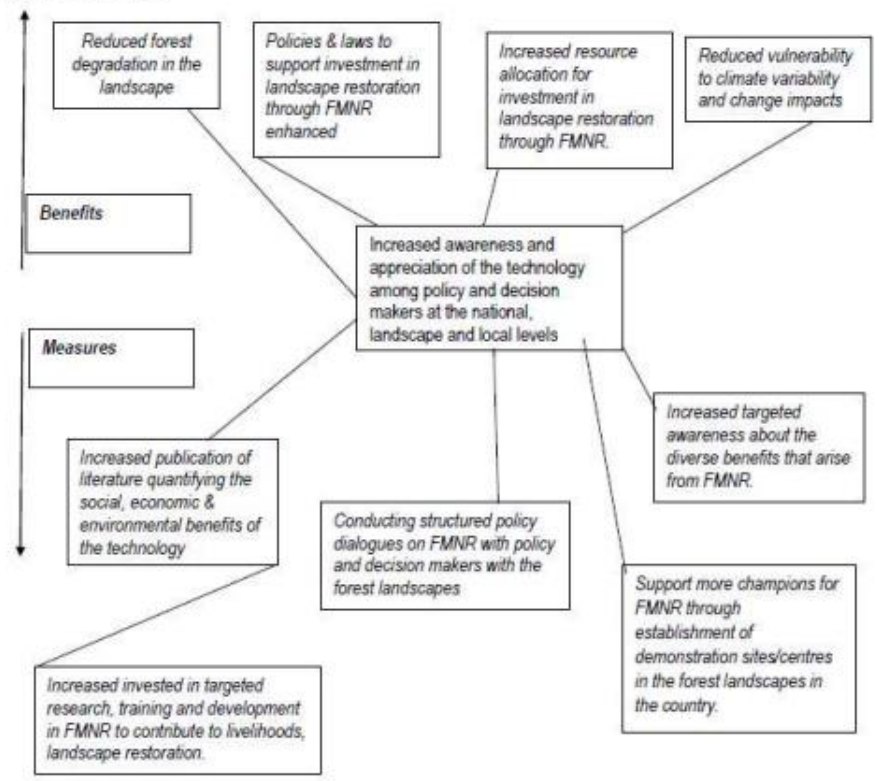


Barrier #4: Limited awareness and appreciation of the technology among policy and decision makers at the national, landscape and local levels.

Problem tree

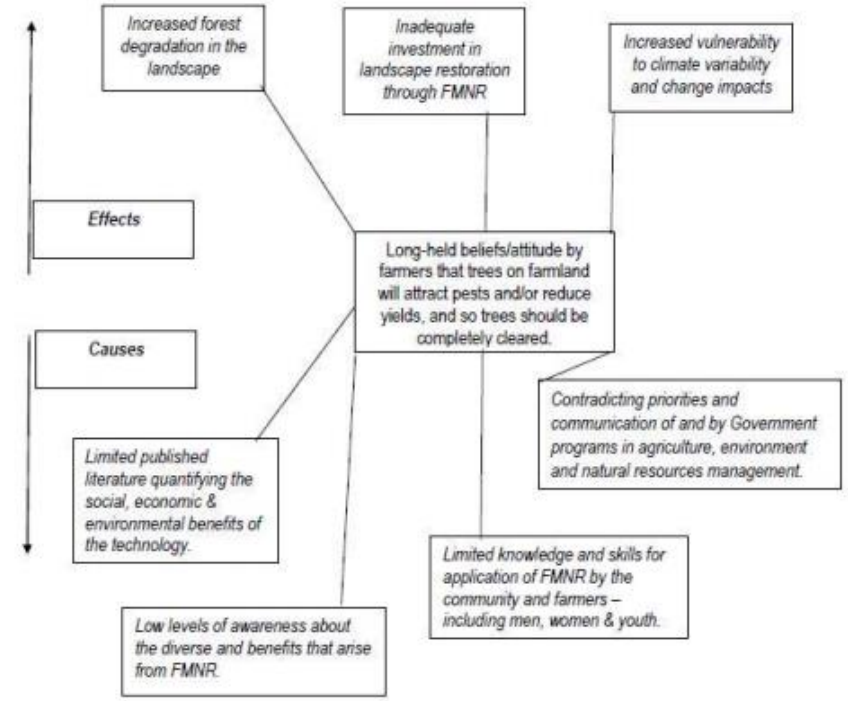


Objective/solution tree

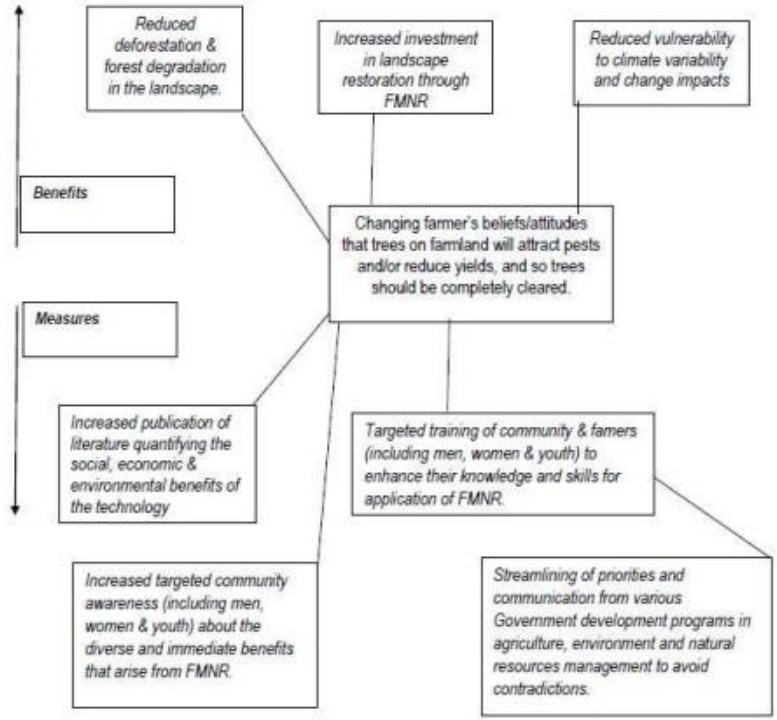


Barrier #5: Long-held beliefs/attitude by farmers that trees on farmland will attract pests and/or reduce yields, and so trees should be completely cleared

Problem tree

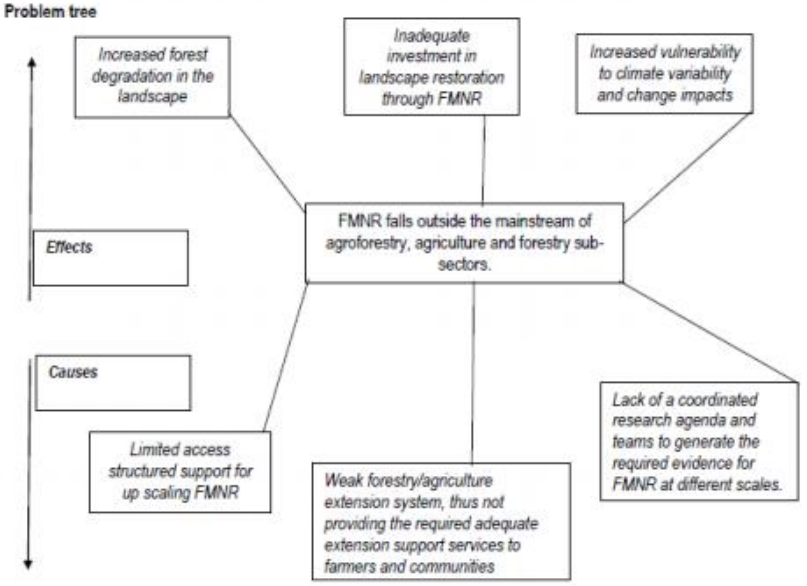


Objective/solution tree

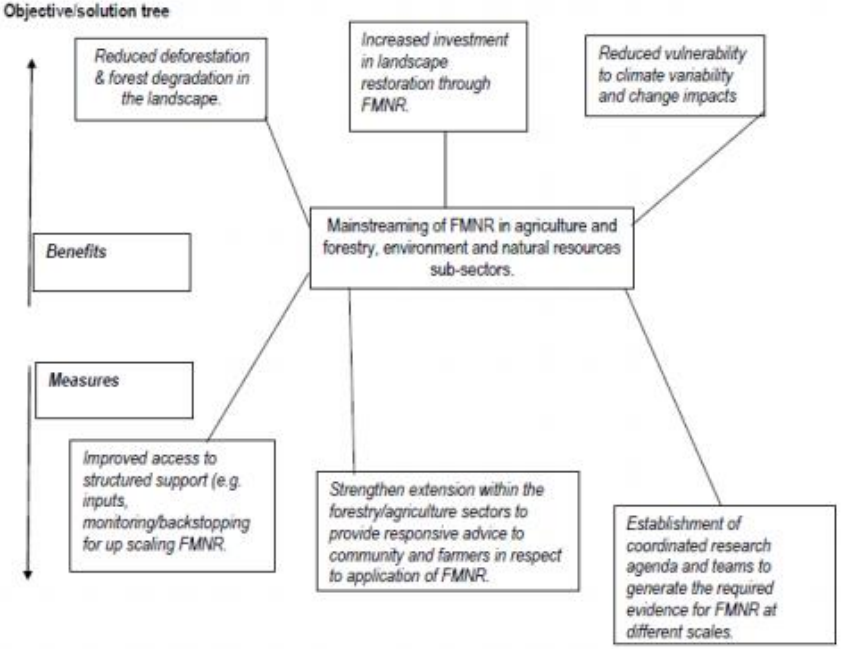


Barrier #6: FMNR falls outside the mainstream of agroforestry, agriculture and forestry sub-sectors, thus making it difficult to access structured support for up scaling, but also acceptance by the appropriate research communities

