THE KINGDOM OF SWAZILAND

BARRIER ANALYSIS AND ENABLING FRAMEWORK, Adaptation

REPORT II OF TECHNOLOGY NEEDS ASSESSMENT

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Barrier Analysis and Enabling Framework
Report II of Technology Needs Assessment
The Kingdom of Swaziland

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Acronyms

ACAT	Africa Cooperative Action Trust
BAEF	Barrier Analysis and Enabling Framework
CA	Conservation Agriculture
CANGO	Coordinating Assembly of NGOs
CASP	Comprehensive Agriculture Sector Policy
CBO	Community Based Organization
CBD	Convention on Biological Diversity
CITES	Convention in Trade of Endangered Species
COSPE	Cooperation for the Development of Emerging Countries
CTCN	Climate Technology Centre and Network
DOM	Department of Meteorology
DVLS	Department of Veterinary and Livestock Services
EST	Environmentally Sound Technologies
FAO	Food and Agricultural Organization
GEF	Global Environment Facility
GHG	Green House Gases
GV	Government
IASP	Invasive Alien Species
IDE-JETRO	Institute of Developing Economies – Japan External Trade Organization
IEC	Information Education and Communication
IFAD	International Fund for Agriculture Development
INDC	Intended Nationally Determined Contributions
IRBM	Integrated River Basin Management
IWRM	Integrated Water Resources Management
KDDP	Komati Downstream Development Project
KOBWA	Komati Basin Water Authority
LDP	Livestock Development Policy
LUSIP	Lower Usuthu Smallholder Irrigation Project
MA	Millennium Assessment
MEA	Millennium Ecosystem Assessment
MOAC	Ministry of Agriculture and Cooperatives
MTEA	Ministry of Tourism and Environmental Affairs
NCC	National Curriculum Centre
NDS	National Development Strategy
NFSP	National Food Security Policy
NCP	Neighbourhood Care Points
NGO	Non-Governmental Organization
NWA	National Water Authority
PA	Protected Areas
PPP	Public Private Partnership
PVC	Polyvinyl Chloride
RBA	River Basin Authority
RWH	Rain Water Harvesting

RWSB	Rural Water Supply Branch
SADC	Southern African Development Community
SCOT	Swaziland College of Technology
SCCF	Special Climate Change Fund
SEA	Swaziland Environment Authority
SKPE	Swaziland Komati Development Project
SNL	Swazi National Land
SNPAS	Strengthening the National Protected Areas Systems of Swaziland
SNTC	Swaziland National Trust Commission
SPGRC	Swaziland National Plant Genetic Resource Centre
SWADE	Swaziland Water and Agricultural Development Enterprise
SWASA	Swaziland Standards Authority
SWOT	Strengths Weaknesses Opportunities and Threats
TAP	Technology Action Plan
TDL	Title Deed Land
TNA	Technology Needs Assessment
TNC	Third National Communication
TPTC	Tripartite Permanent Technical Commission
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention on Combating Desertification
UNDP	United Nations Development Programme
UNDP/GEF	United Nations Development Programme/ Global Environment Facility
UNEP-DTU	United Nations Environment Programme- Denmark Technical University
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollar
VAT	Value Added Tax
WASH	Water Sanitation and Hygiene
WRP	Wetlands Restoration and Protection
WWF	World Wildlife Fund

Executive Summary

Swaziland faces many capacity and technology constraints in addressing climate change challenges, which include low awareness, limited human resources, low technological capacity and inadequate financial resources for adaptation. To address this, the Ministry of Tourism and Environmental Affairs (MTEA), Department of Meteorology (DOM) spearheaded the Technology Needs Assessment (TNA) project, which identified and prioritised technologies for climate change adaptation. Support was received from the United National Environment Programme and Denmark Technical University partnership (UNEP DTU Partnership). The project began in May 2015 and undertook the sector selection, technology prioritisation, barrier analysis and enabling framework development. This report is about the Barrier Analysis and Enabling Framework (BAEF) phase where several stakeholder workshops and interviews were done to understand what barriers prevent implementation and up-scaling of technologies for climate change adaptation in Swaziland.

The sectors covered are: (1) Water, (2) Agriculture, and (3) Forests and Biodiversity. For each sector, the report covers the following:

- Identifying preliminary target of technology transfer and diffusion of each of the adaptation technology;
- Identifying and prioritizing the barriers using barrier analysis tools including: stakeholder consultations in workshops, bilateral meetings, review of documents, problem and solution tree method and market mapping where possible;
- Investigating, assessing and categorising the possible measures to address the barriers for the transfer and diffusion of each technology and eventually; and
- Identifying the enabling environment and support services to enhance the uptake of the technologies.

The major barriers and measures for the three sectors under the TNA project are given in table below.

Technology	**Major barriers**	**Measures to overcome barriers**
Water Sector		
1. Integrated River Basin Management (IRBM)	Financial barriers include inability to get concessional loans due to Swaziland's middle income status and inadequate domestic funds to implement IRBM activities. Institutional barriers include poor capacity of River Basin Authorities to effectively implement the Water Act and water management strategies, weak coordination of IRBM related activities under various other related programmes and conventions that Swaziland is signatory to. Political barriers inlude conflicts in water resources management between formal authorities and traditional authorities. Poor awareness on IRBM	Measures include development of proposals to raise funds for River Basin Authority activities and establishing a "Funds Coordination Platform" in collaboration with relevant stakeholders for creating synergies in usage of funds related to IRBM activities. Other measures included building capacity of RBAs, creating awareness amongst stakeholders about IRBM and creating a participatory forum which includes traditional authorities to provide for participatory decision making at riber basins.

2. Wetland Restoration and Protection (WRP)	Financial barriers include inadequate funds for WRP activities and poor coordination of funds in programmes where wetlands are included. Low level of awareness about the importance of wetlands and the mindset of extracting benefits from wetlands looking at the short term rather than long tern sustainability is another barrier. Inadequate monitoring of wetland health and unclear roles and responsibilities of agencies whose works overlap with WRP were institutional barriers.	Setting up the Funds Coordination Mechanism mentioned under IRBM will help create synergies in activities of WRP too. Developing proposal for funding WRP activities in selected wetalnds is another measure. Creating awareness of importance of wetlands through community level meetings and site visits and setting up a wetlands monitoring system are other measures proposed.
3. Rooftop Rain Water Harvesting (RWH)	Barriers include lack of a legal instrument that makes RWH compulsory and lack of standards for construction of RWH structures. There is low awareness about the technology, inadequate capacity for installation and some social and behavioural barrier were also identified which includes possibility of theft and vandalism of the RWH systems.	Subsidizing RWH tanks by 50% of its cost to selected number of households, creating awareness of RWH systems through including this technology under the Water Sanitation and Hygiene (WASH) Forum and promoting the technology in media as well as setting up demonstration sites were measures proposed.
Agriculture		
1. Livestock and Poultry Selective Breeding	The main economic barrier for poultry farmers is the cost of transportation to reach markets. Low awareness of selective breeding technology and the mind-set of farmers to consider lievstock as a store of wealth rather than a business were some barriers. Another barrier was inadequate capacity in extension services in order to reach larger numbers of farmers.	Measures included creating awareness about the technology through training of farmers, conducting reserach on markets and value chain as well as enhancing capacity of the extension services through providing training and filling vacancies.
2. Conservation Agriculture	The economic barrier was the low level of affordability of mechanised planters. Inadequate awareness of this technology and inadequate capacity of extension staff to promote this technology remains barriers.	Measures include providing subsidy for mechanised planters, training extension workers, setting up demsotration sites and creating awareness of conservation agriculture.
3. Micro and Drip irrigation	The high capital cost of micro and drip irrigation kits were a barrier to its uptake. Availability of affordable finance was also a barrier as interest rates for borrowing is high. Inadequate skilled personnel for micro and drip kits installation was another barrier which also drove up the cost of use of this equipment. Legislative barrier was that of lack of legal instruments that enforce	Subsidising micro and drip irrigation kits for farmers would help address the barrier of affordability of this equipment/ Providing training to farmers assosciations and setting up practcal demostration sites would help to promote this technology. Building capacity for relevant Government staff for and creating awareness amongst

	efficient use of water for irrigation. Furthermore, there is a technical barrier that this technology cannot be used for all types of crops, for example rice which needs flood irrigation.	farmers would help in up-scaling this technology.
Forestry and biodiversity		
1. Agroforestry	Low awareness about the benefits of investing in agroforestry and limited access to agroforestry inputs was a barrier for some, while low capacity of extension workers to promote this technology was another barrier.	Training of farmers by providing knowledge and giving them seedlings was proposed as measure. Furthermore, involving the agriculture extension officers and NGOs in the training programme would enhance promotion of this technology in a sustainable manner.
2. Conservation of Genetic Resources	Inadequate funds for establishment of a national botanical garden and field gene bank was a barrier. There is low level of awareness of the need for conservation of genetic resources and weak capacity in plant genetics resources management.	Establishing a botanical garden and field gene bank is a measure suggested. Creating awareness amongst farmers to collect seeds and multiply them through field days at the botanical garden and field gene bank and providing training to officers working on plant genetics resources as well as providing scholarships for further studies in the area to relevant government officers are measures needed.
3. Invasive Alien Species Management	Inadequate funding was the major barrier for this technology, as funds would be required for chemicals for combat, cost of training workers, provision of protective clothing and logistics which is a large sum of funds. Non-financial barriers included low awareness regarding alien species and need for revision of the invasive alien species management strategy.	Measures include improving awareness about invasive alien species and improving skills in its management. Revision of the strategy for alien invasive species management and impriving political will to implement the streategy through producing a policy brief and development of proposals to raise funds to implement activities of invasive alien species management strategy were other measures .

The summary of the enabling framework developed by stakeholders for all the three sectors are summarised in table below.

Category	**Measures**	**Outcome**
National macro economic conditions	Subsidy for technologies RWH system and, drip and micro irrigation systems	Affordability of technology improves thereby its use is up-scaled, leading to better adaptive capacity
	Setting up a Funds Coordination Mechanism for accruing synergies in	Improved synergies in usage of funds and therefore more work is done using existing funds

	usage of funds for IRBM and WRP activities.	
	Creating a participatory forum for IRBM participatory decision making in river basins	Reduced conflicts and improved participation as well as ownership amongst stakeholders, leading to better management of river basins
	Developing a policy brief to enhance political will for invasive alien species management	Political will can help with support for allocation of funds for management of invasive species management, leading benefits for all sectors affected (water, land, agriculture, biodiversity)
Human, organizational and institutional capacity	Building capacity of River Basin Authorities to implement IRBM	Enhanced river basin management leading to healthier ecosystems in river basins
	Capacity building for relevant officers responsible to implement the National Water Act	Effective implementation of the Water Act leading to healthier water resources
	Awareness raising of all nine technologies chosen under TNA through setting up demonstration sites, providing information, education and communication materials, media reports and road shows	Up-scaling of the technologies will be improved when awareness is enhanced, leading to better adaptation
	Filling vacancies, capacity building and training of officers in River Basin Authorities	River Basin Authorities will be able to carry out their activities in effective manner, thereby healthier ecosystems in river basins
	Include rain water harvesting into national Water Sanitation and Hygiene (WASH) forum	Possibilities for integration of rain water harvesting into WASH projects, thereby up-scaling harvesting
	Enhance capacity of extension services for agriculture	Farmers will gain from better information and timely support for decision making and yields improve
	Providing scholarships for higher education to relevant staff on plant genetics	Skilled human resources aid in making better decisions for conservation of genetic diversity, leading to enhanced biodiversity gains
Research and technological capacity	Research on livestock markets, value chain and gaps identified.	Gaps in markets addressed and farmers fetch better prices for livestock and poultry and consumers have better choice
	Establishment of a National Botanical Garden and Field Gene Bank	This will serve as a demonstration site where farmers can be trained
	Capacity building and training for installers of RWH systems, drip and micro irrigation systems,	Lower cost for installation as skileld personnel to do the work will be available, leading to enhanced adoption og technology

	Setting up demonstration sites for RWH, Conservation Agriculture, Drip and Micro Irrigation and Agroforestry technologies	Communities and farmers can undertake practical training and improve knowledge thereby helping up-scale these technologies, leading to better agricultural outcomes
Social and cultural	Awareness raising regarding all the technologies and debunking myths about the technologies	Better informed communities can up-scale use and diffusion of the technologies, helping them adapt better to climate change

Report II
Barrier Analysis and Enabling Framework Report

1. Chapter 1 Introduction

The Kingdom of Swaziland is a mountainous country of 17,364sqkm area blessed with scenic landscapes, water resources and arable as well as grazing lands, which support agriculture, tourism and industry, which are some of the main economic activities. Swaziland has experienced the impacts of climate change, which has affected many of its sectors (Government of Swaziland, 2016). To respond to these challenges, Swaziland has taken several steps including development of policies and regulations, establishing organizations and committees to coordinate efforts on climate change as well as implementing projects and programmes on climate change adaptation and mitigation, which are geared towards achieving objectives of the United Nations Framework Convention on Climate Change (UNFCCC). The Ministry of Tourism and Environmental Affairs (MTEA), Department of Meteorology (DOM) spearheaded the Technology Needs Assessment (TNA) project with the support from the United National Environment Programme and Denmark Technical University (UNEP DTU) partnership.

The purpose of the TNA project was to assist Swaziland to identify and prioritize technolog y needs, which formed the basis for a portfolio of environmentally sound technology (EST) projects and programmes to facilitate the transfer of, and access to ESTs and know-how in the implementation of Article 4.5 of the UNFCCC Convention (UNFCCC, 2015). Hence TNAs are central to the work of Parties to the Convention on technology transfer and present an opportunity to track an evolving need for new equipment, techniques, practical knowledge and skills, which are necessary to mitigate Green House Gases (GHG) emissions and/or reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change.

The main objectives of the project are:

1. To identify and prioritize through country-driven participatory processes, technologies that can contribute to mitigation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities (TNA);
2. To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies; and
3. To develop Technology Action Plans (TAP) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the participant countries.

This report addresses the second objective of TNA, which is identifying barriers and developed enabling frameworks for technologies. The TNA process in Swaziland began with extensive stakeholder engagement. The sector prioritization process involved brainstorming on country development priorities and discussion of sectors which are most useful for achieving them. Swaziland prioritised the sectors Water, Agriculture and, Forests and Biodiversity for adaptation. Stakeholders prioritised the technology of Integrated River Basin Management (IRBM), Rooftop Rainwater Harvesting (RWH) and Wetlands Restoration and Protection (WRP) under the water sector. For the agriculture sector, Livestock and Poultry Selective Breeding, Conservation Agriculture and Micro and Drip Irrigation technology were retained for Barrier Analysis and Enabling Framework (BAEF) and Technology Action Plan (TAP) phase. For the forests and biodiversity sector, Agroforestry, Conservation of Genetic Resources and Management of Alien Invasive Species were prioritised.

Swaziland has taken steps to ensure that the TNA process is aligned to other important national processes. The TNA prioritised technologies have been included into the Intended Nationally Determined Contributions (INDC). The Third National Communication (TNC) of Swaziland includes a chapter on the TNA process. Additionally, an eco-tourism project titled the Eco-Lubombo Transfrontier Conservation Programme have included TNA technologies into their project plans. Aligning INDC, TNC and the Eco-Lubombo project with TNA prioritised technologies is considered an accomplishment for Swaziland as efforts will be streamlined for managing climate change in the country. Furthermore, as an outcome of the TNA project, Swaziland received funds through Climate Technology Centre and Network (CTCN) for training civil society on climate change and forming a national task team which has both state and non-state actors and is working towards enhancing adaptation and mitigation activities.

This report provides a narrative of the barrier analysis and corresponding enabling framework to facilitate the widespread diffusion of adaptation technologies identified in Swaziland in the TNA project. Discussions of the barriers identified by stakeholders for each of the shortlisted technologies in adaptation are provided. Furthermore, corresponding solutions to these barriers, in the form of policy recommendations and practical actions to be taken are also provided in this report, derived from information collected at the stakeholder workshop in August 2016. Enabling Frameworks for prioritised technologies were developed at the workshop in March 2017.

Figure 1 Participants at initial meeting for Barrier Analysis and Enabling Framework workshop at Piggs Peak, Swaziland in August 2016

At the preliminary BAEF workshop in August 2016, stakeholders undertook exercises in identifying problems and solutions for implementing the prioritised technologies. Problem tree and solution tree methods were used.

Figure 2 Second workshop on BAEF phase held in Piggs Peak between in March 2017

A second workshop was held between 29-31 March 2017 at Piggs Peak where stakeholders came together to discuss at a more detailed level the enabling frameworks for chosen technologies. This was an opportunity for the consultant to present problem trees and solution trees developed in the first workshop and discuss them with the stakeholders, who then worked in groups to come up with enabling frameworks. Market maps were developed for some technologies. The stakeholders also shared several documents and useful information which contributed to this report.

To summarize, the following stakeholder consultations were held as part of TNA project.

Table 1 Progression of the TNA project with regard to stakeholder consultation and prioritisation of technologies

Date	**Stakeholder engagement**	**Activities undertaken**	**Number of participants**
13 June 2015	Inception workshop and Sector prioritisation workshop	Stakeholders prioritised sectors for TNA. The ten sectors that were presented to stakeholders were deliberated and discussed. Then stakeholders choose three sectors and they also guided consultants on which technologies to focus on. After which, factsheets of technologies were sent via e-mail to participants. Sectors chosen for adaptation were: 1. Water 2. Agriculture 3. Forestry and Biodiversity	22
20- 21 August 2015	Technology prioritisation workshop	Stakeholders prioritised technologies during the technology prioritization workshop. Multi Criteria Analysis (MCA) tool was used and following technologies were prioritised: Water Sector: 1. Integrated River Basin Management 2. Artificial groundwater recharge 3. Wetland restoration Agriculture Sector: 1. Livestock and Poultry selective breeding 2. Conservation Agriculture 3. Crop Diversification Forests and Biodiversity Sector: 1. Afforestation 2. Conservation of genetic resources 3. Invasive Alien Species Management	43
9 April 2016	TNA Validation workshop	Changes were made to the prioritised technologies at this workshop. Artificial ground water recharge was considered not a "mature" technology for Swaziland and hence replaced with Rooftop Rainwater Harvesting. Crop diversification was considered included under Conservation Agriculture and hence Micro and Drip Irrigation was included, particularly considering the recent droughts experienced by the country. Afforestation was replaced with agroforestry to benefit farmer's livelihoods and to contribute woody cover within farms and not just afforestation areas.	63

		Water Sector: 1. Integrated River Basin Management 2. Wetland protection and restoration 3. Rooftop Rain water harvesting Agriculture Sector: 1. Livestock and Poultry selective breeding 2. Conservation Agriculture 3. Micro and Drip irrigation Forests and Biodiversity Sector: 1. Agroforestry 2. Conservation of genetic resources 3. Invasive Alien Species Management	
31 August to 2 September 2016	BAEF inception workshop	The BAEF phase was introduced to participants including problem and solution tree methods. Stakeholders chose one technology per sector for detailed analysis.	36
29-31 March 2017	BAEF workshop	Barriers and enabling frameworks for the chosen technologies were identified	46 participants
July/August 2017	Stakeholder consultations/ Interviews	A number of national experts were interviewed by the consultant to gather more information to improve the report. The BAEF report was revised further.	7 experts interviewed, literature review and further analysis done.

