Republic of Zambia

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE ADAPTATION

Barrier Analysis and Enabling Framework Report

(Water and, Agriculture & Food Security Sectors)

Updated May 2013

Supported by:

Foreword

Zambia started the process of a Technology Needs Assessment (TNA) for climate change adaptation with a stakeholder's meeting in September 2011. A similar process for climate change mitigation was initiated in parallel. I am glad to report that both processes have now been concluded and have resulted in the identification and prioritisation of technologies that Zambia should pursue to help our communities adapt to the hazards of climate change.

With the help of her partners, Zambia was keen to engage in the TNA process because the country has seen the reality of climate change for a number of years now. The rise in the frequency of droughts, floods and extreme temperatures, the increase in the unpredictability of rainfall during the rainy season and the increase in mean temperatures are already wrecking hazard on the livelihoods and general wellbeing of our people. What is worse is that the occurrence of such climatic hazards is projected to increase. All our development efforts and the great score we have made over the past decade risk to be reversed by climate change. Clearly we cannot continue with business as usual.

The Government of the Republic of Zambia has recognized this need for some time now and has been preparing ground for action with regards to climate change adaptation. In 2007, it produced the National Adaptation Programme of Action which identified the nature of climate change hazards that threaten Zambia, the most vulnerable sectors and areas of our country and the kind of interventions needed to help our population adapt to these risks. This was followed by the adoption of the National Climate Change Response Strategy and the Pilot Programme for Climate Resilience in 2011. Our national development plans and other national development documents since 2006 have taken climate change as a crosscutting is that should be taken into account in all our strategies and actions. A lot has already been done to respond to climate change and yet the threat remains huge that more needs to be done with even greater urgency.

In conducting the TNA process, consultation with key stakeholders was the core approach taken at every stage. Stakeholders scored and identified the sectors and technologies that needed to be given priority in devising the needed actions. They went on to identify the barriers that would hinder the diffusion of the selected technologies and specified measures required to overcome the barriers. These stakeholder representatives came from civil society, the private sector, academia and government. The determination and desire to forge our effort together is an indication of how climate change adaptation is such an important national issue and is of great concern to all who work to better the lives of our people.

The TNA process on climate change adaptation has produced four reports which should be read together as the unfolding narrative of its results:

1. Technology Needs Assessment Report This report presents the methodology used in the TNA process, how sectors and technologies were identified and prioritized. For climate change adaptation, two sectors – water and agriculture and food security sectors – received the highest scores and were consequently selected for further analysis. In each of the two sectors, three technologies were ranked highest and taken forward for barrier analysis.

2. Barrier Analysis and Enabling Framework Report It documents the barriers to technology diffusion identified by stakeholders and their root causes. Measures and the enabling framework for

technology diffusion in the respective sectors and for each technology are also detailed in this report.

3. Technology Action Plans The TAP report provides the steps and actions required to take forward the identified measures in each sector and for each technology.

4. Project Ideas Report Building on the TAP report, this report develops some specific project ideas for water and agriculture and food security. For the water sector, it is proposed to establish a Pilot Climate Change and Water Access (PCCWA) project meant to enhance access to water in Region I despite the climate change hazards the region is exposed to. For the agriculture and food security, it is proposed that a Pilot Smallholder Climate Change Resilience (PSCCR) Project be established to enhance the resilience of small farmers to climate change hazards. Both are pilot projects from which lessons should be learnt with a view to rollout to other areas, especially Region I where these hazards are increasing in prominence.

This has been a lot of work and I am pleased at its successful conclusion. I am grateful to the stakeholders who participated in the process over a period of nearly two years. I thank our partners, the United Nations Environment Programme (UNEP), the Global Environment Facility, UNEP RISO Centre and ENDA for the financial and technical support rendered to the TNA process in Zambia. I wish to also recognize the work of the Consultant, RuralNet Associates Limited, who facilitated the process and documented the outcomes from the stakeholder consultations into the reports mentioned above.

It remains for all of us to work together to ensure that the results of this intense and long process will not go to waste as has been the case in the past with other processes. The Ministry of Lands, Natural Resources and Environmental Protection has made climate change a top priority in its work. I and my colleagues will therefore work very hard to ensure that the projects identified come to fruition. We need the continued support of everyone.

Hon. Wilbur Simusa (MP)
Minister, Lands, Natural Resources and Environmental Protection

May 2013, Lusaka, Zambia

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Executive Summary

Introduction

The Technology Needs Assessment (TNA) for Zambia for climate change adaptation has four (4) main deliverables namely; TNA Report, Barrier Analysis and Enabling Framework Report, Technology Action Plans and Project Ideas. The initial TNA report (GRZ, October 2012) focused on the process of identifying, prioritizing and selecting sectors and technologies to be taken to the barrier analysis stage. Two sectors were agreed upon by stakeholders, i.e. the Water Sector and Agriculture and Food security Sector. The selected technologies from each of the two sectors are provided below.

Water sector:

1. Rain water collection from ground surfaces - small reservoirs and micro-catchments,
2. Boreholes/tube wells for domestic water supply during drought,
3. Building a concrete apron/collar on the well

Agriculture and food security sector:

1. Conservation farming with agro-forestry (Faidherbia albida, Tephrosia vogelii, Sesbania sesban and Gliricidia sepium)
2. Integrated crop-small livestock-fish-poultry-vegetable production system
3. Promotion of crop diversification and new crop varieties.

This report on *Barrier Analysis and Enabling Framework* is the second deliverable and analyses the likely barriers to transfer the identified technologies and suggests measures to address these barriers in the two sectors. Its main aim is to assess and suggest how to overcome the barriers to the transfer and diffusion of technologies for climate change adaptation in Zambia in the water and agriculture and food security sectors. After this, two more expected deliverables were:

- Technology Action Plans (TAPs): This details the steps needed in each relevant sector and for each technology to diffuse the selected technologies.

- Project Ideas: This provides a brief summary of, and specific, project ideas for each of the two sectors.

The Barrier Analysis and Enabling Framework Process

Stakeholder consultations - To kick start the barrier analysis, various stakeholders were invited to a workshop in October 2012 to be exposed to the proposed process and various methods for identification and analysis of barriers.[1] From that meeting, two technology working groups (TWGs) were formed, one for each sector. In each of these TWGs, the qualitative methods of data collection which included group discussions and key informant interviews were employed to solicit information on the barriers, root causes of the barrier and the related measures of the barriers. The stakeholders were mainly drawn from the University of Zambia (UNZA), Government departments and the Private sector.

[1] The workshop included stakeholders for both adaptation and mitigation. However, participants were later split into two major groups one each for adaption and mitigation. For the adaptation group, participants were further split into the water and agriculture and food security groups.

Key informant interviews: The stakeholder consultations were supplemented with interviews of some carefully selected key informants to obtain specific and expert view on issues under consideration. The experts came from both public and private sectors. In addition, key informant interviews were carried out with two farmers practicing conservation farming with agro-forestry particularly Faidherbia albida, so as to learn lessons on their farming experiences.

Identifying the barriers This included the identification of barriers that could hinder the acquisition and diffusion of the prioritized technologies. Part of the time at the workshop was spent by the two TWGs identifying barriers for each of the technologies listed above. This continued in two further meetings for each group.

Screening the barriers The identification resulted in a long list of barriers. When all barriers were identified, the barriers were screened for non-relevance or according to their significance through TWG participants arguing for and against the barriers. The process aimed at identifying essential barriers.

Decomposition of barriers This process was undertaken to break down the barriers after screening them into component elements. The discussions centered on whether some barriers were composed of some of the other barriers, or whether one barrier was just a more concrete formulation of an overall barrier category.

Root Cause Analysis (RCA): This approach was done as a method of problem solving to the root causes of barriers identified. The RCA practice was used as it tries to solve problems by attempting to identify and correct the root causes of events, as opposed to simply addressing their symptoms and also it allowed the TWGs to look beyond the solutions to the problems and understand the underlying cause(s) of the situation.

Measures: -The process of finding solutions was comprised of translating the identified barriers into measures.

Barriers for Diffusion

The identified barriers once screened were put into two categories, i.e. economic and financial barriers, and non-economic and financial barriers. The decomposition of barriers was done according to the TNA Guidebook on barrier analysis (Boldt, et al, January 2012) which has suggested decomposing barriers at four levels:

- Broad categories of barriers
- Barriers within a category
- Elements of barriers
- Dimensions of barrier elements

Barriers to Technology Diffusion in the Water Sector

Small Reservoirs and Micro- Catchments Technology

- *Economic and Financial Barriers*: The cost of adopting small reservoirs and micro catchment is too high due to due to the high price of building materials, high cost of fuel making mobilization very expensive and the high cost of imported heavy equipment.

- *Non Financial Barriers:* The identified non-financial barrier was inadequate technical skills in constructing dams and micro-catchments.

Boreholes/Tube wells Adaptation Technology

- *Economic and Financial Barriers:* The high cost of installing or drilling bore holes/tube wells. The costs are related to the high price of building materials, cost of mobilization/demobilization, drilling, casing and completion, and development and test pumping.

- *Non Financial Barriers:* The first was that some places in the country are not suitable for this type of technology due to geological reasons, inadequate ground water due to depletion and pollution of ground water sources. The second was the inadequate technical skills in designing and installing the technology.

Building a Concrete Apron/Collar on the Well

- *Economic and Financial Barriers*: The high cost of materials for use to improve the wells. Construction of new wells is very expensive and often requires drill rigs or other specialized equipment. The costs of retro-fitting wells for floods by elevating the apron and hand pump are high for the poor communities in rural areas.

- *Non Financial Barriers:* The TWG identified inadequate information and knowledge as a non-economic/financial barrier that affects the diffusion of building a concrete apron/collar on the well. There is currently little information in Zambia on ways of improving resilience to flooding and the required skills and experience necessary in drilling this type of wells and basic concrete construction skills are inadequate.

Barriers to Technology Diffusion in the Agriculture and Food Security Sector

Conservation Farming with Agro-forestry

- *Non Financial Barriers:* For this technology, only non-financial barriers were identified. The first was the low acceptance of conservation farming with agro-forestry by farmers. The second was the poor access of farmers to farming inputs such as seed and fertilizers.

Integrated Production System

- *Economic and Financial Barriers* The high start-up cost of investing in integrated production systems is a barrier that has affected the diffusion of this technology by small scale farmers.

- *Non Financial Barriers* Inadequate information on integrated production systems was one of the two non-economic/financial barriers identified. This was said to arise from the poor linkage between departments at the Ministry of Agriculture and Livestock Development (MALD), specifically between veterinary, fisheries and agriculture (extension and research) departments. Added to this departmental fragmentation, most of the current structures of the ministry do not reach the community level for effective and holistic outreach to farmers on integrated farming. The other barrier was the fact that integrated farming was labour intensive and there is inadequate manpower in most households to adopt this production system.

Promotion of Drought and Tolerant and Early Maturing Crop Varieties

- *Economic and Financial Barriers*: Inadequate access to improved seed by small farmers due to relatively high cost of improved seed varieties arising from the high cost of research and breeding of new varieties. The capital investment costs include among others purchase of new seed varieties, labour time, training costs, on-farm equipment and field trips.

- *Non Financial Barriers:* However, the non financial barriers identified were firstly inadequate information on promotion of early maturing crop varieties and secondly, inadequate access to drought, stress, heat, pest, diseases, soil acidity tolerant and early maturing crop varieties.

Identified Measures

After a thorough understanding of the barriers (through the RCA process), the TWGs proceeded with analyzing measures of how the barriers could be overcome. According to TNA Guidebook, the term 'measure' is used as a general concept for any factor (financial or non-financial) that enables or motivates a particular course of action or behavioral change with the objective of overcoming a barrier. Below are the measures to address the different barriers and root causes to the diffusion of the selected technologies for water, and agriculture and food security sectors identified above.

Measures for Diffusing Technology in the Water Sector

Small Reservoirs and Micro- Catchments Technology

- *Economic and Financial Measures:* The high price of construction materials e.g. cement has contributed to the failure of this technology to be adopted. Therefore, the recommended measure that can enhance the adoption of small reservoirs and micro-catchment adaptation technology is to provide subsidies on selected construction materials. This will consequently cause the price to come down. This recommendation can either be addressed by the project or the government depending on the implementation framework of the project.

- *Non Financial Measures:* The proposed measures that would combat the inadequate technical skills in constructing and dams and micro-catchments include firstly, the provision of scholarships to government staff who have little or no technical skill in constructing dams and micro-catchments. Secondly, the introduction of outreach programmes, visitations and brochure distribution would serve as an opportunity for creating awareness and sensitizing.

Boreholes/Tube wells Adaptation Technology

- *Economic and Financial Measures* The high cost of construction materials for drilling and installing boreholes/tube wells requires can be mainly offset by introducing subsidies on such materials.

- *Non Financial Measures* In view of the unsuitability of boreholes/tube well technology in certain parts of Zambia, there is need to produce data/maps that clearly shows the areas where this proposed technology is best suited in Zambia. In addition, there is need to have Land Use Plans (LUPs) which will foster planned settlements. In a bid to enhance technical skills in the design and construction of boreholes/tube wells, there is need to raise awareness in training institutions about the benefits of this adaptation technology.

Building of a concrete apron/collar on the well Adaptation Technology

- *Economic and Financial Measures:* The high cost of materials used to improve wells is mainly due to the high price of cement which is induced by high demand of construction materials. There is therefore need to lobby for increased investment in manufacturing of building materials. On the other hand, there is need to encourage the transportation of building materials using the railway line which is recommended for bulky goods and cost-effectiveness.

- *Non Financial Measures* The inadequate information and knowledge regarding the building of a concrete apron/collar on the well can be addressed by identifying institutions that can undertake sensitization programmes. Secondly, there is need to promote information sharing through the existing structures such as D-WASHE and V-WASHE.

Measures for Diffusing Technology in the Agriculture and Food Security Sector

The measures that were identified in the agriculture and food security sector were as follows:

Conservation Farming with Agro-forestry

- *Non Financial Measures* The low acceptance of conservation farming with agro-forestry can be addressed by raising awareness of the long term benefits of conservation farming to farmers using participatory approaches such as the farmer field school models.

Integrated Production Systems

- *Economic and Financial Measures:* Since the adoption of integrated production system is negatively affected by the high start-up cost of investment, the propose measure is to establish a credit facility that will empower the targeted farmers to venture into integrated production system.

- *Non Financial Measures:* In order to address the barrier of inadequate information on integrated production system, there is need to provide funds for production of user-friendly 'how-to manuals' so that farmers can easily access this information. The re-establishment of the position of the Research and Extension Liaison Officer position in the Ministry of Agriculture and Livestock Development will greatly help in coordinating information flow. In addition, the barrier of labour intensity of integrated production system can be addressed by firstly promoting integrated farming on scales that are manageable to farmers and secondly, promotion of farm mechanization.

Promotion of Crop Diversification and New Varieties

- *Economic and Financial Measures* It was admitted that the process of coming up with suitable seed varieties from research to marketing will always make hybrid seed more expensive. There is also need to encourage seed companies to use cheaper methods of seed production such as the 2-way cross method.

- *Non Financial Measures* In terms of addressing the barrier of inadequate information on promotion of early maturing crop varieties, there is need to enhance the production of brochures and leaflets on early maturing varieties in local languages. In a bid to address the barrier on inadequate access to crop diversification and new varieties, there is need to promote consumption of hybrid seed, promote use of quality declared seed (QDS) to farmers and lobby government to encourage public-private partnerships in the supply of genuine seed.

Summary and Conclusions

This barrier analysis and enabling framework process to assess and understand barriers facing the transfer and diffusion of the prioritized technologies for climate change adaptation in Zambia in the water and agriculture and food security sectors took a very consultative process. The primary task was to understand the nature of the individual barriers, relationships between the barriers, determine which barriers were important, and identify barriers that were easiest to remove. The Technical Working Groups representing key stakeholders (Annex II) in the two sectors sifted through a lot of information to identify the barriers and proposed measures for overcoming them. The result of the process was a list of barriers, their root causes and the measures to overcome them.

One barrier identified consistently throughout was the high cost of the required inputs to the technology whether it was equipment, building materials or seed. This is a reflection of the high cost of doing business in the country as well as impediments to financing investors and individuals face. The barrier is not climate change adaptation specific but cuts across everything of commercial value.

Inadequate information as a barrier was common to most of the technologies proposed in the agriculture sector but was also true with respect to promoting flood-resilient improved wells. In agriculture, the root causes were varied. Some had to do with the attitude of small scale farmers while others had to do with the organizational capacity weaknesses of the Ministry of Agriculture and Livestock Development.

There were also barriers specific to each technology. Although it is easier to find synergies in addressing common barriers, synergies could also arise in the way solutions are applied for technology-specific barriers. What is important, therefore, at action planning and project ideas is to have a more holistic view of things and ensure that barriers are not looked at as absolutely delinked from each other either in the constraint they impose or the way the measures to relieve them are applied.

1. Introduction

The Technology Needs Assessment (TNA) for Zambia for climate change adaptation has four (4) main deliverables namely; TNA Report, Barrier Analysis and Enabling Framework Report, Technology Action Plans and Project Ideas. Figure 1 shows these deliverables and their content.

Figure 1: Main deliverables of the TNA Project

The initial TNA report (GRZ, October 2012) focused on the process of identifying, prioritizing and selecting sectors and technologies to be taken to the barrier analysis stage. Two sectors, the Water and Agriculture and Food security sectors were selected. This report on *Barrier Analysis and Enabling Framework* is a second deliverable and analyses the likely barriers to transfer the identified technologies and suggests options/measures to address the identified barriers in the two sectors. Its main aim is to assess and overcome barriers facing the transfer and diffusion of technologies for climate change adaptation in Zambia in the water and agriculture and food security sectors. It also proposes the enabling framework for technological diffusion.

Under the Water sector, the prioritized technologies were the following:

1. Rain water collection from ground surfaces - small reservoirs and micro-catchments,
2. Boreholes/tube wells for domestic water supply during drought,
3. Building a concrete apron/collar around the well.

In the agriculture and food security sector, the prioritized technologies were:

1. Conservation Farming with Agro-forestry (Faidherbia albida, Tephrosia vogelii, Sesbania sesban and Gliricidia sepium)
2. Integrated crop-small livestock-fish-poultry-vegetable production system
3. Crop diversification and new crop varieties.

During the Barrier Analysis and Enabling Framework process the following steps were followed:

- *Organizing the process:* The TNA project places great importance on stakeholder consultations. It is against this background, that various stakeholders were invited to a workshop in Lusaka on 29th October 2012 to be exposed to the methodology of conducting barrier analysis and to kick start the process. Two technology working groups (TWGs) were formed at the workshop, one for water and the other for agriculture and food security. In each of these TWGs, the qualitative methods of data collection which included group discussions and key informant interviews were employed to solicit information on the barriers, root causes of the barrier and the related measures of the barriers. The stakeholders were mainly drawn from the University of Zambia (UNZA), Government agencies such as Ministry of Energy and Water Development and Ministry of Lands, Natural Resource and Environmental Protection. The Private sector was represented by Saro Agro Industrial Limited.[2] In the case of conservation farming with agro-forestry, primary data from the experiences of farmers in Southern Province of Zambia was used during the identification of barriers in the agriculture and food security sector. The main role of the consultant was to facilitate or guide the discussions of the meetings. The TWGs for the water sector and agriculture and food security sectors held a number of meetings between 29th October and 16th November 2012 to identify barriers and measures for technology diffusion. The consultant also went back for further interviews with the experts that had been talked about the technologies selected with a view to refine information for cost benefit analysis.[3]

- *Identifying the barriers:* This included the identification of barriers that could hinder the acquisition and diffusion of the prioritized technologies. Part of the time at the workshop was spent by the two TWGs identifying barriers for each of the technologies listed above. This was carried on in subsequent meetings of the TWG.

- *Screening the barriers:* The identification resulted in a long list of barriers. When all barriers were identified, the barriers were screened for non-relevance or according to their significance through TWG participants arguing for and against the barriers.

- *Decomposition of barriers:* This process was undertaken to break down the barriers after screening them into component elements. The discussions centered on whether some barriers were composed of some of the other barriers, or whether one barrier was just a more concrete formulation of an overall barrier category.

- *Root cause Analysis (RCA):* This approach was done as part of the method of problem solving to the root causes of barriers identified. The RCA practice was used as it tries to solve problems by attempting to identify and correct the root causes of events, as opposed to simply addressing their symptoms and also it allowed the TWGs to look beyond the solutions to the problems and understand the underlying cause(s) of the situation (see Annex I).

  Root Cause Analysis (RCA) is a method of problem solving that tries to identify the root cause of faults or problems that cause operating events. By focusing on the correction of root causes, problem recurrence can be prevented. RCA requires the investigator(s) to look beyond the solution to the immediate problem and understand the fundamental or underlying cause(s) of the situation and put

[2] See list of TWG participants attached as Annex II
[3] List of names included in Annex II

them right, thereby preventing re-occurrence of the same issue. There may be more than one root cause for an event or a problem, the difficult part is demonstrating the persistence and sustaining the effort required to determine them. The purpose of identifying all solutions to a problem is to prevent recurrence at lowest cost in the simplest way. If there are alternatives that are equally effective, then the simplest or lowest cost approach is preferred.

The '5 Whys', which is the simplest method for structured root cause analysis, was the approach taken in this process. It is a question asking method used to explore the cause/effect relationships underlying the problem. The facilitator kept asking the question 'Why?' to the participants until meaningful conclusions were reached. It is generally suggested that a minimum of 5 questions need to be asked, although during the process additional questions were asked before the real cause was identified. In short it was asking why the problem occurred, and then continued to ask why that happened until it reached a point where the process could not continue. The root cause analyses of the identified barriers under each of the technologies are shown in Annex IA below.

- *Measures:* The process of finding solutions comprised of translating barriers into measures.