Problem tree

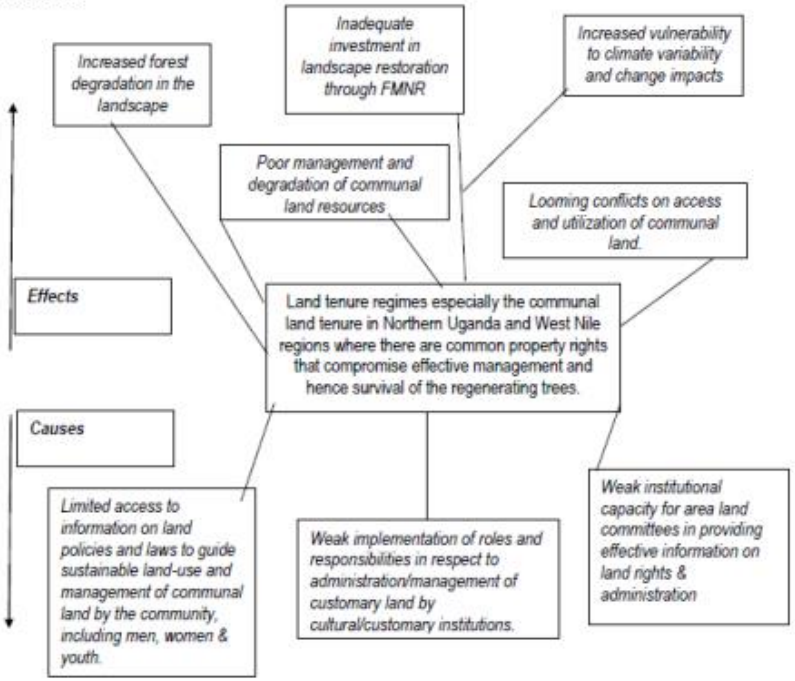


Objective/solution tree

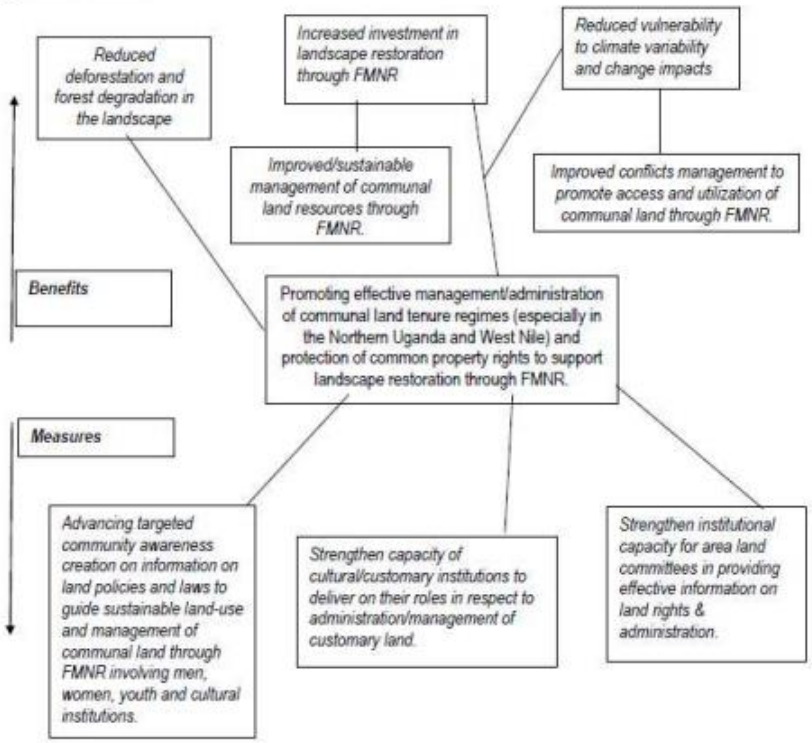


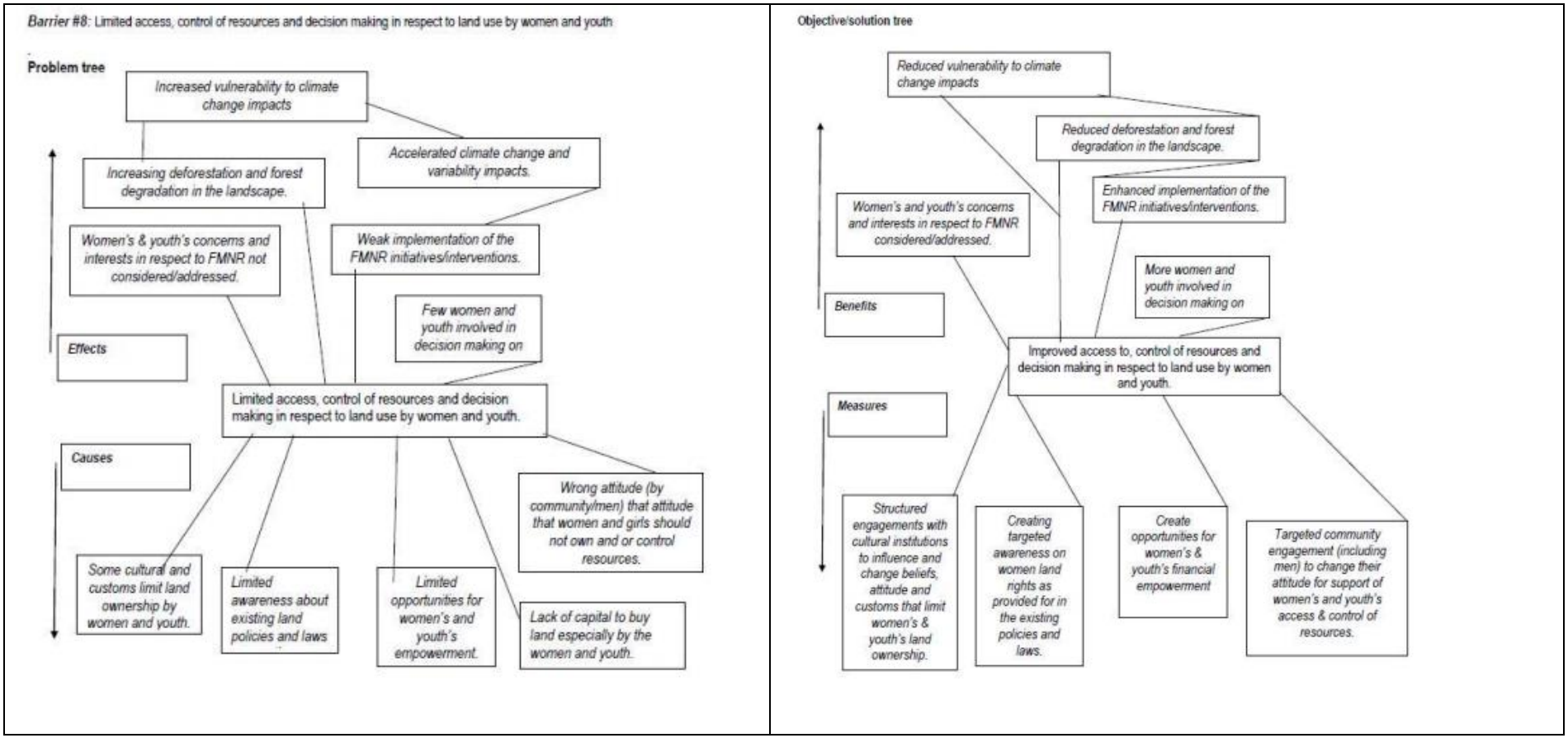
Barrier #7: Land tenure regimes especially the communal land tenure in Northern Uganda and West Nile regions where there are common property rights that compromise effective management and hence survival of the regenerating trees.