Table 2 Additional stakeholder consultation undertook for BAEF

Date of interview	Name	Institution	Areas of expertise and Inputs provided
3 May 2017	Jabulani Tsabedze	Swaziland National Agricultural Union	Expertise in agriculture and micro finance and head of farmers union.
10 July 2017	Prince M. Mngoma	Swaziland Water and Agricultural Development Enterprise (SWADE)	Has undertaken projects that's cuts across all three sectors of water, agriculture, forests and biodiversity. Provided in depth information particularly on conservation agriculture.
11 July 2017	Mvezi Phindumbutfo Dlamini	Peak Timbers	Expertise in Forestry and Biodiversity. Provided Grassland Assessment and Stream Assessment Reports, which provided insight into landscape management and water quality issues.
18 July 2017	Prof. Abshalom Manyatsi	University of Swaziland	Provided information for all three sectors, but further in depth information for the agriculture sector barriers.
26 July 2017	Richard Masimula	COSPE	Expertise in agriculture projects.
8 August 2017	Titus Dlamini	Director, Ecotone Africa. Former Chief Executive Officer of Swaziland National Trust Commission	Provided information on all three sectors and in particular more details on management of invasive alien species.
August 2017	Mbongeni Hlophe	Environment Fund	Provided information via e-mail on wetland rehabilitation and protection project.

A chapter on Strengths Weaknesses Opportunities and Threats (SWOT) analysis of measures and another chapter on linkages between barriers is included in this report. The three sectors are discussed in details with barriers identified for all nine technologies (three per sector) and enabling frameworks were developed.

2. Chapter: Water Sector

Swaziland is blessed with water resources, comprising of five major river systems comprising Lomati, Komati, Mbuluzi, Usuthu and Ngwavuma (or Ngwempisi) rivers (Figure 3). The surface water resources of the country are estimated at 4.5 km^3/year with 42% originating from South Africa (Manyatsi and Brown, 2009). Swaziland has eleven dams which are important for water supply and irrigation in the country. Water is a key driver for economic growth in Swaziland, as agriculture and tourism sector depends highly on this resource. Stakeholders recognized this and prioritized the water sector for the TNA project. The drought experienced in 2015-2016 was a key motivation for stakeholders to prioritize water saving and water efficient technologies. The technologies retained during the BAEF phase for water sector were:

1) Integrated River Basin Management (IRBM);
2) Wetland Restoration and Protection (WRP) and
3) Rooftop Rain Water Harvesting (RWH).

The BAEF was a stakeholder driven process and includes inputs from stakeholders via workshops and interviews, but also contains recommendations for measures which were extracted from the following national documents. Given below are explanations of how the national documents provide motivation for adaptation measures in the water sector:

- **Alignment with national priorities**

Adaptation in the water sector is in alignment with national priorities and has impetus from legislations as well as published Government documents.

- **National Water Policy 2009**

The need for investment in the water sector has been emphasized in the National Water Policy (2009). "Swaziland shall endeavour to provide adequate financial resources for national projects for water resources development and management." Strategies listed in the policy include using a participatory approach, providing adequate funds to finance development of water infrastructure as well as capacity building, institutional development, research and technology development.

- **Intended Nationally Determined Contributions (INDC) 2016**

The INDC (currently known as Nationally Determined Contributions or NDC) prioritized adaptation technologies including RWH, WRP and IRBM across all sectors.

- **Third National Communication to UNFCCC 2016**

The Third National Communication to UNFCCC also talks about the need for water saving technologies and improving adaptation in the sector.

- **Global Water Partnership (GWP) Integrated Water Resources Management Report (Manyatsi and Brown, 2009)**

The report called for measures including capacity building, training and retaining of staff of Department of Water Affairs, strengthening of institutions offering water related courses, innovative mechanisms of

fundraising, improved ways of disseminating information, and development and finalizing of policies and regulations.

- **National Development Strategy and Vision 2022**

The National Development Strategy and Vision 2022 calls for efficient use of water resources, review of regulations, institutional strengthening, promoting water harvesting, improving delivery and improve participation in water resources management.

Swaziland's major rivers are transboundary and shared with South Africa and Mozambique (see figure below).

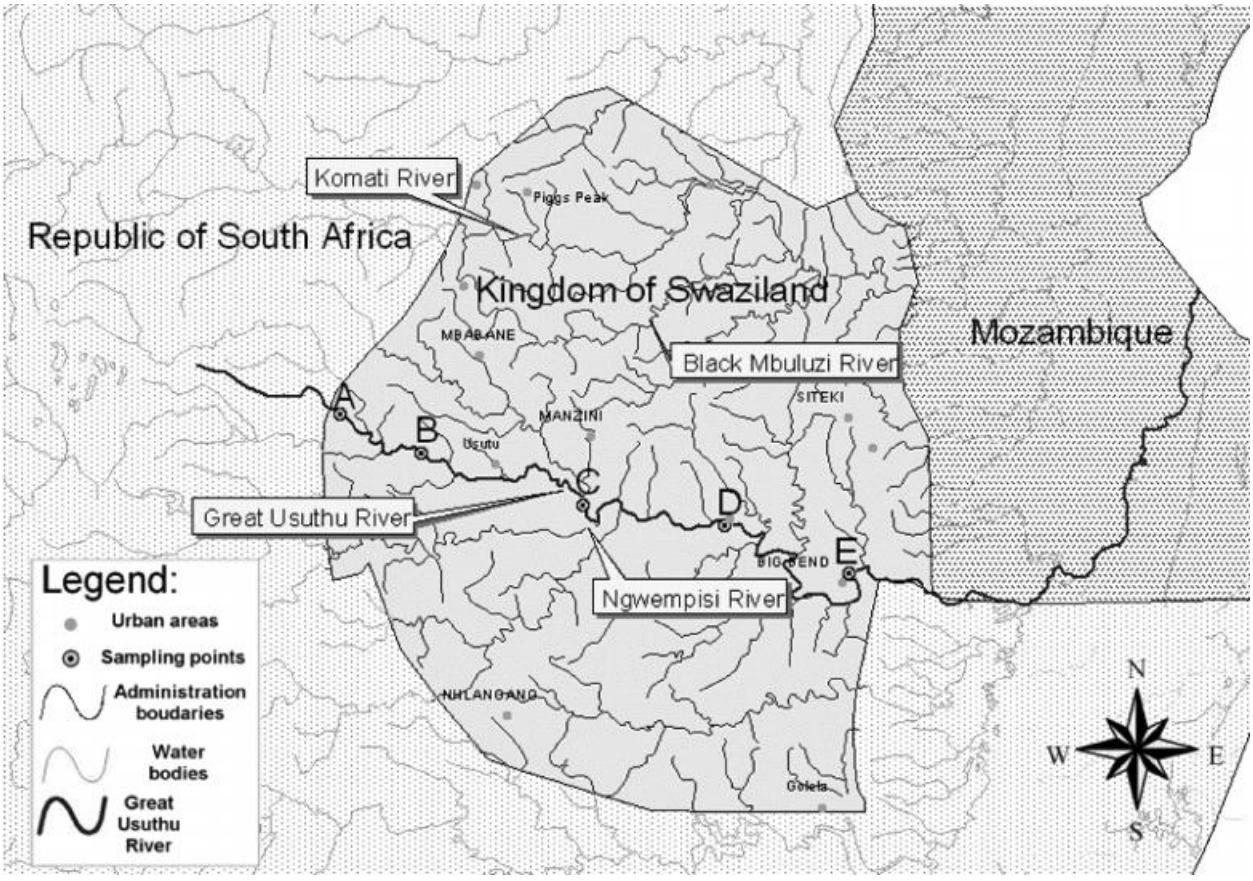

Figure 3 Important River Basins of Swaziland

Source: Kowalkowski et al. (2007)

2.1 Integrated River Basin Management (IRBM)

2.1.1 General description of Integrated River Basin Management (IRBM)

"Integrated River Basin Management (IRBM) is the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximise the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems" (GWP, 2000). IRBM rests on the principle that naturally functioning river basin ecosystems, including accompanying wetland and groundwater systems, are the source of freshwater. Therefore, management of river basins must include maintaining ecosystem functioning as a paramount goal. This "ecosystems approach" is the interdisciplinary technology which integrates all other management and technical methods for sustainable development in a river basin.

IRBM has many social, economic and environmental advantages. IRBM ensures that human and environmental needs are met in a sustainable manner, thus avoiding conflicts on access and use of water. It facilitates balanced, harmonious social and economic development plans. Furthermore, it protects the local environment, habitats and landscapes. This technology needs myriad skills for implementation, collection of various data, as well as strong institutional arrangements to make it a success. Swaziland does not have good reliable data which can help with making river basin management plans, there is limited coordination amongst organizations and communities, and there is need to strengthen the decentralization process in order to effectively adopt IRBM systems (IDE-JETRO, 2017).

Any programmes related to IRBM must take into consideration the transboundary soft laws. The Protocol on Shared Watercourses in the SADC Region, the Regional Water Policy (RWP), the Regional Water Strategy (RWS) and other shared watercourse agreements are to be used for guidance and strategic direction as it is binding to all Member States. According to the National Water Policy (2009) of Swaziland, there is need for raising awareness among the populace on the shared watercourse agreements, harmonising policies and improving cooperation in all shared watercourses agreements to which Swaziland is party, as a basis for cooperation in transboundary water resources management (Government of Swaziland, 2009).

The seven key elements to a successful IRBM initiative are, according to WWF (2017):

1. A long-term vision agreed by all stakeholders for the river basin;
2. Integration of policies, decisions and costs across sectors;
3. Strategic decision-making at the river basin level, with actions at local levels;
4. Taking advantage of opportunities working within a strategic framework;
5. Participatory approach where relevant stakeholders are involved in decision-making;
6. Sufficient investment by governments, the private sector, and civil society organisations in planning and participation processes; and
7. Good understanding of the river basin and the natural and socio-economic forces that influence it.

Mwendera et al. (2002) estimates Swaziland's surface water resources to be 4.45 billion m^3/year with 58% originating within the country. It is imperative that the river basins are managed well in the wake of challenges faced by climate change. Since, for Swaziland, all river basins are shared with Mozambique and South Africa, all three countries have established commissions and committees to safeguard development of the international water bodies. These include the Joint Water Commission, the Komati Basin Water Authority and the Tripartite Commission. Swaziland has established the Komati River Basin Authority through the Tripartite Permanent Technical Committee (TPTC), a collaboration between South Africa, Mozambique and Swaziland. The cooperation on the joint management of the Komati Basin was initiated in 1992 with the signing of the Komati Accord between South Africa and Swaziland. The Accord was signed by Mozambique in 2002, making the Komati River Basin Authority one of the first river basin organizations in Southern Africa. This is to manage the water flow of the Komati River and Maputo River, specifically during times of flooding and drought. At the national level, the Water Act of 2003 established the National Water Authority (NWA) and also five river basin authorities (RBA) (Lomati, Komati, Mbuluzi, Usuthu and Ngwavuma) through which basin specific water management processes will evolve. RBAs works with basin stakeholders to manage water resources. Although the Act states that all water in the country is a national resource and users need to have permit for use of the water, however, for primary (subsistence) use, there is no need for a permit. The five river basin authorities will apportion the water for domestic, agriculture and environmental uses (Manyatsi and Brown, 2009).

During the TNA process, stakeholders raised concerns regarding some of the challenges faced by Swaziland with regard to IRBM. They mentioned slow implementation of the Water Act and water management strategies, weak institutional capacity, poor awareness leading to catchment degradation, pollution from agro-chemical run-off and climate change to be the challenges. They articulated need for capacity building, setting up relevant institutions, better technologies to control water leaks, and called for greater awareness on IRBM.

At the national level, a UNDP funded project "Adapting national and transboundary water resource management to manage the expected impacts of climate change" was implemented in Swaziland from 2011 to 2015. The project was funded by the Global Environment Facility (GEF) through the Special Climate Change Fund (SCCF). USD 7.5million was spent along with received co-financing and in-kind contributions from the Government of Swaziland and the Komati Basin Water Authority (KOBWA). This addressed the need for river basin management programmes to consider and plan for climate change impacts. Technologies such as rain water harvesting, sand dams, automated weather stations, drilling of boreholes, improving water and sanitation, crop diversification, promoting good land use practises and training of officers responsible for negotiations at transboundary authorities was done through this project (UNDP, 2017).

Thus, IRBM is a suite of hard and soft technologies and is best described as an interdisciplinary technology which integrates all other management and technical methods for sustainable development in a river basin. Its benefits include balancing social and economic benefits in an equitable manner, preventing/avoiding conflicts on the access and use of water and facilitating balanced, harmonious social and economic development plans. Its benefits to the environment include saving water, reducing water wastage,

conserving biodiversity and protecting the local environment, habitats and landscapes. Finally, IRBM contributes to adaptation by facilitating the conservation and efficient use of the available water resources to cope with climate change. IRBM has been implemented in the Komati River Basin and can be expanded to all river basins in Swaziland.

Good management of Swaziland's water resources are included in:

- **Draft Water Policy, 2009**

The water policy has produced a number of policy statements and strategies that related to water usage permits.

- **The Integrated Water Resources Master Plan**

This provides strategic guidance to decision makers and water users on how best to develop and manage the country's water resource within the framework for the implementation of existing policies and legislation.

2.1.2 Economic analysis

The Komati River Basin programme is taken as a model for technology diffusion, as it has many successes to report. Wilkinson et al. (2015) assessed the implementation of principles of integrated water resource management (IWRM) in the Komati River Basin, and concluded that good progress has been realised with respect to creating the enabling environment and institutional frameworks and relatively satisfactory degree of stakeholder participation has been achieved. The authors say that financial enabling environment, institutional capacity building and conflict resolution mechanisms need further attention. A phased approach was recommended, followed by formulating and implementing the institutional framework and creation and application of IWRM management instruments.

For the purposes of economic analysis, the Komati Basin Water Authority (KOBWA) capital investment costs have been used as an indicator. KOBWA's main purpose was to construct and maintain two dams; the Driekoppies Dam in South Africa and the Maguga Dam in Swaziland. Additionally, KOBWA is responsible for water management in the basin and has distributed 447 million m^3 of irrigation water to the two member countries of Swaziland and South Africa. Total investment in the Komati Basin Development Project was E 1,716,006,300 and income was realised from sale of irrigation water to sugarcane estates and other users. Areas which previously experienced water shortage (such as Piggs Peak in Swaziland) have been supplied with water through this project. In addition, roads were constructed, community nurseries established for vegetables and fruit trees and the Maguga dam has become a tourist attraction. A river basin management programme of the KOBWA scale would require similar budget and hence for purposes of the BAEF economic analysis, we will assume a budget of E 1.7billion.

2.1.3 Preliminary targets for technology transfer and diffusion

The Swaziland Vision 2022 and National Development Strategy (NDS) promotes conservation and management of water and land resources. It has also been specifically articulated in the vision and strategy

that institutional capacity must be built to manage and coordinate water resources. It also includes the vision to promote catchment management plans for major river systems. The need for ongoing capacity building, training and creating awareness in this sector has been emphasised. Furthermore, Swaziland's Consitution (Section 210) states that in the interests of the present and future generations, the State shall protect and make rational use of its water resources.

The diffusion of IRBM as a technology is meant to contribute to this vision and sector objectives. The objectives with regard to diffusion of this technology is to ensure that River basins are effectively managed by enhancing capacity of River Basin Authorities (which were set up by the National Water Act 2003). Improved participation with communities, improved coordination of resource use and resource mobilisation are all part of this vision. This is in synchonous with Swaziland's Climate Change Strategy and Action Plan and with Swaziland's Intended Nationally Determined Contributions (INDC), where IRBM has been mentioned as helping the country to adapt better in the water sector.

2.1.4 Identification of barriers for Integrated River Basin Management (IRBM)

From stakeholder consultations at workshops, interviews of key experts and from literature review, barriers have been identified for IRBM. As this is not a market technology, market mapping was not done. The cost to implement an IRBM is difficult to estimate as it would depend on the river basin chosen and would need detailed analysis not only in Swaziland but also the countries the river is shared with, namely Mozambique and South Africa. Since the technology is specific to a river basin it is difficult to estimate economics of the programme. However, to implement an IRBM programme at the scale of UNDP project described above, the estimated costs are in the region of USD 7.5 million. It is assumed that this would be a non-profit developmental project that would accrue socio-economic and environmental benefits and help in adaptation thereby justifying the investment.

2.1.4.1 Economic and financial barriers

Key economic and financial barriers identified were inadequate investment and funds for effective IRBM programmes. The domestic funds allocated for IRBM activities by Government are inadequate and there is need to raise funds from external agencies.

Table 3 Economic and Financial Barriers for Integrated River Basin Management

Barrier	Explanation	Effects
Inability to get concessional loans from financial institutions from developed countries as Swaziland is classified as a middle income country.	IRBM needs large scale investments. Loans will be more expensive without concessions. The costs of payment of interest for loans could be high.	Inability to raise funds resulting in weak/poor investment in IRBM

Inadequate domestic funds to implement IRBM programmes in Swaziland	Country funds are allocated for the various sectors and there is inadequate allocation of funds for IRBM activities. There is need to raise funds. Infrastructure costs of buiding structures for erosion control, flood control, water retension and catchment management.	IRBM is not prioritised under Government budgets when there are more urgent priorities in the country
Lack of coordination of funding on programmes under different conventions	Conventions such as the United Nations Convension on Combating Desertification (UNCCD), United Nations Framework Convention on Climate Change (UNFCCC), Convention on Biological Diversity (CBD) influence activities in the river basins. However, their funding streams are separate and not coordinated. Duplicated and uncoordinated efforts cause inefficient use of resources.	Synergies in using funds in a coordinated manner are missed

2.1.4.2 Non-Financial barriers

Non-financial barriers include slow implementation of the Water Act and water management strategies, weak institutional capacity, catchment degradation, pollution from agro-chemical run-off and climate change. As a response, stakeholders articulated the need for capacity building, setting up relevant institutions and greater awareness.