- *Cost Benefit Analysis:* Parallel to discussions above, the consultant undertook further consultations with technology experts to collect more or refine information for Cost Benefit Analysis. Secondary materials were also consulted. Cost Benefit Analysis had been conducted at the TNA stage to get a preliminary view of the economic benefit of the proposed technologies. The process used is discussed in summary in Section 2.2.4.

2. Water Sector

Despite Zambia having abundant surface water resources, communities living in arid parts of the country in Agro-ecological Region I experience severe water shortage during the hot dry season. On the other hand, some parts of the Region have increasingly become prone to floods during the rainy season. Both of these reduce communities' access to good quality water. Droughts reduce water quality as it dries up water bodies such as streams and shallow wells. When this happens, households have to travel long distances in search of water. At times, animals and human beings begin to compete for water. In this situation, the probability of water being contaminated rises. Floods as well reduce the water quality as the floodwaters carry pollutants and fecal matter into the water bodies. Amidst the seemingly abundant water, quality water is actually scarce. Even improved wells if not designed to be resilient to floods would get damaged or easily contaminated.

2.1 Preliminary Targets for Technology Transfer and Diffusion in the Water Sector

The Vision of the water and sanitation sub-sector in the Sixth National Development Plan (SNDP) is spelt as: "*a Zambia where all users have access to water and sanitation and utilise them in an efficient and sustainable manner for wealth creation and improved livelihood by 2030*" (GRZ, 2011). The SNDP also recognizes the challenges climate change poses to the water sector. In the SNDP, climate change is thus treated as a cross-cutting issue for all sectors and a very serious problem that could reverse the gains. The SNDP includes specific objectives to deal with climate change adaptation in the water sector as follows (*Ibid*, p.15):

1. To achieve sustainable water and resource development for social and economic development
2. To strengthen capacity for disaster risk management, mitigation and adaptation to effects of climate change

The diffusion of the three technologies prioritized during the TNA stage is meant to contribute to this vision and sector objectives. However, the objectives with regards to the diffusion of the three technologies are thus to ensure that:

1. Communities in Agro-ecological Region I have access to quality water both for production and domestic consumption throughout the year; and,
2. Communities in flood prone areas in Region I protect their water sources during floods.

The National Action Plan for Adaptation points out that the most vulnerable region to climate change is Region I (GRZ, 2007). Therefore, the main target groups for actions on climate change adaptation in the water sector with respect to the selected technologies are communities of Region I. Climate change has been evident in Region I over the years. The historical rainfall patterns indicate a decreasing trend of annual rainfall (GRZ, 2007). The region is considered a drought-prone/risk area. At the same time, the region is increasingly becoming prone to floods. Most communities in this region face the challenge of accessing clean water for home use, crop production as well as watering their animals.

It is proposed to establish a Pilot Project on Climate Change and Water access to cater for the issues observed above. The pilot project will target a total of 13,500 households in Region I. Table 2 provides the number of households to be targeted with each technology and the associated costs. The preliminary costs of a five year pilot climate change and water access project is estimated at US$17.4 million. It is envisaged that as the pilot project shows good results, it could be rolled out to other areas especially Region II where droughts and floods are also increasing in frequency.

Table 2: Preliminary Targets for the Pilot Climate Change and Water Access Project

Technology	Number of HH	Number of Installations	Cost Per Installation (US$)	Maintenance Cost and Community Facility Management /Yr (US$)	Total Cost (US$)	Project Admin Cost (10% of total costs)	Overall Project Cost
Small reservoirs & micro catchments	1,500	15	284,000	5,680	4,345,200	434,520	4,779,720
Building a Concrete Apron/Collar on the well	10,000	1,000	4,000	5,000	9,000,000	900,000	9,900,000
Borehole/ tubewell with overhead tank and a solar powered pump	2,000	200	12,000	240	2,448,000	244,800	2,692,800
Total	13,500	1,215			15,793,200	1,579,320	17,372,520

2.2 Rain water collection from ground surfaces – small reservoirs and micro- catchments

2.2.1 General Description

Rainwater harvesting has been practiced for hundreds of years in many different countries, in many different ways, but generally with only one purpose: to ensure easy access to a reliable source of water, be it for drinking purposes, irrigation, livestock or some other use. It is a good way to smooth out the risks communities face as erratic rainfall patterns become more prevalent. Rainwater harvesting is defined as a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions. Both small and large scale structures are used for rainwater harvesting collection and storage including water pans, tanks, reservoirs and dams (GRZ, October 2012).

This type of technology/practice involves two broad categories:

i. Collecting rainfall from ground surfaces utilizing "micro-catchments" to divert or slow runoff so that it can be stored before it can evaporate or enter watercourses; and;

ii. Collecting flows from a river, stream or other natural watercourse (sometimes called floodwater harvesting). This technique often includes an earthen or other structure to dam the watercourse and form "small reservoirs."

Micro-catchments are often used to "store" water as soil moisture for agriculture. Small reservoirs are typically used in areas with seasonal rainfall to ensure that adequate water is available during the dry season (Elliot, et al, August 2011).

The collection and storage infrastructure can be natural or constructed and can take many forms and these may include some of the following:

i. Below ground tanks (i.e. cisterns) and excavations (either lined for waterproofing or unlined) into which rainwater is directed from the ground surface. Volumes of these are typically small and they are usually used by one household or institution (e.g. a school or health clinic).

ii. Small reservoirs with earthen bunds or embankments to contain runoff or river flow. The earthen bunds or embankments are typically built from soil excavated from within the reservoir to increase storage capacity. A spillway or weir allows controlled overflow when storage capacity is exceeded. Surveys of small reservoirs in Ghana and Sri Lanka revealed a wide range of surface areas and volumes; median surface areas for Ghana and Sri Lanka were 5 ha and 12 ha, respectively. The mean storage volume in Ghana was roughly 50,000 m^3.

iii. Groundwater aquifers can be recharged by directing water down an unlined well. Groundwater recharge is also an added benefit of unlined reservoirs; stored water will infiltrate permeable soils during storage and eventually reach the groundwater table.

2.2.2 Identification of Barriers for Diffusion

The TNA project places great importance on stakeholder consultations. It is against this background, that various stakeholders were invited to a workshop in Lusaka, on 29th October 2012 to be exposed to the methodology of conducting barrier analysis for the adaptation climate change technologies. A water technology working group (TWG) was formed (see list of TWG participants attached as Annex IIA) and had two follow-up meetings on the 7th and 16th November 2012 on the barrier analysis process.

Barriers once screened were put into two categories, i.e. economic and financial barriers, and non-economic and financial barriers. The decomposition of barriers provided in Table 1 was done according to the TNA Guidebook on barrier analysis (Boldt, et al, January 2012) which has suggested decomposing barriers at four levels:

1. Broad categories of barriers
2. Barriers within a category
3. Elements of barriers
4. Dimensions of barrier elements

2.2.2.1 Economic and Financial Barriers

Only one barrier fell in the economic and financial category, i.e. the high cost of adopting the technology. The decomposition (see Table 3a) and the root cause analysis (see Annex I) give the underlying causes for this barrier. Mainly the construction of dams involves use of heavy equipment imported from abroad. High landing cost of the machinery due to the country's distance from sea ports, high customs duty and high interest rates if the equipment were to be financed with a bank loan make it difficult to acquire the necessary equipment for dam construction. Currently, the relevant government departments for dam construction are poorly equipped and very little by way of installing this technology in rural areas is therefore taking place. Besides costly equipment, prices of construction materials such as cement were also said to be very high. Mobilization costs are also very high due mostly to the high cost of fuel.

Table 3a: Decomposed Barriers to the Diffusion of Small Reservoirs and Micro- Catchments Technology – Economic and Financial Barriers

Barrier	Broad Category	Barriers within a category	Elements of Barriers	Dimensions of Barrier Elements
The cost of adopting this technology is very high	Economic and financial	The price of construction/building materials is very	• High demand for construction/building materials	• Huge infrastructure deficit leading to massive construction projects
		Mobilization costs are very	• The high cost of fuel	• Cumbersome procurement process • Too many taxes on oil
		Construction equipment is very expensive	• High duties on imported machinery • High landing costs • High interest rates	• Few sources of tax revenue • Long distance to ports

2.2.2.2 Non-Financial Barriers

The non-financial barrier in installing small reservoirs and micro-catchments identified was the inadequate technical skills in constructing dams and micro catchments. A further decomposition (Table 3b) and root cause analysis (Annex I), show that the shortage of skills is as a result of the low number of people being trained in the field caused by a number of factors. A culture that makes training in technical skills not to be preferred was one underlying factor identified. This is caused by gender stereotypes, absence of programs offering career guide courses to train a pool of career guide specialists and the absence of outreach efforts by tertiary institutions offering technical training to promote their programs in technical skills.

Besides Zambia's population's bias against technical skills, inadequate training facilities and equipment also led to few people to be trained in technical skills. The underlying factors are mostly economic and financial, i.e. the high cost of training equipment, high import duties, high landing costs due to long distances to ports. The same factors were said to lead to the high cost of training which makes it difficult for such training to be provided.

Table 3b: Decomposed Barriers to the Diffusion of Small Reservoirs and Micro- Catchments Technology – Non-Financial Barriers

Barrier	Broad Category	Barriers within a category	Elements of Barriers	Dimensions of Barrier Elements
Inadequate technical skills for designing and constructing of dams and micro-catchments?	Human skills	• Few people being trained in the field	• Culture (technical skills/ training not preferred)	• No effective career guide programs in higher institutions of learning • Lack of outreach programs from training institutions
			• Inadequate training facilities & equipment	• High cost of equipment • High import duties • High landing costs due to long distance to ports
			• High cost of training	• High cost of equipment • High import duties • High landing costs due to long distance to ports • Long training duration

2.2.3 Identified Measures

After a thorough understanding of the barriers (through the RCA process), the water TWG proceeded with analyzing measures of how the barriers could be overcome. According to the TNA Guidebook, the term 'measure' is used as a general concept for any factor (financial or non-financial) that enables or motivates a particular course of action or behavioral change with the objective of overcoming a barrier. The measures to address the different barriers and root causes to the diffusion of small reservoirs and micro-catchments adaptation technology can also be classified into two categories i.e. economic and financial and non-financial measures.

2.2.3.1 Economic and Financial Measures

To deal with the high cost of construction materials, two measures proposed were meant to reduce their price, i.e. increase supply through greater investment in the manufacturing of such materials and an accelerated investment in infrastructure so that the deficit could be reduced and demand for construction/building materials stabilized. Admittedly, the last measure would make things worse in the short run but should contain the upward pressure on prices in the long run. To deal with high mobilization costs, because the main underlying factor here was the cost of fuel, it was proposed that the numerous taxes imposed on oil along its value chain be streamlined and reduced. A search for alternative and cheaper sources of fuel including bio-fuel should be accelerated as well. The Government of the Republic of Zambia should also consider a subsidy on fuel for climate change projects. For the high cost of imported heavy equipment, proposed measures for creating an enabling environment for the diffusion of this technology centred on promoting greater access to finance for contractors.

Table 4a: Overcoming Barriers to Adoption of Small Reservoirs and Micro- Catchments – Economic and Financial Measures

Barrier	Root Causes	Proposed Measures
The cost of adopting this technology is very high	The price of construction/building materials is very	• Promote investments in the manufacturing of building materials • Accelerate investment in infrastructure such as housing to reduce deficit and demand • Promote access to finance by reducing commercial bank's reliance on physical collateral when providing credit for construction
	Mobilization costs are very	• Streamline fuel procurement process & reduce number of taxes. • Promote use of alternative and cheaper sources of fuel
	Construction equipment is very expensive	• Promote conditions for access to affordable finance for the procuring equipment • Encourage commercial banks not to use physical collateral as the only requirement when giving out loans

2.2.3.2 Non-Economic and Financial Measures

The main identified barrier here was the inadequate technical skills for constructing dams and micro catchments which is caused by the few government staff who possess the relevant technical skills. With this is mind, there is need for the Pilot Project for Water Access to provide scholarships for skills development in dam and micro-catchment. There will also be need to raise awareness of these scholarships to the relevant government by means of outreach programs, visitations and distribution of brochures. See Table 4b for details.

Table 4b: Measures to Overcome Barriers to Small Reservoirs and Micro- Catchments Technology

Barrier	Root Causes	Dimensions of Barrier Elements
Inadequate technical skills in designing and constructing of the technology	• Culture (technical skills/ training not preferred)	• Review current education system to change people's mindset to value every sector and job • Introduce career guide courses at tertiary level • Promote outreach programs to provide intensive information for awareness and sensitization: booths, brochures, open days, etc.
	• Inadequate training facilities & equipment	• Promote conditions for access to affordable finance for procuring equipment • Promote easier conditions for training institutions accessing finance – less reliance on physical collateral by commercial banks
	• High cost of training	• Provide scholarships for skills development in dam and micro-catchment construction

2.2.4 Cost Benefit Analysis

With measures determined, a cost benefit analysis (CBA) needed to be presented with a view to demonstrate that the technology will improve the situation for the users. It is noted here that this is not a project/programme CBA but of the technology itself at the point of adoption by the users. For each prioritised technology during the TNA stage, a CBA was conducted so that only technologies clearly deemed as beneficial to users were included for barrier analysis. A summary of results was represented in the TNA report. The detailed results and assumptions used are presented in Tables 5 and 6 for the small reservoirs and micro-catchment technology.

The summary steps in calculating CBA.[4] is provided here. CBA is a method widely used to assess the desirability of a given action, which could be a policy, project or programme, on the basis of whether the benefits outweigh the costs. Across a range of alternatives, the idea is to select a choice that offers maximum benefits at least cost. To do this, it is possible to rank the benefit cost ratios (BCR) of alternative actions and then choose an action with the highest ratio. Applying CBA to the prioritization of technologies for climate change adaptation followed the steps recommended by the UN Framework Convention on Climate Change as given below (UNFCCC, 2011):

1. *Agree on an Adaptation Objective*
2. *Establish a Baseline*
3. *Quantify and Aggregate Costs and Benefits of the Adaptation Intervention*
4. *Compare the aggregated Costs and Benefits:* To do this, the Net Present Value (NPV) and the Benefit Cost Ration (BCR) have been used. The NPV is "*the difference between the present value of cash inflows and the present value of cash outflows*".[5] The BCR is the ratio of the benefits of a technology in this case expressed in monetary terms, relative to its costs, also expressed in monetary terms.

This CBA is done from the perspective of households in terms of the benefits and costs of the adaptation technology compared to a business as usual baseline situation. The baseline situation in this case involves farm households growing vegetables common in some parts of Region I.[6] Tomato was picked because it is the most common vegetable grown. Households water their gardens using buckets with water drawn from a

[4] For a fuller description, please refer to Section 4.5 of the TNA adaptation report.
[5]see http://www.investopedia.com/terms/n/npv.asp#ixzz1sTrlbKbt
[6] RuralNet Associates Limited conducted a detailed investigation of one of these communities in Sinazongwe (Vwavwa) from December 2009 to March 2011 as part of a study for UNICEF on Shifting Vulnerabilities. Community members grow vegetables which they sale to Choma and Maamba. A number of assumptions here are based on the results of that study supplemented with some key informant interviews. See RuralNet Associates Limited, 2011

stream. Gardens are sited near a stream but a lot of man-days are used in walking to and from the stream to draw the water. Furthermore, the streams are usually seasonal and tend to dry up quickly. The household can therefore only do one cycle of vegetable growing in a year. Given the labour constraints and the erratic supply of water, farm households growing vegetables can only manage 0.25 lima.

The adaptation technology on the other hand, involves building a small dam and farm households irrigating their vegetables through furrow system. The labour requirement is reduced and the farm households are able to grow two cycles of vegetables on the same piece of land up to 1 lima for a year. The yield increases significantly from 1.8 MT to 15 MT per lima because of the ease with which water is accessed and its constant supply throughout the year.

Table 5: Descriptive Information and Assumption for Small Reservoir and Micro-catchment Technology

	Conventional Technology	Adaptation Technology
Description	- Irrigating the field using the water from the nearby stream	- This technology involves collecting clean surface water or ground water into a small dam.
Adaptation Objective		- To harvest the rain water to be used for irrigation to mitigate high temperatures & droughts.
Key Assumptions	- Farmers could walk10m to fetch water to and from stream to water garden[7] - Irrigation using buckets - One cycle of vegetable production in a year[8] - Total of 4 workers - Unit Labour cost at $2.3/man-day[9] - Mandays:290/16=18.13[10] - Total land cultivated: 0.25 Lima of tomatoes[11] - Selling price is $0.35 per kg[12]	- Dam able to support 100 households - The Dam is for the community considered a public good - Irrigation using furrows - Two cycles of vegetable production in a year - Total of 2 workers - Unit Labour cost at $2.3/man-day - Mandays:290/4=72.5 - Total land cultivated: 1 Lima of tomatoes - Selling price is $0.35 per kg
Benefits	- Yield: 1,800kg/ 0.25 Lima[13] - Income: $630.73	- Yield:15,000 kg/Lima[14] - Income: $10,512.13
Breakdown of costs[15]	- Seed, fertilizer and Chemicals: $64.88 - Mandays: 18.13*$2.3= $41.69 - Repairs & maintenance :3% of Variable Costs=$3.20 - Total Variable costs(TVC) + Interest=$131.72 - Fixed costs=30% (TVC + Interest): $39.52 - Total costs=$171.72	- Seed, fertilizer and Chemicals: $259.53 - Mandays: 72.5*$2.3= $166.75 - Repairs & maintenance:3% of Variable Costs=$12.79 - Total Variable costs(TVC) + Interest=$1,053.76 - Fixed costs=30% (TVC + Interest): $316.13 - Total costs=$ 1,369.88
Total costs	- Total investment costs=$ 171.72	- Total investment costs=$ 1,369.88

With these benefits and despite the higher costs, the NPV of US$82,491 and US$78,149 discounted at 5% and 10% respectively for the adaptation technology was better than the NPV of US$4,361 and US$4,131 at the same respective discount rates (see Table 6). Equally, a 7.67 BCR for the micro-catchment technology was higher than that for the conventional technology which was 3.67.

[7]RuralNet Associates Limited, 2011.
[8] Interview with Killian Muleya, Senior Technical officer-Land husbandry section; Technical Service Branch, Sinazongwe distrtict
[9] Zambia National Farmers Union (2011): Enterprise Budgets, Lusaka.
[10] ibid
[11] ibid
[12] ibid
[13] ibid
[14] ibid
[15] Costs of inputs are based on enterprise budgets compiled by the Zambia National Farmers Union.

Table 6: Net Present Value for 10 Year Horizon and Benefit Cost Ratio: Small Reservoir and Micro-catchment

							With Adaptation			Without Adaptation		
Year	Benefits with adaptation	Benefits, without adaptation (Baseline)	Additional enefits, Total	Costs, with adaptation	Costs, without adaptation (baseline)	Additional Costs, total	Net Benefits with adaptation	Discounted Net Benefits 5%	Discounted Net Benefits 10%	Net Benefits without adaptation	Discounted Net Benefits 5%	Discounted Net Benefits 10%
1	10512.13	630.73	9881.4	1369.88	171.72	1198.16	8683.24	8249.08	7814.92	459.01	436.06	413.11
2	10512.13	630.73	9881.4	1369.88	171.72	1198.16	8683.24	8249.08	7814.92	459.01	436.06	413.11
3	10512.13	630.73	9881.4	1369.88	171.72	1198.16	8683.24	8249.08	7814.92	459.01	436.06	413.11
4	10512.13	630.73	9881.4	1369.88	171.72	1198.16	8683.24	8249.08	7814.92	459.01	436.06	413.11
5	10512.13	630.73	9881.4	1369.88	171.72	1198.16	8683.24	8249.08	7814.92	459.01	436.06	413.11
6	10512.13	630.73	9881.4	1369.88	171.72	1198.16	8683.24	8249.08	7814.92	459.01	436.06	413.11
7	10512.13	630.73	9881.4	1369.88	171.72	1198.16	8683.24	8249.08	7814.92	459.01	436.06	413.11
8	10512.13	630.73	9881.4	1369.88	171.72	1198.16	8683.24	8249.08	7814.92	459.01	436.06	413.11
9	10512.13	630.73	9881.4	1369.88	171.72	1198.16	8683.24	8249.08	7814.92	459.01	436.06	413.11
10	10512.13	630.73	9881.4	1369.88	171.72	1198.16	8683.24	8249.08	7814.92	459.01	436.06	413.11
Total	105121.3	6307.3	98814	13698.8	1717.2	11981.6	86832.4					
NPV	NPV= $\sum$ Net Benefits$_t$ / $(1+i)^t$, Where t is the year and i is the discount rate.							82,491	78,149		4,361	4,131
BCR	Benefits/Costs								7.67			3.67

2.3 Barrier Analysis and Possible Enabling Measures for Boreholes/Tube Wells for Domestic Water Supply Technology

2.3.1 General Description

According to the technology fact sheets compiled at TNA stage, tubewells are a narrow, screened tube or casing driven into a water bearing zone of the subsurface. Boreholes are tubewells that penetrate bedrock, with casing not extending below the interface between unconsolidated soil and bedrock. Tubewells can often be installed by hand-auguring while boreholes require a drilling method with an external power source. A hand-powered or automated pump is used to draw water to the surface or if the casing has penetrated a confined aquifer, pressure may bring water to the surface. A tubewell consists of a plastic or metal casing; usually 100-150 diameter, in unconsolidated soils, a “screened” portion of casing below the water table that is perforated, a “sanitary seal” consisting of grout and clay to prevent water seeping around the casing and a pump to extract the water.