Problem tree



Objective/solution tree

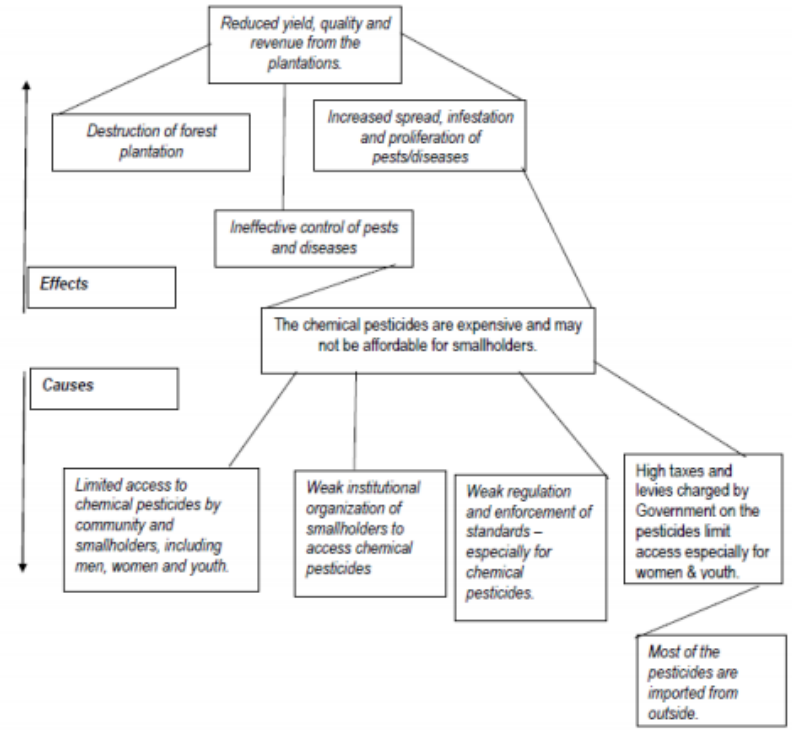



Barrier #8: Limited access, control of resources and decision making in respect to land use by women and youth
Problem tree
Increased vulnerability to climate change impacts
Increasing deforestation and forest degradation in the landscape.
Accelerated climate change and variability impacts.
Women's & youth's concerns and interests in respect to FMNR not considered/addressed.
Weak implementation of the FMNR initiatives/interventions.
Few women and youth involved in decision making on
Effects
Limited access, control of resources and decision making in respect to land use by women and youth.
Causes
Wrong attitude (by community/men) that attitude that women and girls should not own and or control resources.
Some cultural and customs limit land ownership by women and youth.
Limited awareness about existing land policies and laws
Limited opportunities for women's and youth's empowerment.
Lack of capital to buy land especially by the women and youth.
Objective/solution tree
Reduced vulnerability to climate change impacts
Reduced deforestation and forest degradation in the landscape.
Enhanced implementation of the FMNR initiatives/interventions.
Women's and youth's concerns and interests in respect to FMNR considered/addressed.
More women and youth involved in decision making on
Benefits
Improved access to, control of resources and decision making in respect to land use by women and youth.
Measures
Structured engagements with cultural institutions to influence and change beliefs, attitude and customs that limit women's & youth's land ownership.
Creating targeted awareness on women land rights as provided for in the existing policies and laws.
Create opportunities for women's & youth's financial empowerment
Targeted community engagement (including men) to change their attitude for support of women's and youth's access & control of resources.

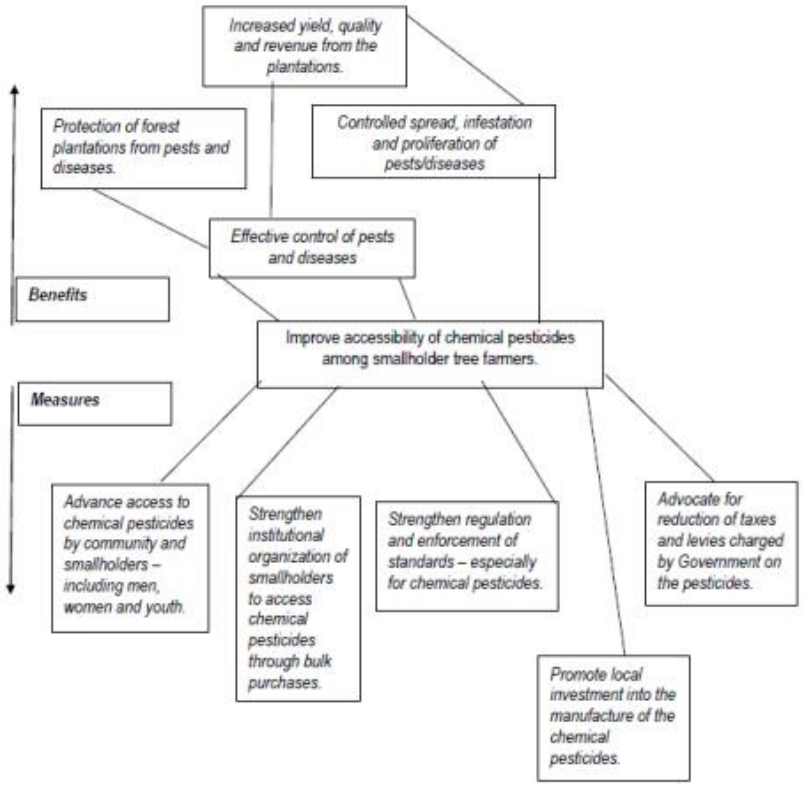
Annex 2: Technology 2 -- *Integrated pest management (IPM) in natural forests and forest plantations.*

Barrier #1: The chemical pesticides are expensive and may not be affordable for smallholders.

Problem tree

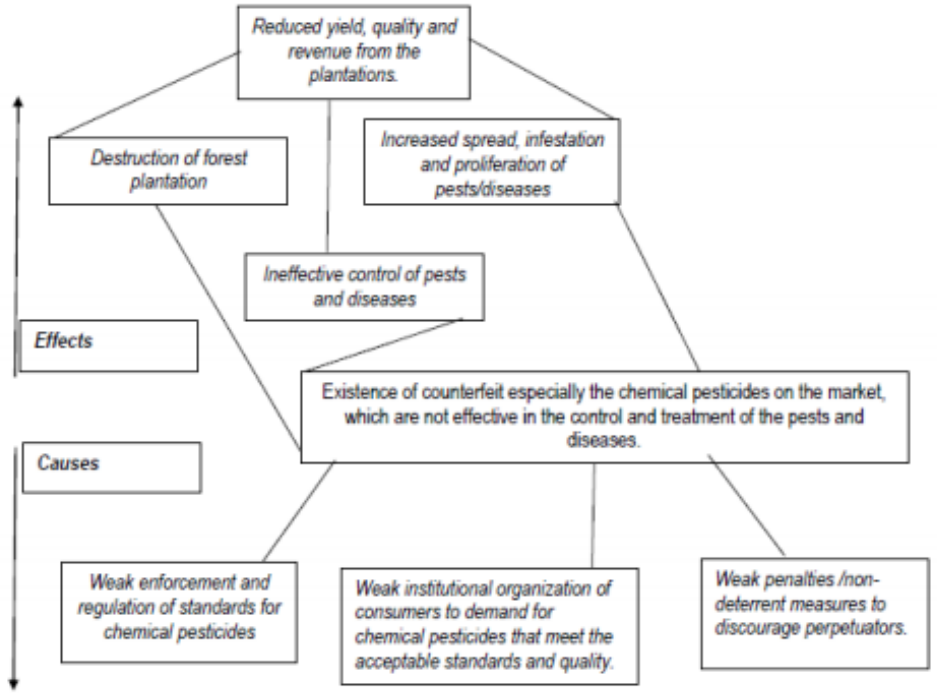


Objective/solution tree

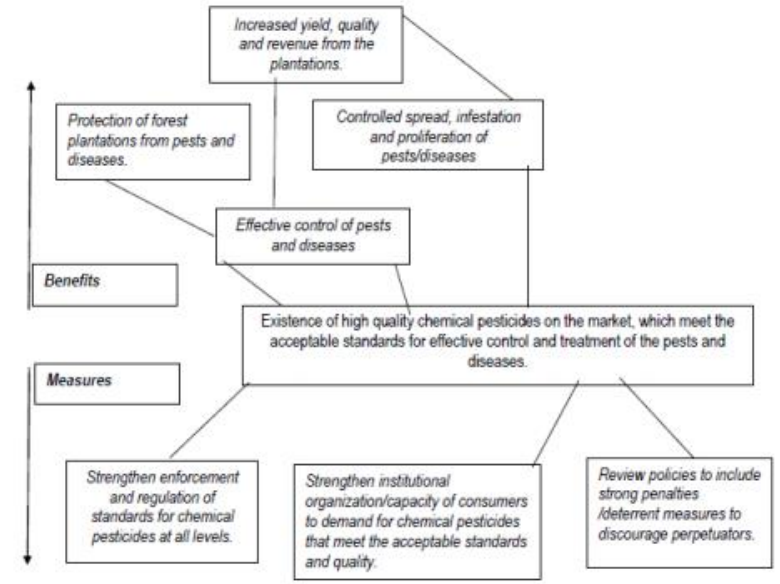


Barrier #2: Existence of counterfeit especially the chemical pesticides on the market, which are not effective in the control and treatment of the pests and diseases.