Table 4 Non- Financial Barriers for Integrated River Basin Management

Barrier	**Explanation**	**Effects**
Institutional Barrier: Slow implementation of the Water Act and Water Management Strategies	The Act is in place but not effectively implemented due to weak capacity of RBAs to implement it.	Due to legislations not implemented fully, over abstraction, pollution and poor land management activities may continue, costing the country in terms of lost revenue, clean up costs and reduced water quality and quantity.
Weak coordination of IRBM related programmes such as land degradation management, which is covered under United Nations Convention to Combat Desertification (UNCCD),	Institutions such as Ministries responsible for agriclture, natural resources, water and forestry need to coordinate efforts for rehabilitation of land, catchment management and water resources	Costs may get duplicated when efforts are not streamlined/coordinated. Resource efficiency is improved when efforts are coordinated.

United Nations Framework Convention on Climate Change (UNFCCC) and United Nations Convention on Biological Diversity (UNCBD).	management, which are all arms of IRBM systems.	
Political Barrier: Conflicts in water use at multi country level	As the rivers are shared with neighbouring countries, IRBM will need to involve all countries.	If conflicts arise, it will stall progress of IRBM programmes, thereby causing loss of revenues and benefits from good basin management.
Conflicts in water use at local level	River basin authorities are controlled by central govt. But at community level, there are traditional authorities responsible for allocating resources (such as land) for use. Participation and involvement of all authority structures is needed to ensure there are no conflicts	Conflicts at local level could possibly cause inequitable sharing of water resources and vandalism of exisiting infrastructure as well as lack of cooperation from stakeholders involved.
Awareness Barrier: Limited awareness on IRBM and its benefits especially in the wake of water scarcity and climate change	Due to poor awareness, people may resort to activities which affect the river basin adversely.	Effects may include over abstraction of water, pollution and poor land management activities.
Mindset of communities is that water is free and available for all	The mindset that "Water is free" and since it is God given, it should not be controlled by humans, but freely available for anyone to use.	There is no ownership of water as a communal resource. Water, if considered free and available for all, could promote wastage and inefficient use.

2.1.5 Identified measures for Integrated River Basin Management (IRBM)

The following measures are identified to overcome barriers in implementing IRBM. They include both financial and non-financial measures.

2.1.5.1 Economic and financial measures

A major barrier to implementing IRBM is availability of funds. Since Swaziland cannot get concessional loans from the international community due to its middle income country status, other avenues are to be

used to acquire low cost finance. These include developing proposals to target other funds available including regional funds.

Financial Measures

Measure 1: Develop proposals to raise funds from international and regional institutions/opportunities.

Measure 2: Raise funds at national level through Public Private Partnerships (PPP).

Addressing Institutional Barriers

Measure 3: Establish a "Funds Coordination Platform" within Swaziland in collaboration with development partners, private sector, and other non-state actors. This platform can develop common strategies for usage of funds so that activities which are related to river basin management could be streamlined and synergies attained in usage of funds. The Funds Coordination Mechanism can create synergies and more efficient use of funds through coordinating activities in the river basin, such that duplication is avoided and cooperation and sharing of resources is encouraged.

2.1.5.2 Non-financial measures

Institutional Capacity building

Measure 1: Build capacity of officers responsible for implementing relevant legislations (such as the Water Act) through providing them training, technical support and equipment where needed.

Measure 2: Build capacity of institutions responsible, such as the River Basin Organizations through filling vacancies and adding more staff where needed (such as for water quality checks and leakage management).

Awareness Raising

Measure 3: Create awareness amongst stakeholders about IRBM and water resources management. Develop Information Education and Communication (IEC) materials, conduct road shows and hold community meetings and awareness sessions on utilization of water from river basins, role of RBA and environmental as well as developmental activities in river basins.

Addressing Political Barrier (reducing conflicts)

Measure 4: Create a Participatory Forum, where traditional authority and relevant stakeholders can be given a voice in decision making. This will prevent conflicts, create transparency, encourage dialogues and improve decision making.

2.1.6 Enabling framework for Integrated River Basin Management (IRBM)

Enabling framework for IRBM is presented in table below. In order to successfully implement IRBM, Swaziland must focus on developing proposals to raise funds for RBA activities, improving coordination of existing funds, improving awareness and institutional capacity, and improving participation with all players.

Table 5 Enabling framework for Integrated River Basin Management

Barriers	Measures	Economic consequence of measures	Other consequences of measures
Financial			
1. Inability to get concessional loans from financial institutions from developed countries as Swaziland is classified as a middle income country.	Develop proposals to raise funds from international and regional institutions/opportunities.	Funds needed for technical support, trainers and to hold workshops and meetings for proposal development	No negative consequences anticipated
2. Inadequate domestic funds to implement IRBM programmes in Swaziland	Raise funds at national level through Public Private Partnerships (PPP)	Government internal budget would need to be used for the PPP	Government internal budgets may not be enough. Private companies may not be keen to join
3. Lack of coordination of funding on programmes under different conventions	Create a Funds Coordination Mechanism, to create synergies and more efficient use of funds.	Meetings costs for the committee	There could be resistance to creating this mechanism, as agencies may prefer to manage their resources autonomously
Non-Financial			
Institutional Capacity 4. Inadequate capacity of RBA officers leading to slow implementation of the Water Act and Water Management Strategies	Build capacity of officers responsible for implementing relevant legislations (such as the Water Act) through providing training, technical support and equipment where needed and review outdated legislations.	Costs related to effective implementation of legislation, through recruitment of staff responsible for collection of revenues, inspectors, checking water usage and wastage, and review of legislations.	Adequate expertise may not be available in the country which may cause vacancies to remain unfilled. Review of legislations is a long process.
5. Weak institutional capacity	Build capacity of institutions responsible,	Costs related to training of staff and	Adequately trained people may not be

	such as the River Basin Authorities through filling vacancies and adding more staff where needed (such as for water quality checks and leakage management).	recruitment of new staff	available to fill positions
Awareness 6. Inadequate awareness on IRBM and its benefits especially in the wake of water scarcity and climate change	Create awareness amongst stakeholders about IRBM and water resources management. Develop IEC materials, conduct road shows and hold community meetings and awareness sessions.	Costs related to awareness campaigns, IEC materials, community meetings, road shows etc.	Changing mind-sets of people may take a long time. There could be resistance to ideas.
7. Mindset of communities is that water is free and available for all			
Political 8. Conflicts in water use at local level	Create a Participatory Forum, where traditional authority and relevant stakeholders can be given a voice in decision making. This will prevent conflicts, create transparency, encourage dialogues and improve decision making.	Involve traditional authorities and those who are influential at local level	People in authority at local level may resist
9. Weak coordination of IRBM related programmes such as land degradation management, which is covered under UNCCD, UNFCCC and CBD conventions.		At the forum stakeholders responsible for implementing programmes as part of UNCCD, UNFCCC and CBD conventions must be included	Resistance may be faced from stakeholders responsible for conventions as this is in addition to their normal duties

2.2 Wetland Protection and Restoration

2.2.1 General description of Wetland Protection and Restoration

Wetlands have important ecological functions of maintaining biodiversity and act as a sponge in regulating water flow thereby controlling floods. The dense root mats of wetland plants also help to stabilize shore sediments, thus reducing erosion. Wetlands can be of many types and sizes. Wetland restoration relates to the rehabilitation of previously existing wetland functions from a more damaged to a less damaged or operational state of overall function. Human activities of farming on wetlands, filling wetlands for using the land for settlements and allowing livestock to drink water in wetlands, all upset the soil conditions and damage its ecological functions.

Wetland rehabilitation and restoration helps maintain its ecological functions of flood control and biodiversity maintenance. It also helps maintain the micro climate and allow vegetation to thrive. Some special vegetation such as reeds and medicinal plants grow on wetlands which have human well-being benefits. Wetlands are aesthetically pleasing. Wetland restoration needs expertise especially if transplantation of wetland plants is needed. Activities include planting wetland plants and providing fencing around wetlands to prevent livestock from entering. The advantages of wetland restoration and protection far outweigh the disadvantages.

Communities tend to allow their livestock to graze on wetlands during dry spells which causes negative impacts as the soil in wetlands is compacted by livestock. The importance of wetland restoration needs to be elevated and awareness raised in Swaziland in this regard. If communities are made aware of the economic benefits of restoring wetlands, then there is potential for self-help groups undertaking this at their own expense. Furthermore, through eco-tourism and sustainable harvesting of products, communities will be able to offset the cost of restoration. With climate change, it is expected that wetlands will face drying up, but this will accelerate if human activities are degrading wetlands. Conservation of wetlands helps build ecosystem resilience as well as resilience of humans through hazard mitigation and biodiversity and micro climate maintenance.

Wetlands can be used as public spaces for recreation and eco-tourism. Wetlands have natural flood control mechanisms and so saves costs of dealing with flood disasters. Restoration provides a small number of jobs. Other goods and services provided by wetlands, such as the provision of wood, insects, reeds for basketry, medicinal plants and fibres help in income generation for local communities. Micro climate around wetlands and its aesthetic qualities can have healing effects for humans. The case for protecting wetlands is also a biodiversity conservation one. Swaziland has 2,600 species of flowering plants, approximately 121 species of mammals, 153 amphibians and reptiles, and 350 species of birds; making it unique in floral and faunal species richness (UNDP, 2011). Many species need wetlands as habitats for survival and/or breeding.

Awareness raising on wetlands have been done to some extend in Swaziland through the commemoration of World Wetlands Day. The Water Act of Swaziland promotes the need for protecting water resources including wetlands. In many of Swaziland's regulations (e.g. National Climate Change Strategy and Action Plan), ecosystem approach is recommended and in this approach, maintaining ecological functions of

important natural areas such as wetlands comes in. But, more needs to be done to ensure wetland's ecosystem functions remains protected in Swaziland.

2.2.2 Economic analysis

There are two major sources of funding for the restoration and protection of wetlands, internal/governmental budgets and development partners funds. It is difficult to estimate the cost of a wetland restoration and rehabilitation programme unless the area to be restored is known. For the purposes of economic analysis, two projects were examined, one is a large UNDP implemented project and the other, a smaller National Environment Fund project.

The UNDP and Government of Swaziland funded project "Strengthening the National Protected Areas System of Swaziland" is examined first. The Protected Areas (PA) programme had three areas namely:

Component 1: Knowledge based platform operationalized at the National and regional level to address current and emerging threats to PAs and biodiversity conservation.
Component 2: Landscape approach operationalized and leads to expansion of PA network.
Component 3: Strengthening PA functioning through improved conservation management and operational support for existing and new PAs, including both formal and informal PAs.

The total budget for this Global Environment Facility (GEF) and Government of Swaziland funded programme, implemented from 2011 to 2015 was USD 28,990,000. Implementing partners were the Swaziland National Trust Commission (SNTC) a parastatal organisation, in close cooperation with the Ministry of Tourism and Environmental Affairs (MTEA).

A smaller project funded by National Environment Fund is examined next. The Lawuba wetlands protection project was implemented by the Environment Fund, Swaziland Environment Authority (SEA) and World Vision on protecting the Lawuba wetland which provided livelihoods to communities living around it. The Environmental Fund started operating in 1999 and continues donga restoration, botanical gardens restoration and wetlands protection projects. The total budget for the Lawuba wetland protection (covering 20 hectares) was E278, 000. The project entailed holding awareness raising sessions, fencing the wetland and sustainable harvesting of grasses and reeds for basketry by women in the area. Women weavers reported earnings of E1.2million from selling crafts made from fibres harvested from the wetland (see figure below).

The Lawuba wetland project is chosen for purposes of the TNA as a model for budgeting in this BAEF. The project has accrued benefits which are desirable for helping communities and the environment adapt to climate change (see figure below).The UNDP project has a larger scope and hence not used as a model in this case.

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E1.2M GENERATED THROUGH WETLAND PROTECTION PROJECT

"... women harvest grass and reed to make crafts from the wetland"

BY THAKASILE DLAMINI

LAWUBA – Communities that benefit from wetlands can be affected by their degradation.

This was evidenced in the Lawuba community where it was discovered that the wetland was fast diminishing and was becoming less productive in terms of natural fibre plants with each passing season.

There was not enough water and the biological species of birds were migrating and becoming extinct.

Mbongeni Hlophe, the National Environment Fund Officer at Swaziland Environmental Authority (SEA) said the main cause for the degradation of the wetland was overgrazing and trampling by the cattle in the community.

SEA, through the National Environment Fund, embarked on a E228 000 wetland protection project, with an additional E50 000 from SPTC and World Vision.

The wetland protection project involved first sensitising the community members about the value of the wetland ecosystem.

The next step was to provide funding to fence off the entire wetland, thus sealing it off from the livestock. Once the National Environment Fund had purchased the fencing equipment, the community members provided the labour needed to build it. Hlophe said this was particularly important as public participation is the cornerstone for the success of any environmental project or issue.

Following the protection of the wetland, the migrated animal species such as birds returned.

Also, there was a rejuvenation of the dormant plant species as well as the emergence of new plant species. Some of the plants species that returned and began to thrive after the wetland had been protected included *Likhwane* (Cyperus latifolius), *Incoboza* (Cyperus articulates) and *Umtsala* (Miscanthus capensis) which were in turn harvested by the local women for business purposes.

Mbongeni Hlophe from SEA and some of the women who harvest weaving fibres from the Lawuba wetland. They made an estimated E1.2 million through selling crafts.

Figure 4 Newspaper article on wetlands protection project

Swaziland's range of wetlands are found along the country's rivers, flood plains, swamps, bogs, vleis, and dams (man-made). An inventory of major wetlands in Swaziland was done by Masarirambi et al. (2010) and presented in table below.

Table 6 Inventory of wetlands in Swaziland

No.	Name	Type*	Area (ha)	Remarks
1	Milwane	D	25	Protected
2	Hlane	D	4	Protected
3	Matsapha	D	92	Proposed for protection
4	Sand River	D	727	Limited protection, increased protection proposed
5	Malolotja	V	8	Protected
6	Nyetane	D	2	Future protection unlikely
7	Mlawula	D	4	Proposed for protection
8	Nyetane	D	260	Proposed for protection
9	Ubombo	D	22	Proposed for protection
10	Pangolo	D	492	Proposed for protection when filled
11	Ndlotane	V	5	Proposed for protection
12	Sukasihambe	B	2,000	Now being planted with sugar-cane but rich in bird-life
13	Mangwenya	P	6	Proposed for protection
14	Mnjoli	D	2,565	Proposed for protection

15	Shovella	D	8	Proposed for protection

*: B = basin, D = dam, P = pan, S = shallows, V = vlei

Choosing five wetlands for protection which range from size of 4 to 22 hectares, costs are calculated approximately using Lawuba wetland protection costs as datum. The costs for fencing may reduce in some wetlands if hectarage is low, but community awareness sessions and other expenses remain similar, hence total cost comes to E278,000 x 5 = E1.39million. The wetlands chosen are the ones proposed for protection, namely; Mlawula, Ubombo, Ndlotane, Mangwenya and Shovella. Larger wetlands of over 22 hectares have been left out as cost estimation would be difficult.

2.2.3 Preliminary targets for technology transfer and diffusion

The Swaziland Vision 2022 and National Development Strategy (NDS) promotes wetland restoration and protection through its overall vision of conservation and management of water and land resources. Wetland restoration is targeted through this vision as it contributes to managing, coordinating and monitoring water resources in a systematic and equitable basis. This is further supported by Swaziland's Consitution (Section 210) which promotes rational use of its water resources. The diffusion of the WRP technology contributes to this targets as it supports flood protection, biodiversity and livelihoods enhancement which contributes to management of water resources. This is in synchonicity with Swaziland's Climate Change Strategy and Action Plan and with Swaziland's Nationally Determined Contributions, where WRP has been mentioned as a technology helping Swaziland to effectively adapt to climate change. Here, community participation and awareness is key for success and these are included as measures.

2.2.4 Identification of barriers for Wetland Restoration and Protection

2.2.4.1 Economic and financial barriers

Wetlands rehabilitation and protection in Swaziland received inadequate funding and many wetlands which have been earmarked for restoration and protecton have not been provided funds for implementation of restoration activities. There are many environmental activities such as protected areas management, livelihood projects, agricultural projects and others which have overlaps with wetlands restoration and protection. Hence funds get allocated into different streams and this could cause duplication of efforts. Hence, a funds coordination mechanism is suggested where any activities related to environment, agriculture, tourism, development or conservation have the opportunity to coordinate use of funds for wetlands restoration activities. Thus, synergy in usage of funds can be achieved, thereby having greater results for wetlands restoration and protection. The barriers are discussed in further detail in table below.

Table 7 Barriers identified by the stakeholders for Wetlands Restoration and Protection

Barrier	Explanation	Effects
Inadequate funds for wetland rehabilitation and protection	Due to inadequate knowledge of economic benefits from wetlands, funds are prioritised for other perceivably more urgent and important activities (such as health,	While wetland degradation is less costly to address in the early stages, this

	education) and wetland restoration gets less importance and is relegated to fall under environmental "donor funded" projects.	opportunity may be lost and some wetlands may completely lose their ecological function in future.
Poor coordination of funds which are used for environmental projects which may entail wetlands protection.	Funds used for environmental project and climate change activities could be synergised and activities related to wetlands restoration and protection could be coordinated. Synergies could be lost when sectoral approach is used due to inadequate coordination.	

2.2.4.2 Non-financial barriers

Table 8 Non-financial barriers for Wetland Restoration and Protection

Barriers	Explanation	Effects
Awareness Low awareness about the importance of wetlands	Awareness on the miriad functions of wetlands as habitats for biodiversity, flood protection and micro climate regulation is not fully appreciated by community who view it as a resource to be exploited. Awareness of professionals in the construction sector need to be improved so that they do not build on wetlands. Farmers must be made aware not to farm on wetlands. Banks must be informed that their agricultural loans must not be used to promote farming on wetlands.	Communities resort to using wetlands for livestock grazing during dry periods, thereby disturbing soil and fauna. Over abtraction of reeds, grasses and hunting of wild animals will threaten the habitats and cause species loss.
Mindset of looking at short term benefits versus long term ones	Wetland's long term benefits of flood control and habitats for biodiversity are not appreciated. Immediate needs of grazing and farming on wetlands to utilise the moisture retained contribute to degradation. People must be made aware of long term benefits.	When short term gains are looked at, exploitation of resources occur.
Institutional capacity Monitoring of wetlands health is inadequate	Regular inventory of wetlands and monitoring their health is needed in order to take remedial actions when needed.	Some wetlands may continue to be degraded and authorities may be unaware of their status. If timely actions are taken they could be restored to good health.
Unclear roles and	As wetlands fall under a variety of land uses, such as land for agriculture, land for forests and land	When there is confusion of roles and responsibilities in

responsibilities on wetland protection	for settlements, there is less clarity on who should manage it. Participatory management should be encouraged where traditional authorities are involved in wetlands protection.	management of areas with wetlands, the environment ultimately suffers. Activities of farming and building may occur on wetlands thereby compromising its ecological functions.