To further enhance productivity, it is proposed that the boreholes/tube wells have a *Solar powered pump for water supply photovoltaic system (PVP)* with a particular focus on Agro-ecological Region I. Although the technology is relevant to the other agro-ecological areas, its adaptation to the higher frequency of droughts due to climate change is in focus here. In this system, the women and children will not spend time operating the hand pump. The time would then be used in other productive activities. The water pump is powered by solar and will involve pumping the water into an overhead tank which later flows down using gravity. The PVP equipment would comprise of:

- PV generator which generally constitutes one or more polycrystalline photovoltaic solar module;
- Inverter which converts direct current (DC) into alternating current (AC). This is not applicable when the pump is for DC;
- Pumping system, this could be DC or AC; and,
- Overhead tank for water storage.

2.3.1.1 Market Mapping for Borehole/Tube-Well Technology

Solar powered boreholes/tube-wells depending on how they are utilized could be either market goods or public goods. As conceived here, where the technology is utilized at community level with each facility servicing a community, the facility qualifies as a public good. However, the technology itself remains a market good in the sense that it has to be acquired in the market place. Therefore, a market map for the technology needed to be drawn to identify actors in the market.

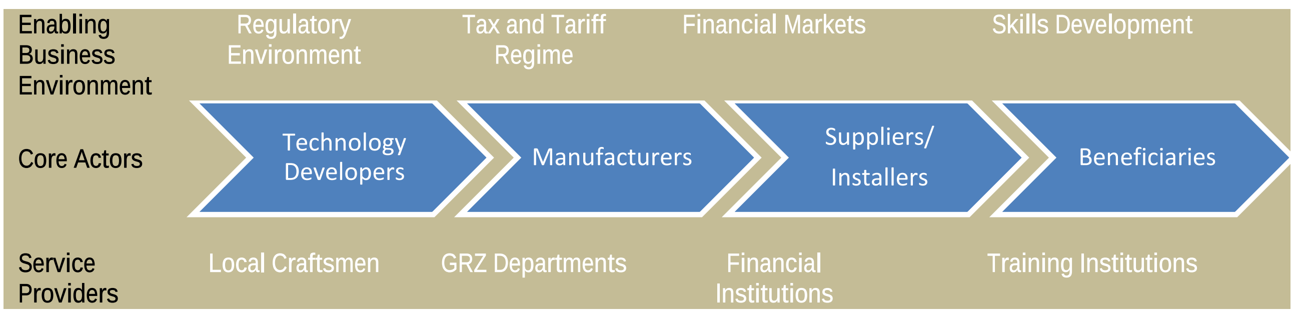

Figure 2: Market Map for the Boreholes/Tube-Wells Technology

Figure 2 above is the market map for the solar powered boreholes/tube-wells technology. As for any market map, there were three broad categories of players, i.e. those who formed the enabling business environment, the core actors and the service providers. Four types of actors formed the enabling business environment. First were the regulators especially those administering the Water Act, the Land Act, the Agriculture Act and the Local Government Act. Second were actors related with the tax and tariff regime, various government departments as well as the Zambia Revenue Authority, including the customs officials that administered the various taxes. Given that most parts of the technology are imported, the tax and tariff regime is an important part of the enabling business environment. Financial markets are the third aspect of the enabling business environment for this technology. Acquisition of the technology and the capacity to successfully install it where it is needed is expensive. Access to funding from the financial markets would help facilitate this. Well functioning financial markets of commercial banks and non-bank financial institutions is very important in supporting an environment in which this technology would be promoted. The fourth aspect of the enabling business environment is skills development. Appropriate skills for developing and installing the technology in different environments ought to be readily available if the technology is to be successfully promoted.

The core actors in the market chain of the solar driven boreholes/tube-wells technology also fell into four categories. The first were the technology developers. Most of the components of this technology is imported from outside Zambia. However, there is need to adapt it to Zambian conditions. There have been some efforts at this through research institutions such as the National Institute of Scientific and Industrial Research (NISIR) and the Technology Development Unit (TDAU) at the University of Zambia. Both of these institutions have worked closely with the Ministry of Energy and Water Development to test various types of technology and adapt it to the Zambian environment. The second category of the core actors are manufacturers. Although much of the technology is imported, there are some components such as water tanks, casings and pipes which are manufactured in the country. Suppliers, who are the third category of the core actors, have to pull these different components of the technology together to offer a one stop shop service. They often offer installation services as well. However, there are also private firms specializing in installation as a standalone activity.

Lastly and most important among the core actors are the beneficiaries. These are the target of the adaptation technology proposed here. The communities live in the rural semi-arid regions of Agro-ecological Region I. Crops and livestock production are their main livelihoods. Some artisanal fishing is done in the Zambezi river and Lake Kariba but agriculture is the dominant activity. It is however beset with a lot of challenges. The increasing frequency of droughts, floods and extreme weather make agriculture a very risky enterprise. Agriculture is also beset by seasonality challenges given the long dry period. Inadequate access to markets and unfavourable price are the other challenges. For communities with access to sizeable urban markets, the growing of vegetables such as tomatoes and onions has seen a rising trend in the last few decades. The targeted beneficiaries of the solar powered boreholes/tube-wells are therefore in desperate need of this technology to be assured of water supply for domestic use and for watering their gardens and livestock. They are not in a position to acquire this technology as individuals but would benefit greatly from an initiative that delivers this as a public good.

Service providers identified included, energy suppliers like local craftsmen needed to perform some repairs and maintenance. Projects often identify and train them in how to repair or maintain certain parts of the technology. Financial institutions, i.e. commercial banks and non-bank financial institutions, where the other set of service providers. GRZ departments responsible for the policy and regulatory framework and training institutions were also identified as important service providers in the solar powered boreholes/tube wells adaptation technology.

2.3.2 Identification of Barriers to Diffusion of Technology

The barriers to the boreholes/tube wells adaptation technology identified by the TWG are presented in Table 7 below. They can as in Section 1.2.2 be grouped into two categories, economic/financial and non-economic/financial barriers.

2.3.2.1 Economic and Financial Barriers

As with the construction of dams, there was only one economic/financial barrier identified for the diffusion of boreholes/tube wells technology, i.e. the high cost of drilling and installing bore holes/tube wells. The costs are related to material acquisition and the process of construction including mobilization/demobilization, drilling, casing and completion, and development and test pumping. See Table 7a for details.

Table 7a: Decomposed Barriers to the Diffusion of Boreholes/Tube wells Adaptation Technology

Barrier	Broad Category	Barriers within a category	Elements of Barriers	Dimensions of Barrier Elements
Cost of drilling and installing boreholes/tube wells is very expensive	Economic and financial	The price of construction/building materials is very	• High demand for construction/building materials	• Huge infrastructure deficit leading to massive construction projects
		Mobilization costs are very high	• The high cost of fuel	• Cumbersome procurement process • Too many taxes on oil
		Construction equipment is very expensive	• High duties on imported machinery • High landing costs • High interest rates	• Few sources of tax revenue • Long distance to ports

2.3.2.2 Non-Economic and Financial Barriers

Two non-economic/financial barriers were identified. The first was that some areas in the country are not suitable for this technology. Although this could be due to geological factors such as the soil type the identified site and rocky and sandy places, other factors were poor water quality due to pollution and the depletion of ground water sources. Underlying factors for the former include effluent in places with a lot of industrial activity, indiscriminate use of agriculture chemicals and simply activities that have been sited in wrong places. In the case of the latter, unsustainable farming methods and deforestation, one of the most rapid in Africa, were said to be contributing to depletion of ground water sources. The second barrier was inadequate technical skills in construction. This has been exacerbated by the length of training program that involves engineering and the inadequate incentives that the few trained personnel get.

Table 7b: Decomposed Barriers to the Diffusion of Boreholes/Tube wells Adaptation Technology – non-economic and financial

Barrier	Broad Category	Barriers within a category	Elements of Barriers	Dimensions of Barrier Elements
Some places in the country are not suitable for this type of technology	Others – Geological landscape, Environmental regulation	Pollution of ground water sources	• Industrial effluent • Indiscriminate use of agricultural chemicals • Wrongly sited activities	• Inadequate use of Land Use Plans • Weak enforcement of regulations • Inadequate knowledge of proper use of agriculture chemicals
		Ground water depletion	• Unsustainable farming Methods • Deforestation	• Weak enforcement of regulations • Inadequate knowledge in sustainable agriculture
		Rocky, sandy and some soil type not recommended	• Geological formation	

Table 7b: Decomposed Barriers to the Diffusion of Boreholes/Tube wells Adaptation Technology (*Continued*)

Barrier	Broad Category	Barriers within a category	Elements of Barriers	Dimensions of Barrier Elements
Inadequate technical skills in designing and constructing boreholes/wells	Human skills	• Few people being trained in the field	• Culture (technical skills/ training not preferred)	• No effective career guide programs in higher institutions of learning • Lack of outreach programs from training institutions
			• Inadequate training facilities & equipment	• High cost of equipment • High import duties • High landing costs due to long distance to ports
			• High cost of training	• High cost of equipment • High import duties • High landing costs due to long distance to ports • Long training duration

2.3.3 Identified Measures

The proposed measures for overcoming the identified barriers are presented in Table 8. The economic and financial measures identified were similar for those of small reservoir and micro-catchments in Table 4 because the barrier related to the high cost of the technology with similar root causes. The non-economic/finance measures were more diverse. A number of environmental regulatory measures were proposed to ensure that underground water sources remained safe and therefore the technology could be utilized in more areas than is currently the case. Available skills for designing and installing the technology needed to be promoted through career guidance at secondary and tertiary level and outreach programmes from higher institutions of learning, expected to bring about a change in the mindset of the population that has tended to shun these skills.

Table 8: Measures to Overcome Barriers to the Diffusion of Boreholes/tube wells Adaptation Technology

Barrier	Root cause(s)	Proposed Measure(s)
High cost of drilling and installing boreholes/tube wells	The high price of building materials (e.g. cement) due to high demand	• Promote investments in the manufacturing of building materials to increase supply • Accelerate investment in infrastructure to reduce deficit
	High mobilization costs due to The high cost of fuel	• Streamline fuel procurement process, reduce number of taxes & promote transparency • Promote use of alternative and cheaper sources of fuel
	High cost of imported heavy equipment	• Promote conditions for ease of access to affordable finance for procuring equipment • Remove import duties on construction equipment
Some places in the country are not suitable for this type of technology	Polluted ground water sources due to industrial effluent and wrongly sited activities	• Enforce environmental laws and other regulations • Sensitize industries on environmental pollution issues • Promote the development and enforcement of land use plans as a management tool
	Indiscriminate use of agricultural chemicals leading to ground water contamination	• Promote effective regulation of the use of agricultural chemicals • Increase awareness on use of agricultural chemical to farmers
	Unsustainable farming Methods leading to ground water depletion	• Promote sustainable farming methods such as conservation farming practices

Table 8: Measures to Overcome Barriers to the Diffusion of Boreholes/tube wells Adaptation Technology (continued)

Barrier	Root cause(s)	Proposed Measure(s)
Inadequate technical skills in the designing and construction of boreholes /tube wells	Culture (technical skills/ training not preferred)	• Promote outreach programs; visitations and brochures for intensive information awareness and sensitization • Introduce career guide courses at tertiary level and create a pool of career guide specialists
	High cost of training equipment	• Remove duty on imported training equipment • Promote conditions for ease of access to affordable finance for procurement and importation of training equipment
	Inadequate training facilities & equipment	• Remove duty on imported training equipment • Promote conditions for ease of access to affordable finance for procurement and importation of training equipment

2.3.4 Cost Benefit Analysis for Borehole/tube-well with Overhead Tank and a Solar Powered Pump

The rationale and steps for conducting cost benefit analysis are provided in Section 2.2.4. The key assumptions required in the calculation of the BCR and NPV for the borehole/tube wells are shown in Table 9. The baseline scenario is that households are forced to draw water from a stream about 1 kilometre away because their shallow wells dry up during the dry season or are inaccessible/contaminated during the rainy season due to floods. Households are therefore prone to water diseases and lose time that they could otherwise employ in productive activities.

Unlike in the previous case of dams, the benefits of the baseline scenario have been set at zero because. from an economic point of view, benefits of the adaptation technology consist in the workdays gained by avoiding lost workdays due to sickness and the cumbersome process of drawing water from a stream to water the garden. They can use this time gained on any economic or social activity. A shadow price is applied on the time gained by utilizing the average wage of US$2.3 for a work day.

Table 9: Descriptive Information and Assumption for Borehole/tube-well with Overhead Tank and a Solar Powered Pump Technology

	Conventional Technology	Adaptation Technology
Description	- Obtain water from a stream. Shallow well not accessible for most parts of the year due to drought and floods as a result of the effects of climate change. the year	- Borehole/tubewell with water pump powered by solar pumping water into an overhead tank which later flows down using gravity.
Adaptation Objective		-To supply water from the boreholes to the communities affected by the droughts when the water levels are very low - Borehole supplies four different outlets, designed to reduce the time spent on the queue for water collection
Key Assumptions	- People walk 1 km to draw water from the stream - Family prone to water borne diseases - Family spend 2 hrs/day to collect water thrice a day - Unit Labour cost at $2.3/day or $0.2875/hr of an 8 hrs workday. - Two or three adults per household. - Two adults in HH fall sick once a year due to water borne diseases - Average of 2 work days lost per case of adult diarrhea[16] - Three children fall sick each twice a year due to water borne diseases - An adult caregiver of the sick child loses 2 days of production time each time a child falls sick	- People walk to draw water from the borehole within the community
Benefits	- Baseline scenario with benefits put at zero.	- Benefits (=gains of not incurring manday losses due to walking long distance for water and high incidence of disease) Production days due to reduced incidence of illness: - 2 adults x once in year x 2 workdays = 4 workdays gained - 3 children x 2/yr x 2 days of adult workdays gained from avoiding care giving =12 workdays - Workday gained = 16 x $2.30 = $36.8 - Value of workdays gained due to ease of availability of water: 2hrs x 30days x $0.2875/hr =$17.25[17] - Value of Annual time gained=$36.8 + $17.25 = $54.05
Breakdown of costs	- No monetary costs incurred	- Equipment costs & Installation Costs: $11,320.75 (not imputed to household)[18] - Contribution to maintenance costs including borehole community management @ $10[19]
Total costs	-	- Total investment costs=$ 10.00

Table10 are the calculations of the BCR and NPV. The adaptation technology has an NPV of US$418 and US$396 at a discount rate of 5% and 10% respectively. The NPV and BCR for the baseline or business as usual scenario were set at zero as explained above. From Table 10, we note that benefits of adaptation technology are not very significant. However, it should be considered that there are many human development and social related benefits attributable to accessing safe water throughout the year. Some of

[16] Guy Hutton and Laurence Haller, Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level, http://www.who.int/water_sanitation_health/wsh0404.pdf
[17] 2 hours is based on observations from the Splash Baseline Survey, undertaken by RuralNet Associates Limited, 2012
[18] Based on a quotation obtained from Ganga Drilling & Exploration Ltd, Lusaka
[19] Splash Baseline Survey, Op Cit

these benefits would include a better health status and higher education outcomes for children because they can consistently attend school and learn without the distraction of sickness.[20]

Table 10: Net Present Value for 10 Year Horizon and Benefit Cost Ratio: Borehole/tube-well With Overhead Tank and a Solar Powered Pump

							With Adaptation			Without Adaptation		
Year	Benefits with Adaptation	Benefits, without adaptation (Baseline)	Additional Benefits, Total	Costs, with adaptation	Costs, without Adaptation (baseline)	Additional Costs, total	Net Benefits with adaptation	Discounted Net Benefits 5%	Discounted Net Benefits 10%	Net Benefits without adaptation	Discounted Net Benefits 5%	Discounted Net Benefits 10%
1	54.05	0	54.05	10	0	10	44.05	41.85	39.65	0.00	0.00	0.00
2	54.05	0	54.05	10	0	10	44.05	41.85	39.65	0.00	0.00	0.00
3	54.05	0	54.05	10	0	10	44.05	41.85	39.65	0.00	0.00	0.00
4	54.05	0	54.05	10	0	10	44.05	41.85	39.65	0.00	0.00	0.00
5	54.05	0	54.05	10	0	10	44.05	41.85	39.65	0.00	0.00	0.00
6	54.05	0	54.05	10	0	10	44.05	41.85	39.65	0.00	0.00	0.00
7	54.05	0	54.05	10	0	10	44.05	41.85	39.65	0.00	0.00	0.00
8	54.05	0	54.05	10	0	10	44.05	41.85	39.65	0.00	0.00	0.00
9	54.05	0	54.05	10	0	10	44.05	41.85	39.65	0.00	0.00	0.00
10	54.05	0	54.05	10	0	10	44.05	41.85	39.65	0.00	0.00	0.00
Total	540.5	0	540.5	100	0	100	440.5					
NPV	NPV=$\sum$ Net Benefits$_t$ / $(1+i)^t$, Where t is the year and i is the discount rate.							418	396		0	0
BCR	Benefits/Costs								5.41			0

2.4 **Barrier** Analysis and Possible Enabling Measures for erecting a collar around wells

2.4.1 General Description

This technology aims at ensuring good quality water in situations of increased occurrence of floods. It involves enhancing wells at design and construction stages for high resilience to flooding. Wells not properly designed and constructed to provide high resilience to flooding are vulnerable during flooding and may lead to water contamination, collapse of the well or failure by the community to reach the water point when the area gets submerged.

The specific technology selected was the building of a concrete apron/collar on the well. This requires changing the design of most wells provided in Zambia by building concrete works on the well and around the well. The concrete rings would form an apron/collar of 1.5 m high and 3.0m in diameter. The slope of

[20] Although CBA requires that we assign monetary value on all possible benefits and costs, we were unable to find clear examples of how to capture and monetize social and human development benefits of access to safe water.

the base is 45-degrees, gradual enough to prevent damage to the base during flooding. The wells would be operated with the hand pump (GRZ, October 2012).

2.4.1.1 Market Mapping for erecting a collar around the wells

It is expected that building a concrete apron/collar around a well will be mostly utilized at community level as proposed in our preliminary targets. However, the technology itself would have to be obtained from the market place and therefore a market map was necessary to understand market linkages and the nature of actors involved. Actors were found similar to those for the solar powered boreholes/tube-wells technology found in Figure 2. See Figure 3 below for the market map for protected wells.

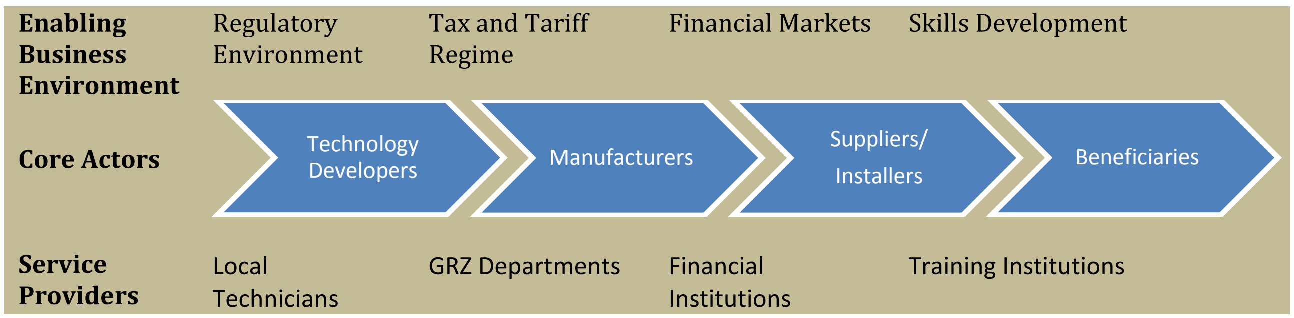

Figure 3: Market Map for Protected Wells

2.4.2 Identification of Barriers to Diffusion of Technology

Following the same process as in the previous two cases, two key barriers were identified by the TWG as seen in Table 11. Although only two such barriers were identified, they were nevertheless categorized into the two broad categories of financial and non-financial categories as in the two technologies presented previously.

2.4.2.1 Economic and Financial Barrier

The economic/financial barrier to the diffusion of building a concrete collar/apron around a well was the high cost of materials especially cement. Although the elements leading to the high cost are different, this barrier is similar to the economic and financial barriers identified in the first two technologies discussed above.

Table 11a: Decomposed Barriers for erecting a collar around the wells

Barrier	Broad Category	Barriers within a category	Elements of Barriers	Dimensions of Barrier Elements
The high cost of materials for use to improve the wells	Economic and financial	• High price of construction materials such as cement • High cost of transportation of cement	• High cost of cement • High cost of fuel • High cost of pan bricks	• A bag of cement costs on average ZMK65,000 (US$ 13) • One pan brick would cost ZMK 7,000 (US$ 1.4) • Cost of diesel per litre is ZMK 7,890 (US$ 1.56)

2.4.2.2 Non-Economic and Financial Barriers

Inadequate information and knowledge was the non-economic/financial barrier identified by the TWG. This referred to the fact that there was little information currently in Zambia on ways of improving building a concrete collar around a well and that the needed skills and experience necessary in drilling this type of wells and basic concrete construction skills were inadequate.

Table 11b: Decomposed Barriers for erecting a collar around the wells

Barrier	Broad Category	Barriers within a category	Elements of Barriers	Dimensions of Barrier Elements
Inadequate information and knowledge by the intended users of the technology	Information and awareness	• Inadequate sensitization campaigns • Inadequate coordination amongst organizations involved in sensitization campaigns resulting in duplication of roles	• Inadequate personnel (extension officers) • Platforms for dialogue and information sharing not effective	• Inadequate funds

2.4.3 Identified Measures

Through the Root Cause Analysis process, the water TWG identified and proposed measures for both the financial and non-financial barriers. The financial measures proposed are similar to that already discussed above given that the identified barrier was the high cost of materials. However, there were some differences in the details. The material referred to by the TWG in this case were cement, pan bricks and fuel. Measures proposed were thus meant to address these barriers. The non-financial measures that were proposed to deal with the barrier of inadequate information and knowledge of erecting a collar around the wells involved employing personnel for awareness creation, creation of platforms for information sharing, identifying specific institutions to undertake sensitization programs on water quality and also supporting the existing platforms for program implementation using structures such as D-WASHE. See Table 12 for details.