Problem tree

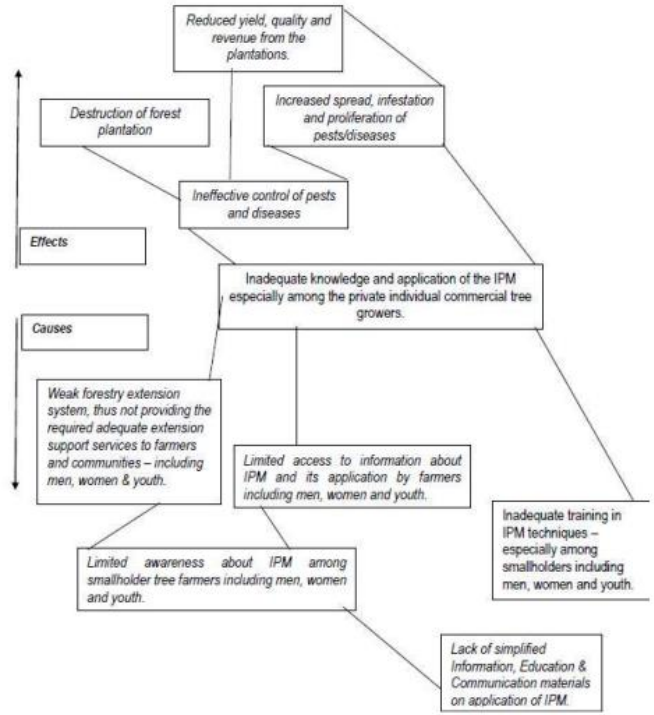


Objective/solution tree

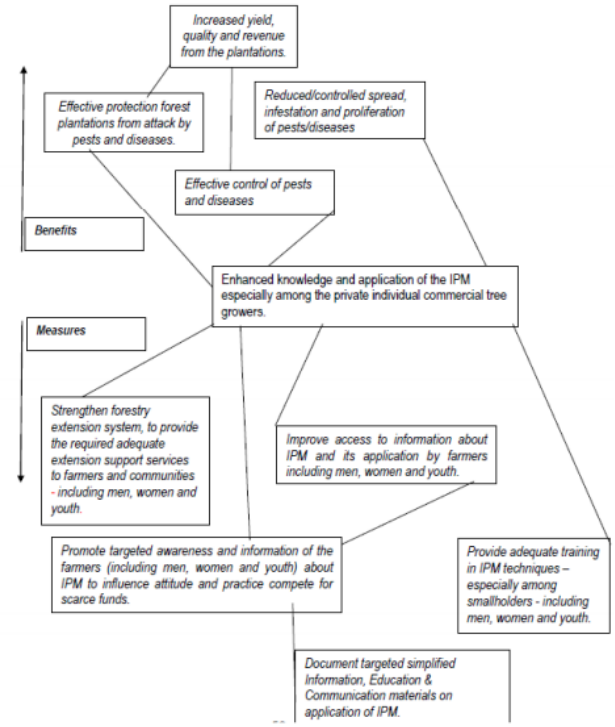


Barrier #3: Inadequate knowledge and application of the Integrated Pest Management (IPM) especially among the private individual commercial tree growers.

Problem tree

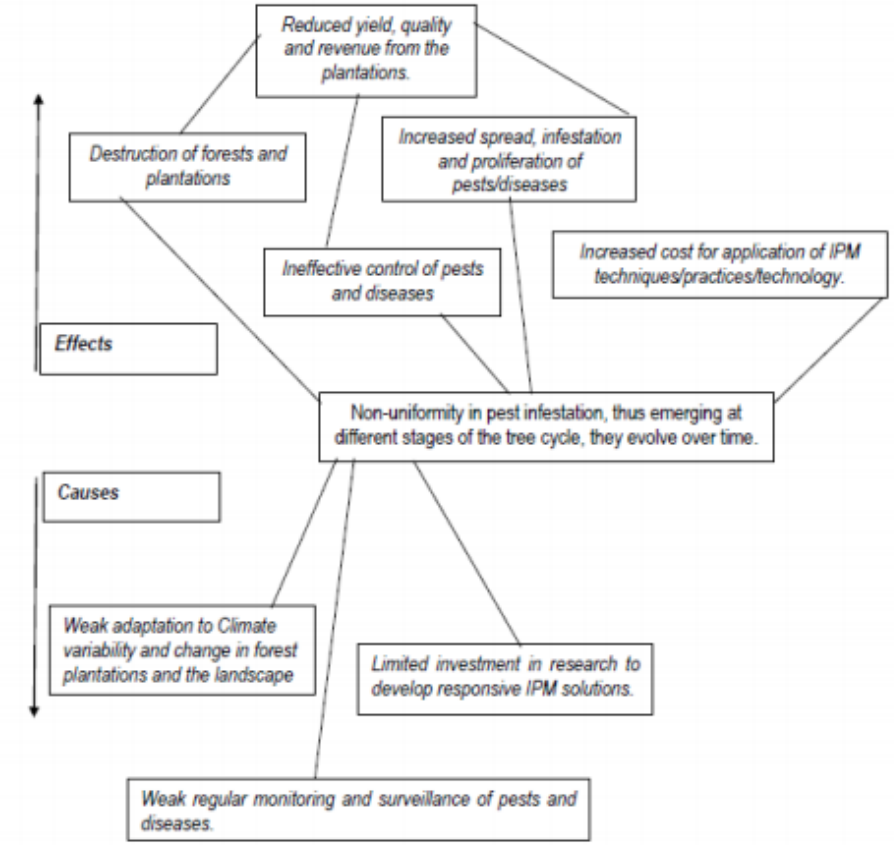


Objective/solution tree

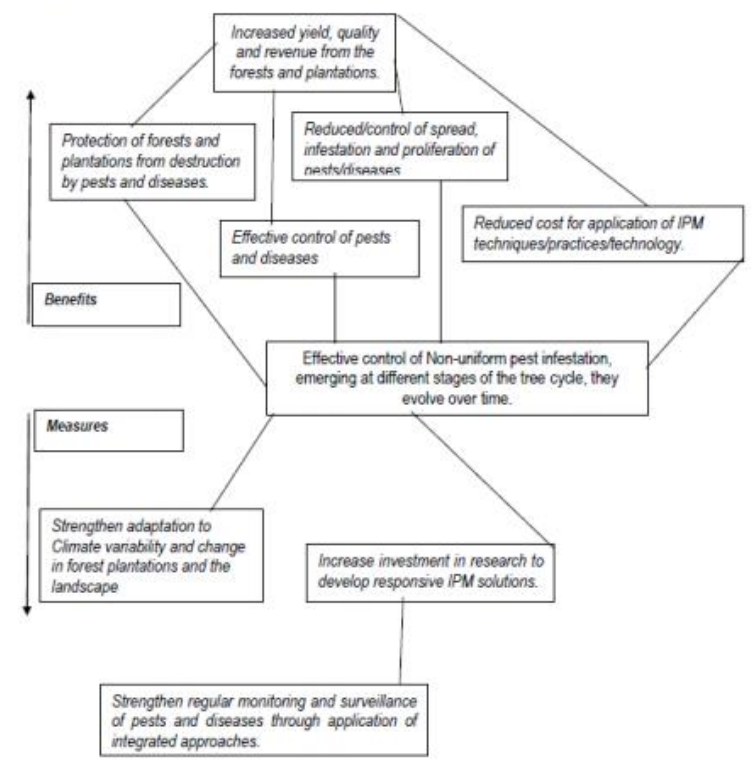


Barrier #4: Non-uniformity in pest infestation, thus emerging at different stages of the tree cycle, they evolve over time, some IPM technologies are divisible and rarely do complete 'packages' exist for an entire crop or ecosystem