2.2.5 Identified measures

2.2.5.1 Economic and financial measures

Financial

Measure 1: Set a funds coordination mechanism involving stakeholders where meetings are held regularly and synergies in usage of funds for wetlands restoration and protection by agencies working in same areas are realised.

Measure 2: Proposal development for wetlands restoration and protection for shortlisted wetlands Mlawula, Ubombo, Ndlotane, Mangwenya and Shovella.

2.2.5.2 Non-financial measures

Awareness

Measure 1: Create awareness of importance of wetlands through community level meetings and site visits for communities living near wetlands. Long terms benefits of wetlands need to be emphasised.

Institutional capacity

Measure 2: Create a wetlands monitoring system to be implemented and published regularly by Swaziland Environment Authority on an ongoing basis.

Measure 3: At the funds coordination mechanism meetings grey areas in roles and responsibilities can be discussed and better clarity arrived at.

2.2.6 Enabling framework for Wetlands Restoration and Protection

The barriers for wetlands restoration and protection is presented here and measures are presented alongside with their expected economic and other consequences.

Table 9 Enabling framework for up scaling Rain Water Harvesting technology in Swaziland

Barriers	**Measures**	**Economic consequence of measures**	**Other consequences of measures**
Financial	Proposal development for wetlands restoration and	Proposal writing workshops and follow	Other positive consequences

Inadequate funds for wetland rehabilitation and protection.	protection for shortlisted wetlands Mlawula, Ubombo, Ndlotane, Mangwenya and Shovella.	up meetings may cost a nominal amount as they can be held in Mbabane at SEA conference venue	may arise from this by development of larger projects which cover more than wetlands restoration and protection.
Poor coordination of funds for environmental projects which may entail wetlands protection.	Set-up a funds coordination mechanism involving stakeholders where meetings are held regularly and synergies in usage of funds for wetlands restoration and protection by agencies working in same areas are realised.	To hold meetings for this coordination team, it is assumed SEA Conference venue is used at nominal rates or as in-kind contribution.	Stakeholders may want to have autonomy in funds usage for their projects and may not be willing to work together to create synergies.
Awareness Mind-set of looking at short term benefits versus long term ones	Create awareness of importance of wetlands through community level meetings and site visits for communities living near wetlands. Long term benefits of wetlands need to be emphasised.	Costs would entail community meetings and this would be part of wetlands restoration and protection project.	Improved awareness of importance of wetlands will promote conservation by communities.
Institutional capacity Monitoring of wetlands health is inadequate	Create a wetlands monitoring system to be implemented and published by SEA on an ongoing basis.	Costs for setting up a monitoring system may be reduced as SEA can use remote sensing to monitor wetlands and this capacity already exists.	Other positive consequences may be that general monitoring of landscapes will improve due to this deliverable.
Unclear roles and responsibilities on etland protection	At the funds coordination mechanism meetings grey areas in roles and responsibilities can be discussed and better clarity arrived at.	There are positive consequences to this measure, as more efficient use of funds will be achieved	Improved clarity of roles and responsibilities through improved dialogues and regular meetings.

2.3 Rooftop Rain Water Harvesting

2.3.1 General description of Rooftop Rain Water Harvesting

Due to climate change, rainfall patterns are expected to change and water stress may be experienced in Swaziland (Government of Swaziland, 2016). Hence it is vital that rain-water be stored, conserved and reused. Collecting rainwater from rooftops is an easy and fairly inexpensive way to increase amount of water availability in a household. The harvested water can be used for a myriad of uses from domestic to irrigation uses, depending on how it is filtered and treated. A range of rainwater harvesting (RWH) technological options are available and depends on the quality, cost, and sustainability of other residential water supplies, precipitation patterns, household income, and other factors. Furthermore, it depends on rainfall available and this varies with the ecological zones in Swaziland, which are highveld, middleveld, lowveld and lubombo plateau. Table below gives rainfall data for ecological zones of Swaziland.

Table 10Rainfall in ecological zones of Swaziland

Ecological zone	Rainfall mm/year
Highveld	700 – 1550
Middleveld	550 – 850
Lowveld	400 – 550
Lubombo Plateau	550 – 850

Source: FAO (2005)

RWH helps households adapt to climate change primarily through two mechanisms: (1) diversification of household water supply; and (2) increased resilience to water quality degradation. Harvesting rainwater helps reduce the pressure on surface and groundwater resources by decreasing household demand. With climate change affecting rainfall patterns, storage of rainwater can provide short-term security against periods of low rainfall and the failure or degradation of other water supplies. Water scarcity impacts of hindering economic development and affecting human health and well-being can be reduced using RWH.

A rooftop RWH system includes: (1) a catchment surface such as the roof of a house where precipitation lands; (2) a conveyance system of gutters and pipes to move and direct the water; and (3) containers such as tanks to store the water for later use. It is important to protect and maintain water quality in RWH systems and it can be done through filtration/screening, chemical disinfection, or a “first flush” system. First flush systems rejects the first rainwater volume which may contain impurities. Harvested rainwater can be used with proper filtration for potable use, or with no treatment for watering gardens and flushing toilets. Construction and repairs should be done/managed by households and there must be some training provided in this regard. It is suggested that households must install the RWH tanks as far as possible without external “experts” as it is a simple technology and this will help up-scale the technology. A simple plastic tank RWH system is fairly easy to install with minimal training. The Department of Water Affairs can provide technical advice whenever necessary by their skilled personnel. Arrangements should be provided by the Department of Water Affairs to test quality of stored water on a regular basis.

The hard roof of a house or building is the catchment area should not have paint on roofs which is toxic. Roofs made out of organic materials such as a thatched roof are also suitable for RWH provided they have guttering and in some instances one may use polythene coverings or other materials to reduce the permeability of thatched structures. Capture of the runoff via gutters or tanks is done and gutters and pipes can be of aluminium or PVC. Maintenance is required especially to ensure that contaminants present on the roof do not fall into the storage tank. This can be done by closing the downpipe with an end cap or valve and discarding the first flush of rainwater. Chemical disinfectants may be used to maintain water quality. Cleaning of screens and filters is essential. Storage tank should be closed using a lid and should not allow sunlight to enter to prevent algal growth. The whole rainwater collecting system should be cleaned at least 2-3 times per year, especially prior to the rainy season and after a long period of dry weather or after strong winds. Catchment surface and gutters have to be kept free of bird droppings, leaves and rubbish. The filter should be changed once in every three months. Mosquitoes can also breed in tanks if lids are not provided. Rooftop harvesting of rain water can be done at scale of households. A typical operating lifetime of a rooftop RWH system is about 15 years and can be more, if maintained well. Operational costs are minimum aside from regularly changing the filter, cleaning for debris and sediments, and repairs of potential leaks.

RWH technology has many advantages. It can help augment water supply during dry spells, thus helping households adapt to climate change. Use of RWH for agriculture is complementary to the current practice of irrigation and would strengthen system resilience. Harvesting rainwater also reduces demand from other sources of water such as surface and groundwater which are affected by climatic variations and assures water supply for various uses in a household. With this technology, water resources are diversified and households are better able to adapt to dry spells. Other advantages include improved water security as RWH helps provide extra water for food production and improves household hygiene and health. Households can improve their health from better sanitation using the additional water available from RWH systems. Using water from clean RWH system reduces waterborne diseases compared to usage of unclean sources. RWH helps in reduced ecosystem degradation through preventing siltation and erosion due to reduced runoff and helps to maintain or increase groundwater table, as there would be less reliance on groundwater for household use. Furthermore, RWH can increase job opportunities. Farmers using RWH for augmenting irrigation can lower the risk of their crop failures and thereby raise profits. The cost for water supply in households can be reduced with RWH systems, thereby providing them with extra funds for other economic activities that will improve their wellbeing. It also saves the time taken to collect water from sources far away and ensures continuous supply of water if the tank is large enough.

Singwane, and Kunene (2010) argue that rainwater harvesting is a viable technology for Swaziland. It is being used in a number of households, but only a few households who have tanks large enough to store water for the whole year. The authors argue that "if households could afford big storage facilities the acute water shortage problem could be averted especially when there is adequate rainfall during the wet season" (Ibid, 2010). Furthermore, this technology can provide water for household gardens where vegetables can be grown, which have positive impacts on nutrition (Ibid, 2010). The technology is viable because of Swaziland's subtropical climate with summer rains (75% in period of October till March). "The long-term average rainfall figure for the Highveld, the Middleveld, the Lowveld, and the Lubombo Plateau are 950 mm, 700 mm, 475 mm, and 700 mm respectively" (Manyatsi and Brown, 2009). RWH systems if large

enough can store enough water for a household to supplement piped systems and for extra water use such as for household vegetable gardens and for sanitation during dry periods. During dry periods water may also be used for domestic purposes. Below is a picture of RWH tanks at a local school in Hhohho region.

Figure 5 Rainwater harvesting at a school near Mbabane in Swaziland

Economic analysis of RWH tanks:

RWH installation costs are assumed to be E20,000 for two 5000litre plastic tank, pipes, guttering, preparation of roofs for harvesting, platform for placing the tank and labour for installation (Bruce Jameson, *Pers. Comm*). In 2007, Swaziland had 212,403 households with an average household size 4.7 persons (African Health Observatory, 2017). But only 19.5% of Swazis use plastic tanks for rooftop RWH, according to Vilane and Mwendera (2011). More recent data was not available, so this data was used for purposes of this economic analysis. This economic analysis will assess the up-scaling of RWH to 50% of households in Swaziland. That is an additional 64,783 households to be served. The average life of plastic tank is assumed to be 15 years (although well maintained tanks can last 20 years too).

Stakeholders suggested including soil erosion control and groundwater infiltration methods such as soak-aways as part of the RWH system (*Personal Communication*, Prince Mngoma). It is anticipated that such structures do not need much external inputs except for labour which we assume the household will provide and hence not included in the economic analysis.

Table 11 Cost benefit analysis for RWH

Year	**Cost of Installation (E-Emalangeni)**	**Cost of maintenance (E-Emalangeni)**	**Savings in terms of water cost (E-Emalangeni)**

Year 1	20,000 for 64,783 households = 1,295,658,300 (approx. 1.3 billion)	1,000. Every year maintenance would increase by 10% taking into consideration rise in labour costs and inflation. The maintenance includes cleaning, adding chlorine tablets, maintaining guttering etc.)	Assuming each household saves 50,000 litres of water in a year. The unit cost of water is E10 per 1000litres. Water savings is E500 per household per year. For total number of households targetted, it amounts to E32,391,500.
Year 2		1,100 (assuming increase of 10% every year)	35,630,650
Year 3		1,210	39,193,715
Year 4		1,331	43,113,087
Year 5		1,464	47,424,395
Year 6		1,611	52,166,835
Year 7		1,772	57,383,518
Year 8		1,949	63,121,870
Year 9		2,144	69,434,057
Year 10		2,358	76,377,463
Year 11		2,594	84,015,209
Year 12		2,853	92,416,730
Year 13		3,138	101,658,403
Year 14		3,452	111,824,243
Year 15		3,797	123,006,667
TOTALS	**E 1,295,658,300**	**E31,772**	**E1,029,158,341**

The recommendation is to subsidise the tanks to up to 50% and subsidy vouchers could be provided to 64,783 households in areas where RWH will be viable (where households have adequate roofing, can afford to pay the remaining 50% cost and rainfall is adequate) in selected districts of Swaziland. The cost of subsidy is **E 647,829,150** (half of price of system multiplied by the number of targeted households) and time frame recommended is three years**.** This will form the bulk of the project cost. Although the water savings are less than the investment costs, there are other benefits that this technology brings which have not been costed. These include improved hygiene and health, improved food security by using rain water for household gardens and access to water during dry periods. During dry periods, usage of contaminated water can have adverse health effects and RWH can prevent this through making water available during such times. Spill-over effects will include saved times for women to collect water, improved attendance at school for children and improved general household hygiene and health. The technology could last up to 20 years if well maintained and by then, the returns in terms of water savings will be **E 1,855,223,146** which is much greater than investment.

2.3.2 Preliminary targets for technology transfer and diffusion

The RWH technology meets the targets set by Swaziland's National Climate Change policy which includes "Enhance the adoption of rain harvesting technologies" as a policy statement. Furthermore, the Swaziland Vision 2022 and National Development Strategy (NDS) promotes efficient use and conservation of water including emphasising on water harvesting. The Water Act 2003 promotes increasing access to water. The need for ongoing capacity building, training and creating awareness in this sector has been emphasised. Additionally, Swaziland's Constitution (Section 210) promotes rational use of its water resources. The diffusion of RWH technology achieves these targets laid out in the country's vision. Access to water is improved in communities through water harvesting and this is also in synchonicity with Swaziland's Nationally Determined Contributions, where RWH have been mentioned as helping the country adapt better for the water sector.

2.3.3 Identification of barriers for Rain Water Harvesting

Based on literature review, the stakeholder consultations, bilateral meeting with Bruce Jameson (Moss Foundation) who has installed over 200 rainwater harvesting tanks in Swaziland and the consultant's own knowledge, barriers were identified for RWH technology in Swaziland. In addition, a market mapping exercise was done to identify any bottlenecks in the value chain.

Figure 6 Participants at the BAEF workshop preparing problem and solution trees

The market mapping was done by stakeholders during the BAEF workshop (see Appendix). Stakeholders were split into groups and key results of the discussions are as follows:

1. The major barriers were weak implementation of legislations, affordability of tanks, poor awareness, labour intensive method of concrete tanks construction, inadequate number of accredited builders in rural areas, lack of quality standards and information on how to make the RWH system structurally compatible with dwellings. Rainfall variability was also mentioned as a barrier as it demotivates people to invest in RWH especially during drought periods.
2. The major players listed in the market map were Government that directly imports tanks for their projects, private companies that import tanks and one tank manufacturing company (Oasis). In case of concrete tanks, wholesalers and retailers that supply construction materials are then linked to builders and end users.

3. The other players are retailers that sell tanks and installers (plumbers, contractors) and finally the consumers themselves. These were all mapped in the market maps and their connections are also mapped.
4. Government buys directly from manufacturers as well as imports tanks or buys from retailers and uses contractors who would install tanks for the various projects.
5. Manufacturering and importing companies sell tanks to retailers, who then sells to consumers.
6. The enabling measures listed in the market map included enforcing regulations (this was reconsidered during further analysis under Chapter 5), providing subsidies, outreach activities, review of relevant policies and encouraging Swaziland Standards Authority (SWASA) to provide standards for RWH.

The market maps highlighted the linkages between Government, suppliers, retailers, wholesalers, builders and end users. The bottlenecks identified from market mapping was few suppliers for RWH tanks and few trained people for installation of RWH systems. Other bottlenecks were affordability and lack of proper standards for RWH systems.

2.3.3.1 Economic and financial barriers

Key economic barriers identified include the high cost of the tank, costs related to fixing rooftops which are in state of disrepair and costs related to treatment of water when it is stored for a long duration. The following table provides information on the barriers identified by stakeholders and cost breakdown for items.

Table 12 Barriers identified by the stakeholders for Rooftop Rainwater Harvesting and its related costs

Barrier	Cost for individual	Remarks	Effects
Relatively high cost of rainwater harvesting tank, due to inadequate local manufacturing (only one company manufactures tanks in Swaziland, others import from South Africa)	Cost of purchasing the tank, transporting to the homestead and installing is E10,000 for a 5000litre tank.	The system has to be replaced after 10 years.	Due to high costs, there would be fewer adopters of this technology and people may rely on streams and rivers to supplement their water supply thereby risking using contaminated water.
Many households do not have corrugated rooftops. The root cause is availability of affordable finance as bank loan interest rates range from 15-17%.	The cost for roofing the house is substantial and difficult to estimate.	Costs would include that of corrugated iron roof, PVC gutters and pipes, filters and costs of building a base for the tank.	
Costs of treatment for water when it gets infested by pathogens	Cost of chlorine tablets, approximately E20 ($1.25) to be used every six months. The cost of labour for cleaning the tanks and gutters may also be added.	Tanks must be cleaned 2 to 3 times a year	

Stakeholders suggested in the second BAEF workshop that the technology "rooftop rainwater harvesting tank" should be changed to an integrated rooftop rainwater harvesting system which includes soil erosion control methods and ground water recharge methods such as construction of sumps and erosion dykes. These are assumed to be done by the household on their own and required labour and minimal external inputs.

2.3.3.2 Non-financial barriers

Several Non-financial barriers were identified by stakeholders (see table below). Swaziland does not have a legal requirement for households to harvest rainwater. Some countries have a law that makes it compulsory to build rainwater harvesting structures when constructing a house (Singwane and Kunene, 2010). Swaziland does not have standards for RWH systems and there is a need for raising awareness on RWH methods and how to design the system for those who are building houses. There are some technical barriers too, as the different types of roofs as well as slope of roofs will impact the ease of harvesting

rainwater. Stakeholders mentioned that there is a need in Swaziland for training of people who can install these structures as well as households need to be trained to manage the systems. There is a possibility of the systems being vandalised and stolen including the threat of people using the tanks for unlawful activities such as poisoning the water in the tank. This is particularly relevant as the tanks are placed outside the house and therefore accessible for people from outside.