Table 12: Measures to Overcome Barriers to erecting a collar around the well

Barrier	Root cause(s)	Proposed Measure(s)
The high cost of materials for use to improve the wells	High price of cement	• Promote investments in the manufacturing of building materials • Accelerate investment in infrastructure such as housing
	High cost of mobilization	• Streamline fuel procurement process, reduce number of taxes & promote transparency • Promote use of alternative and cheaper sources of fuel
	High cost of equipment	• Promote conditions for ease of access to affordable finance for the procuring equipment
Inadequate information and knowledge by the intended users on the technology	• Inadequate sensitization campaigns • Inadequate coordination amongst organizations involved in sensitization campaigns resulting in duplication of roles	• Employ more extension staff for sensitization campaigns • Creation of more forums for inter-departmental dialogue and collaboration on water, sanitation and hygiene • Support existing platforms for program implementation such as D-WASHEs • Identify specific institutions to undertake sensitizations programs on water, sanitation and hygiene

2.4.4 Cost Benefit Analysis for Building a Concrete Apron/Collar on the well

The rationale and steps for conducting cost benefit analysis are as provided in Section 2.2.4. The case for adaptation and its benefits are similar to the previous case of borehole/tubewell as both are about domestic water supply for a community of up to 75 households. The only difference is that the number of working days gained is slightly lower because of loss of time fetching water from a well compared from a solar powered borehole designed to supply water to four water points. See Table 13 for the key assumptions of this cost benefit analysis for building a concrete apron/collar on the well.

Table 13: Descriptive Information of building a concrete collar/apron around a well

	Conventional Technology	Adaptation Technology
Description	- Obtain water from a stream. Well destroyed by floods.	- A well built for resilience against destruction or contamination during floods.
Adaptation Objective		- To supply water to the community from a borehole with a concrete/apron collar so that the community could access water even during floods.
Key Assumptions	- People walk 1 km to draw water from the stream - Family prone to water borne diseases - Family spend 2 hrs/day to collect water thrice a day - Unit Labour cost at $2.3/day or $0.2875/hr of an 8 hrs workday. - Two or three adults per household. - Two adults in HH fall sick once per year - Average of 2 work days lost per case of adult diarrhea - Three children fall sick each twice a year - Adult caregiver of sick child loses 2 days of production time each time a child falls sick	- People walk to draw water from the well within the community

Benefits	- Baseline scenario with benefits put at zero.	- Benefits (=gains of avoiding workday losses due to walking long distance for water and high incidence of disease)
		- Production days due to reduced incidence of illness:
		  - 2 adults x once in year x 2 workdays = 4 workdays gained
		  - 3 children x 2/yr x 2 days of adult workdays gained from avoiding care giving =12 workdays
		  - Workday gained = 16 x $2.30 = $36.8
		- Annual time gained due to ease of availability of water: 1hr x 30days x $0.2875/hr =$8.63
		- Value of Annual time gained=$36.8 + $8.63 = $45.43

Breakdown of costs	- No monetary costs incurred	- Well & Apron Costs: $4,000[21] - Contribution to maintenance costs including well community management @ $5[22]
Total costs	-	- Total investment costs=$ 5.00/yr

The Benefit Cost Ration (BCR) and Net Present Value (NPV) for building a concrete collar/apron around a well are presented in Table 14.

[21] Based on a quotation obtained from Ganga Drilling & Exploration Ltd, Lusaka
[22] Based on SPLASH study findings. Community members were generally asked to contribute K2,500 towards well maintenance and management.

Table 14: Net Present Value for 10 Year Horizon and Benefit Cost Ratio for Building a Concrete Apron/Collar on the Well

							With Adaptation			Without Adaptation		
Year	Benefits with adaptation	Benefits, without adaptation (Baseline)	Additional Benefits, Total	Costs, with adaptation	Costs, without Adaptation (baseline)	Additional Costs, total	Net Benefits with Adaptation	Discounted Net Benefits 5%	Discounted Net Benefits 10%	Net Benefits without adaptation	Discounted Net Benefits 5%	Discounted Net Benefits 10%
1	45.43	0	45.43	5.00	0	5	40.43	38.41	36.39	0.00	0.00	0.00
2	45.43	0	45.43	5.00	0	5	40.43	38.41	36.39	0.00	0.00	0.00
3	45.43	0	45.43	5.00	0	5	40.43	38.41	36.39	0.00	0.00	0.00
4	45.43	0	45.43	5.00	0	5	40.43	38.41	36.39	0.00	0.00	0.00
5	45.43	0	45.43	5.00	0	5	40.43	38.41	36.39	0.00	0.00	0.00
6	45.43	0	45.43	5.00	0	5	40.43	38.41	36.39	0.00	0.00	0.00
7	45.43	0	45.43	5.00	0	5	40.43	38.41	36.39	0.00	0.00	0.00
8	45.43	0	45.43	5.00	0	5	40.43	38.41	36.39	0.00	0.00	0.00
9	45.43	0	45.43	5.00	0	5	40.43	38.41	36.39	0.00	0.00	0.00
10	45.43	0	45.43	5.00	0	5	40.43	38.41	36.39	0.00	0.00	0.00
Total	454.3	0	454.3	50	0	50	404.3					
NPV	$NPV=\sum Net Benefits_t / (1+i)^t$, Where t is the year and i is the discount rate.							384	364		0	0

2.5 Linkages of the Barriers Identified

The linkages between the barriers identified in previous sections should first of all be seen from the view point of the preliminary targets set above. A key objective for the water sector in providing the adaptation technologies identified is to assure access to good quality water for domestic and production use despite the effects of climate change – drought, floods and extreme temperatures. Because all the three technologies revolve around this key objective, it is not surprising that the identified barriers are closely related. Three barriers were mentioned in at least two technologies – the high cost of installation, the inadequate technical skills in producing and installing the technology and that the technology could not be applied to all areas of Zambia for varying reasons.

The cost of acquiring and installing the three types of technology is high. Cost for a dam are estimated at US$284,000 for a small dam below the depth of 10m, US$378,000 for a medium dam (between 10 to 15m depth) and US$1,133,000.00 for a large dam.[23] The cost for a solar powered borehole was estimated at between US$8,000 and US$12,000.[24] Lastly, wells with an apron or collar were estimated to cost US$5,800. These are high costs for an individual household, community or even government or charitable

[23].Interview with Mr. Albert Chongo, Water Engineer, Water Board, March 2012

[24]Interview with Mr. Albert Chongo, Water engineer, Water Board, March 2012, SARO Agriculture Engineering Limited and Mr. Chibesakunda, Commercial Manager, SunPower Africa both August 2012.

organization to provide. The technology is by its own nature very expensive given the various components involved and the equipment used in installing it. However, this is made worse by the high tariff rates charged on imported capital equipment and the inadequate access to affordable loans from financial markets in Zambia. Furthermore, inputs required in installation such as cement are expensive because of the huge infrastructure deficit the country faces. The water sector infrastructure deficit is thus just a part of the story and competition is high for materials used in construction.

Inadequate technical skills and experience necessary in the design and construction of these technologies was said to arise from the low number of people trained in the necessary skills due to various reasons including non-preference of these careers by college entrants, high cost of training equipment and an unsuitable school curriculum.

2.6 Enabling Framework for Overcoming the Barriers in the Water Sector

2.6.1 Common Barriers

The common barriers identified in the water sector were the high cost of construction/building materials and inadequate technical skills in constructing the technologies. The common barriers opened up opportunities for synergies in terms of enhancing measures to overcome them, even though there were some differences in some details. Arising from these synergies, enabling access to good quality water despite the effects of climate measures are required to promote and implement policies that will achieve the following:

- Zero rating import duty on bulk equipment for construction of technologies for climate change adaptation for a period of at least 5 years. The cost of equipment for installation of the technology is very high and hence needs government intervention.
- Provision of scholarships to enhance technical skills in the proposed technologies.
- A strong Public Private Partnership policy framework to promote capacity building and dialogue platforms for skills development.
- Promoting conditions that would ease access to affordable finance for the procuring of equipment.

For barriers specific to a technology, measures as proposed above should be implemented to foster a supportive enabling framework.

3. Agriculture and Food Security Sector

The agriculture sector faces many challenges that undermine its ability to be the main driver of economic development and a meaningful provider of incomes and employment to the country. Farmers struggle with diseases and pests, high input prices, an unsupportive macro-economic environment and inappropriate sector policies. In the recent past the sector has been faced with the negative effects of climate change especially in Agro-ecological Regions I and II. Below, we describe the effects of climate change in the different sub-sectors of agriculture.

The key climate change hazards affecting small and medium scale farmers in crop production are droughts and floods. Droughts besides damaging crops also create the loss of crop land and water shortages in communities. Floods on the other hand create excessive precipitation that leads to water logging, soil erosion and hindrance to field operations. Again these effects result in crop failure. Besides frequent droughts and floods, the increase in the occurrence of extreme temperature has been noted for their adverse effects on crops. The agricultural sector in sub-Saharan Africa is predicted to be especially vulnerable to climate change because this region already endures high heat and low precipitation, provides the livelihoods of large segments of the population, and relies on relatively basic technologies, which limit its capacity to adapt (Centre for Environmental Economics and Policy in Africa, 2006, p.7).

The rise in the frequency of droughts and floods is also a major concern to livestock producers. Droughts lead to loss of grazing land, decreased livestock feed and water shortages for animals. Ultimately animals get malnourished and there is a higher incidence of livestock diseases. During drought periods, households dependent on cattle are very vulnerable. In such moments, these farmers tend to resort to distress selling to avoid losing their animals completely as well as to mitigate for the general effects of droughts including crop loss as seen above.

There is an obvious relationship between extreme temperature and livestock productivity. When temperatures are high, the population of livestock reduces and when the temperature is low, the population of livestock increases. According to the Assessment of Impact and Adaptation to Climate Change (AIACC) Study with the Gwembe Valley as a case study, the greatest correlation between climatic indicators and livestock population was observed in cattle (Assessment of Impacts and Adaptation to Climate Change, 2002). As temperatures rose, the cattle population reduced, and as they fell, the population increased. In the same vein, when rainfall increases, livestock productivity improves on account of increased availability of pasture leading to good nutrition and enhanced immunity to diseases.

Thus the negative impacts of Climate change on agriculture are diverse. All the sub-sectors of the agriculture sector are adversely affected. Producers (small, medium and commercial farmers) are all very vulnerable, but especially small scale farmers whose resilience is extremely low because they produce at very low scale in the first place and have few resources to help them recover quickly. Since the producers are inter-linked with other actors in the value chain, the adverse impacts of the hazards inevitably affect actors like input suppliers, intermediaries (processors, wholesalers, retailers) and consumers (local and foreign) through various transmission mechanisms.

The SNDP vision for the agriculture sector is "*an efficient, competitive, sustainable and export-led agriculture sector that assures food security and increased income by 2030*"(GRZ, 2011).This is supposed to be achieved by promoting crops, livestock and fisheries production through higher commercialization.

Unfortunately climate change is threatening the country's potential to realize its vision for the agriculture sector in the coming years. Therefore, adaptation measures to climate change are urgent for Zambia to achieve her development objectives.

3.1 Preliminary Targets for Technology Transfer and Diffusion

3.1.1 Target Group

The main target groups in the agriculture and food security sector are the producers who belong to Region I. Depending on their scale of operation, the producers can be classified as small scale, medium scale and commercial scale producers. The producers are mostly engaged in crop, livestock and fish production as a way of increasing household food security and income levels. However, the most vulnerable producers to the negative effects of climate change are the small scale farmers in Region I. As already noted, Region I is extremely vulnerable to climate change. At the same time, the agriculture sector is one of the most vulnerable sectors to climate change consequences. These two aspects put together make it highly necessary that interventions be instituted to address the consequences.

To address these concerns, it is proposed to establish a Pilot Smallholder Climate Change Resilience (PSCCR) Project and its preliminary targets are provided in Table 15. .

Table 15: Preliminary Targets for the Pilot Smallholder Climate Change Resilience and Adaptation Project

Technology	Number of Households	Cost Per Household (US$)	Total Direct Costs	Project Admin Cost (15%)	Total Cost
Conservation farming with Agro-forestry	3,000	943	2,829,000	424,350	3,253,350
Integrated small livestock-fish-poultry-vegetable production system	500	1,938	969,000	145,350	1,114,350
Promotion of drought-tolerant and early maturing food crops (cassava).	3,000	300	900,000	135,000	1,035,000
Total	**6,500**		**4,698,000**	**704,700**	**5,402,700**

Although this is a separate project from the Pilot Climate Change and Water Access Project, synergies could be drawn from the two projects drawn to ensure maximum impact given that they will cover the same region. The PSCCR project will have the following specific objectives:

1. Enable farmers in Agro-ecological Region I achieve higher yields with less water and less chemicals while conserving soil fertility;
2. Help farmers build crop resilience to diseases, pest organisms and environmental stresses; and,
3. Enable farmers spread the risk widely by diversifying their enterprises while in the process making their farming systems more profitable

A brief explanation of the preliminary targets for each technology is as follows:

- *Conservation farming with Agro-forestry:* The pilot project will target 3,000 agricultural HHs in Region I who will each be supplied with 100 agro-forestry tree species to be planted on a 1 hectare plot of land.

- *Integrated Production Systems:* The pilot project will target 500 agricultural HHs who will each be assisted to acquire fingerlings, livestock (5 goats & 10 ducks), sorghum and sugar beans and vegetable seeds sufficient for a 1.25 Ha plot of land.

- *Promotion of drought and early maturing varieties:* The pilot project will target 3,000 agricultural HHs who will each be supplied with drought and early maturing seed varieties of cassava and sorghum.

3.1.2 Cost of Technology diffusion

The literature review indicates the following costs for each technology:

- *Conservation farming with agro-forestry*: The cost of a Faidherbia albida seedling (musangu tree), as an example, is ZMK 5000 ($0.93). A total of 100 trees are required for 1 hectare piece of land. A total of ZMK 5,000,000 ($943) would be an investment cost for a small scale farmer with 1 hectare piece of land in Zambia. Therefore, the cost for the 3,000 agricultural households will be $2,829,000.

- *Integrated production system*: The estimated capital cost of a small medium farmer who is engaged in mixed production system (farming) of fish[25], livestock (5 goats & 10 ducks), crops (sorghum & sugar beans), and vegetables (cabbage) on a 1.25 ha of land is US$1,937.37[26]. Therefore, the estimated cost for the 500 agricultural HHs will be US$968,690.

- *Promotion of drought and early maturing varieties*: The capital investment costs include among others; purchase of new seed varieties, labour time, training costs, on-farm equipment and field trips in a project in Mexico, estimated total costs of a five-year project involving around 1,000 farmers came to around $300,000 (Smale et al, 2003)[27]. This translates to a unit cost of $300 per farming household. Therefore, the cost to cover 3,000 agricultural households will be $900,000.

3.1.3 Time frame of implementation

It is proposed that the pilot project runs for five years covering the 2014/15 to 2019/20 agricultural seasons. This has been proposed so that the effects of promoting conservation farming with agro-forestry could begin to show.

3.2 Barrier Analysis and Possible Enabling Measures for Conservation Farming With Agro-forestry

3.2.1 General Description

The main objective of conservation farming with agro-forestry is to fertilize the field where food crops like maize are intercropped. There are numerous benefits that are attributed to this farming practice. These include enhanced food crop yield as a result of intercropping with nitrogen-fixing trees. For instance,

[25] International Journal of Fisheries and Aquaculture Vol. 2 (15), pp.271 – 278, 23 December 2011: Profitability analysis of small scale aquaculture enterprises in Central Uganda.
[26] Zambia National Farmers' Union (ZNFU): Enterprise Budgets, Lusaka, Zambia, 2011.
[27] Clements, R., J. Haggar, A. Quezada, and J. Torres (2011). TNA *Guidebook series-Technologies for Climate Change Adaptation-Agriculture Sector.* X. Zhu (Ed.) UNEP RisØ Centre, Rosklide, August 2011; Page 107.

Faidherbia albida is an excellent agro forestry tree that contributes to soil fertility. Organic matter, nitrogen and other nutrients are added to the soil as a result of the falling leaves and seed pods. These leaves and seed pods are used as protein-rich livestock fodder, the tree bark as a medicine and the wood for construction. Unlike other trees, Faidherbia albida produces leaves in dry season and defoliates in the rains and this reduces competition for sunshine with the cultivated crop. The root systems and higher levels of organic matter in the soil increases water retention and assists to stabilize the soil against landslides and soil erosion (GRZ, October 2012).

The main drawback of conservation farming with agro-forestry is that it is a long term investment. For instance, the Faidherbia albida tree requires more than 15 years to fully achieve its benefits on maize production. In view of this, Faidherbia albida trees are found on less than 2% of Africa's maize area and on less than 13% of its sorghum and millet area. The survival rate of the tree ranges between 15% and 60% in the fields for small scale farmers (Ibid.).

3.2.2 Identification of Barriers to Diffusion of Technology

The decomposed barriers to the diffusion of conservation farming with agro-forestry are provided in Table 16. Three barriers were identified, i.e. inadequate information about conservation farming with agro-forestry, some trees are not adapted to certain regions in the country and that agro-forestry does not produce immediate results and hence is less attractive to poor farmers trying to survive from one year to the other.

Table 16: Decomposed Barriers to Diffusion of Conservation Farming with Agro-forestry

Barrier	Broad Category	Barriers within a category	Elements of Barriers	Dimensions of Barrier Elements
Inadequate Information on conservation farming with agro-forestry	Institutional Organization Capacity	• Inadequate linkage between R&D and extension	• Abolition of the position of Research and Extension Liaison Officer in 2008 • Research and extension sections working as separate departments parallel to each other	• Inappropriate restructuring Ministry of Agriculture
		• Ineffective communication strategies	• Use of top down communication approaches	• Not enough extension officers • Grassroots structures not fully utilized in communication approaches
		• Scarcity of farmer literature in local languages	• High cost of translating farmer literature	• Scarcity of skilled personnel in translation
		• Uncoordinated information flow	• Lack of consultation with professional bodies	• Agric SAG not effective as a coordinating body • Weak professional bodies
Species may not grow in some areas	Botanical Traits	• Genetic make up	• Not much research to increase varieties suited to different regions of the country	• Poor budgetary allocation to research
Does not produce immediate benefits	Botanical Traits	• Long maturity period	• Genetic make up	• Not much research into fast growing trees with other desired traits

The first two barriers to the diffusion of this farming practice identified were non-economic/financial barriers. The barrier that conservation farming with agro-forestry does not give immediate benefits could be considered as an economic barrier in view of the opportunity cost involved. Inadequate information about conservation farming with agro-forestry is seen in the low awareness among farmers in Zambia. This was true even in regions where the right trees grew naturally. There are anecdotal reports that farmers at times cut down the trees when preparing their land. That some tree species are not adapted to some regions can be seen from the musangu tree which does not grow in high rainfall areas, specifically Region III. Lack of immediate benefits is as a result of the long maturation of agro-forestry trees which start yielding results only after 3 years. Most species will give their maximum benefit after 10 years. The musangu tree, as an example, takes 25 years to reach maximum plant canopy and hence maximum results.

3.2.3 Identified Measures

3.2.3.1 Economic and financial measures

It will be difficult for conservation farming with agro-forestry to be adopted by small farmers if there are no immediate results. Their pre-occupation is to survive in the short-term. They are too poor to invest for the long term and want immediate results. Because this has to do with the botanical traits of the species, the only way out is to develop species that have traits for fast growth and could produce results quicker. It is thus proposed that there be more research into agro-forestry tree species. Research could also focus on enhancing other desired traits such as the ability to produce large biomas.

Table 17a: Measures to Overcome Barriers to Adoption of Conservation Farming With Agro-Forestry-Economic and Financial

Barrier	Root causes	Dimensions of Barrier Elements
Does not produce immediate benefits	Long maturity period	Promote research leading to selection of desired traits of agro-forestry trees such as early maturing varieties and ability to produce large biomass

3.2.3.2 Non financial measures

The measures to deal with non-financial barriers were diverse given the range of underlying factors identified to the barrier of inadequate information on conservation farming with agro-forestry (see Table 17b). They are meant to deal with institutional and organizational weaknesses at the Ministry of Agriculture and Livestock Development (MALD) that make it difficult to produce and effectively disseminate information. The measures are meant to strengthen the research and extension linkage, promote communication strategies well adapted to grassroots structures and generally come up with strategies that are cost-effective given the funding inadequacies at MALD.

With respect to the barrier that some species are adapted to only a few regions in the country, research is again proposed develop species that could be grown more widely in the country.

Table 17b: Measures to Overcome Barriers to Adoption of Conservation Farming With Agro-Forestry – Non-Economic and Financial

Barrier	Root causes	Dimensions of Barrier Elements
Inadequate Information	Lack of linkages between R&D and extension	• Re-establish the position of Research and Extension Liaison Officer in MALD • Ensure greater coordination between the research and extension branch
	Ineffective communication strategies effective	• Employ and deploy extension staff in all camps with their activities adequately funding • Devise grassroots anchored communication strategies such as farmer field schools and radio listening groups • Promote farmer-led communication programs • Strengthen cooperatives to work as information centres
	Scarcity of farmer literature in local languages	• Help the National Agriculture Information Service acquire skilled personnel in translation
	Uncoordinated information flow	• Provide funds to promote flow of information • Strengthen Agric SAG as a coordinating body • Strengthen professional bodies to play advisory role
Species may not grow in some areas	Botanic traits	• Promote research leading to selection of desired traits of agro-forestry trees such as ability to grow all regions, early maturing variety and ability to produce large biomass

3.2.3.3 Cost Benefit Analysis of Conservation Farming with Agro-forestry

The baseline scenario is the cultivation of maize using conservation farming. The assumption is that maize is planted on one hectare of land with the farm household applying the recommended amount of fertilizer. The adaptation technology on the other hand involves introducing one of the agro-forestry tree species known. Faidherbia albida (musangu tree) is used here for illustration. Key assumptions are in Table 18.