Problem tree

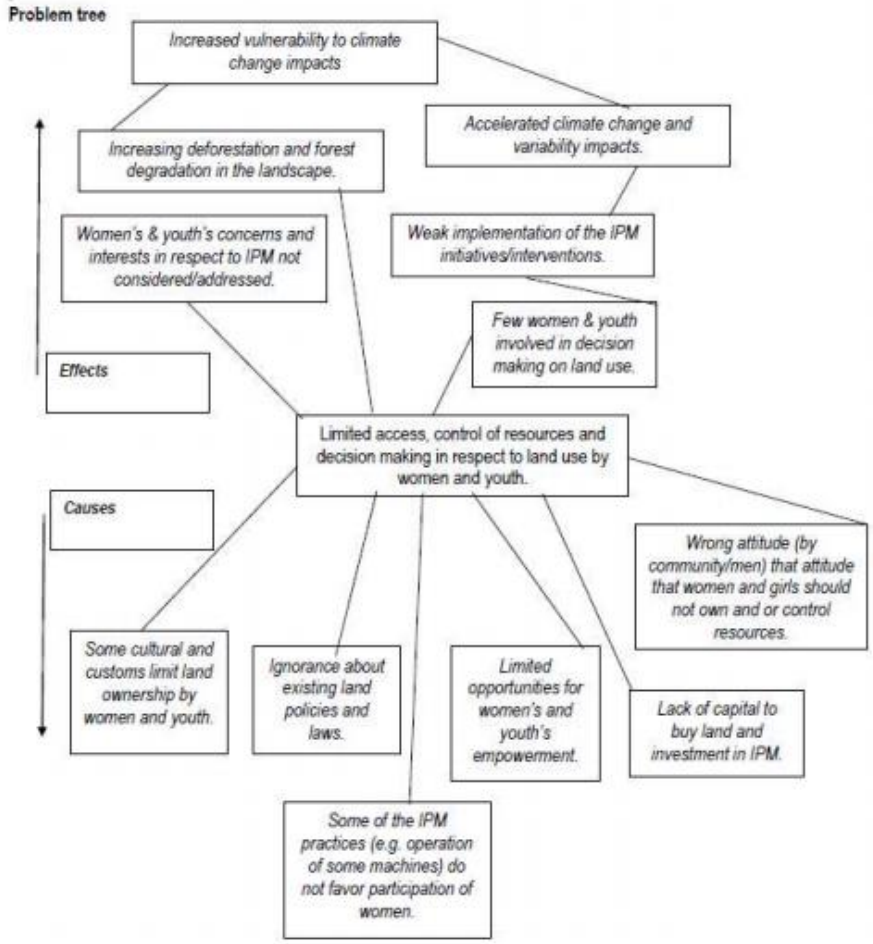


Objective/solution tree

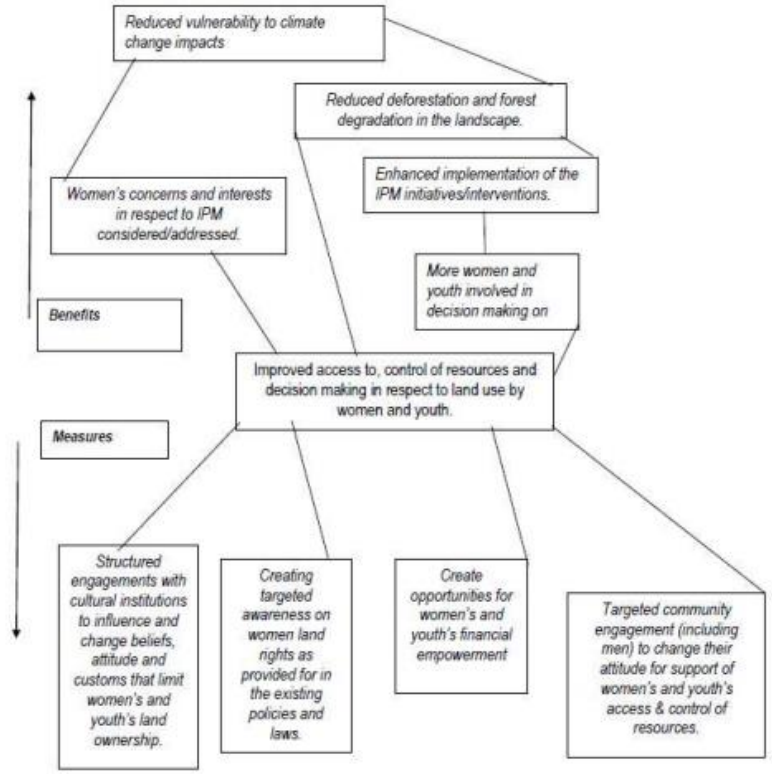


Barrier #5: Limited access, control of resources and decision making in respect to land use by women and youth

Problem tree



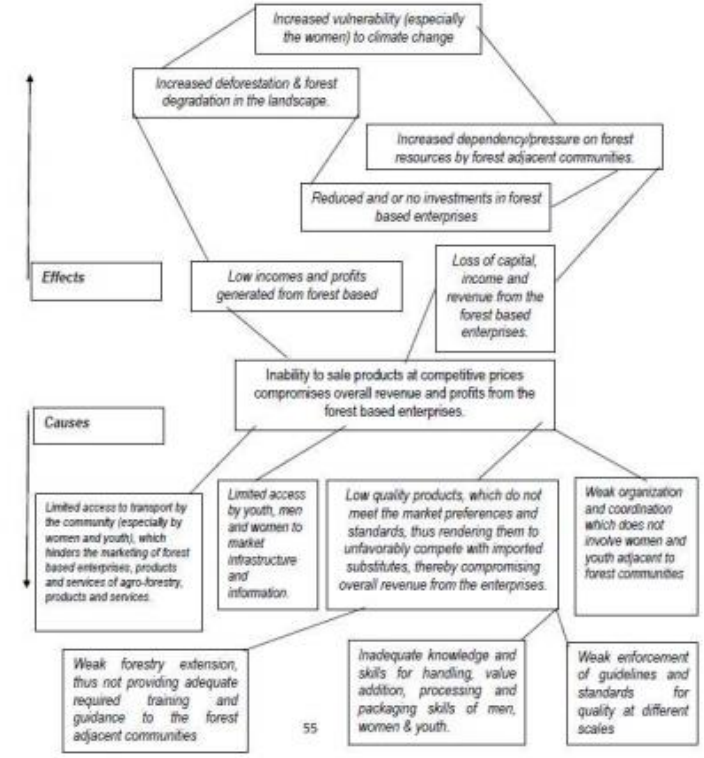
Objective/solution tree



Annex 3: Technology 3 – *Promoting Forest based enterprises e.g. bee keeping/apiary; butterfly farming, fruit trees production; ecotourism.*

Barrier #1: Inability to sale products at competitive prices compromises overall revenue and profits from the forest based enterprises.

Problem tree



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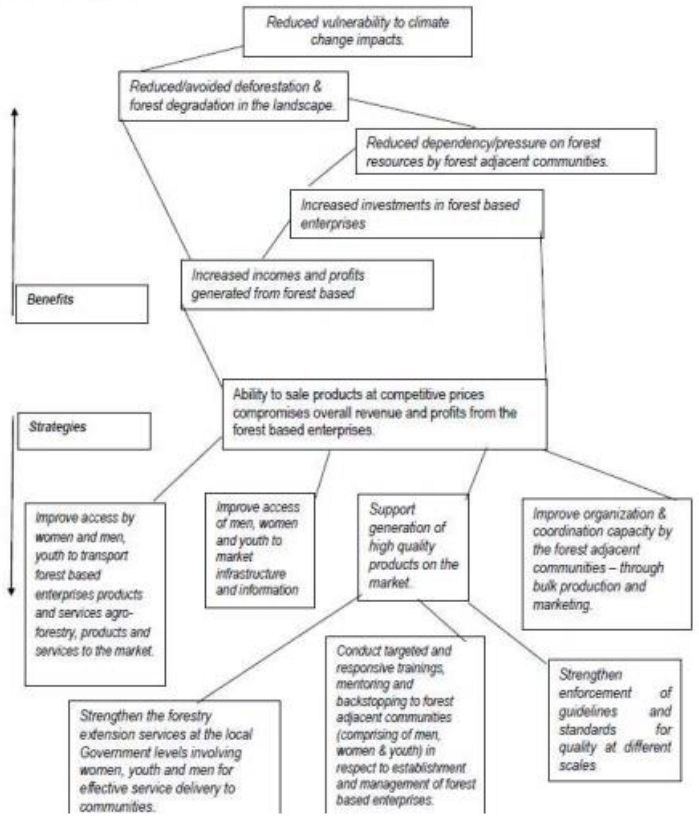
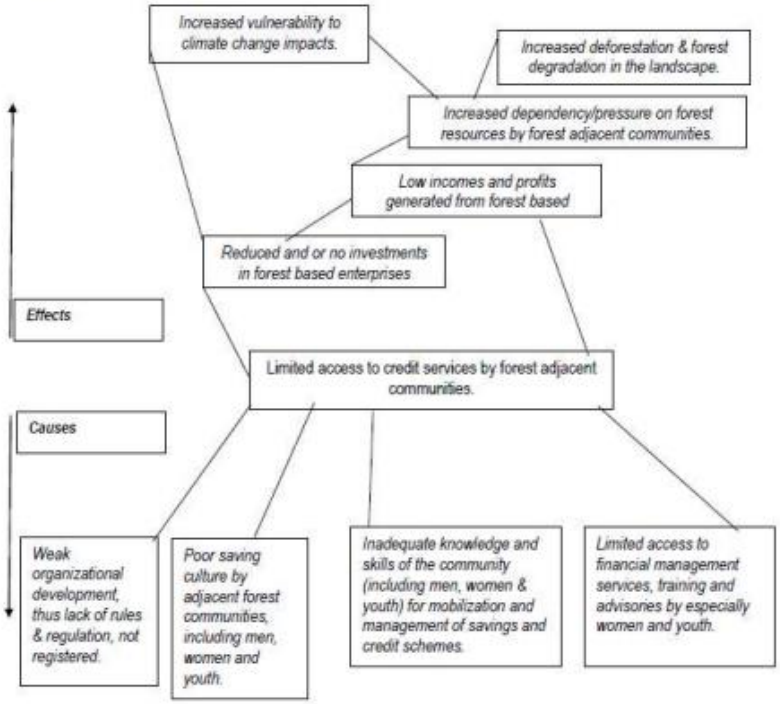
Objective/solution tree