Table 13 Non-financial barriers for Rain Water Harvesting technology

Barriers	Explanation	Effects
Legislative Lack of legal instrument and building standards for RWH	The construction of rainwater harvesting systems is not compulsory by law in Swaziland. Neither does building standards provide guidance on RWH standards.	• Fewer adopters of this technology, as it is not required by law. • There is ambiguity regarding RWH system in projects where systems are constructed in schools. When pathogens are found in the water, it is unclear who should address this, Ministry of Health or Department of Water or the development agency who funded the project.
Awareness Information is inadequate and awareness of technology remains low	In Swaziland, there is less focus on RWH and more focus on piped water supply in rural water supply schemes. Information on how to design RWH systems in houses and in general about the technology is inadequate in Swaziland. There has not been much advocacy work on RWH in Swaziland, as previously water was considered plenty, until the severe droughts of 2015-2016 were experienced. RWH is not emphasised in school curricula.	Since awareness is low, there are limited adopters of this technology. As a result, people do not harvest rainwater. Water scarcity may be experienced in dry season, which could have easily been reduced through rainwater harvesting. Thus, it's a lost opportunity.
Technical Setting up the system depends on roofing and rainfall patterns	In areas where low rainfall is experienced, RWH may not be viable. The type of roofing material and the slope of roof will influence use of this technology. The subsidy that is recommended to be provided to up-scale RWH includes funds for repair of roofs to make it compatible for this	There is a missed opportunity of designing houses with RWH systems during its construction phase, as it is costlier to set the system up after building is already constructed.

	technology. Training on such technical matters will help.	
Capacity Inadequate skilled installers available locally	There is need for people to be trained in proper installation of tanks and its management. Often it is the owner of the house that installs the tank when he/she constructs the house and if they are not installed in proper manner, their performance may be poor.	When RWH systems are incorrectly installed and fails, there is a tendency to criticise the technology and lose faith in it. Furthermore, if skilled people are not available locally, they have to come from far distances and this ads to the cost of the system. Lack of capacity also translates into loss of jobs locally, as people have to rely on people who are not from their area.
Social and behavioural Theft and vandalism of RWH systems is possible	Since the tanks are often placed outside the buildings, there is fear of the possibility of theft and vandalism of the tanks and even poisoning of the water in the tank.	Awareness and popular use of this technology may help address these barriers.

2.3.4 Identified measures

Based on the stakeholder consultations, the consultant's own knowledge and international experiences, the following measures were identified to overcome the barriers for RWH technology.

2.3.4.1 Economic and financial measures

In order to overcome the economic and financial barriers, stakeholders suggested a number of measures. Measure 1: Government could subsidise RWH tanks (by 50% of its cost) by providing vouchers to homeowners which could be provided to tank suppliers and subsidised tanks. Households that would be targeted would be lower middle income category, as costs to repair roofs would be within the budget planned. Total number of households targeted are 64,783.

2.3.4.2 Non-financial measures

Legislative

Measure 1: Legislative measures may help in improved adoption of RWH technology. A policy to promote RWH may be required in Swaziland or it could be amended into the Building Control, Water and Public Health Acts of the country.

Measure 2: SWASA needs to make RWH standards and link it to building standards. These standards will maintain quality for construction of RWH systems for individual households and when RWH is done as part of a development project in collaboration with several partners such as non-governmental organizations (NGOs), community based organizations (CBOs), donors and Government Institutions.

Awareness and social/behavioural

Measure 3: Improving awareness. Measures to improve awareness would include setting up a RWH Forum which includes all relevant stakeholders. This forum may be part of the existing Water Sanitation and Hygiene (WASH) forum in Swaziland and take the role of exchanging knowledge and experiences as well as updating stakeholders on progress with RWH in the country. Information on rainfall data and simple methods of calculating size of RWH tanks, could be shared with general public though awareness campaigns, which may include television shows, radio broadcasts, posters and flyers. This is anticipated to address barriers with regard to concerns regarding poisoning, theft and vandalism when awareness raising is done in a community covering all memebrs of varying socio-economic groups.

Capacity building

Measure 4: Demonstration projects may be set up in prominent places in the country.

Measure 5: School curricula needs to be revised to include RWH with a practical approach and hands on training at tertiary level.

Measure 5: Introducing RWH technology in tertiary schools, and providing skills training. This will help ensure availability of many skilled people to install and maintain RWH systems in Swaziland. This will reduce the cost of bringing people from far distances for installation and maintenance.

2.3.5 Enabling framework for RWH systems

Below is the enabling framework for RWH systems. The barriers for RWH is presented here and measures are presented alongside with their expected economic and other consequences.

Table 14 Enabling framework for up scaling Rain Water Harvesting technology in Swaziland

Barriers	**Measures**	**Economic consequence of measures**	**Other consequences of measures**
Financial High cost of installing RWH system	Subsidize the tanks (by 50%) by Government and provide vouchers to households which can be presented at shops to buy the tanks at subsidized rates.	Cost of subsidy provided to 64,783 households is E647, 829,150.	There is possibility of vendors of tanks misusing the vouchers, possibility of conflict on selection of benefitiaries, and risk of tanks being bought but not used.
Capacity There are few skilled people to install and maintain RWH systems and this drives up the cost of setting RWH	Schools, tertiary institutions and vocational training centres to provide skills training on RWH technologies and incorporate this into curricula. Short courses and community outreach	This can be done with budgets for educational institutions and the Ministry of Education.	Educational institutions may be resistant due to additional resources needed and extra load for teachers.

systems in Swaziland	activities to train installers who are from the communities in RWH systems conducted.		
Legislative Harvesting rainwater is not compulsory by law in Swaziland and hence there are few adopters.	Review of Building Control Act, Water Act 1967 and Public Health Act to encourage RWH systems and clarify roles of agencies who would be responsible for maintenance of systems under development projects.	Review of legislation requires time and resources and may not be an immediate priority for the country.	Buy-in of all stakeholders concerned, as well as custodians of the legislation is required and this may take time and resources.
Awareness Weak capacity in constructing RWH systems and poor awareness of systems and their benefits	Set up a RWH Forum within Water Sanitation and Hygiene (WASH) Forum.	Setting up the forum may require minimal resources, as the WASH Forum already exists and RWH can be a sub-committee within that.	There could be resistance for WASH Forum to include RWH, but this can be overcome by discussions with m embers and making a convincing case.
	Prepare promotional materials which includes information on rainfall and methods of choosing size of tanks according to needs and region.	Preparing, printing and distribution of promotional materials in the form of television programmes, radio broadcasts, posters, flyers and manuals will require resources.	Internal budgets of Government could be used for preparing and printing promotional materials. Funds may have to be sought from development partners for this purpose.
	Set up demonstration sites which will be used for educational sites to create awareness of RWH systems.	Setting up new demonstration sites will require resources. Alternatively existing schools with RWH could be used as demonstration sites.	Demonstration projects may be vandalised if not managed well.

The above barriers and measures as well as enabling frameworks were derived from problem and solution trees developed by the stakeholders and further developed during the second workshop held under BAEF phase. Further analysis and selection of measures was done in Chapter 5.

2.3.6 Linkages between barriers and complementarities between technologies

The three technologies prioritised for water sector have certain linkages and complementarities. The common barriers in all three technologies was inadequate funding, weak capacity and low awareness. When applying for funds, integrated projects (which include more than one of the technologies) will help in attaining synergies. A Funds Coordination Mechanism is therefore proposed to coordinate usage of funds as projects that include wetlands restoration may which also falls within river basins. IRBM and WRP will enhance the ecosystem health, leading to improved water quality and reduced flooding, which will be beneficial for agriculture and forestry sectors. Harvesting rain water will help reduce demand on water supply systems and thereby provide positive complementarities with IRBM.

3. Chapter: Agriculture Sector

Swaziland's agriculture sector is dualistic and encompasses the traditional sector and commercial sector. This is due to land tenure system in the country. Two major systems of land tenure are present in Swaziland, Title Deed Land (TDL) and Swazi Nation Land (SNL). TDL is privately owned land and is used primarily for commercial ranching, forestry or estate production of crops such as sugar cane, citrus and pineapples. It covers 46 % of the country. SNL is land held in trust by the King for the Swazi people, and covers the remaining 54 % of the country and traditional agriculture subsector is based in this land. For administrative purposes the country is divided into four districts, each of which is administered by a Regional Administrator:

- Hhohho in the north, with its administrative headquarters in Mbabane;
- Manzini in the centre, with headquarters in Manzini;
- Shiselweni in the south, with headquarters in Nhlangano;
- Lubombo in the east, with headquarters in Siteki.

Agriculture is the mainstay of the Swaziland economy and is critical for the achievement of the overall development objectives of the country. Total cultivated area (arable land and area under permanent crops) is 190 000 ha and arable land is 178 000 ha (FAO, 2005). Sugar, citrus fruit, maize, cotton, forestry, livestock and vegetables production serves both domestic and export market. Maize is the most important crop in SNL; however farmers are increasingly growing sugar cane, especially those with irrigation facilities, due to its profitability. Climate change induced dry spells and erratic rainfall patterns are affecting crop production in Swaziland. Most farmers are dependent on rainfall for crop production and are therefore vulnerable to reduced rainfall and accompanying moisture stress on crops. Irrigation can help farmers in Swaziland to adapt to changing climate and substantially improve food production.

In Swaziland, the Government set up smallholder irrigation schemes to raise smallholder incomes by linking them to markets (Dlamini et al., 2014). A good example is that of the successful Lower Usuthu Smallholder Irrigation Project (LUSIP) project, had in ten years of its implementation covered six chiefdoms with an area of 3,370 hectares under irrigation and benefitted about 20,500 community people by improving their incomes (Ibid, 2014). Another important project was the Komati Downstream Development Project (KDDP) which started in year 2000 supporting farmers in 6000hectares, financed by African Development Bank. Such irrigation projects aid in poverty reduction and economic growth in the country.

Livestock have traditionally been an important component of the agricultural industry in Swaziland. There are about 700,000 cattle, 350,000-450,000 goats, 20,000 sheep, 50,000 pigs and large number of poultry in the country (*Personal Communication*, Roland Xolani Dlamini). Livetsock is important for Swaziland as it brings in foreign exchange when imported and culturally it is considered a store of wealth.

The three technologies prioritised under the TNA were livestock and poultry selective breeding, conservation agriculture and micro and drip irrigation. In Swazi culture, cattle is a measure of wealth and to maximise production cattle are kept to their maximum age (Doran et al., 1979). Overgrazing has been a

problem since the seventies as documented by Doran et al. (1979). In 1973, UNDP set up a livestock production and extension program to address the seriousness of the overgrazing problem in Swaziland. The programme included breeding stations, feeding, and pasture improvement trials and development in marketing facilities. Breeding of cattle is an age old indigenous knowledge that farmers have been using for generations. With climate change, breeds that are sturdy and able to withstand drought conditions are much needed. The El-Nino induced drought in 2016 had caused cattle deaths of over 88,000 (Mngoma, *pers.comm*). Thus, prioritising livestock and poultry selective breeding indeed helps this sector to adapt to the changing climate.

The next technology prioritised was conservation agriculture, which is well known to aid with adaptation through improving yields, soil fertility, reducing need for irrigation and also helps with mitigation by aiding in storing below ground carbon.

Figure 7 Two young smallholder farmers using drip irrigation technology in Swaziland

Irrigation accounts for 96% of water use in the country and in the wake of climate change it is imperative that this valuable resource be efficiently used and conserved. In this regard, micro and drip irrigation as a technology is useful and was prioritised under the TNA project. The goal of efficient irrigation (micro and drip) is to supply each plant with just the right amount of water it needs, thereby reducing wastage of water. Micro irrigation systems include drip irrigation which target roots of field crops, and sprinklers, which are pressurized irrigation systems that use moving platforms or devices to simulate natural rainfall. Water efficiency for sprinklers is 50-70%, while for drip irrigation it is up to 90% and can also be used in greenhouses, nurseries, orchards and plants in containers. Both systems can be gravity fed or pressurized. Adaptation of this technology promotes sustainable management of energy, water, land, and labour. Under conditions of increased water stress resulting from climate change the benefits of the technology rises quite significantly.

Detailed description of shortlisted technologies, their barriers, measures and enabling framework is discussed below, starting with livestock and poultry selective breeding.

3.1 Livestock and Poultry Selective Breeding

3.1.1 General description of Livestock and Poultry Selective Breeding

Selective breeding is a technology that aims to improve the value of animal genetic diversity. It is the systematic breeding of animals in order to improve productivity and other key characteristics that can help them adapt better such as thermal tolerance, low quality feed, high kid survival rate, disease resistance, good body condition and animal morphology. Various methods for selective breeding exist, from high-tech and costly processes such as in-vitro fertilisation or genetic engineering to more simple low-cost techniques that rely on the selection and controlled mating of animals based on observable characteristics.

This technology can be applied to all types of livestock, including cattle, sheep, goats, pigs and chickens. This method helps in the productivity of livestock species as well as improvements in the health and welfare of livestock and other animals. The livestock and poultry produced through this method will be sturdier and can withstand shocks such as prolonged dry spells, extreme temperatures, pests and diseases. The methods of controlled mating is very simple to do and does not incur high costs. Selective breeding through controlled mating enables farmers to breed animals that are more resistant to the impacts of climate change, such as sudden changes in temperature, prolonged droughts or the appearance of new diseases. It can reduce mortality rates, increase fertility rates, and can also be used to improve the quality of livestock products such as milk and fibre. As a result, livestock producers are at a lower risk from losing animals to climate change impacts and they are also able to diversify their income-generating activities by capitalising on higher-quality dairy or fibre production.

The selective breeding programmes usually do not produce immediate improvements. Improvements are usually not seen for at least one growing season, so a livestock producer must be able to incorporate long-term planning into production management strategies. Such measures could include: (i) identifying and strengthening local breeds that have adapted to local climatic stress and feed sources and (ii) improving local genetics through cross-breeding with heat and disease tolerant breeds. One of the main limitations of this technology is that selective breeding of certain genes can run the risk of reducing or removing other genes from the overall pool, a process which is irreversible. This can create new weaknesses amongst animals, particularly with the emergence of a new pest or disease. Depending on the animal traits chosen, selective breeding may not always lead to higher productivity rates.

There are three main approaches to selective breeding:

1) Outcrossing

Mating two animals that are unrelated for at least 4 to 6 generations back is called an outcross. Outcrossing improves fitness traits such as reproductive ability, milk production, kid survivability and longevity.

2) Line-breeding

Line-breeding involves mating related animals like half-brother/half-sister, cousins, aunt/nephew, and other more distant relationships. This is usually done to capitalize on a common outstanding ancestor who appears in recent generations of the pedigree. There is a higher degree of uniformity with line-breeding than in outcrossing, and a reduced possibility of harmful genetic defects than inbreeding.

3) Inbreeding

This breeding method involved mating directly related animals, like mother/son, father/daughter, and full brother/full sister (full siblings). This method is used generally to create uniformity and pre-potency (the ability of this process to continue) and to force out latent weaknesses from the gene pool. Fitness traits are especially at risk with this breeding scheme.

Climate change will create extreme weather events, heat waves and cold waves and therefore sturdier varieties of livestock and poultry are needed. Specific advantages of selective breeding through controlled mating include low input and maintenance costs once the strategy is established, and permanence and consistency of effect. In addition, controlled mating can preserve local and rare breeds that could be lost as a result of climate change-related disease epidemics. This can be applied by a small scale farmer to a commercial livestock production facility. The technology varies and can range from simple controlled breeding to more advanced in-vitro fertilization.

Government, through the livestock extension department, educates farmers in all aspects of livestock and poultry production. Cattle production in Swaziland can be divided by breeds into a) exotic dairy cattle and b) other cattle (traditional and beef specific cattle). Production, processing and marketing of livestock and poultry is carried out by the private sector in Swaziland. The Livestock Improvement Act 2007 and supporting legislations and policies have endorsed methods that will improve productivity. Helping farm animals adapt to climate change is supported by the Government. There is need for awareness raising of this technology and Government can play a role in providing necessary information to farmers.

Benefits of this technology are many. Sturdier livestock and poultry will improve availability and quality of meat, which will boost agricultural economy. Greater production will create more jobs and improved varieties and increased production of livestock and poultry will improve incomes for farmers. With less imports of meat, the country will benefit in preserving foreign exchange. Importance for livestock production will boost the need for improved grazing land management. Increasing number of livestock will also supply dung which can be used for biogas and organic fertilizer.

Social benefits include opportunity for preserving indigenous knowledge, improved nutrition for humans and better management of land. Documentation of the indigenous knowledge of livestock keepers about animal breeds and breeding should be an integral part of the work of rural development projects, institutions and organisations because it can be a source of information about the existence of breeds that scientists have overlooked and which may have unrecognised advantages and potential. Investments in science and technology for developing new breeds and genetic types also present an opportunity for larger-scale interventions where funding is available. Improved livestock health will have nutrition benefits for people in Swaziland, which will improve health. Improved incomes of farmers will also provide them with means to improve household nutrition and health. Reduced livestock deaths have environmental benefits as livestock depends on grazing and therefore managing them will help in sustainable grazing land management.

In Swaziland, the Nguni cattle and indigenous varieties have been suited for climate variability and been in production for many years. Indigenous knowledge exists about this in farmers of Swaziland. It will be relatively inexpensive and easy to spot varieties that are sturdy and implement selective breeding. Many farmers in the private sector have the means to undertake this and therefore there are many opportunities in Swaziland for this. Improved varieties of cattle have a demand in the market, as beef from Swaziland is in demand both domestically and for export. In this regard, cattle breeding ranches have been helpful.

Cattle breeding ranches are managed by Livestock Extension Service and were established to produce high quality bulls that farmers can use to improve the genetics of their herds. A secondary purpose of the breeding ranches is to provide a venue for conducting animal breeding and nutrition research. High-quality bulls produced on the breeding ranches (mainly Nguni, Brahman, Simmental and Drakensberger breeds) have been distributed to farmers by the Livestock Extension Service under the Bull Loan Scheme. While introduction of bulls of exotic breeds has led to overall productivity gains in herds being grazed on communally held SNL, there is concern that widespread interbreeding could pose a threat to the continued existence of the indigenous Nguni breed, with its unique characteristics. It is important to note that the capacity of government cattle breeding ranches is not being fully used. For instance, the Mpisi ranch has the potential to produce 75 bulls per year, but due to various technical and financial constraints, it produced only 35 bulls in 2009/10 (World Bank, 2011). Chicken rearing is done by 91% of Swazi households. The demand for indigenous poultry is increasing and indigenous poultry rearing helps improve food security and are profitable (Siyaya and Masuku, 2013). However, access to markets for farmers who rear indigenous chickens is limited.

Development of livestock and poultry in the country is supported by the following national strategies:

- **The National Development Strategy (NDS)** (2002) backs up the country's Vision 2020, which focuses on long term development, and provides guidelines for formulating development plans based on equitable allocation of resources. Food security, innovation and research, land use, and marketing and trade are all listed as priorities. Of particular importance to the agricultural sector, the NDS emphasizes the government's commitment to achieving equitable and rational land use with security of tenure, as well as community participation and empowerment in economic decision-making.