Table 18: Description Information of Conservation Farming with Musangu Tree

	Conventional Technology	Adaptation Technology
Description	- Production of hybrid maize using conservation tillage but with application of chemical fertilizers (Compound D and Urea)	- Production of hybrid maize using conservation farming with Faidherbia albida (Musangu Tree).
Adaptation Objective		- Increase maize yields and reduce use of chemical fertilizers and have farmers more resilient to the negative effects of climate change (e.g. drought).
Key Assumptions	- 1 ha piece of land by 1 medium scale farming household[28]. - Maize is produced using chemical fertilizers such as compound D & Urea. - Land is valued at zero as this is untitled land under traditional land tenure system - $1=ZMK 5,300 - Household spends 5 hrs per day in the field. - Unit price of labour is $2.3. - Total of 70 man-days. - 10 Chaka hoes used. - Yield for maize is 5000 Kg/Ha[29]. - Unit price of maize per Kg is $ 0.4[30] - Chaka hoes to depreciate in 10 years. - Annual maintenance cost is 4% of hardware technology (Chaka hoes)[31].	Assumptions are the same as for conventional technology except for the following: - Use of Musangu Tree to supply fertilizer and lime. - Maize yield increases by an average of 30% for young Musangu Trees (<5 yrs old)[32]. - Maize yield increases by an average of 42% for mature Musangu Trees (>15 yrs old)[33]. - Thus, yield for maize is 6,500 Kg/Ha when the Musangu tree is young (i.e. less than 5 years old). - Yield for maize is 7000 Kg/Ha when the Musangu tree is mature (i.e. more than 15 years old).

[28] Zambia National Farmers Union (2011): Op cit
[29] Ibid
[30] Ibid

Table 18: Description Information of Conservation Farming with Musangu Tree (continued)

	Conventional Technology	Adaptation Technology
Benefits	- Crop yield x price=5000 Kg x $0.4x 10 years = $ 20,000	
Adaptation Technology Benefits		- Crop yield x price=7000 Kg x $0.4x 10 years = $ 28,000
Breakdown of costs	- Total Variable Cost (seed, chemicals, fertilizers, packing, labour)=$747 - Total Fixed Cost =$224	- Total Variable Cost (seed, packing, labour)=$452 - Total Fixed Cost =$224
Total costs	- Total costs=$ 970	- Total investment costs=$676

The NPV and CBA demonstrate the economic benefits that yield with young musangu trees of less than 5 years (see Table 19 for details).

Table 19: Net Present Value for 10 Year Horizon and Benefit Cost Ratio (Musangu Tree < 5 Years)

Year	Benefits with adaptation	Benefits, without adaptation (Baseline)	Additional Benefits, Total	Costs, with adaptation	Costs, without adaptation (baseline)	Additional Costs, total	Adaptation Technology			Without Adaptation Technology		
							Net Benefits	Discounted Net Benefits 5%	Discounted Net Benefits 10%	Net Benefits	Discounted Net Benefits 5%	Discounted Net Benefits 10%
1	2600	2000	600	676	971	-295	1,924	1,828	1,732	1,032	978	926
2	2600	2000	600	676	971	-295	1,924	1,828	1,732	1,032	978	926
3	2600	2000	600	676	971	-295	1,924	1,828	1,732	1,032	978	926
4	2600	2000	600	676	971	-295	1,924	1,828	1,732	1,032	978	926
5	2600	2000	600	676	971	-295	1,924	1,828	1,732	1,032	978	926
6	2600	2000	600	676	971	-295	1,924	1,828	1,732	1,032	978	926
7	2600	2000	600	676	971	-295	1,924	1,828	1,732	1,032	978	926
8	2600	2000	600	676	971	-295	1,924	1,828	1,732	1,032	978	926
9	2600	2000	600	676	971	-295	1,924	1,828	1,732	1,032	978	926
10	2600	2000	600	676	971	-295	1,924	1,828	1,732	1,032	978	926
Total	**26,000**	**20,000**	**6,000**	**6,760**	**9,710**	**-2950**	**19,240**			**10,320**		
NPV	NPV= $\sum$ Net Benefits$_t$ / $(1+i)^t$, Where t is the year and i is the discount rate.							**18,280**	**17,320**		**9,780**	**9,260**
BCR	Benefits/Costs						3.8			2.1		

It is seen that the proposed adaptation technology, i.e. conservation farming of maize with agro-forestry (Musangu tree) yielded better NPV of US$18,280 and US$17,320 at 5% and 10% discount rates respectively compared to the NPV of conventional maize cultivation of US$9,780 and US$9,260 at the two respective discount rates (see Table 19a). The BCR of 3.8 for the adaptation technology was also better than the 2.1 BCR for the conventional technology.

31 Ibid

32 Golden Valley Agricultural Research Trust (GART): 2010 Year Book; Lusaka, Zambia, Page 30 – 33.

33 Conservation Farming Unit (1996): Faidherbia albida and Conservation Farming-A long term solution for sustainable cereal production in regions of mono-modal rainfall, Lusaka, Zambia

3.3 Barrier Analysis and Possible Enabling Measures for Integrated Production System

3.3.1.1 General Description

An integrated small livestock-fish-poultry-vegetable-crop production system operates on the premise of inter-dependency. Crop production depends on the supply of animal manure. Livestock plays a key role fertilizing the fish pond and field crops. The small livestock depends on extensive grazing of natural pasture and crop residues during the dry season. This is a closed system in which waste products from one activity are used as input in the other activity. For example, the waste products from crops and vegetables are used by livestock and fish.

This integrated production system provides various benefits to farmers. For farmers with pigs, there is potential to generate bio-gas energy from the waste of pigs. It helps to maintain the environment in a sustainable way due to recycling of natural resources such as animal waste products and crop residues. In addition, there is an increase in the conservation of water resources. The water that is used by small livestock can also be transmitted to the fish pond and later used to irrigate vegetables (GRZ, October 2012).

Therefore, the production system involving non-ruminants (village chickens, ducks and pigs), ponds (fish) and annual cropping with cassava and maize production is a good option for small scale and medium scale farmers in Zambia. The proposal is for small scale farmers to be engaged in the production of non-ruminants such as village chickens, ducks and pigs and ruminants such as goats, coupled with fish farming and production of drought-tolerant cassava and early maturing maize varieties. In addition to this, vegetables can be grown using basic irrigation systems.

Small scale and medium scale farmers can benefit from the sale of pig, fish, ducks and vegetables. The non-ruminants are less location specific than ruminants and have less reliance on the land base. The growth of the poultry and pork industry in Zambia provides an assured market for the small and medium scale farmers.

A study on integrated farming systems[34] for smallholders in India conducted from 1984-2000 indicates that various integrated crop-animal systems gave highest average net returns with high employment days as compared to arable farming systems. For instance, the average net return on 1 hectare irrigated land for arable farming was $236 with 182 employment days while 1 hectare irrigated land for mixed farming with one crossbred cow was $710 with 559 employment days. The drawback with integrated small-livestock-fish-poultry-vegetable production system is that it is labour intensive and this raises the total cost of labour.

[34] Cruz EM and Shehadeh ZH. 1990. Preliminary results of integrated pig-fish and duck-fish production tests. *ICLARM Conf. Proc. N° 4* 225-238.

3.4 Identification of Barriers to Diffusion of Integrated Production Systems

3.4.1 Economic and Financial Barriers

The high start-up cost for integrated farming made the adoption of this technology by small farmers very difficult. The estimated capital cost of a small medium farmer integrated farming of fish[35], livestock (5 goats & 10 ducks), crops (sorghum & sugar beans), and vegetables (cabbage) on a 1.25 ha of land is US$1,937.37[36]. Given the high levels of poverty among small scale farmers, this is a very high figure.

Table 20: Decomposed Barriers to Diffusion of Integrated Crop-Small Livestock-Fish-Poultry-Vegetable Production Systems

Barrier	Broad Category	Barriers within a category	Elements of Barriers	Dimensions of Barrier Elements
High start-up cost of investing in integrated production system	• Economic and Financial	• High input requirements	• Need to invest in different enterprises at the same time	
Little knowledge of how to move from mixed farming to integrated farming	• Information and awareness	• Inadequate Information on integrated production systems	• Poor linkage among departments, veterinary, fisheries, agriculture, research • Most structures in MALD do not reach grassroots • Low number of extension staff • Inadequate funds for raising awareness on integrated production system	• Abolition of position of RELO • Poor budgetary allocatiobn
Labour constraints	• Social, Cultural and Behavioral	• Inadequate manpower at HH level • High cost of hired labour • Competition of farm activities	• High dependency ratio • Death/illness of production age group • Rural-urban migration by energetic age group	• High fertility • High HIV&AIDS prevalence • Low employment opportunities in rural areas

3.4.2 Non-Economic and Financial Barriers

Small farmers in Zambia although they generally practice mixed farming have little knowledge regarding integrated farming. Inadequate information was identified as the key root cause. This in turn is as a result of inadequate linkages between departments at the Ministry of Agriculture and Livestock Development, specifically between veterinary, fisheries and agriculture (extension and research) departments. Added to this departmental fragmentation, most of the current structures do not reach the community level for effective and holistic outreach to farmers on integrated farming.

The other non-economic/financial barrier was the fact that households practicing integrated farming face serious labour constraints. This is due to inadequate manpower in most households due to the high dependency ratio as a result of the high fertility ratio of the rural population. Deaths and illnesses due to HIV&AIDS, and generally the low health status in rural areas, deplete further manpower in households.

[35] International Journal of Fisheries and Aquaculture Vol. 2 (15), pp.271 – 278, 23 December 2011: Profitability analysis of small scale aquaculture enterprises in Central Uganda.
[36] Zambia National Farmers' Union (ZNFU): Enterprise Budgets, Lusaka, Zambia, 2011.

Integrated farming is inherently labour intensive and therefore such labour shortage makes it difficult to sustain the farming practice. Households will face a lot of competition for labour between different enterprises. There are few options to supplement household labour with hired labour because the latter is expensive as there is a general shortage of labour in rural communities. The high rural-urban migration by the young people due to the few employment opportunities in rural areas continues to deplete available manpower in making the labour shortage arising from the factors discussed above even worse.

3.4.3 Identified Measures

3.4.3.1 Economic and Financial Measures

The identified measure to overcome barrier of high start-up cost of investing in integrated production system is the establishment of a credit facility that will assist the targeted farmers to venture into this adaptation technology. See Table 21 for details.

3.4.3.2 Non-Financial Measures

The measures proposed for the inadequate information on integrated production system include provision of funds to translate materials, utilize cost-effective communication channels like the farmer field schools, promote farmer-led communication programs and re-establishment of the position of Research Extension Liaison Officer (RELO) (see Table 21). With regards to the barrier of the labour intensive nature of integrated farming, it was proposed that farmers should be encouraged by the promoters of integrated farming to take up the practice at the scale they could manage and upscale gradually. Promotion of farm power mechanization was the other measure to counter labour scarcity.

Table 21: Measures to Overcome Barriers for Integrated Crop-Small Livestock-Fish-Poultry-Vegetable Production Systems

Barrier	Root causes	Proposed Measures
High start-up cost of investing in integrated production system	• High input requirements	• Encourage farmers to adopt IF through a phased approach • Encourage farmers to adopt integrated farming at lower scale and expand slowly • Promote the practice of agriculture sector as a business and make it attractive for lending
Little knowledge of how to move from simple mixed farming to integrated farming	• Inadequate Information on integrated production system	• Provide funds to translate materials on integrated production system into easy-to-read and user-friendly format. • Devise cost-effective communication channels e.g. farmer field schools community schools, radio listening groups etc • Promote farmer-led communication programs • Re-establish the position of RELO
Labour constraints	• Inadequate manpower at household level • High cost of hired labour • Competition of farm activities	• Promote integrated farming at scales of production that can be managed by farmers in view of labour constraints • Promote farm power mechanization

3.4.3.3 Cost Benefit Analysis of Integrated Crop-Small Livestock-Fish-Poultry-Vegetable Production

Table 22 gives basic information for cost benefit analysis with respect to the calculation of the NPV and BCR for integrated farming systems. Table 23 on the other hand uses this information to calculate the two variables. Conventional farming (baseline scenario) is the mixed farming of small livestock, crops, fish and vegetables. As an adaptation technology, the same products are produced in an integrated manner, i.e. all the enterprises are seen as part of one production system in an inter-dependent system. It is seen that the NPV for conventional technology of US$30,170 and US$28,580at 5% and 10% discount rates respectively is less than the NPV for integrated farming of US$39,040 and US$36,980 at the respective discount rates. However, the BCR for integrated farming is nearly the same as that for mixed farming.

Table 22: Description and Assumptions of Integrated Production System

	Conventional Technology	Adaptation Technology
Description	Mixed farming involving small livestock, crop, fish, vegetable production system without integration.	- Integrated mixed farming involving small livestock, crop, fish, vegetable production system.
Adaptation Objective		- To reduce the negative effects of climatic hazards on farming households through integrated farming involving small livestock, crops, fish, and vegetable production on the same piece of land.
Key Assumptions	- Mixed farming involving production of crops (sorghum & sugar beans), vegetables (cabbages), poultry (10 ducks), small livestock (10 goats) and fish farming (3100 fingerlings)[37]. - Production system engaged by emergent farming household. - 1.50 ha of land under utilization (crop=0.50 Ha, Vegetables=0.25 ha; Fish pond=0.50 ha) and goats =0.25 ha. - Land is valued at zero due to unlimited supply in rural areas. - Farming household spends 5 hrs per day in the field. - Unit price of labour is $2.3 per day/person. - Total of 90 man-days[38]. - $1=ZMK 5,300 - 4 rippers and 8 oxen bought at USD $ 849 (ZMK 4,500,000) per ripper & 2 oxen. - The producer prices ZMK/Kg are as follows: the price of sorghum is $0.3, sugar beans is $0.94, cabbage is $0.23, fish is $2.3, ducks and goats is $1.1 per Kg. - The annual production of mixed farming (without synergies & interdependence) is as follows: sorghum (375 Kg), sugar beans (275 Kg), cabbage (7,500 Kg), ducks (20 Kg), fish (1,376 Kg) and goats (350 Kg) - Hardware equipment (rippers) depreciates in 10 years. - Annual maintenance cost is 4%[39] of total cost	Assumptions are the same as for conventional technology except for the following: - Total of 186 man[40]-days are being used. - Total costs are 29%[41] more than mixed farming enterprise. - Total revenue is 32%[42]more than mixed farming enterprise. - Crop yield reduces by 5%[43]. - Annual production of integrated mixed farming enterprise is as follows: sorghum (226 Kg), sugar beans (165 Kg), cabbage (9000 Kg), ducks (40Kg), fish (2,232 Kg) and goats (770 Kg). - Farming household spends 5 hrs per day in the field. - Livestock production increased from 10 to 15 goats in a year (by 67%).
Benefits	- $\sum$ production $_{scenario\ C0}$* Price =$56,960	$\sum$ production $_{scenario\ C1}$* Price = $73,600

[37] The commodities for mixed farming were selected in view of the climatic condition of Region I in Zambia, which is drought-prone. Therefore, drought-tolerant crops like sorghum and drought-tolerant livestock like goats have been used in this integrated model.
[38] M.S. Swaminathan (2009): Demonstration and Replication of Integrated Farming Systems at Chidambaram, India.
[39] Zambia National Farmers Union (2011): Op cit
[40] Swaminathan (2009): Op cit
[41] Ibid
[42] Ibid
[43] P. Viaux: Integrated Farming Systems and Sustainable Agriculture in France, Technical Institute of Cereals and Forages (ITFC), Boigneville, France.

	Conventional Technology	Adaptation Technology
Breakdown of costs	- Cost for cabbages: $ 1078 - Cost for duck (20): $40 - Cost for goat : $ 327 - Cost for Fish farming: $864 - Cost for sorghum: $108 - Cost for sugar beans: $103	- Cost for cabbages: $1391 - Cost for duck (20): $52 - Cost for goat : $422 - Cost for Fish farming: $1114 - Cost for sorghum: $139 - Cost for sugar beans: $133
Total costs	- Total costs=$2,520	- Total investment costs=$3,252

Table 23: Net Present Value for 10 Year Horizon and Benefit Cost Ratio for Integrated Crop-Small Livestock-Fish-Poultry-Vegetable Production

Year	Benefits with adaptation	Benefits, without adaptation (Baseline)	Additional Benefits, Total	Costs, with adaptation	Costs, without adaptation (baseline)	Additional Costs, total	Adaptation Technology			Without Adaptation Technology		
							Net Benefits	Discounted Net Benefits 5%	Discounted Net Benefits 10%	Net Benefits	Discounted Net Benefits 5%	Discounted Net Benefits 10%
1	7,360	5,696	1,664	3,251	2,520	731	4,109	3,904	3,698	3,176	3,017	2,858
2	7,360	5,696	1,664	3,251	2,520	731	4,109	3,904	3,698	3,176	3,017	2,858
3	7,360	5,696	1,664	3,251	2,520	731	4,109	3,904	3,698	3,176	3,017	2,858
4	7,360	5,696	1,664	3,251	2,520	731	4,109	3,904	3,698	3,176	3,017	2,858
5	7,360	5,696	1,664	3,251	2,520	731	4,109	3,904	3,698	3,176	3,017	2,858
6	7,360	5,696	1,664	3,251	2,520	731	4,109	3,904	3,698	3,176	3,017	2,858
7	7,360	5,696	1,664	3,251	2,520	731	4,109	3,904	3,698	3,176	3,017	2,858
8	7,360	5,696	1,664	3,251	2,520	731	4,109	3,904	3,698	3,176	3,017	2,858
9	7,360	5,696	1,664	3,251	2,520	731	4,109	3,904	3,698	3,176	3,017	2,858
10	7,360	5,696	1,664	3,251	2,520	731	4,109	3,904	3,698	3,176	3,017	2,858
Total	**73,600**	**56,960**	**16,640**	**32,510**	**25,200**	**7,310**	**41,090**			**31,760**		
NPV	NPV= $\sum$ Net Benefits$_t$ / $(1+i)^t$, Where t is the year and i is the discount rate.							**39,040**	**36,980**		**30,170**	**28,580**
BCR	Benefits/Costs						**2.264**			**2.260**		

3.4.4 Barrier Analysis and Possible Enabling Measures for Promotion of Crop Diversification and New Varieties

3.4.4.1 General Description

Climatic changes exacerbate the loss of crops due to poor moisture content in the soil as a result of poor precipitation and prolonged dry spells. Promotion of drought-tolerant and early maturing food crop varieties helps to reduce the risk of crop loss and enhance crop resilience to disease and harsh climatic conditions. Drought-tolerant and early maturing crop varieties have varied benefits. The main one is that they have a shorter maturity period as compared to traditional crop varieties. They are able to enhance plant productivity, quality, health and nutritional value and/or building crop resilience to diseases, pest organisms and environmental stresses. Improved crop varieties possess resistance to water during wet climatic conditions and heat stress during dry climatic conditions. When new crop varieties are introduced to farmers, environmentally sustainable farming practices such as minimal or no application of chemical fertilizers is emphasized.

In Zambia, various studies show that improved cassava variety has better yields compared to traditional cassava varieties. In 2006, a study on cassava as drought insurance-food security was conducted in Central Zambia (Barrat, et al, 2006).The yield for high yielding variety (HYV) of cassava was 3 tonnes per hectare as compared to 1.5 tonnes per hectare of local cassava. In 2010, FAO conducted a *study on value chain mapping and cost structure analysis for cassava in Zambia.* The results indicate that the average yield per hectare of early maturing cassava variety was 10.96 tonnes per hectare while the average yield per hectare of various traditional varieties was 4 tonnes. However, drought-tolerant and early maturing crop varieties are not without difficulty when promoting them. The main one is the cautious approach by small farmers to adopting improved crop varieties which they are not familiar with. In addition, the introduction of improved crop varieties by research institutes have at times escaped control and resulted into pests or weeds.

3.4.4.2 Identification of Barriers

Following various steps outlined in the introduction, the TWG on agriculture and food security identified the following two key barriers to the promotion of appropriate crop varieties with traits to enhance climate change adaptation: (i) Inadequate knowledge regarding drought tolerant and early maturing varieties among farmers; and (ii) inadequate access to appropriate varieties.

3.4.4.3 Economic and financial barriers

Of the two barriers in Table 24, inadequate access to drought appropriate crop varieties was deemed an economic and financial barrier because it arose mainly from the high cost of producing hybrid seed. This in turn resulted from the high cost of research and breeding new varieties. The capital investment costs include among others; purchase of new seed varieties, labour time, training costs, on-farm equipment and field trips. In a project in Mexico, estimated total costs of a five-year project involving around 1,000 farmers came to around $300,000 (Smale et al, 2003)44.

Table 24: Decomposed Barriers Against Adoption of Drought Tolerant and Early Maturing Crop Varieties

Barrier	Broad Category	Barriers within a Category	Elements of Barriers	Dimensions of Barrier Elements
Low farmer confidence in improved seed	Legal, Regulatory Environment	• Inadequate enforcement of regulations	• Low capacity by the Seed Certification Council Institute (SCCI) to enforce regulation	• Low number of staff at SCCI • SCCI's lack of power to power to prosecute offenders
Inadequate knowledge regarding new varieties	Information and awareness	• Inadequate Information on the appropriate varieties	• Poor funding of extension • Inadequate linkages between R&D and extension	• Allocation of funds biased towards FISP and FRA • Abolition of position of RELO (2008)
Inadequate access to appropriate seed varieties	Economic and Financial	• High prices of hybrid seed • Poor markets for hybrid seed • Poor storage facilities for seed in remote areas • Limited number of outlets supplying genuine seed	• High cost of producing seed varieties • Low demand of hybrid seed • Poor rural infrastructure	• Inadequate research in appropriate seed varieties • Long duration to produce seed varieties • Low consumption of traditional crops in urban areas

[44] Clements, R., J. Haggar, A. Quezada, and J. Torres (2011). TNA *Guidebook series-Technologies for Climate Change Adaptation-Agriculture Sector.* X. Zhu (Ed.) UNEP RisØ Centre, Rosklide, August 2011; Page 107.