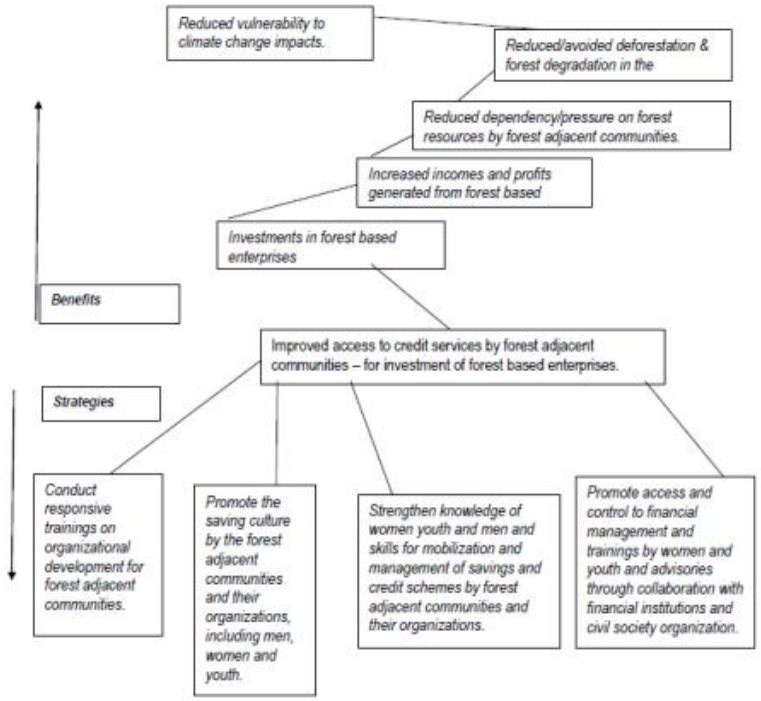


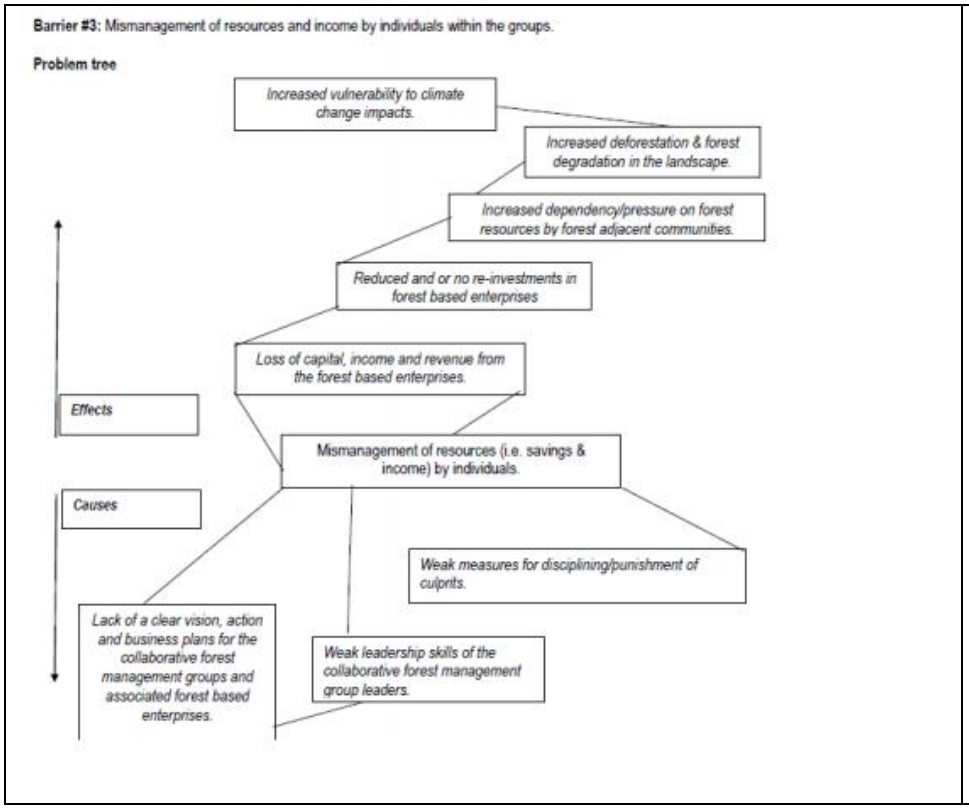
Barrier #2: Limited access to credit services by forest adjacent communities.

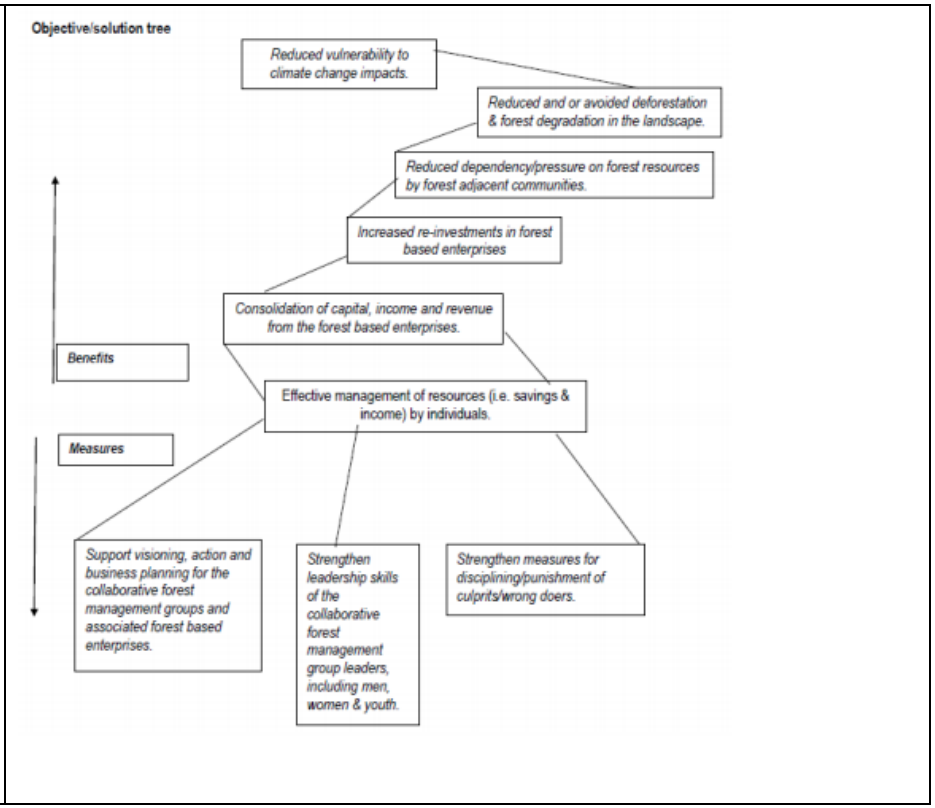
Problem tree



Objective/solution tree

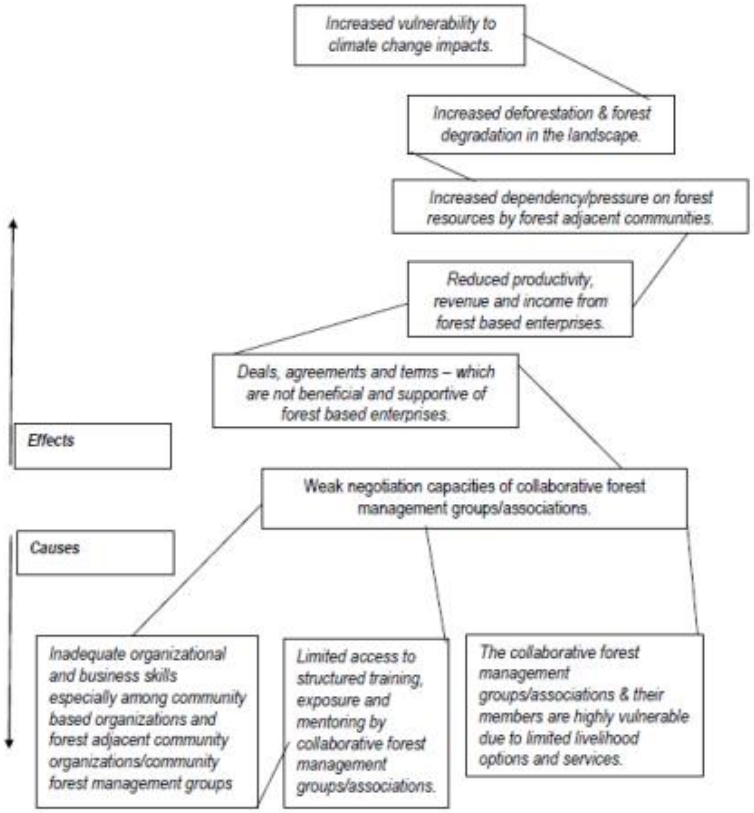



Barrier #3: Mismanagement of resources and income by individuals within the groups.
Problem tree
Increased vulnerability to climate change impacts.
Increased deforestation & forest degradation in the landscape.
Increased dependency/pressure on forest resources by forest adjacent communities.
Reduced and or no re-investments in forest based enterprises
Loss of capital, income and revenue from the forest based enterprises.
Effects
Mismanagement of resources (i.e. savings & income) by individuals.
Causes
Weak measures for disciplining/punishment of culprits.
Lack of a clear vision, action and business plans for the collaborative forest management groups and associated forest based enterprises.
Weak leadership skills of the collaborative forest management group leaders.

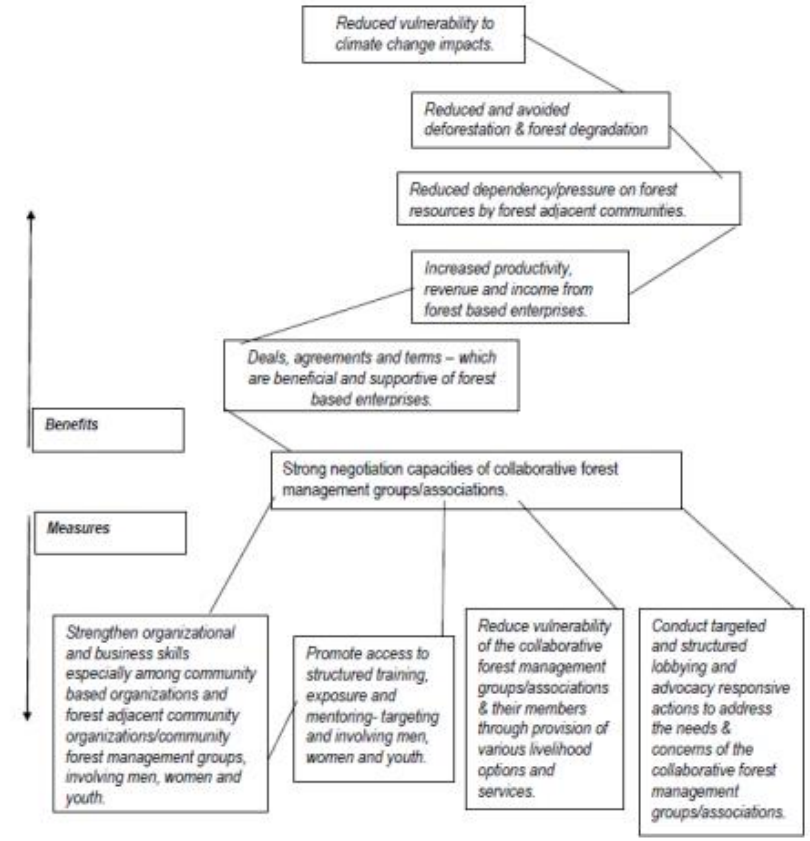

Objective/solution tree
Reduced vulnerability to climate change impacts.
Reduced and or avoided deforestation & forest degradation in the landscape.
Reduced dependency/pressure on forest resources by forest adjacent communities.
Increased re-investments in forest based enterprises
Consolidation of capital, income and revenue from the forest based enterprises.
Benefits
Effective management of resources (i.e. savings & income) by individuals.
Measures
Support visioning, action and business planning for the collaborative forest management groups and associated forest based enterprises.
Strengthen leadership skills of the collaborative forest management group leaders, including men, women & youth.
Strengthen measures for disciplining/punishment of culprits/wrong doers.