- **The National Food Security Policy (NFSP)** (2005), promotes (i) food availability, (ii) food access, (iii) food utilization and nutritional requirements, and (iv) stability in equitable food provision.

- **The Comprehensive Agricultural Sector Policy (CASP)** provides guidance on the policy options and measures necessary to enhance agriculture's contribution to overall economic growth. The main goal of CASP is "to give direction to the development of the sector in a harmonized and coordinated manner" and "to enhance the contribution of the agricultural sector in meeting the country's Vision 2020 and the national development goals of the NDS." Specific objectives include: (i) increase agricultural output and productivity; (ii) promote diversification, sustainable

intensification, and use of appropriate technology; (iii) assure food security; (iv) promote sustainable use and management of land and water resources; and (v) stabilize agricultural markets (World Bank, 2011).

- **The Livestock Development Policy (LDP)** identifies policy objectives in 12 areas specifically related to livestock development: (i) animal health and production extension; (ii) livestock marketing; (iii) processing industries; (iv) cost-recovery and commercialization of livestock development; (v) veterinary and livestock research; (vi) promotion of livestock enterprises and entrepreneurship; (vi) sanitation and meat hygiene standards assurance; (vii) national herd improvement; (viii) livestock nutrition, (ix) legislation; (x) communication; (xi) disease prevention and delivery of animal health care; and (xii) range conservation and management. The Livestock Development Policy states as an objective, "To improve the national herd through selection and breeding, research, the protection of Swaziland's indigenous gene pool and the application of internationally acceptable quality assurance measures for breeding eggs, semen, ova, embryos or tissues to prevent the spread of diseases".The LDP is comprehensive and robust, in the sense that it effectively identifies all major issues in the livestock subsector and proposes a series of practical measures to address them. However, implementation of the LDP has been slow (World Bank, 2011).

3.1.2 Cost Benefit Analysis

The costs involved in this technology are fairly low if in-vitro fertilization is not used, but rather mating of animals in mating pens are used. The costs and financial requirements will depend on the livestock species and location. However, in general controlled breeding is a low-cost technology.Where building materials such as stones are locally available and can be used to build the mating pens, an average investment would come to around US$ 30. In areas with clay soils, adobe bricks may be used, at an average cost of US$ 90. In many cases, cattle mesh has been the chosen alternative, with an average investment of US$ 200 for each mating pen (Source: Climatetechwiki.org). Maintenance of cattle pens and costs of undertaking selective breeding will vary, but is generally affordable. The costs of breeding, construction of cattle pens, costs of awareness raising are to be added up, but these are offset by the gains in reduced livestock deaths and improved production.

In Swaziland, according to World Bank (2011), "The government plays a key role in providing extension services through the Animal Production Division and the Animal Health Division of the Department of Veterinary and Livestock Services (DVLS). Publicly owned and operated cattle breeding ranches provide breeding bulls to improve farmers' herds. Fattening ranches condition farmers' cattle in order to attract better market prices, thereby encouraging off-take and reducing grazing pressure on SNL rangelands".

3.1.3 Preliminary targets for technology transfer and diffusion

Preliminary targets are derived from visions of several national documents and policies regarding the livestock sector. The National Food Security Policy (NFSP) (2005), The Comprehensive Agricultural Sector Policy (CASP) and the Livestock Development Policy (LDP) promotes livestock breeding through its focus on stability for food provisioning. Furthermore, Swaziland's National Development Strategy says, "Develop cost-effective and environmentally-friendly farming technologies and disseminate through a strengthened extension services network". It further states, "Promote production of crops and livestock for domestic and international markets by both small and large scale farmers" and "Determine livestock activities to be carried out in the different ecological zones on the basis of climatic conditions". The strategy also calls for promotion of marketing of livestock.

The Swaziland Livestock Department's vision and mandate states, "To be a leader in facilitating efficient service delivery for a sustainable and prosperous livestock sector. The mandate is to equip livestock producers with adequate knowledge, skill and technical expertise on the efficient management of all resources that will ensure profitable returns and an efficient and sustainable livestock industry. The thrust is to promote commercialization of cattle, poultry, pig and goat production to ensure food security, poverty alleviation and improved living standards of the farming community. Selective breeding technology will support commercialisation. Swaziland's Constitution says, "The State shall take appropriate measures to promote the development of agriculture and industry". The Swaziland Vision 2022 and National Development Strategy (NDS) prioritises agriculture as a means to reduce food insecurity and improve nutrition security. Livestock and poultry selective breeding helps Swaziland achieve these goals through helping livestock and poultry adapt better to climate change impacts. Food security and nutrition would be improved when market access is improved for this technology. Awareness raising for farmers and training on breeding technology, enhancing capacity of Department of Livestock and conducting research to identify market gaps are suggested measures to reach these targets.

3.1.4 Identification of barriers for Livestock and Poultry Selective Breeding

3.1.4.1 Economic and Financial Barriers

Swaziland aims to equip livestock producers with adequate knowledge, skill and technical expertise on the efficient management of all resources that will ensure profitable returns and an efficient and sustainable livestock industry. The thrust is to promote commercialization of cattle, poultry, pig and goat production to ensure food security, poverty alleviation and improved living standards of the farming community. Selective breeding as a technology will help to achieve this aim and furthermore, allow for effective adaptation for this sector. Although the beef industry is well organized, there is limited coordination between production and consumers for goats and sheep. The supply chain has to be improved. For poultry, introduction of indigenous chickens has improved the production. The major economic barrier in breeding is the cost of transport for poultry farmers to go to the markets. This is particularly so for poultry farming, as noted by Siyaya and Masuku (2013). The authors undertook an economic analysis of the indigenous chickens' production in Swaziland, and explored what affects profitability of indigenous chickens' production. A sample of 147 smallholder poultry farmers trained by poultry officers on indigenous poultry production in the four regions of Swaziland were interviewed. They reported that, "the cost of breeding stock (hen and cock) costed E66.00 on average, while the most expensive cock was bought at E200.00. The

maximum price for a hen of E120.00 was reported. The average price of a cock was at E78.00, while the average price of a hen was E54.00. The average chicken price at the market was E60.00, with a range of E35.00 to E150 maximum per bird. Flea markets to which farmers sell their chickens were located 22 km away from the farmers, with a minimum of 1km to 95 km away. Farmers far away from flea markets complained of high transport costs that reduced their returns as they had to hire cars to the flea market" (Siyaya and Masuku, 2013). The high transport cause as a financial barrier can be overcome with measures of having market access in areas closer to the farmers. Authors called for research on market size and spread to determine demand patterns of indigenous chickens and gaps where new markets may help this industry.

3.1.4.2 Non-Financial Barriers

Low awareness was cited as a barrier. Stakeholders stated that in Swaziland, cattle is equated to wealth of a household. The cultural value attached to cattle is a barrier in treating livestock as a business. Stakeholders mentioned the example of Botswana, where livestock is treated as a business and sale of cattle is done at the right time to make profits. While in Swaziland, farmers delay the sale of their cattle due to the cultural mind-set of attaching them to wealth. In 2016, farmers did not sell their cattle and due to the drought, thousands (over 88,000) of cattle died. The mind-set of farmers to commercialise livestock rearing will help improve the sector. In this regard, using technologies such as selective breeding will be helpful. However, care must be taken when introducing this technology as incorrect breeding techniques may result in breeds being less tolerant to drought as they may need more feed and water. Some breeds cannot tolerate the heat and therefore caution must be exercised in choosing the right breeds. The other barrier is that of inadequate capacity for extension services. The capacity of Ministry of Agriculture's Department of Livestock needs to be improved for providing enhanced extension services and reaching out to larger number of farmers.

3.1.5 Identified Measures for Livestock and Poultry Selective Breeding

The following measures are identified for this technology.

Awareness

Measure 1: Awareness on the technology to be improved through training of farmers. This will help change mind-set of farmers to consider livestock farming as a business and use correct breeding techniques to maximise benefits for adaptation.

Markets

Measure 2: Conduct research on markets spread and gaps and improve value chain by creating new markets where needed. This will help increase breeding opportunities as farmers can buy poultry to breed from the markets.

Capacity building

Measure 3: Promote indigenous chickens by enhancing capacity of Department of Livestock for extension services. Ministry of Agriculture promotes indigenous chickens, and could benefit from scaling up.

3.1.6 Enabling Framework for Livestock and Poultry Selective Breeding

The table below gives the enabling framework for livestock and poultry selective breeding.

Table 15 Enabling framework for Livestock and Poultry Selective Breeding

Barriers	Measures	Economic consequence of measures	Other consequences of measures
Awareness Inadequate awareness of technology amongst farmers leading to low up-take	Create awareness through training of livestock farmers associations in the country	There is cost involved in providing training	It is difficult to change cultural perceptions of cattle being viewed as wealth and there could be resistance to some aspects of the training
Capacity Inadequate capacity in Animal Production Division and the Animal Health Division of the Department of Veterinary and Livestock Services (DVLS) to provide extension services	Provide training to extension staff and fill vacancies	Costs for training and recruitment	There could be few trained personnel available in the country to fill vacancies
Markets High cost of travel to markets reduces opportunities for breeding and profits for farmers	A research needs to be done on markets and gaps where new markets can be created	Creating a new market has costs of infrastructure provision. Availability of suitable breeds of livestock and poultry for breeding must be ensured.	Availability of new markets will improve availability of food in rural areas and fetch better prices for farmers

3.2 Conservation Agriculture

3.2.1 General description of Conservation Agriculture

According to FAO (2017), Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three linked principles, namely:
(1)Continuous minimum mechanical soil disturbance; (2) Permanent organic soil cover; and (3) Diversification of crop species grown in sequences and/or associations. Agriculture alters land forms and using tillage disturbs soil and may contribute to increased runoff and erosion. Tillage of the soil stimulates microbial decomposition of soil organic matter, which results in emissions of carbon dioxide to the atmosphere. Therefore, minimising the amount of tillage promotes sequestration of carbon in the soil, increases water retention and reduces erosion. Thus it has consequences for both climate mitigation and adaptation. With rising temperatures in the wake of climate change, there will be higher need for water for agriculture and this technology helps in water retention in soil, thus aiding in adaptation. In conservation tillage, the soil should remain permanently covered by crop residues from previous cash crops or green manure cover crops, and most of these residues will remain undisturbed on the soil surface after seeding. Maintaining soil fertility, reducing runoff and erosion will have positive climate change adaptation values for agriculture. Conservation agriculture leaves the previous year's crop residue (such as corn stalks or wheat stubble) on fields before and after planting the next crop to reduce soil erosion and runoff, as well as other benefits such as carbon sequestration. Climate change will also cause more weed growth and pest infestation and this technology reduces growth of weeds and pests, thus helping in adaptation.

CA principles can be applied to all agricultural landscapes and land uses with locally adapted practices. Very little external inputs such as agrochemicals and plant nutrients of mineral or organic origin are needed. CA facilitates good agronomy, and complemented by other known good practices, including the use of quality seeds, and integrated pest, nutrient, weed and water management, it is a base for sustainable agricultural production intensification. It also allows for integration of production sectors, such as crop-livestock integration and the integration of trees and pastures into agricultural landscapes. Stakeholders prioritised this technology as an adaptation measure for Swaziland. CA increases the ability of soil to store or sequester carbon, enrich the soil, improve soil surface stabilization, reduce leaching of nutrients, decreases evaporation and hereby improve water retention, increase yield and reduces the need for tractors to pass on farm thus reducing use of fossil fuels. Furthermore, CA reduces labour by up to 40%. In this technology burning crops and residue is avoided and it is a truly sustainable technology.

In Swaziland, CA has been practised for over 10 years, with the use of champion farmers, demonstrations and continuous extension contact training for farmers in all four regions of the country. However, most of the training and practice has been on manual / hand-operated implements such as jab planter and hoe. But mechanisation has caught on with Government led tractor system in place. CA has been promoted through the European Union and FAO funded project Swaziland Agricultural Development Programme (SADP) which began in 2009. The objectives of the 5-year programme were to improve the food security and nutrition of the vulnerable, and to help transform agriculture into a vibrant commercial sector. More than

20 000 smallholder farmers have learned to produce larger quantities of high-quality food and connect with new markets. In addition, construction and rehabilitation work in the livestock sector, water infrastructure and government services have also been top priorities for SADP. Under the programme, 800 backyard vegetable gardens have been established for vulnerable households, and 60 youth groups have been established, reaching 2,250 young people (FAO, 2017). Swaziland's Ministry of Agriculture has been supported by FAO and Cooperation of the Development of Emerging Countries (COSPE) in implementing conservation agriculture since 2002. In addition, World Vision International have also implemented similar programmes and Africa Cooperative Action Trust (ACAT) has brought out a CA Compendium and raised awareness of CA. Whilst all initiatives have successfully promoted CA, there is a need to mechanise it. This will make it attractive to a broader spectrum of farmers and thrust it into the commercial front.

3.2.2 Economic Analysis

The main cost for promoting CA would be that of purchasing a mechanised planter for the farmer. Other expenses such as labour and inputs are limited. TNA Factsheet on CA from Lebanon stated, "CA has less expenditure in capital cost (for machinery), in labour and energy than conventional agriculture. In field crops, the cost of implementing the technology is reduced to the cost of the seeder or planter ($2000)" (Source: tech-action.org). This cost is offset by the long term savings for farmers on increase in chemical and water use to preserve soil fertility which adds to the cost of production. In South Africa, seed planters range from R2, 800 for a small planter to R37, 000 for medium sized one to R240, 000 for large scale commercial one. Swaziland's agriculture equipment's suppliers import from South Africa and other countries and have to pay an additional Value Added Tax (VAT) of 14%.

For purposes of this TNA project, smallholder farmers are targeted and hence medium sized planter is preferred which costs R42, 180 including VAT. According to FAO (2011), Swaziland has 100,000 farm households with average farm size of 1.3ha. Economic analysis is done using the experiences from the Shiselweni Piggery Farmers' Cooperative. The farmer's cooperative made a Memorandum of Understanding with Swazi Bank, and based on that, sourced funds from Central Bank to provide collateral/security for the loan taken for farmers. The Swazi Bank was able to secure the funds for collateral successfully. In the piggery project, the farmer contributes 7% of the loan and the farmer organization (cooperative) contributes 8% and Swazi bank provides the balance 85%. Each farmer got a maximum of E30, 000, which they used to buy feed for pigs, new stock for their piggery project, provide treatment for pigs and market the pork. Five farmers were able to pay back all their loan within a year and others are still paying off their loan. The plan is to expand the project to other areas and include other commodities like chicken, goats and for farming maize. The insurance for natural disasters is not covered, which is a risk factor. All farmers are trained and that is a pre-condition of securing the loan and training is provided by an accredited training provider thereby reducing risk of failure (*Pers. Comm,* Jabulani Tsabedze).

Using the model of the Shiselveni Piggery project, and combining with a subsidy programme, the recommendation is to undertake the following investments:

1. Identify 20,000 farmers who have medium sized crop fields who can be supported through this project

2. Train the 20,000 farmers on CA
3. Provide loan for 50% of cost of planter to farmer, where farmer contributes 7%, farmer association/cooperative contributes 8% and Central Bank can provide collateral of 85%. The farmer will be expected to pay back the loan through production from his/her farm.
4. 50% of cost of planter is to be subsidized by Government, which amounts to the value of E 18,500 per farmer, for 20,000 farmers that amounts to E370,000,000 (370million).

3.2.3 Preliminary targets for technology transfer and diffusion

The Swaziland National Development Strategy advised preliminary targets for transfer and diffusion of technology as it prioritises agriculture as a means to reduce food insecurity and improve nutrition security and commercialisation of agriculture in Swazi National Land. Furthermore, Swaziland's Constitution says, "The State shall take appropriate measures to promote the development of agriculture and industry". The technology measures of providing subsidies for planters and creating awareness of CA through training are addressing this vision.

3.2.4 Identification of barriers for Conservation Agriculture

3.2.4.1 Economic and Financial Barriers

The major financial barrier identified by stakeholders was that the cost of mechanised planter was too high and famers wanted to take advantage of the Government's tractor schemes (where farmers can rent tractors for their use as subsidised rates) and use planters to reduce labour and increase production.

Table 16 Economic and Financial Barriers for Conservation Agriculture

Barrier	Explanation	Effects
Cost of planter is high	This is due to high interest rate (around 14%) to borrow money from bank and cost of importing from South Africa (14% VAT is added to the cost) According to Manyatsi and Mhazo (2014) hardly any CA equipment is manufactured in Swaziland, they are all imported.	Farmers may not afford to buy planters and hence uptake of CA will be low.

3.2.4.2 Non-Financial Barriers

There are over 30 CA demonstration sites established in Swaziland with the help of close to 300 farmers (FAO, 2011). Yet, stakeholders say that awareness remains low and many farmers are yet to take up this technology. Hence, awareness remains a barrier for scaling up CA. Below are barriers listed along with their explanation and effects. Furthermore, capacity building needs to be done for extension staff and ways to machanise CA using mechanised planters is suggested.

Table 17 Non-Financial barriers to adoption of Conservation Agriculture

Barrier	Explanation	Effects
Awareness Inadequate awareness	Awareness can be improved in Swaziland through setting up more demonstration sites can be set up to up-scale this technology.	Due to inadequate awareness farmers continue traditional ways of farming.
Capacity Capacity building of extension workers	Extension workers need to be trained on this technology and this can be doe through setting up demonstration sites.	Extension work helps scale up the technology use
Technology is lagging behind due to inadequate mechanisation efforts	Mechanisation is needed for the technology to be up-scaled, which is availability of mechanised planters.	The technology is not scaled-up to desirable levels.

3.2.5 Identified Measures for Conservation Agriculture

The following measures are suggested for scaling up CA in Swaziland.

Awareness

Measure 1: Create awareness amongst farmers and extension staff through setting up demonstration sites and conducting site visits.

SWADE has produced a CA manual which provides all information on how to set up a demonstration plot and principles of CA (SWADE, 2013). This can be used by implementers for awareness raising.

Financial

Measure 2: Provide subsidies of 50% for planter equipment to 20,000 farmers.