3.4.4.4 Non financial barriers

The non-financial barrier was inadequate knowledge regarding the appropriate varieties. This arose from inadequate information being provided to farmers with respect to what varieties they should plant and the required management interventions at various stages of the production cycle. As with other technologies, inadequate information resulted from the inappropriate restructuring at the Ministry of Agriculture and Livestock which led to the abolition of the RELO position while the research and extension branch which had hitherto fallen under one directorate were elevated to directorates and started operating in parallel. This finally led to poor linkage between research and extension.

3.4.5 Identified Measures

3.4.5.1 Economic and Financial Measures

It was admitted that the process of coming up with suitable seed varieties from research to marketing will always make hybrid seed more expensive. There is therefore need to encourage seed companies to use cheaper methods of seed production such as the 2 – way cross method. On the other hand, promoting cottage seed production among small farmers could improve access because it will lead to proximity of hybrid seed supply besides improving the quantity supplied.

Table 25: Measures to Overcome Barriers Against Adoption of Drought Tolerant and Early Maturing Crop Varieties

Barrier	Root causes	Proposed Measures
Low farmer confidence in improved seed	• Inadequate enforcement of regulations Environment	• Give the Seed Certification Institute (SCCI) powers to prosecute • Employ more staff at SCCI
Inadequate access to appropriate varieties	• High prices of hybrid seed. • Inadequate supply of appropriate varieties • Poor storage facilities for seed in remote areas • Limited number of outlets supplying genuine seed	• Encourage seed companies to use cheaper methods of seed production such as the 2-way cross method. • Build capacity and devise incentives for cottage seed production so hybrid seed can be produced within their communities • Promote use of Quality Declared Seed (QDS) to farmers. • Provide storage facilities for seed across the country • Raise consumption and demand for traditional crops by promoting value addition and exports to regional and international markets
Inadequate knowledge regarding new varieties	• Inadequate Information on promotion of early maturing varieties.	• Institute intensive and sustained awareness programs for quality seed

3.4.5.2 Non-Financial Measures

The non-financial measures were meant to deal with a wide range of issues in institutional organization capacity and policy, legal and regulatory. These include promotion of quality declared seed (QDS) to farmers, promotion of value addition and consumption of hybrid crops and lobby government to encourage public-private supplying genuine seed.

3.4.6 Cost Benefit Analysis for Promotion of Crop Diversification and New Varieties

The cost-benefit analysis of promotion of drought-tolerant and early maturing varieties has used the example of cassava production. It is assumed that the small scale farmers specialize in the growing of cassava on 1 ha piece of land. Key assumptions for the CBA for cassava production are contained in Table 26.

Table 26: Description of Technology: Drought, and Early Maturing Crop Varieties

	Conventional Technology	Adaptation Technology
Description	Cultivation of local cassava variety using hand hoes on 1 ha plot of land.	- Cultivation of improved cassava variety using hand hoes on 1 ha plot of land.[45]
Adaptation Objective		- To increase yields and resilience of farmers in drought-prone areas (e.g. Region I of Zambia).
Key Assumptions	- Cultivation of local cassava variety[46] (1994/1995 farming season) - 1 ha piece of land by 1 small scale farming household. - Land is valued at zero due to unlimited supply in rural areas. - $1=ZMK 5,300 - Farming household spends 5 hrs per day in the field. - Unit price of labour is $2.3 per day/person[47]. - Total of 78man-days[48]. - 10 Chaka hoes bought at USD $ 4.7[49] each - Yield for local cassava is 4,000 Kg/ha[50] - Unit price of cassava per Kg is $ 0.0043[51] Chaka hoes depreciate in 10 years. - Annual maintenance cost is 4%[52] of hardware technology (Chaka hoes).	Assumptions are the same as for conventional technology except for the following: - Cultivation of improved cassava variety[53] (1994/1995 farming season) - Total of 87 man-days are being used[54]. - Yield for improved cassava is 5,000 Kg/Ha[55].
Benefits	- Crop yield x price=4000 Kg x $0.043x 10 years= $1,720	- Crop yield x price=8000 Kg x $0.043x 10 years= $3,440
Breakdown of costs	- Ploughing & ridging: $31 - Weeding (x2): $22 - Planting: $12.4 - Harvesting: $11.4 - Transport/Marketing: $17.2 - Total variable cost: $94 - Total fixed cost (10 Chaka hoes)=$ 24	- Ploughing & ridging: $31 - Plant protection: $3.1 - Weeding (x2): $21.7 - Planting: $15.5 - Harvesting: $12.4 - Transport/Marketing: $ 43 - Total variable cost: $ 127 - Total fixed cost (10 Chaka)=$ 24
Total costs	- Total costs=$ 118	- Total investment costs=$ 151

[45] According to cassava studies conducted by the Marketing Development Bureau in Mtwara Region (Southern Zone, Tanzania) during the 1994/95 farming season, evidence shows that when farmers use recommended practices, the net benefit per unit area and labour productivity are higher than when traditional practices are used (MDB: 1983;COSCA Tanzania, 1996).
[46] Ndunguru, G., Modasha, F. Digges, P & Ulrich, K (1994): Urban/needs assessment study for non-grain starch staple food crops in Dares-Salaam NRI-report code: NGSS 94/95 IC3.
[47] Zambia National Farmers Union (2011): Op cit
[48] Ndunguru, G., Modasha, F. Digges, P & Ulrich, K (1994): Op cit
[49] Golden Valley Agricultural Research Trust (GART): 2010 Year Book, Lusaka.
[50] Ndunguru, G., Modasha, F. Digges, P & Ulrich, K (1994): Op cit
[51] Ibid
[52] Zambia National Farmers Union (2011): Op cit
[53] Ndunguru, G., Modasha, F. Digges, P & Ulrich, K (1994): Op cit.
[54] Ibid
[55] Ibid

Information for conducting a cost benefit analysis, specifically the NPV and BCR, is in Table 27 The conventional technology is hand hoe cultivation of cassava of using a local variety. The adaptation technology is the hand hoe cultivation usingimproved variety of cassava. The cultivation of improved cassava is to be preferred over the conventional technology because it had a better NPV which was US$1,320 and US$1,250 at 5% and 10% discount rates respectively compared to US$510 and US$486 with the respective discount rates. The BCR for conventional technology which was 1.45 was lower than that of the adaptation technology of 2.28.

Table 27: Net Present Value for 10 Year Horizon and Benefit Cost Ratio for Drought, and Early Maturing Crop Varieties

Year	Benefits with adaptation	Benefits, without adaptation (Baseline)	Additional Benefits, Total	Costs, with adaptation	Costs, without adaptation (baseline)	Additional Costs, total	Adaptation Technology: Net Benefits	Adaptation Technology: Discounted Net Benefits 5%	Adaptation Technology: Discounted Net Benefits 10%	Without Adaptation Technology: Net Benefits	Without Adaptation Technology: Discounted Net Benefits 5%	Without Adaptation Technology: Discounted Net Benefits 10%
1	344	172	172	151	118	33	139	132	125	54	51	48.6
2	344	172	172	151	118	33	139	132	125	54	51	48.6
3	344	172	172	151	118	33	139	132	125	54	51	48.6
4	344	172	172	151	118	33	139	132	125	54	51	48.6
5	344	172	172	151	118	33	139	132	125	54	51	48.6
6	344	172	172	151	118	33	139	132	125	54	51	48.6
7	344	172	172	151	118	33	139	132	125	54	51	48.6
8	344	172	172	151	118	33	139	132	125	54	51	48.6
9	344	172	172	151	118	33	139	132	125	54	51	48.6
10	344	172	172	151	118	33	139	132	125	54	51	48.6
Total	**3,440**	**1,720**	**1,720**	**1,510**	**1,180**	**330**	**1,390**			**540**		
NPV	NPV=$\sum$ Net Benefits$_t$ / $(1+i)^t$, Where t is the year and i is the discount rate.							**1,320**	**1,250**		**510**	**486**
BCR	Benefits/Costs							2.28			1.45	

3.5 Linkages of the barriers identified

Inadequate information was identified as a barrier to the diffusion of integrated production system and promotion of crop diversification and new varieties. This is a barrier imbedded within the organizational weaknesses of the Ministry of Agriculture and Livestock Development with regards to the way it was restructured over the years but especially in 2008. Inappropriate restructuring led to some fragmentation in the way research, extension and fisheries operated. The abolition of the Research and Extension Liaison Officer position was said to have led to poor information flow between research and farmers. The fact that the extension branch and research branch that were once housed under one directorate, the Directorate of Field Services, now became two stand alone directorates was another factor. However, information dissemination is also weak within extension given its poor funding.

The high cost as a barrier to the diffusion of technology was common to two technologies, i.e. integrated farming and suitable seed varieties. This was exacerbated by the inability to have a credit facility which would assist the targeted farmers to venture into integrated production system. On the other hand, the high cost of hybrid seed has affected its access to farmers at household level

Barriers specific to each individual technologies were, low acceptance of conservation farming among farmers, poor access to farming inputs, labour intensive (for integrated farming) and inadequate access to improved and early maturing varieties.

3.6 Enabling framework for Overcoming Barriers

The enabling framework for overcoming the barriers in the Agriculture and Food Security Sector is presented at two levels, i.e. addressing the common barriers and barriers specific to a technology. These are a presented in turn below.

3.6.1 Enabling Framework for Common Barriers

3.6.1.1 Inadequate information

In view of the weak linkages within the Ministry of Agriculture and Livestock (MAL) between research and extension, there is need for re-establishing the position like the one occupied by the Research and Extension Liaison Officer (RELO) before 2008. This should be facilitated by the Government of the Republic of Zambia (GRZ) through the Cabinet Office. It will enhance coordination of information dissemination across the departments responsible for crops, livestock and fisheries development. This position should also have a presence at provincial level where the dissemination of agricultural information should be coordinated to ensure that farmers and fishers receive timely information regarding agricultural technologies suitable to adapt to climate change.

3.6.1.2 Cost Implications

The cost of embarking on integrated crop-small livestock-fish-poultry-vegetable production system and crop diversification is high. This is another area that requires government intervention which is currently providing huge subsidies to the production of maize. Similar intervention is required to promote crop varieties that are drought, stress, heat, pest, disease tolerant and early maturing. This will inevitably reduce the price of seed. In addition, the reduction of import duty on basic agricultural implements necessary in integrated farming will go a long way in making the technology accessible. The government can also create an enabling environment for the private sector to play a supportive role of providing start-up capital to small scale farmers. The concept of out-grower schemes will address some of the barriers on costs.

3.6.2 Enabling Framework for Specific Barriers of Prioritized Technologies

Although some barriers may be specific to a technology, there may be ways in finding synergies in resolving these individual barriers. For example, promoting farm power mechanization to relieve the labour constraints faced in integrated farming could find application in all farm practices, including conservation farming. This means that although a barrier would stand out in one specific technology, it could also have some bearing in the other technologies as agriculture as a sector faces similar challenges.

4. Summary and Conclusions

This barrier analysis and enabling framework process to assess and understand barriers facing the transfer and diffusion of the prioritized technologies for climate change adaptation in Zambia in the water and agriculture and food security sectors took a very consultative process. The primary task was to understand the nature of the individual barriers, relationships between the barriers, determine which barriers were important, and identify barriers that were easiest to remove. The Technical Working Groups representing key stakeholders (Annex II) in the two sectors shifted through a lot of information to identify the barriers and proposed measures for overcoming them. The result of the process is a list of barriers, their root causes and the measures to overcome them.

One barrier identified consistently throughout the barrier analysis was the high cost of the required inputs to the technology whether it was equipment, building materials or seed. This is a reflection of the high cost of doing business in the country as well as impediments to financing that investors and individuals face. The barrier is not climate change adaptation specific but cuts across all commerce. Government has undertaken to reduce the cost of doing business through interventions such as the Private Sector Development Programme but clearly this needs to be accelerated if adaptation measures being proposed are to be successful.

Inadequate information as a barrier was common to most technologies proposed in the agriculture sector but was also true with respect to promoting flood-resilient improved wells. In agriculture, the root causes were identified mostly with the organizational capacity weaknesses of the Ministry of Agriculture and Livestock. For the water sector, the root causes were more widespread but pointed mostly at institutional weaknesses regarding sector coordination that negatively affected information flow. It is thus clear that resolving poor information floor requires tackling organizational weaknesses of the critical institutions in a given sector.

There were also barriers specific to each technology. Although it is easier to find synergies in addressing common barriers, synergies could also arise in the way solutions are applied for technology-specific barriers. Therefore, where farm mechanization is promoted to resolve the high labour demands integrated farming introduces, other agriculture systems including conservation farming and crop diversification using early maturing varieties could also be benefit. What is important, therefore, at action planning and project ideas is to have a more holistic view of things and ensure that barriers are not looked at as absolutely delinked from each other either in the constraint they impose or the way the measures to relieve them are applied.

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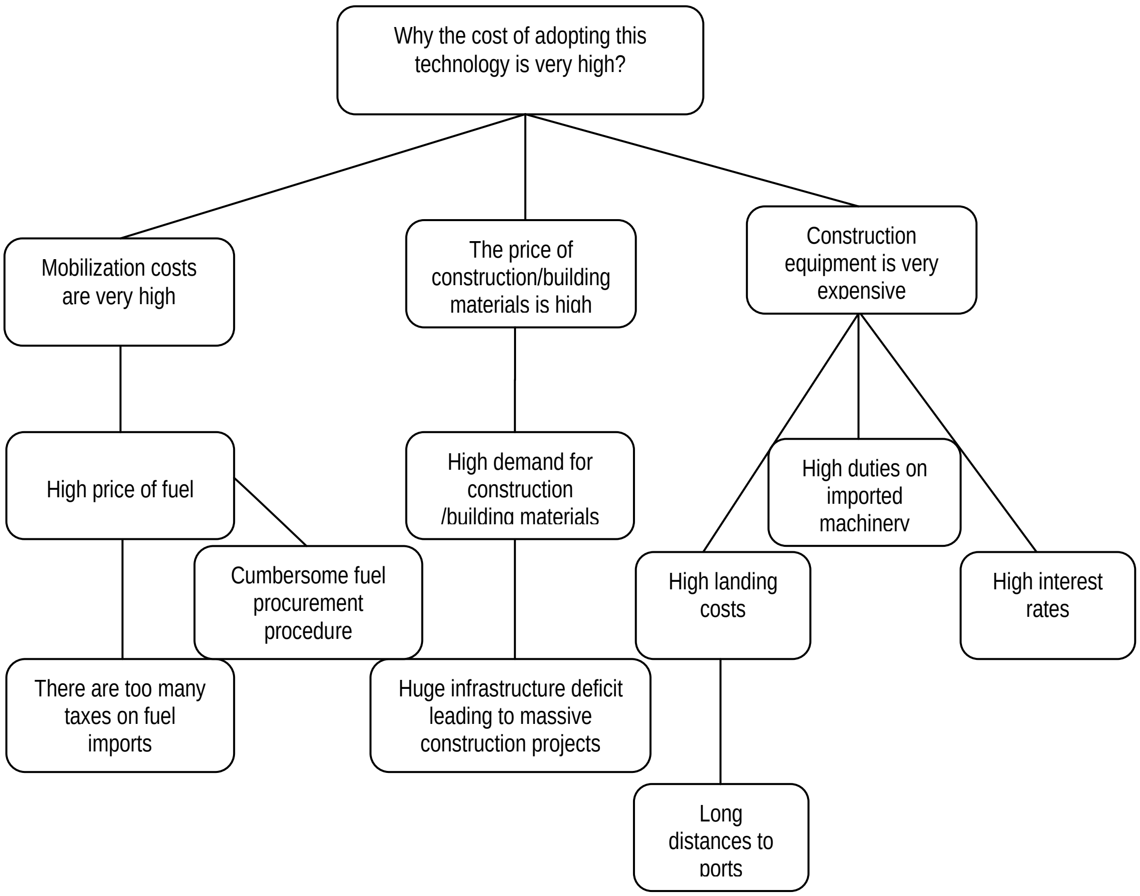
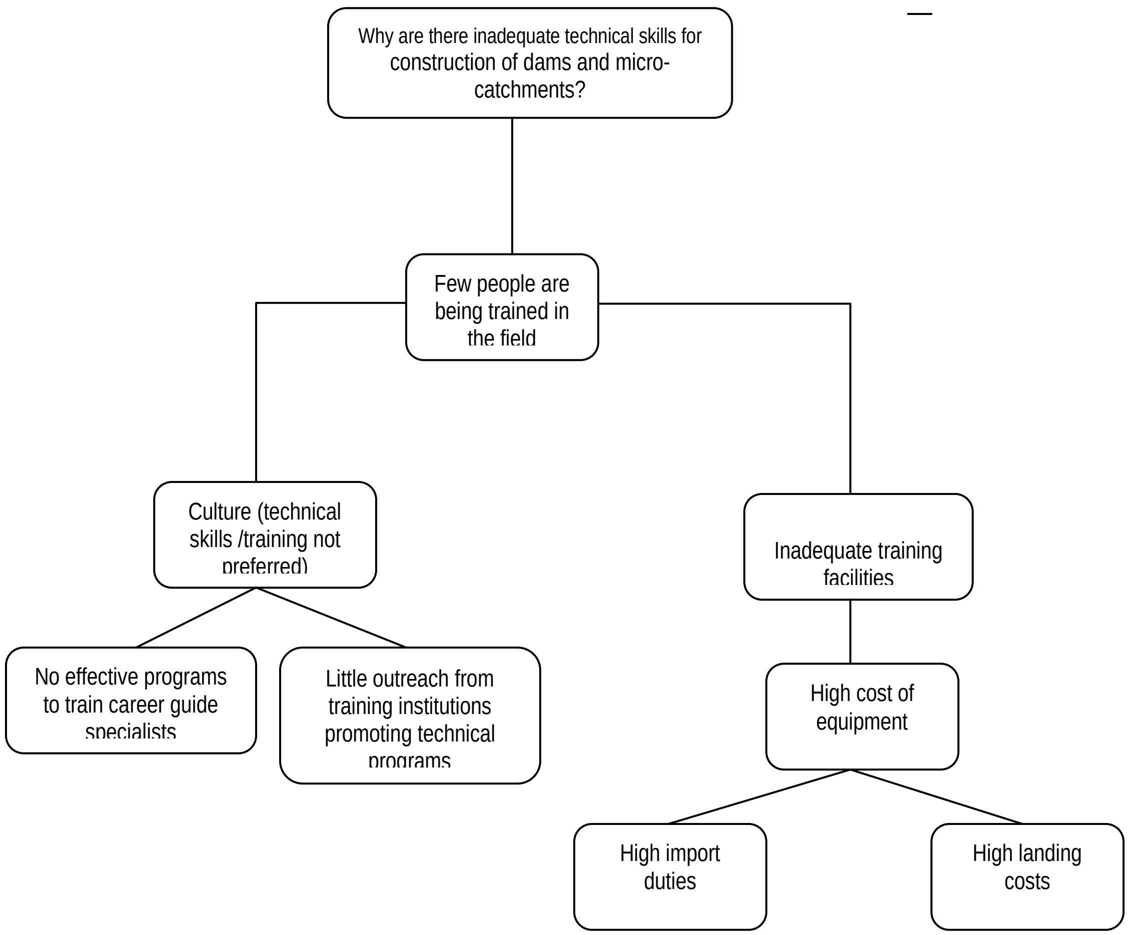
Annex IA: Root cause Analysis for Barriers under the Water & Energy Sector Technologies

Adaptation Technology: Rain water collection from ground surfaces-small reservoirs and micro-catchments