Barrier #4: Weak negotiation capacities of collaborative forest management groups/associations.

Problem tree

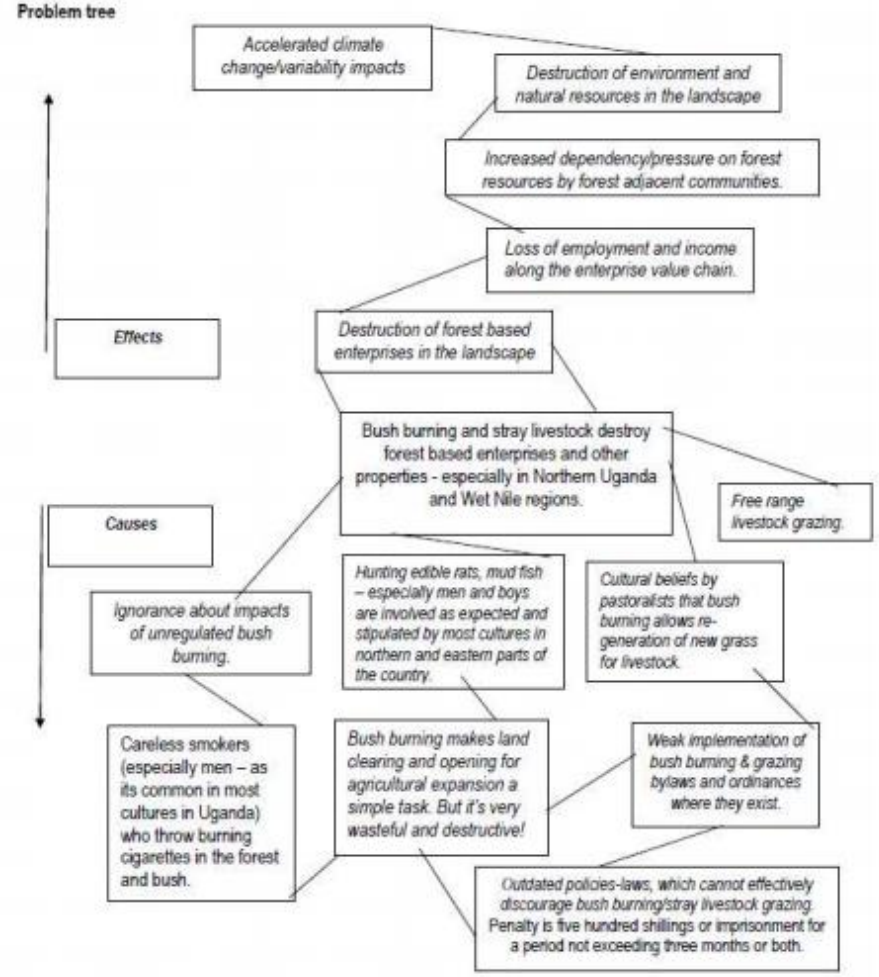


Objective/solution tree

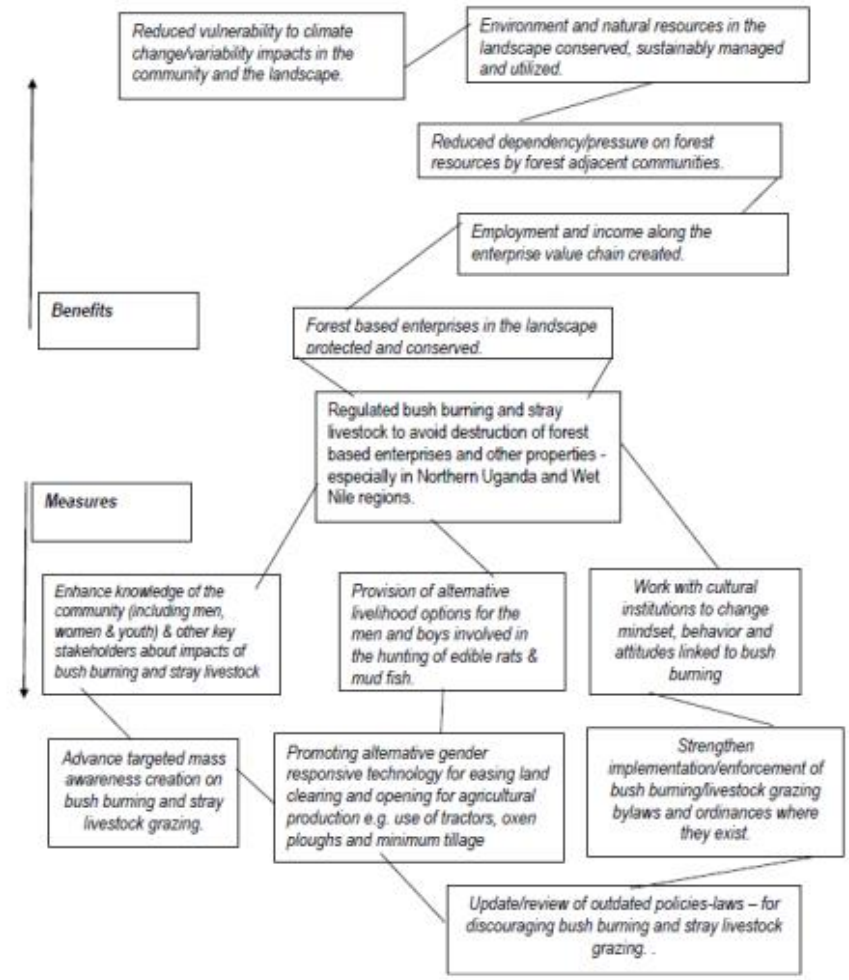


Barrier #5: Bush burning and stray livestock destroy forest based enterprises and other properties - especially in Northern Uganda and West Nile regions.