3.2.6 Enabling Framework for Conservation Agriculture

Table 18 Enabling Framework for Conservation Agriculture

Barriers	Measures	Economic consequence of measures	Other consequences of measures
Low awareness of CA technology	Create awareness amongst farmers through setting up demonstration sites	Setting up demonstration plots would cost funds. But this can be covered through existing NGO projects where CA is being promoted. Thus synergies are attained.	If demonstration plots are not well managed, it can discourage technology adopters.
	Conduct site visits to demonstration plots	Site visits would require transportation and refreshment costs to be covered. This should be covered within Ministry of	When budgets are inadequate there could be low priority for this activity, however, to make it sustainable

		Agriculture's extension budgets.	entrenching this within the ministry is essential.
	Training of extension workers.	These have to also be part of the Ministry of Agriculture's budget. The CA manual developed by SWADE can be used in training sessions.	Budgets must be planned to incorporate this. If not, it will remain low priority.
High Cost of equipment	Provide subsidy of 50% to purchase planters for 20,000 farmers	Cost amounts to E370million (see economic analysis)	There could be people who take advantage of the subsidy and purchase equipment for resale. This can be avoided by monitoring the farmers who are beneficiaries.

3.3 Micro and Drip Irrigation

3.3.1 General description of Micro and Drip Irrigation

This technology contributes to improving food security by enhancing food production. Both drip and sprinkler irrigation systems use water efficiently and therefore save water by reducing water losses. Water is also distributed more evenly across crops helping to avoid wastage. Both systems increase crop yield and allow for various types of crops including row, field and tree crops that are grown closely together, such as cereals, pulses, wheat, sugarcane, groundnut, cotton, vegetables and fruits. Swaziland is a mountainous country but has varying topographies suitable for agriculture. Both drip and sprinkler irrigation technology is well adapted to a range of topographies and is suitable for all types of soil, except heavy clay. Soluble fertilizers may be used in sprinkler systems. Since less water is used at a time, there is less risk of soil erosion because soil disturbance is low. There are secondary benefits from improved crop productivity such as income generation, employment opportunities and food security.

Sprinkler irrigation is a method by which water is distributed from overhead by high-pressure sprinklers, sprays or guns mounted on risers or moving platforms. A sprinkler irrigation system typically consists of a pump unit, pipes, lateral delivery system and water emitting devices. Mechanised and manual systems are existing. A wide range of sprinkler systems is available for small and large-scale application. The technology that is prioritised here is micro sprinkler system which is more efficient than normal sprinklers. Micro irrigation using spray sprinklers have a relatively high energy demand. Regular maintenance inspections are needed to maintain system effectiveness. Spray-sprinkler systems may require the land to be levelled for the systems to work, which is an additional cost. There is a risk of sabotage, vandalism and theft for sprinkler and drip systems.

Drip irrigation is based on the constant application of a specific and focused quantity of water to soil crops. A drip irrigation system typically consists of pumps or pressurised water system, filtration systems, nutrients application system, backwash controller, pressure control valve, pipes, control valves and safety valves, poly fittings and accessories and emitters. A wide range of components and system design options are available. The wetting pattern of water in the soil from the drip irrigation tape must reach plant roots. Emitter spacing depends on the crop root system and soil properties.

Maintenance of the system mainly relates to regular cleaning of the component parts. Seals on pipes and sprinkler nozzles should be checked to avoid water seepage. During periods when the equipment is not being used, it is recommended to store component parts in a cool, dark place. When installing micro irrigation and drip irrigation, one must take note of the following factors:

- The type of crops to be cultivated and their water requirements throughout the growing season;
- Land tenure issues and the shape and size of the field, as this will determine the range of suitable technologies, investment and labour requirements;
- Topography, in particular the location and elevation of the water source relative to the field, land slopes and uniformity;

- The water rights and type of water source, whether it is surface water or groundwater and if it is available in sufficient quantity from a locally accessible source. A clean supply of water free of sediment is required to avoid blockage in sprinkler nozzles and crop spoilage;
- Available labour force. Where skilled labourers are not available on location, local farmers will require training to install, maintain and repair the various components of the sprinkler system;
- The soil profile. Sprinkler irrigation technology is best suited to soils with high infiltration rates so that ponding and surface runoff can be avoided. The application rate of the sprinkler system must therefore be matched to the infiltration rate of the most restrictive soil in the field;
- Energy requirements of different systems, including the manufacturing, transportation and installation of the various systems. The location of the water source will also affect the need for energy for pumping;
- Social aspects such as local preferences, capacity to maintain the system, implications for labour requirements and how these may affect different members of the community;
- Financial aspects of the project and funds for maintenance;
- An understanding of existing health risks is crucial to avoid schemes that may promote water borne diseases; and
- A small environmental impact assessment should be conducted to fully understand potential impacts of drainage and diverting water resources, amongst others.

Swaziland has several institutions that help manage water resources including for irrigation and these include:

- Water user associations are at community level, responsible for managing water systems;
- The Water Resources Branch, within the Ministry of Natural Resources and Energy, manages water for irrigation;
- Komati Project Co-ordination Unit, within the Ministry of Natural Resources, manages water in Komati River;
- Small Irrigation Section (also referred to as a Unit) within the Ministry of Agriculture caters for small-scale farmers including small scale sugar growers, providing design work and extension mainly on irrigated vegetables;
- The Rural Water Supply Branch (RWSB) has responsibility for rural water supply and falls under the Ministry of Natural Resources and was setup with donor funding and NGO support during the United Nations Decade of Water and Sanitation;
- The Water Services Corporation, within Ministry of Housing and Urban Development (privatized in 1994) facilitates better planning, budgeting, and overall management of urban water supplies;
- The sugarcane irrigators and the Swaziland Sugar Association (based in Simunye) have contributed towards the development of water resources legislation and together have built up considerable levels of expertise in water resources management; and
- The Swaziland Komati Development Project (SKDP) office which is located in Tshaneni, in the northern part of the lowveld.

The Government of Swaziland has identified the development of smallholder agriculture from subsistence farming to commercialization and intensification farming as the main element in its aims to alleviate

poverty. Irrigation plays an important role in achieving this and is a priority for the Government of Swaziland. Improving irrigation has been mentioned as a priority in various national policies and documents including the National Strategy and Action Plan.

Climate change is affecting rainfall patterns and reduction in precipitation in some areas. By its design and working principle the drip irrigation system best meet the environmental, energy-efficient and resource-saving requirements. Drip and sprinkler systems are a means for climate change adaptation as they aid in sustainable water use and management, thereby increasing productivity and strengthening the adaptive capacities of people that are heavily dependent on agriculture. When faced with water scarcity, sprinklers and drip irrigation systems allows for efficient use of water and represent an adaptation strategy against scarcity of water.

Other advantages of using drip irrigation technology for agriculture include:

- Increase food productivity helps improve nutrition and thereby health;
- Saving of labour provides farmers with time for leisure;
- Lowered water withdrawal from ground water resources, particularly during more sensitive dry months, drip technology prevents depletion of ground water table and pollution from infusion of saline and other contaminants;
- Increased use efficiency of chemical fertilizer through fertigation prevents resource waste and development of water pollution problems such as eutrophication;
- Drip irrigation reduces crop disease pressure as foliage are kept dry;
- Agricultural production will increase leading to decrease in the dependence of imported agricultural products at local markets;
- The technology can be employed in combination with other adaptation measures;
- Intensive agriculture with mixture of crops is possible using this technology and year round production is enabled; and
- It contributes to efficient water use, reduces requirements for fertilisers and increases soil productivity as well as due to fertigation and reduced need for weed control, requires less labour.

Micro sprinklers (also known as: spray jets, micro sprayers, misters) are a combination of surface spray irrigation and drip irrigation and are rated by flow rate, wetting diameter or radius. They operate at low pressures but create a larger wetted area than drip irrigation and are used when low volume overhead irrigation is desired, and for areas where drip irrigation are not practical. The micro sprinklers and micro sprayers deliver water through micro tubing to a series of nozzles attached to risers, and have small to medium sized droplets with good uniformity of coverage and lower precipitation rate, allowing longer watering time with less runoff. Micro sprayers are used extensively in agriculture using one micro sprayer per tree and under the tree canopy. Micro-Spray Irrigation provides many of the same benefits as drip irrigation.

Both the drip and micro irrigation technology is suitable for various users from small scale to large scale and can be low-cost gravity-fed or automatic and pressurized. Suppliers are available locally or equipment

can be imported from South Africa. The irrigation potential for the country, based on the physical land capability and water availability, is estimated at 93,220 ha. Currently about 10 large irrigation schemes (> 500 ha) occupy 67 % of the irrigated land, medium irrigation schemes (50,500 ha) and small irrigation schemes (< 50 ha) occupy 20 % and 13 % of the land respectively. This technology can be implemented within a short period, but land preparation and levelling may be needed. Technical skills for installation is not adequately available in Swaziland, although suppliers import this from South Africa and sell it in the country. This technology has already been used in Swaziland and is widely accepted by stakeholders. Development partners such as African Development Bank, International Fund for Agriculture Development (IFAD), European Commission and UNDP have supported use of this technology in Swaziland.

3.3.2 Economic analysis

Costing for drip irrigation kit is E 862.98 for gravity drip kit and E 1,026 for a 100litre tank, which amounts to **E1, 888** for a 100m^2 small crop field. The gravity drip kit contains 12mm x 0.8l/hr x 0.3m dripper pipe, valve and filter between tank and drippers, 16mm pipe for sub-main and connectors. Prices were obtained from averages of three suppliers in South Africa.

Costing for a micro irrigation system (spray sprinkler) is shown in the table below.

Table 19 Cost calculation for micro irrigation kit

Item	**Number/pack**	**Cost (E)**	**Total cost**
Assembled microjets	1000	4530 per pack of 1000	4350
Tube fittings	1000	6000 per pack of 1000	6000
Rigid riser with adapter	1000	2904 per pack of 1000	2904
Choke	100	18.50 each	18.50
Complete stake assembly	100	13.63 per 100	13.63
Flexible PVC tube	100m length	3.74 per m	374
Connector	20	2.42 each	48.40
Tee pieces	20	38.82 each	776.40
Reducing elbow	20	3.19 each	63.80
End plug	20	2.63 each	52.60
Flow control	20	39.16 each	783.20
Tap connector	20	11.39 each	227.80
Hose tail	20	7.00 each	140
Hose clamp	20	7.01 each	140.20
Vacuum breaker	20	43.32 each	866.40
		TOTAL	**16,758.93**

Prices were obtained from Microjet (https://www.microjet.co.za/secure/), South Africa and VAT was added.

Providing subsidies for 20,000 selected farmers chosen representatively from all regions would entail the costs as indicated below. Criteria for selection of farmers would be that they are small to medium sized farms and able to afford the balance amount after subsidy to purchase the irrigation kits. This is to ensure their commitment and to enable monitoring of their progress so that they do not resell the equipment.

Assuming equal number of drip and micro irrigation kits, the total cost is as below.
10,000 drip irrigation kits would cost E1, 888.98 x 10,000 = E18, 889,800
10,000 micro irrigation kits would cost E 16,758.93 x 10,000 = E167, 589,300

If 50% subsidy is provided, the costs would be a total of E 186,479,100 (186million). Subsidy vouchers can be given to farmers, and equipment obtained via local supplier. The project can be phased in five years with annual budget of approximately E37million given out as subsidies annually. Selection of farmers can be done using existing knowledge from projects being implemented on the ground by development partners and NGOs. As much as possible farmer groups need to be supported.

Additional costs will be needed to provide necessary capacity building activities for local farmers. However, this can be recovered from profits of higher yield and quality of crops. Micro-irrigation can increase crop yield by 30- 40 %. The harvest increases by 30-40% times, thereby increasing yields, food security and incomes. Livelihoods of farmers will be improved and they will be better able to adapt to climate change. It improves water use efficiency and crop yield and quality by providing year round production, more efficient water use and less cost of water.

Maintenance of irrigation equipment needs skilled labour and use of this technology creates jobs for the skilled labour. The technology can facilitate gainful employment of the farm family labour throughout the year. The technology can facilitate participation of women in farming through the operation of the system and carrying out regular maintenance operations. The overall time spent is decreased as a result of less time spent on irrigating crops and this time saved can be used for other income generating activities. Thus, it contributes to diversification of economic activities priority of the country. It also leads to improvement of economic condition of rural population and leads to efficient use of resources such as land, water and fertilizers. Furthermore, the technology contributes to food security priority by increasing productivity and leads to increase in income of rural population as well as reduces migration to urban areas from rural communities.

3.3.3 Preliminary targets for technology transfer and diffusion

The Swaziland National Development Strategy states that the country must raise its capability of the agricultural sector to generate a higher volume of goods and services for given factors of production, without destroying the environment. This includes “efficient water resource management and usage” and in this regard, drip and micro irrigation is a good technology. The strategy also calls for expansion of small holder irrigation. As a strategy to end poverty the documents says, “Promote irrigation-based agricultural production among rural households”. This is in alignment with Swaziland’s Intended Nationally Determined Contributions (INDC) document, which has emphasised micro irrigation as a water efficient

technology for irrigation contributing to climate change adaptation. This technology (micro and drip irrigation) is supported by the National Irrigation Policy (2004). The policy provides guidance regarding the measures that must be adopted in order to increase the national irrigated area and to improve agricultural water management and existing irrigated agriculture thereby adding increased value to the productivity of labour and natural resources in Swaziland. Furthermore, this target is also aligned with Swaziland National Climate Change Strategy and Action Plan. The measure of promoting manufacture of drip and micro irrigation kits, creating awareness, providing training to farmers and subisiding irrigation kits will help address these targets.

3.3.4 Identification of barriers for Micro and Drip Irrigation

At the stakeholder's workshop of BAEF phase, problem and solution tree method was used for developing measures and brainstorming was done to list barriers for this technology. The main disadvantage of this technology is that initial investment cost associated with pumps, pipes, tubes, emitters and installation is higher than other irrigation systems. Heavy rainfall episodes may affect drip systems. When farms use mechanized production such as tractors, it is difficult to combine with drip system. Root development may be restricted by the limited soil area wetted. This technology requires a clean source of water and, this is a challenge when rainfall is becoming less predictable and water sources are affected by siltation. The technology has some technical limitations and disadvantages. No matter how clean the water looks, a water quality analysis should be completed to determine if precipitates or other contaminants are present that could affect operation of the irrigation system, especially for drip irrigation. The technology for automated and mechanized systems is expensive and needs high amount of initial investment. Some farmers may be put off by the fact that there may be limited market for repurchased (second hand) equipment. Drip irrigation equipment can only be used when field conditions are right. Technical conditions such as soil clay presence or steep slopes can increase implementation and maintenance costs or affect drip system efficiency. Furthermore, with climate change affecting water resources, there could be uncertainty in availability of water for irrigation, which may discourage investment in this technology for some. Insufficient skills for installing drip irrigation equipment and those being expensive initially are also barriers.

3.3.4.1 Economic and financial barriers

Stakeholders listed economic and financial barriers (see table below). The capital costs of buying and installing the irrigation equipment and costs of maintenance are not affordable to many. Since highly skilled labour is needed for installation, operation, storage and movement of irrigation systems, this adds to the costs. The high capital cost is due to few suppliers available for this technology. Often the technology has to be imported from South Africa and transportation to remote areas is costly. Furthermore, the high interest rate for borrowing money (15-17%) and need for collateral as asked by banks, make it difficult for farmers to get loans to buy this technology. Furthermore, in the wake of climate change, farmers have unreliable yields and therefore may not be able to pay back the loans on time. As a result, there are few adopters of this technology and inefficient ways of irrigation contribute to wastage of water. Those who rely on rain fed agriculture have unstable yields and this leads to food insecurity and low incomes for some farmers.

The model of sourcing funds as farmer groups through banks, such as seen in the Shiselveni Piggery project has to be explored. Subsidising irrigation kits for selected farmers can help uptake of this technology.

Figure 8 Participants at the stakeholder workshop brainstorming on barriers for micro and drip irrigation technologies in Swaziland

Table 20 List of economic and financial barriers, barriers, costs for individual and effects of the barriers

Barrier	**Cost for individual**	**Remarks**	**Effects**
High capital cost of micro and drip irrigation kits	Cost of a micro or drip irrigation kit depends on size of farm, topography and location of farm.	Farmers may not be able to afford the costs and the system has to be installed by skilled personnel, which also entails cost.	Due to high costs, there would be fewer adopters of this technology. Farmers may depend on rain fed farming, which can have unreliable crop yields, thereby leading to food insecurity and low profits.
High cost of borrowing funds from the bank for purchase of this technology	Availability of affordable finance is also a barrier, as bank loan interest rates range from 15-17%.	Banks may not tend to fund an individual farmer due to risk involved unless collateral is provided.	
Cost of skilled labour needed for installation and maintenance	If skilled labour is not available nearby, farmer has to arrange for transport costs for labour to come from far distances.	If unskilled people handle the system it can get damaged leading to further loss for the farmer.	

Table above gives a list of economic and financial barriers for micro and drip irrigation technology.

3.3.4.2 Non-financial barriers

Non-financial barriers include barriers related to legal and regulatory framework and weak technical knowledge and skills for this technology (see table below). There is no legal instrument in Swaziland forcing people to use water efficient technologies and there are lack of incentives for efficient use of water. Furthermore, there is no Irrigation Act that can control and regulate methods of use of water for irrigation. In Swaziland, there is inadequate technical skills to install and maintain micro and drip irrigation systems. This is due to low demand for the technology, as there are no manufacturing plants that manufacture these irrigation kits in the country. The poor investment climate in Swaziland may be one reason and the other reason may be the low demand and the presence of South Africa nearby where suppliers are plentiful, making it less attractive for investors to invest in Swaziland. Curricula of technical colleges does not include micro and drip irrigation in detail and with practical applications, hence there are few skilled people who know this technology. As a result, the cost of maintenance of the system is high, as skilled people may have to come from far distances and this may contribute to reduced profits for smallholder farmers. When irrigation equipment get faulty and suffer from poor maintenance, it affects crop yields and thereby profits of farmers.

Other barriers include the unsuitability of this technology for all crop types. Crops that require flood irrigation and those that need ploughing may not be suited for this technology. Crop rotation and intercropping may not favour use of this technology, especially when using static irrigation systems. The type of soil and water available also affects use of this technology. When there is high quantity of clay and silt the drip irrigation kits may get clogged. There is also inadequate technical skills in determination of moisture in soils and detecting mechanical faults in equipment. Also, there are cultural barriers where farmers are used to wetting the soil and be able to visibly see the moisture on the soil, may find drip irrigation to be derisory as only a small drop of water is visible on the outside (see table below).