Barrier: *The cost of adopting this technology is very high*

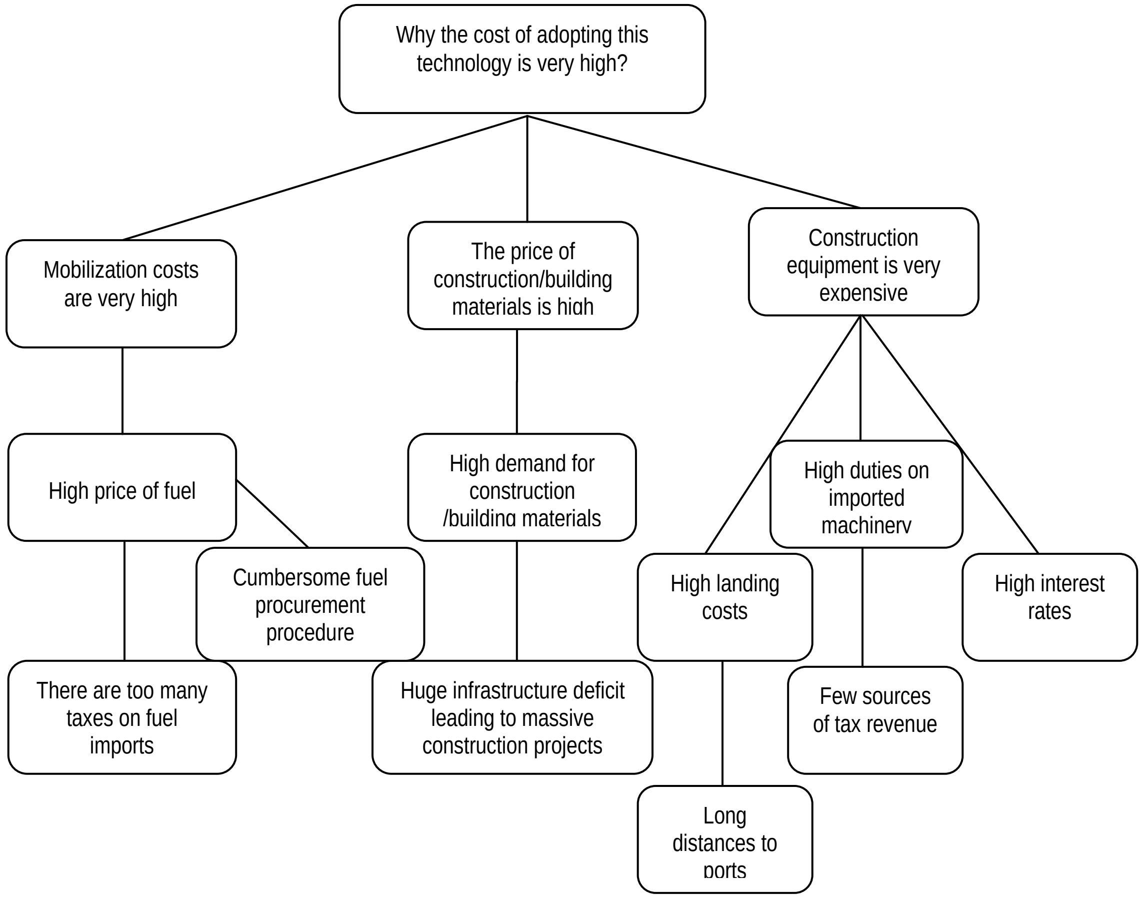


Barrier: *Inadequate technical skills in constructing dams and micro-catchments*

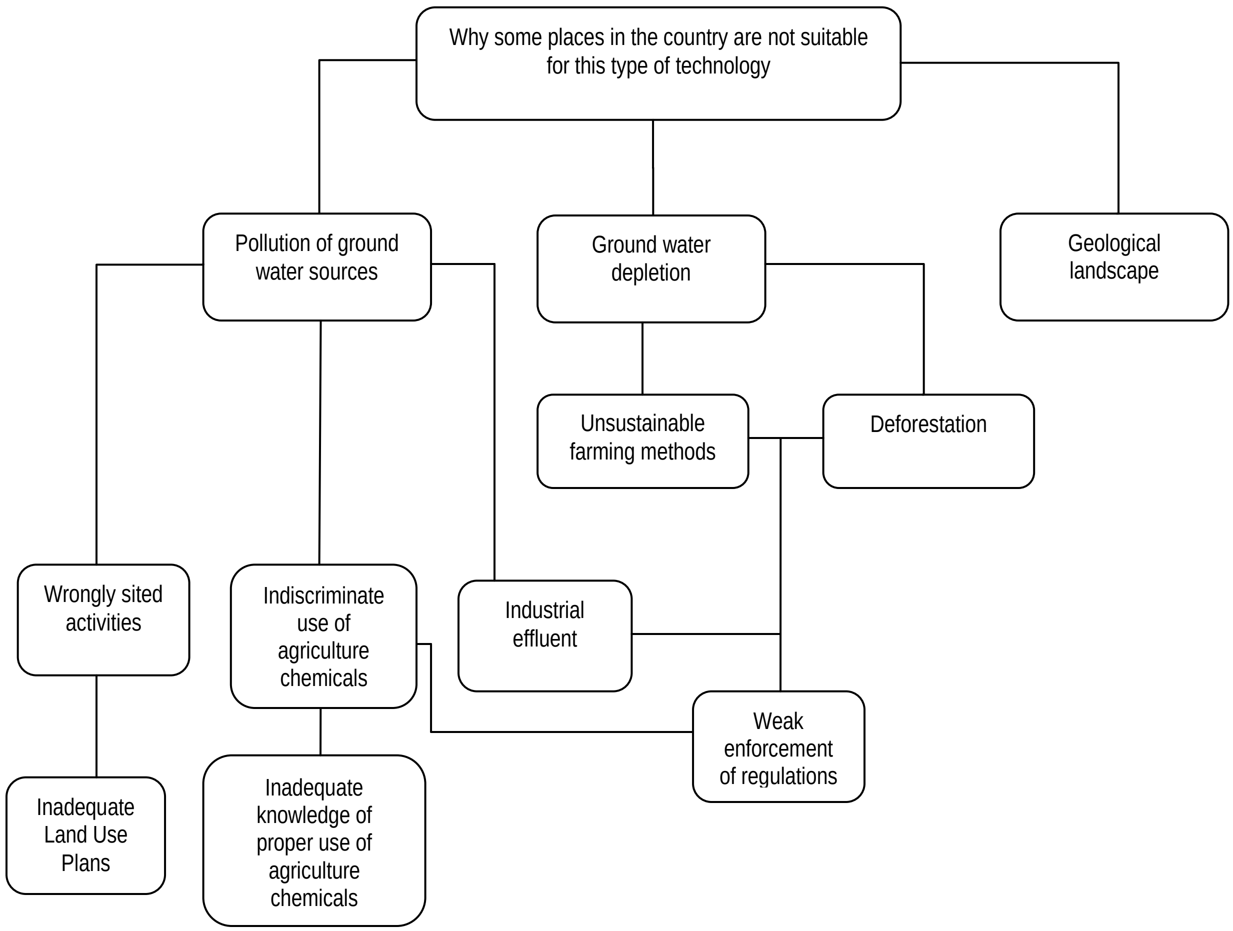


Adaptation Technology: Borehole/Tube wells for Domestic Water Supply

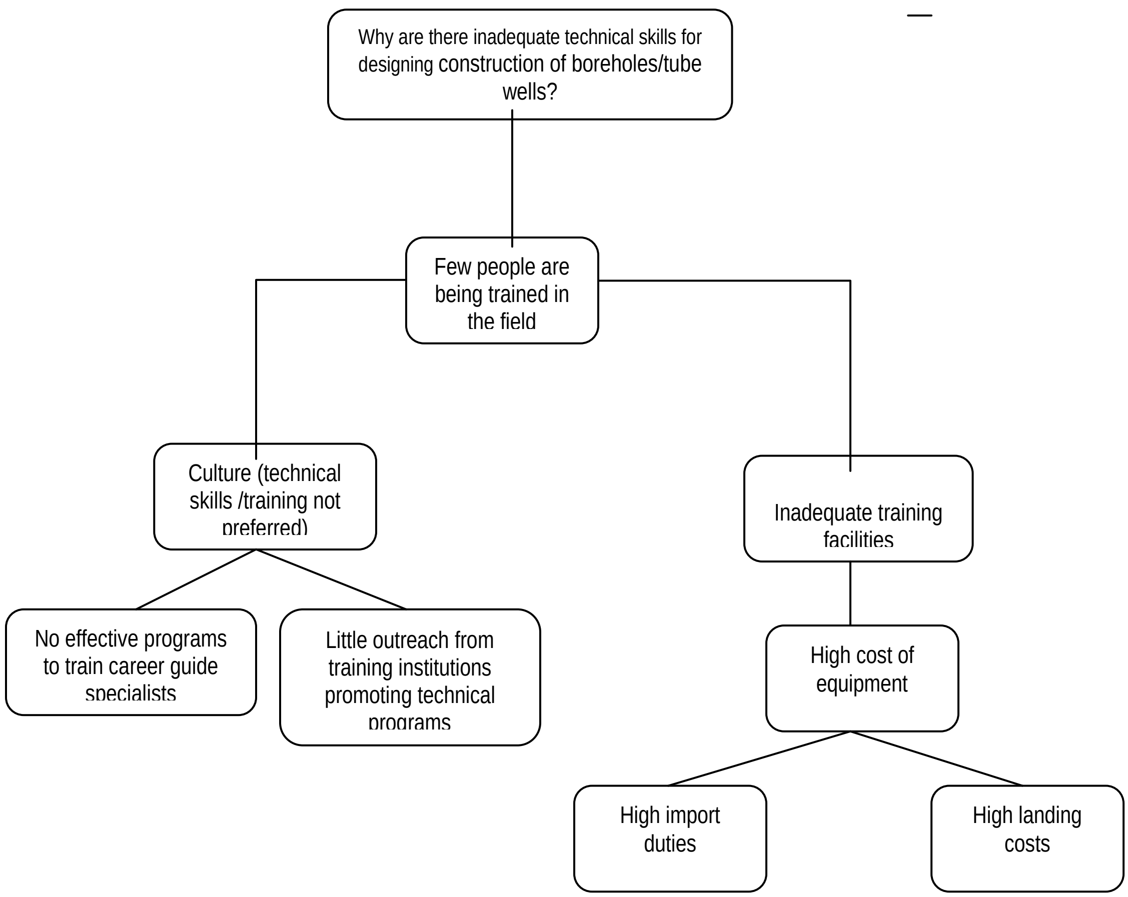
Barrier: *The cost of drilling and installing bore holes/tube wells is very expensive*



Barrier: *Some places in the country are not suitable for this type of technology*

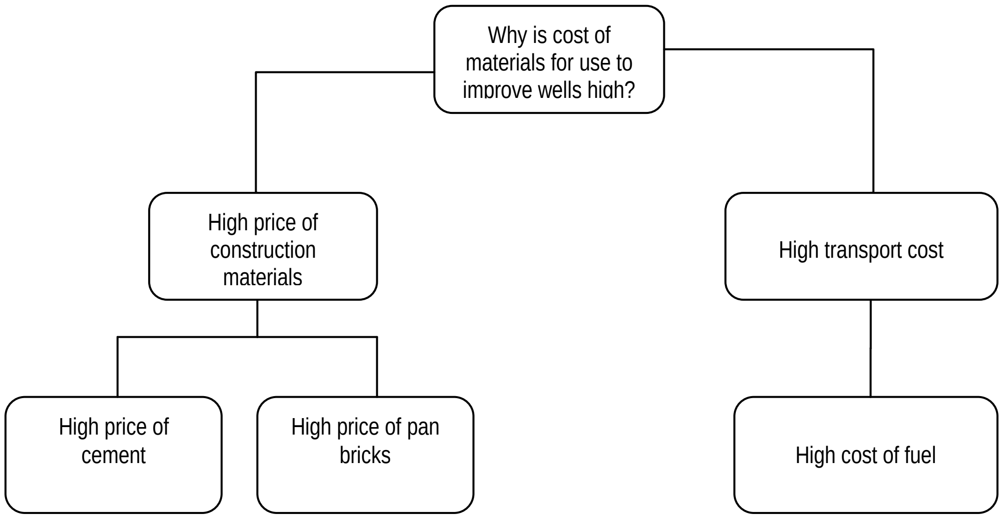


Barrier: *Inadequate technical skills in the designing and construction of the technology*

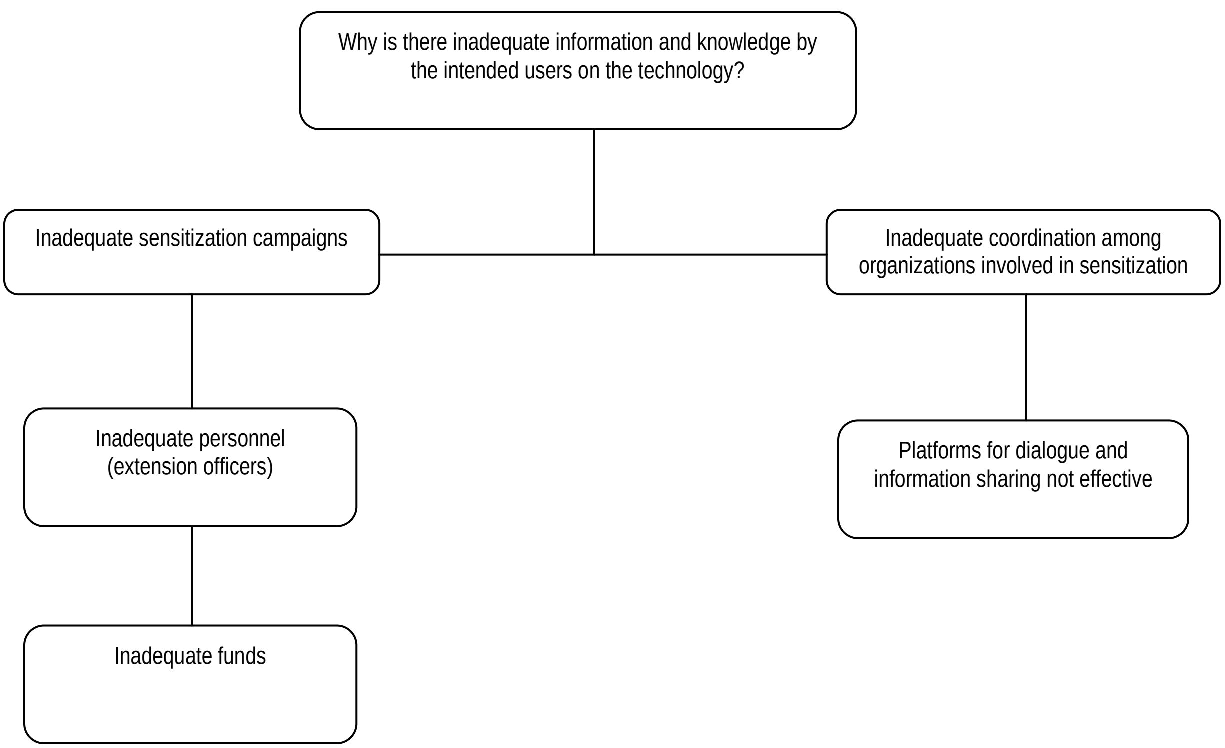


Adaptation Technology: Erection of a collar around the wells

Barrier: *The high cost of materials for use to improve the wells*



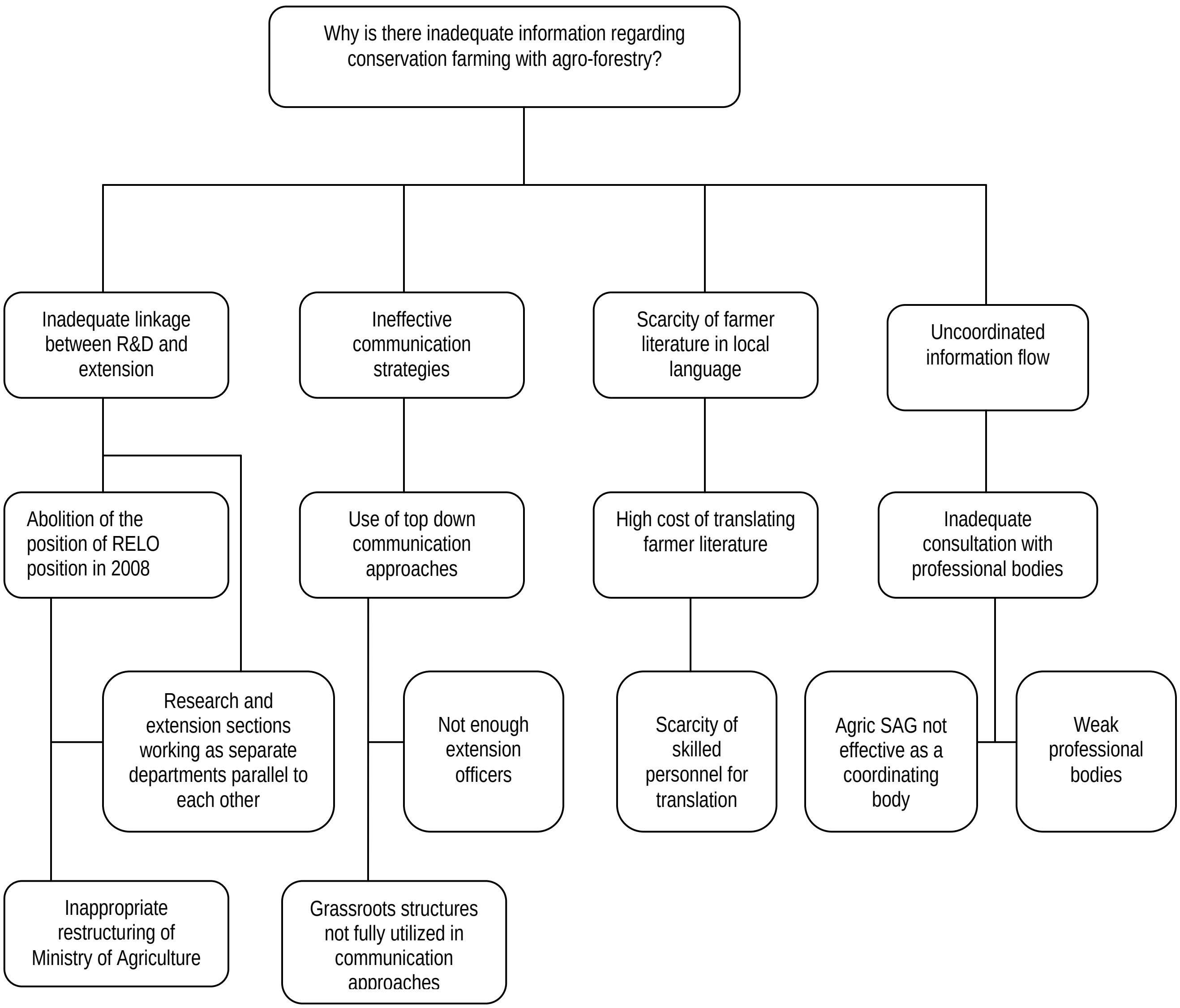
Barrier: *Inadequate information and Knowledge by the intended users on the technology*



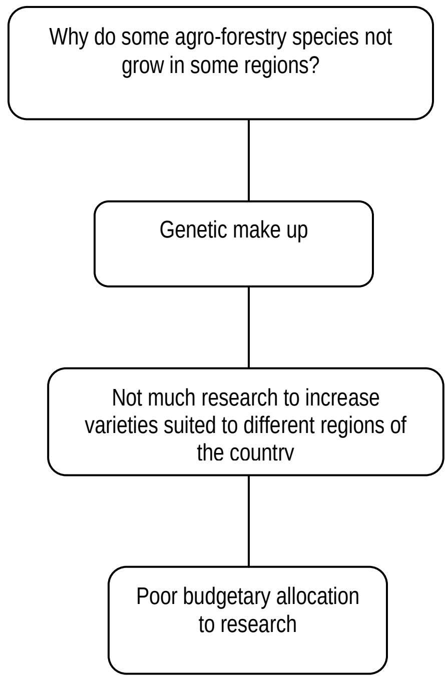
Annex IB: Root cause Analysis for Barriers under the Agriculture & Food Security Sector Technologies

Adaptation Technology: Conservation farming with Agro-forestry

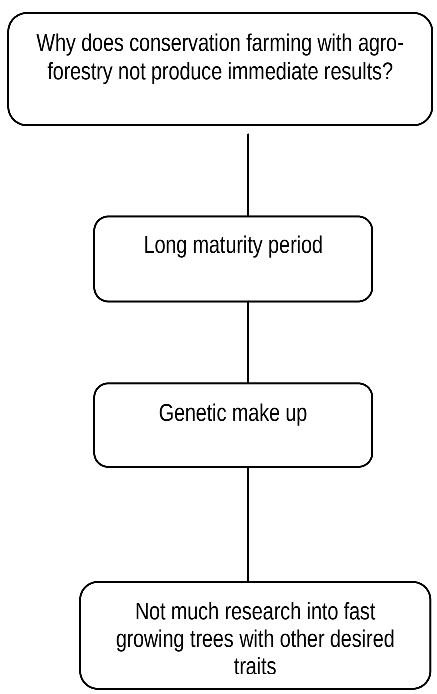
Barrier: Inadequate information among farmers regarding conservation farming with agro-forestry



Barrier: *Species may not grow in some areas*



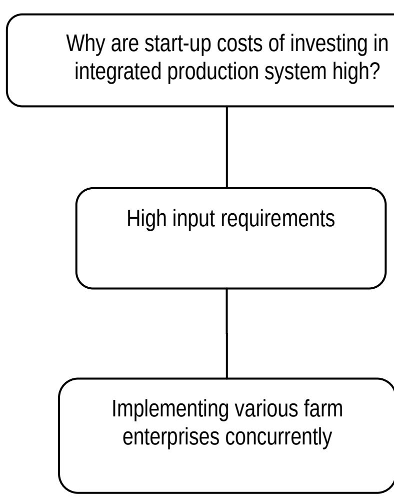
Barrier: *Conservation farming with agro-forestry does not produce immediate results*