Problem tree

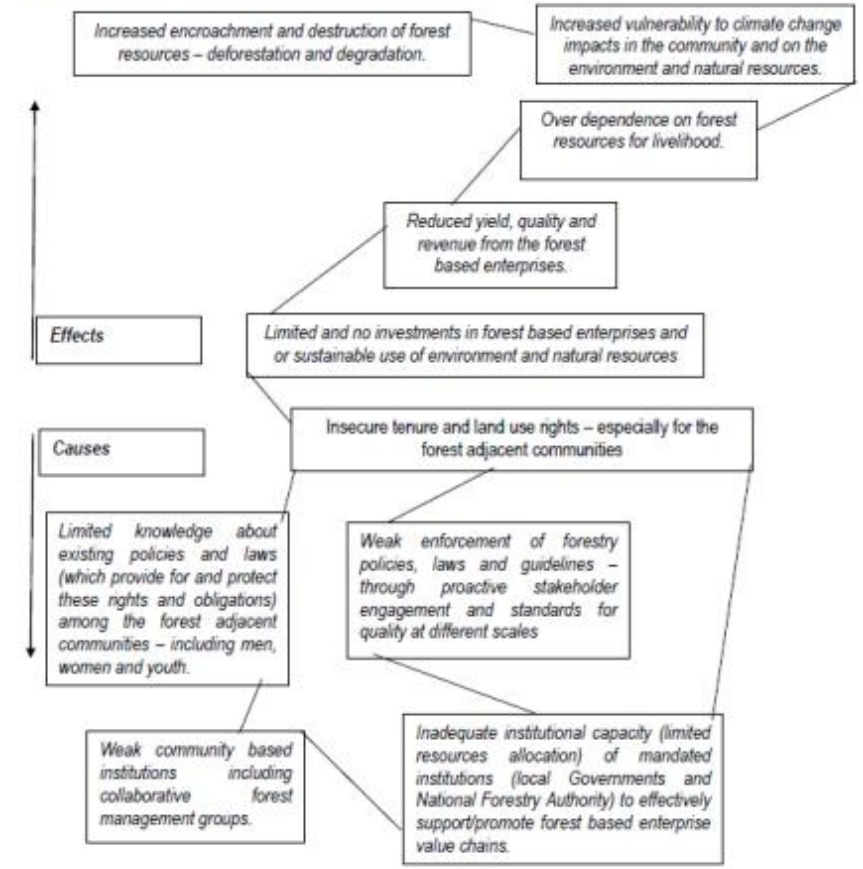


Objective/solution tree

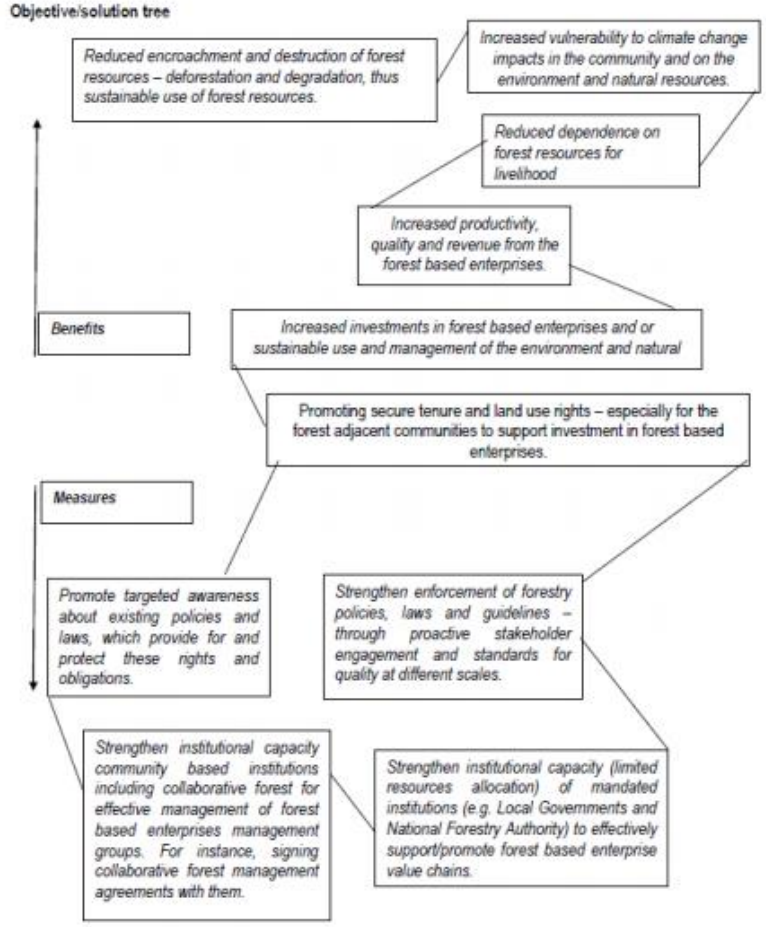


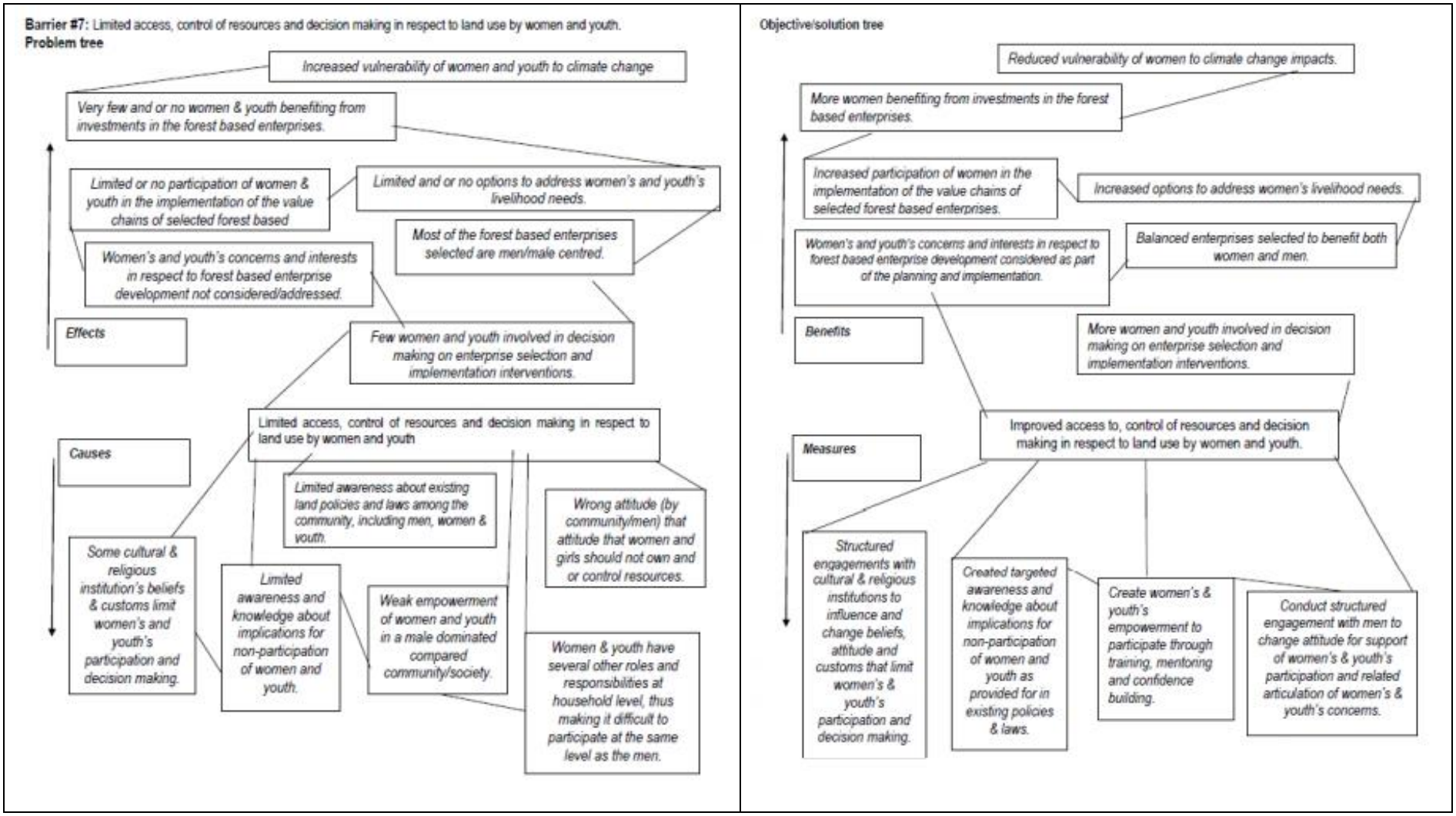
Barrier #6: Insecure tenure and land use rights – especially for the forest adjacent communities.

Problem tree



Objective/solution tree




Barrier #7: Limited access, control of resources and decision making in respect to land use by women and youth.
Problem tree
Increased vulnerability of women and youth to climate change
Very few and or no women & youth benefiting from investments in the forest based enterprises.
Limited or no participation of women & youth in the implementation of the value chains of selected forest based
Limited and or no options to address women's and youth's livelihood needs.
Most of the forest based enterprises selected are men/male centred.
Women's and youth's concerns and interests in respect to forest based enterprise development not considered/addressed.
Effects
Few women and youth involved in decision making on enterprise selection and implementation interventions.
Limited access, control of resources and decision making in respect to land use by women and youth
Causes
Limited awareness about existing land policies and laws among the community, including men, women & youth.
Wrong attitude (by community/men) that attitude that women and girls should not own and or control resources.
Some cultural & religious institution's beliefs & customs limit women's and youth's participation and decision making.
Limited awareness and knowledge about implications for non-participation of women and youth.
Weak empowerment of women and youth in a male dominated compared community/society.
Women & youth have several other roles and responsibilities at household level, thus making it difficult to participate at the same level as the men.
Objective/solution tree
Reduced vulnerability of women to climate change impacts.
More women benefiting from investments in the forest based enterprises.
Increased participation of women in the implementation of the value chains of selected forest based enterprises.
Increased options to address women's livelihood needs.
Women's and youth's concerns and interests in respect to forest based enterprise development considered as part of the planning and implementation.
Balanced enterprises selected to benefit both women and men.
Benefits
More women and youth involved in decision making on enterprise selection and implementation interventions.
Improved access to, control of resources and decision making in respect to land use by women and youth.
Measures
Structured engagements with cultural & religious institutions to influence and change beliefs, attitude and customs that limit women's & youth's participation and decision making.
Created targeted awareness and knowledge about implications for non-participation of women and youth as provided for in existing policies & laws.
Create women's & youth's empowerment to participate through training, mentoring and confidence building.
Conduct structured engagement with men to change attitude for support of women's & youth's participation and related articulation of women's & youth's concerns.

Annex 2. Stakeholders involved

Working group	Name
Agriculture sector working group	Ms. Christine Talwisa
	Dr. Damalie Akwango, National Agricultural Research Organisation
	Ms. Christine Kaaya Parliamentary Forum for Climate Change
	Ms. Deborah Kasule, Uganda National Council for Science and Technology
Water sector working group	Ms. Ashabrick N. Bamutaze Rural Water & Sanitation Dept, Ministry of Water and Environment (MWE)
	Mr. Brian Ssemakula, Directorate of Water, MWE
	Prof John-Baptist Kaddu, Makerere University
Forestry sector working group	Mr. Xavier Mugumya National Forestry Authority
	Prof. Joseph Obua CAES, Makerere University
	Dr. Robert Nabanyumya Green Approaches
	Mr. A. Kalema Private Sector
	Dr. Hilary Agaba, National Forestry Resources Research Institute
	Chief Executive Officer Uganda Timber Growers Association