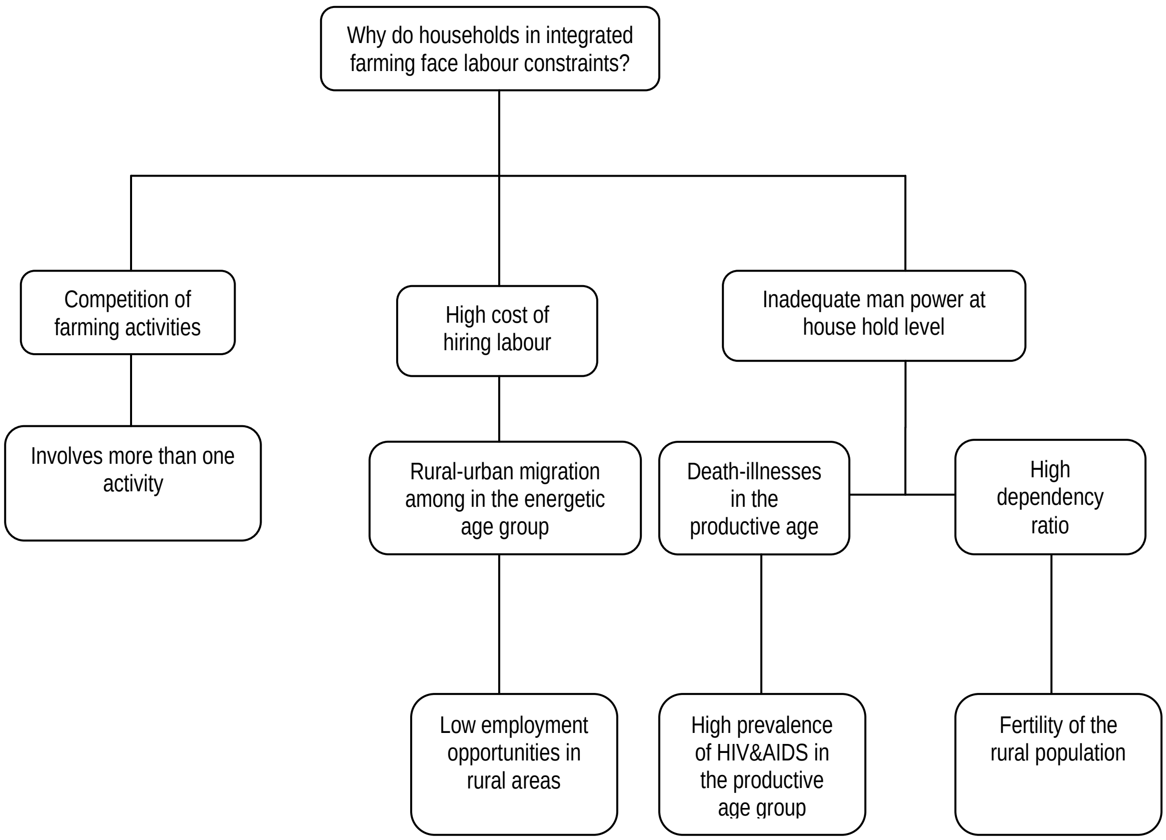
Adaptation Technology: Integrated Production System

Barrier: *Little knowledge among farmers of how to move from mixed farming to integrated farming?*

Barrier: *High start-up cost of investing in integrated production system*

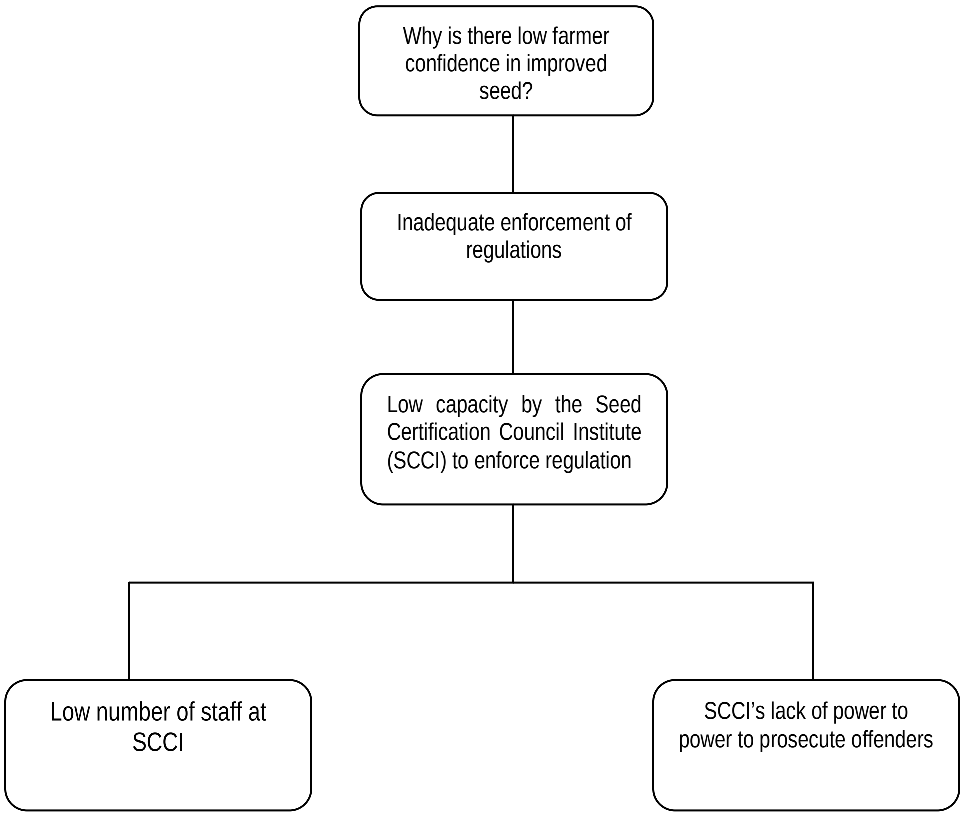


Barrier: *Labour constraints due*

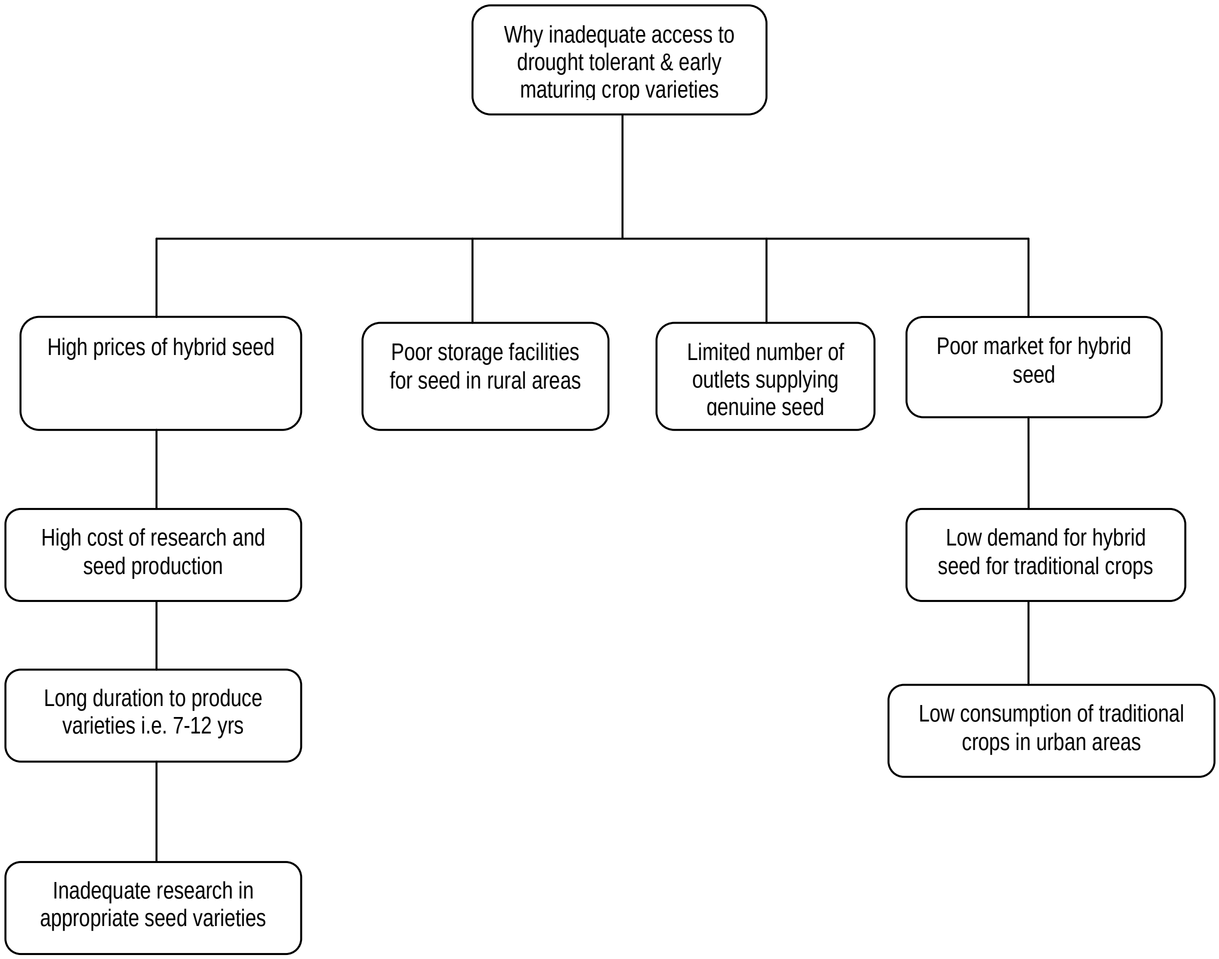


Adaptation Technology: Promotion of Drought, Stress, Heat, Pest, Disease and Soil Acidic Tolerant and Early Maturing Crop Varieties

Barrier: *Low farmer confidence in improved seed*



Barrier: *Inadequate access to appropriate seed*



Annex II: List of Stakeholders Involved and Their Contacts

Annex IIA: Attendance List for Barrier Analysis Workshops for Water & Energy sector held on 7th & 15th November 2012 at RuralNet Associates Limited

Name	Position	Organisation	Contact
Joel Kabika	Lecturer	IRWM - UNZA	0977 880 126 kabikajoel@gmail.com
Daniel Kanyembe	M & E Specialist	IDE	0977 783 806 kanyembe@gmail.com
Namakau L. Phiri	Sales & Service Engineer	SARO	0977 792 806 Namakau.lp@saroagri.co.zm
Alice Nambeye	Water Quality Officer	DWA	0977 151 416 alicenchimunya@yahoo.com
Christelle Makonga	Intern	MLNREP	0978 004 110 christellemakonga@gmail.com
Memory Sankando	Intern	MLNREP	0976 228 583 msankando@gmail.com
Wiseman Chisulo	Intern	MLNREP	0976 716 355 chisulomwale@yahoo.com
Charles M.Phiri	Facilitator/Consultant	RuralNet Associates Limited	0977 760 469 phiricharlie@gmail.com

Annex IIB: Attendance List for Barrier Analysis Workshops for Agriculture and Food Security sector held on 9th & 15th November 2012 at RuralNet Associates Limited

Name	Position	Organization	Contact details
Frank M. Kayula	Consultant	Kaypro Consulting	fmkayula@yahoo.co.uk 0966/0955/0978-506945
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Kalaluka Munyinda (Dr)	Lecturer	University of Zambia (UNZA)	munyinda_kalaluka@yahoo.com 0978-270898
Justin Chuunka	PAS	Ministry of Agriculture and Livestock (MAL)	justinchuunka@hotmail.com 0977-788951
Moses Kaumba	Research Officer	Forestry Department	moses.kaumba@yahoo.com 0977-187642
Emmanuel Chunda	Researcher/Facilitator	RuralNet Associates Limited	emmanuel@ruralnet.co.zm 0977-745290
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Dennis K. Chiwele (Dr.)	Consultant	RuralNet Associates Ltd	chiwelek@ruralnet.co.zm 0977-475029

Annex IIC: Key Informant Interviews

Name	Position	Organisation	Contact
Kalaluka Munyinda (Dr)	Lecturer	University of Zambia (UNZA)	munyinda_kalaluka@yahoo.com 0978 270898
Mr. Pheston Sikanyika	Water Engineer	Water Board, Lusaka.	phestonsikanyika@yahoo.com 0977 804909
Mr. Chimwanga Maseka	Senior advisor & WASH Sector Leader	SNV, Lusaka	cmaseka@snvworld.org 0955 860260
Mrs. Namakau Phiri	Sales & Service Engineer	SARO Agriculture Engineering Limited	namakau.lp@saroagri.co.zm 0977 792806
Mr. Geoffrey Kaila	Managing Director	Muhanya Solar Limited	geoffreykaila@gmail.com 0975 998340
Mr. S. Shashi	Manager	Ganga Drilling and Exploration Limited	gangadrilling@gmail.com 0977 201305
Killian Muleya	Senior Technical officer	Ministry of Agriculture and Livestock	msilumesii@yahoo.co.uk 0977 695890
Albert Chomba	Acting Principal Water Engineer	Water Affairs, Lusaka	0977 825940
Dr. Mpamba	Assistant Director- Ground water	Water Department, Ministry of Energy and Water	mpambanh@hotmail.com 0977 829150
Mr. Masinja	Small scale farmer	Nega Nega farm, Mazabuka	0976 070653
Mr. Kabalo	Small scale farmer	Kabalo farm, Mazabuka	0969 785083

Annex III – Policy Factsheets

Policy	The Water Resources Management Act
Name of field	
Date Effective	2011
Date Announced:	2011
Date Promulgated:	2011
Date Ended:	Still in force
Unit:	CC, Water Resource Management
Country:	Zambia
Year:	2011
Policy Status:	In force
Agency:	Water Resource Management Authority
Funding:	From the Government of Zambia
Further Information:	
Enforcement:	Ministry of Energy and Water Development
Penalty:	Not stipulated
Related Policies:	Water and Sanitation Act 1997, Water Act of 1949, Water Policy of 1994
Policy Superseded by:	nil
Policy Supersedes:	Water Act of 1949
Stated Objective:	
Evaluation:	
Policy Type:	Based on policy type list (provided); or filled in based on information provided regarding policy type.
Policy Target:	Water, climate change , environment, energy and agriculture sectors
URL:	www.mewd.org.zm
Legal References:	
Description:	Provide for the management, development, conservation, protection and preservation of the water resource and its ecosystems; provide for the equitable, reasonable and sustainable utilisation of the water resource; ensure the right to draw or take water for domestic and noncommercial purposes, and that the poor and vulnerable members of the society have an adequate and sustainable source of water free from any charges; create an enabling environment for adaptation to climate change; provide for the constitution, functions and composition of catchment councils, sub-catchment councils and water users associations; provide for international and regional cooperation in, and equitable and sustainable utilisation of, shared water resources; provide for the domestication and implementation of the basic principles and rules of international law relating to the environment and shared water resources as specified in the treaties, conventions and agreements to which Zambia is a State Party.

Policy	The Water Policy
Name of field	
Date Effective	1994
Date Announced:	1994
Date Promulgated:	1994
Date Ended:	Still in force
Unit:	CC, Water Resource Management
Country:	Zambia
Year:	1994
Policy Status:	In force
Agency:	MEWD
Funding:	From the Government of Zambia
Further Information:	Water sector reforms in Zambia started with a realization that service provision was inadequate and so was protection, conservation, development and management of water resources as the main shortcomings regarding water in Zambia.
Enforcement:	Ministry of Energy and Water Development
Penalty:	Not stipulated
Related Policies:	Water and Sanitation Act 1997
Policy Superseded by:	Water Policy of 2007
Policy Supersedes:	Water Policy of 1949
Stated Objective:	Recognizing the important role of the water sector in the overall socio-economic development of the country, vesting control of water resources in the country under state control, promoting water resources development through an integrated management approach, providing adequate, safe and cost effective water supply and sanitation services with due regard to environmental protection, defining clear institutional responsibilities of all stakeholders in the Water Sector for effective management and co-ordination and, recognizing water as an economic good
Evaluation:	Following the water supply and sanitation sub-sector reforms at different levels, the Government of Zambia launched the Water Resources sub-sector reforms with the Water Resource Action Programme in 2001 which developed a Water Resources Management Bill, proposed a new Water Resources Institutional Framework (legal and institutional paper), an improved Water Resources Management Information System and a Draft Water Action Plan on how to overcome the challenges related to water resources issues in Zambia.
Policy Type:	Based on policy type list (provided); or filled in based on information provided regarding policy type.
Policy Target:	Water, climate change , environment, energy and agriculture sectors
URL:	www.mewd.org.zm
Legal References:	
Description:	Promoting sustainable water resources development with a view to facilitate an equitable provision of adequate quantity and quality of water for all competing groups of users at acceptable costs and ensuring security of water supply under varying conditions4. Under the Water Policy, the Water and Sanitation sector in Zambia is divided into a rural and urban sector with the peri-urban sector falling under the urban sector. The Water Policy clearly outlines a long term strategy for meeting the water and sanitation needs of the urban and rural sector and also the body responsible for the strategy implementation. The Water Policy has been partially implemented with some of its fruit being the commercialization of the water sector in Zambia and other water sector reforms.

Policy	Land Administration and Management Policy
Name of field	
Date Effective	2007
Date Announced:	2007
Date Promulgated:	2006
Date Ended:	Still in force
Unit:	Land
Country:	Zambia
Year:	2007
Policy Status:	In force
Agency:	Ministry of Lands & Natural Resources
Funding:	Government
Further Information:	
Enforcement:	Lands Department
Penalty:	
Related Policies:	Agriculture Land Policy
Policy Superseded by:	None
Policy Supersedes:	The Land Act of 1949
Stated Objective:	To ensure effective and efficient land administration, promote equitable access to and control of land, provide for security of land tenure for all Zambian men and women, and promote sustainable land use for the socio-economic development of Zambians
Evaluation:	Not yet
Policy Type:	Land policy
Policy Target:	Land administration in Zambia
URL:	http://www.aec.msu.edu/fs2/zambia/resources/draft%20%20land%20policy_june%202007.pdf
Legal References:	The Land Act
Description:	The vision of the Government is to have an efficient and effective land administration system that promotes security of tenure equitable access and control of land for the sustainable socio-economic development of the people of Zambia'

Policy	National Policy on Environment
Name of field	
Date Effective	2005
Date Announced:	2005
Date Promulgated:	2005
Date Ended:	Still in force
Unit:	Environment, CC, Natural Resources etc
Country:	Zambia
Year:	2005
Policy Status:	In force
Agency:	Ministry of Lands & Natural Resources
Funding:	Government
Further Information:	
Enforcement:	Ministry of Lands & Natural Resources
Penalty:	
Related Policies:	Water Policy 1994, Wildlife Policy of 1998, Policy on Forestry of 1998, Land Policy, National Policy on Wetlands Conservation of 2000, National Energy Policy of 1994
Policy Superseded by:	None
Policy Supersedes:	The National Environmental Action Plan of 1994
Stated Objective:	The goal and overall objective is to have a national policy on environment that will support the Government's development priority to eradicate poverty and improve the quality of life of the people of Zambia.
Evaluation:	Not yet
Policy Type:	Environment policy
Policy Target:	Environment Management in Zambia
URL:	
Legal References:	Environmental Management Act Number 12, 2011, Fisheries Act No.22 of 2011, Zambia Wildlife Act No.12 of 1998, The Water Resources Management Act No.21 of 2011, The Lands Act of 1995.
Description:	The National Policy on Environment is designed to create a comprehensive framework for effective natural resource utilization and environmental conservation and which will be sensitive to the demands of sustainable development. It can be expected that the vision of a holistic, adequately funded approach, that will create a critical mass of public support throughout the economic sectors in particular and Nation as a whole, will help overcome deficiencies and will usher in a period of coordination that will reverse prevailing trends of over-utilization, waste and environmental degradation.

Policy	Government Interest Rate Policy
Name of field	A cap on the effective annual lending interest rates that non-bank financial institutions licensed by the Bank of Zambia can charge their customers.
Date Effective	January 2013
Date Announced:	3rd January 2013
Date Promulgated:	
Date Ended:	Still in force
Unit:	CC
Country:	Zambia
Year:	2013
Policy Status:	In force
Agency:	Bank of Zambia
Funding:	
Further Information:	Monetary Policy, http://www.boz.zm/
Enforcement:	Bank of Zambia
Penalty:	Not stipulated
Related Policies:	Bank of Zambia Policy Rate
Policy Superseded by:	Nil
Policy Supersedes:	Monetary Policy
Stated Objective:	Market regulation, Affordable interest rates
Evaluation:	Not yet
Policy Type:	To regulate lending rates to Financial and Non financial institutions
Policy Target:	Financial and Non financial institutions
URL:	http://www.boz.zm/
Legal References:	Bank of Zambia Act No. 43 of 1996
Description:	This measure has been necessitated on account of the exorbitant interest rates that some non-bank financial institutions have continued to charge their customers. The capping of interest rates therefore is aimed at making borrowing from non-bank financial institutions more affordable and equitable especially to the vulnerable micro-borrowers served by this sector

Policy	Technical Education, Vocational and Entrepreneurship Training (TEVET) Policy
Name of field	The Government of The Republic of Zambia through the TEVET Policy expressed intention to enhance the ability of the active labour force (15-64yrs) to Set Up And Run Viable Growth-oriented Business Enterprises as a "Deliberate Career Alternative" through: 1)Exposure To Entrepreneurship Education and Training and 2) Provision of Appropriate Business Enterprise Start-up or Expansion Incubation Support Services.
Date Effective	2007
Date Announced:	2007
Date Promulgated:	
Date Ended:	Still in force
Unit:	CC
Country:	Zambia
Year:	2007
Policy Status:	In force
Agency:	TEVET
Funding:	
Further Information:	The TEVET Act No. 13 of 1998 read together with TEVET (Amendment) Act No. 11 of 2005, http://www.teveta.org.zm/,
Enforcement:	If any particular enforcement provisions, institutions etc.
Penalty:	Not stipulated
Related Policies:	Education Policy
Policy Superseded by:	If the policy has been superseded, this provides a link to the more recent policy
Policy Supersedes:	1996 TEVET Policy
Stated Objective:	To reform the country's system of technical education, vocational and entrepreneurship training
Evaluation:	
Policy Type:	Technical Education, Vocational and Entrepreneurship Training
Policy Target:	All sectors e.g. Environment, Energy, Education, Agriculture, Water, Mining etc
URL:	http://www.teveta.org.zm/
Legal References:	TEVET (Amendment) Act No. 11 of 2005
Description:	The Government has therefore identified the need to formulate a broader national policy on technical education and vocational training. The aim of the policy is to improve technical education and vocational training and link it to the requirements of the employment sector. The new policy is broader in three aspects. First, it incorporates entrepreneurship development. For this reason, the Policy will be known as the technical Education, Vocational and Entrepreneurship Training (TEVET) policy. Second, the new policy encompasses all types of technical education and vocational training like nursing, agriculture, community development and engineering. Third, it covers training being conducted at all levels in both the formal and informal sector.