Table 21 Non-Financial Measures for improving use of micro and drip irrigation in Swaziland

Barriers	Explanation	Effects
Legal Lack of legal instruments for enforceability of this technology	There are no laws that enforce efficient use of water for irrigation in Swaziland.	With climate change, water stress is likely to be experienced in the country. Inefficient use of water for irrigation will contribute to worsening of water scarcity.
Capacity Inadequate skills	There are few skilled people who can install and maintain micro and drip irrigation equipment.	The cost of using this technology increases when skilled people have to travel far distances to reach the farmer.
Awareness The mindset of assosicating	Farmers are used to seeing the wet soil around the roots of crops and as drip irrigation does not wet the soil	There could be few adopters of this technology if this barrier is not addressed. The mindset of farmers can be changed through

wet soil with irrigation	excessively, they do not feel it sufficiently waters their crops.	site visits to farms where drip kits have been used successfully.
Technical Not suitable for all crops	Not all crops could use this technology. The technology limits crop rotation and intercropping and so may not be favourable for some farmers.	Some farmers who wants to adopt crop rotation and intercropping as well as regular ploughing of land may find this technology not useful and therefore adopt less efficient ways of irrigation.

3.3.5 Identified Measures for Micro and Drip Irrigation

Based on the stakeholder consultations, the consultant's own knowledge and international experiences, the following measures were identified for micro irrigation technology. These were further prioritised under Chapter 5.

3.3.5.1 Economic and financial measures

Measure 1: Tax cuts for local manufacture of drip and micro irrigation kits.

Tax cuts for local manufacturers will be an incentive for producing micro irrigation equipment in the country. Once supply is increased through domestic manufacture, the costs of this technology will fall and transport costs will also be lower compared to importing from South Africa.

Measure 2: Subsidize drip and micro irrigation kit for 20,000 farmers. Government can subsidise micro and drip irrigation kits (by 50%) for farmers and encourage purchase of kits by farmer groups. It may be easier to get bank loans when farmers are organized as groups. Farmers Associations or Cooperatives trained in using this technology could be encouraged to pool transport to procure the equipments and thereby bring down their costs.

Figure 9 Participants developing problem and solution trees at the BAEF workshop

3.3.5.2 Non-financial measures

Legal

Measure 1: Set up an Irrigation Act which should contain incentives for efficient use of irrigation water and fines and penalties for wastage of water.

Capacity

Measure 2: Capacitate the National Water Authority and Agricultural extension services through providing training to staff, providing improved facilities and information technology infrastructure. The National Water Authority is the authority that can implement and monitor efficient use of water. Extension services can help create greater awareness and up-scale this technology.

Measure 3: Create a pool of skilled labour through providing training at vocational schools on drip and micro irrigation installation.

Awareness

Measure 4: Create awareness of the benefits of drip and micro irrigation technologies. Changing cultural beliefs of associating irrigation with wet soil (visible to farmer) can be addressed through site visits to farms where the technology is used. Awareness raising can also be done through media and farmers shows.

3.3.6 Enabling framework for Micro and Drip Irrigation

The table below gives the enabling framework for micro and drip irrigation in Swaziland.

Table 22 Enabling framework for micro and drip irrigation in Swaziland

Barriers	Measures	Economic consequence of measures	Other consequences of measures
Financial High capital cost of micro and drip irrigation kits	Provide tax cuts for local manufacture of irrigation kits. The recommendation is to not tax the drip and micro irrigation kits at all.	Loss of tax revenues for Government, but this will be offset by the gains in efficient use of water.	Increased supply of irrigation kits due to availability of local manufacturers will bring the price down. Transport costs will be much lower than importing kits from South Africa and hence they will become more affordable for Swazi farmers. This may help improve adoption of this technology.
Capacity Highly skilled labour needed for installation and maintenance	Training to be provided to Farmers Associations and targeted training at	Cost of training may be borne by the Government or funds sought from development partners	Training farmers as a group may allow for collaborative work, where farmers may pool transport to buy irrigation kits,

	vocational training centres		thereby economising on their investments.
There are few skilled people who can install and maintain micro and drip irrigation equipment	Targeted training on drip and micro irrigation installation at vocational schools. Practical demonstrations can be conducted in farms and opportunities for youth to volunteer may be provided.	The Government should fund this through internal budgets or with funding from development partners.	The cost of using this technology increases when skilled people have to travel far distances to reach the farmer.
Capacity of National Water Authority needs to be enhanced to enforce efficient irrigation equipment are used	Training for staff of National Water Authority Improving office infrastructure Support in developing social media messaging and use of information technology by the authority	Internal Government Funds may be used and support of development partners may be used for provision of training and support to the authority.	This is a long term investment which will be beneficial for the country.
Legal There are no laws that encourage efficient use of water for irrigation in Swaziland.	Irrigation Act to be developed incentivising efficient irrigation technologies for water stressed areas	Developing a new Irrigation Act is a costly process and must be borne by Government with support from internal funds or funds from development partners.	The costs will be offset by funds received from fines for those who are non-compliant and savings from efficient water use.
Awareness Farmers want to see soil wet near the roots of crops and do not feel drip irrigation	Awareness raising session with farmers and demonstration plots are to be made to change mind-set of farmers.	The Government should fund this through internal budgets or with funding from development partners.	There could be resistance to changing mind-sets and hence traditional authorities must be involved who could influence the communities.

sufficiently waters their crops.	Incorporating this technology into curricula of tertiary education will address this to some extent.		
Technical Not all crops could use this technology (for example rice that needs flood irrigation). The technology limits crop rotation and intercropping and so may not be favourable for some farmers.	Awareness raising on suitable crops that be grown using this technology	Incorporating this information into curricula of tertiary education.	Adoption of the technology may not be high amongst farmers who want to follow crop rotation and intercropping methods.

3.3.7 Linkages between barriers and complementarities between technologies in Agriculture Sector

Inadequate access to finance is a hindrance for adopting these technologies. The weak capacity of the agricultural extension services affect all three technologies. It is recognised that low awareness affects all the three technologies and when awareness raising is done, there is opportunity for integrative approach so that all technologies are covered. Another root cause of barriers in adoption of the technologies is inadequate skilled personnel for example to install drip and micro kits, inadequate trained farmers who could train other farmers on conservation agriculture and livestock and poultry selective breeding. There is opportunity for a wholistic training programme to cover more than one technology and thereby helping the sector to up-scale all three technologies. When developing proposals for promoting any of these technologies, integrating more than one technology into the proposal will help generate concerted effort.

4. Chapter: Forests and Biodiversity Sector

Although a relatively small country with a land area of 17,364 km^2, Swaziland is rich in biodiversity with an inordinately large plant and animal diversity. The cultural and economic significance of biodiversity in Swaziland is high. Besides a large population depending on natural resources for subsistence income, many livelihoods are natural resources based in Swaziland, including those that trade medicinal plants and those who work in the plantation forestry sector. The diverse flora and fauna of Swaziland is entrenched in Swazi culture and used in various traditional ceremonies including the reed dance, the Kingship ceremony, traditional attire, traditional hunting, and burial rituals (Matsebula, 1988).

Despite forests and biodiversity being of supreme importance for the country, these resources are under threat. According to Swaziland Environment Authority (2014), "A total of 4,280 km^2 of biodiversity rich ecosystems have been converted to industrial timber plantations, sugarcane plantations and urban areas. The main pressures on Swaziland's biodiversity include:

- Conversion of natural habitats to others land uses;
- Invasion of habitats by alien species with the country's protected areas;
- Rapid expansion settlements and urbanization into biodiversity rich areas;
- Indiscriminate use of fires destroying ecosystems and altering habitats;
- Climate change; and
- Unsustainable use of natural resources".

Under the TNA, for the agriculture sector, technologies of Agroforestry, Conservation of Genetic Resources and Invasive Alien Species (IASP) were prioritised. The IASP management was discussed in detail at the BAEF workshop because it is an important area for the country as the country declared an emergency with regard to IASPs in 2005. However not much funds have been allocated for managing this. Studies have been done to identify the IASP species and published on Swaziland National Trust Commission (SNTC) website, however actual work on the ground to uproot and remove/destroy IASPs have lacked budgetary support. Next, we look at each technology and analyse their barriers, starting with agroforestry.

4.1 Agroforestry

4.1.1 General description of Agroforestry

Agroforestry helps restore agro ecosystems degraded due to lack of organic matter from agricultural intensification and poor ecosystem management. It is a land-use practice that encompasses planting of trees along with crops and also keeping livestock in the same field. This practice helps improve soil fertility. The crops can be grown together at the same time, in rotation, or in separate plots when materials from one are used to benefit another. The trees help in holding the soil, to increase fertility through nitrogen fixation, or through bringing minerals from deep in the soil and depositing them by leaf-fall, and to provide shade, construction materials, foods and fuel. In addition to adaptation benefits, agroforestry also has a function of carbon sequestration.

Agroforestry has many advantages. It is a technology that improves fertility of soil and thereby productivity of land. It provides multiple benefits including provision of firewood, organic materials that can be used as natural fertilisers, provision of forage, improvement in soil fertility and improve water flows as soil structure is improved. Crops planted along with trees such as *Acacia albida* provide higher yields. Agroforestry helps the farmer have income for the whole year as they can now derive construction materials (wooden poles) and fuel wood and reduce needs for purchased inputs such as fertilizers.

There are some disadvantages to this technology. Agroforestry systems require considerable management. Incorporating trees and crops into one system can create struggle for space, light water and nutrients and can hamper the use of tractors in the field as there are trees growing in between the crops. It is important to manage the land effectively to reduce the competition for resources and maximise the ecological and productive benefits. Yields of cultivated crops can also be smaller than in alternative production systems, however agroforestry can reduce the risk of harvest failure.

Generally, agroforestry systems can be categorised into three broad types: agro silviculture (trees with crops), agri silvipasture (trees with crops and livestock) and silvo pastoral (trees with pasture and livestock) systems. Agroforestry practices include:

- Alley cropping: growing annual crops between rows of trees;
- Boundary plantings/living fences: trees planted along boundaries or property lines to mark them well;
- Multi-strata: including home gardens and agro-forests that combine multiple species and are particularly common in humid tropics such as in South East Asia; and
- Scattered farm trees: increasing a number of trees, shrubs or shaded perennial crops (such as coffee and cocoa) scattered among crops or pastures and along farm boundaries.

It is important to plan the features of soil erosion control, earthworks, and gully maintenance, plan spacing of fruit trees according to final spacing requirements and plan a succession of annual or short-lived perennials beginning with the most shade tolerant for the final years of intercropping. To plan for the use of trees in agroforestry systems, considerable knowledge of their properties is necessary. Desirable

information includes the uses, the climatic adaptations of the species, including adaptations to various soils and stresses; the size and form of the canopy as well as the root system; and the suitability for various agroforestry practices. The selection of crops also requires knowledge of uses, adaptation, and market opportunities.

Agroforestry can improve the resilience of agricultural production to current climate variability as well as long-term climate change through the use of trees for intensification, diversification and buffering of farming systems. Trees have an important role in reducing vulnerability, increasing resilience of farming systems and buffering agricultural production against climate-related risks. Trees are deep rooted and have large reserves, and are less susceptible than annual crops to inter-annual variability or short-lived extreme events like droughts or floods. Thus, tree-based systems have advantages for maintaining production during wetter and drier years.

Agroforestry is part of climate smart agriculture which is being promoted by the Ministry of Agriculture, however, up-take is still slow. LUSLM project has supported 689 households with orchards and agroforestry. Land rehabilitation and agroforestry demonstration supported by GEF, IFAD and SWADE were done in 100hectares in Swaziland (IFAD, 2014). There are also unconventional ways in which agroforestry is done connecting it with tourism. In Swaziland, the Khula Tree Project, an initiative of "All Out Africa" (a tourism and volunteering organization) undertakes indigenous tree planting and growing and encourages the establishment of local small nurseries as a livelihoods initiative in the rural areas. The trees they grow are from seeds collected from wild indigenous trees (All Out Africa, 2017). According to stakeholders, there is need for creating awareness amongst NGOs in Swaziland to up-scale this technology.

Manyatsi and Mhazo (2014) states that agroforestry practises in Swaziland include planting beneficial trees such as fruit trees. Fruit trees such as avocadoes, bananas, peaches were common followed by citrus (oranges, naartjies, and lemons), guava, mango, mulberry, and papaya. "The total number of fruit trees planted on a single homestead was generally less than 10, except in cases where bananas were planted" Allen (1990). "The most common planted fruit trees are avocadoes, peaches and mangoes to name a few. They are planted in arable fields adjacent to homesteads where they can be looked after and protected from unauthorised harvesting. The indigenous fruit trees that are left to grow in grass filter strips between ploughed lands include Marula (*Slerocarya birrea*), water berries (*Syzigium cordatu*m), figs (*Ficus spp*) and Velvet-Wild-medlar (*Vangueria infausta*)" (Manyatsi and Mhazo, 2014).

In Swaziland, trainings in Agroforestry was held in July 2011. The selected farmers were grouped according to the regions where they came from and the workshops were held in the regional offices so that the farmers could not travel long distances to the training areas. The training's were organized by the Forestry Department of the Ministry of Tourism together with the Extension Officers from the Ministry of Agriculture (*personal communication*: Wilfred Mbhekeni Nxumalo). The training included theory and practise techniques of intercropping, improved fallow, alley planting, live fence, fodder production and woodlots. There is renewed interest in fodder production for livestock farming and so here is a link between the two sectors. Feed and fodder production for livestock feeding is an important aspect for agriculture and agrofroestry technology can help in this regard (*personal communication*: Roland Xolani Dlamini).

Other benefits to agroforestry include diversification of economic activities, diversification of agricultural revenues, increase in yield from conventional agricultural systems, reclamation of fragile or marginal lands, increase in plant diversity, decrease in wind and water erosion, improvement in soil fertility and carbon sequestration amongst other.

Agroforestry is supported by the following legislations in Swaziland as follows:

- **The Kingdom of Swaziland Constitution Act 2005**

The Constitution Section 210 (2) provides that the State shall protect and make rational use of its land, mineral, water resources as well as it fauna and flora, and shall take appropriate measures to conserve and improve the environment for the present and future generations.

- **The Natural Resources Act, 1951**

This Act supports conservation and improvements of the natural resources and for other matters incidental thereto.

Agroforestry also helps Swaziland meet its commitments to 2020 Aichi Biodiversity Targets and contributions to the Sustainable Development Goals. Furthermore it is in alignment with Swaziland's National Development Strategy and Vision 2022 which supports environment friendly agriculture.

4.1.2 Cost Benefit Analysis

Agroforestry at household level or community level can be fairly inexpensive to implement as the costs entail purchase of seedlings, land preparation and, capacity building and training of farmers. For large scale agroforestry projects, costs can increase due to construction of community nurseries, seedling production and distribution and installation of plantations and rejuvenation of regional forests. Exact costs have to be calculated on a case by case basis. There are minimal operating costs except for managing the farm and its products.

According to Rwanda's BAEF report, the average cost to put in place 1 ha of agro forestry plantations is 10 000 $ covering land preparation, seedling preparation (seeds purchasing, tubing, shade construction, nursery maintenance) and baby trees plantation (Government of Rwanda, 2012). The economic analysis was done using the model of Rwanda's agroforestry programme.

This economic analysis will assume that 20,000 farmers are targeted for training and capacity building in agroforestry with equal representation of all regions. This is the same number of farmer's targeted for drip irrigation and rain water harvesting. The reason in choosing this number is to reach a large proportion of the potential market (target population group). Neither is it too large that efforts may get diluted and availability of finance may become a problem.

The following costs are anticipated:

1. Awareness and knowledge raising among farmers

A comprehensive one day training (including giving out brochures) on agro forestry would be given to the 20,000 farmers chosen at regional centres (such as church halls or school halls to bring down the cost). Extension agents and NGOs working in the field would undertake the training and equal number of farmers per region would be targeted for this. Cost estimate based on Rwanda's model would be $15 (E195) per farmer which equates to $300,000 or E3.9 million

2. Provision of seedlings to farmers

Ten seedlings of indigenous trees would be provided to farmers and this would cost E 15 per seedling, amounting to a total cost of E3 million. The cost per seedling was $0.1 in the case of Rwanda and this was too low for Swaziland and hence the price raised to E15 ($1.15) per seedling, as it also includes transporting the seedlings to the regional training centres.

4. Cost of labour and fertilizers

It is assumed that the farmer will plant the trees himself as the land belongs to him and use organic fertiliser such as dung. No costs were budgeted for this.

The total cost of the project will thus be E6.9 million and this can be funded from internal Government funds, or funds can be sought from development partners. Ideally, this project could be broken up and incorporated into current programmes which focus on agriculture and farming.

The return on investment is estimated as follows:

1. Availability of fruits for the farmer, contributing to the household food security.
2. Availability of poles and firewood which can be sustainably harvested from the trees after a few years for farmer's own use or for sale.
3. Opportunity for farmers to begin beekeeping and generate income from honey production.
4. Improved soil fertility, reduced soil erosion and availability of fodder from leaves of tree for livestock are other benefits from this programme.

Although the benefits are difficult to quantify in terms of money, worldwide, this technology has been recognised as aiding the farmers improve income as well as being good for the environment.

4.1.3 Preliminary targets for technology transfer and diffusion

Agroforestry helps Swaziland achieve its greater goals of climate smart agriculture and effective adaptation. This technology helps both in agriculture and, forestry and biodiversity sectors achieve its targets. Environment friendly farming has been envisioned in important national documents such as the Swaziland National Development Strategy. Furthermore, Swaziland's National Climate Change Policy promotes tree planting as it supports carbon sequestration. Furthermore, this target is also aligned with Swaziland National Climate Change Strategy and Action Plan. The measure of training farmers to undertake agroforestry activities and providing them seedlings will help up-scale this technology.

Table 23 Preliminary Targets for Technology Transfer and Diffusion

Set of measures for enabling framework	Preliminary targets	Rationale for choosing targets
Training of 20,000 farmers from four regions, and providing them with 10 seedlings each.	The 20,000 farmers would be chosen equally from the four regions. Training at all four regions to be conducted by Ministry of Agriculture's Extension Officers and NGOs working on the ground. (within 5 years)	The farmers must be equally represented from all regions for equality. Ministry of Agriculture's Extension Officers and NGOs work closely with farmers at local level and will be the trainers, so that they can continue working with them even after the training is completed.

4.1.4 Identification of barriers for Agroforestry

There is limited adoption of agroforestry in Swaziland, although some programmes are promoting it and it is gaining momentum. However, stakeholders felt that the technology needs to be scaled up. They identified the following barriers:

1. Farmers think of short-term benefits and agroforestry only accrues benefits in the long term. This mind-set needs to be changed and can be changed through training and awareness raising.
2. Extension agents are not promoting agroforestry enough. This could be due to knowledge gap or lack of impetus. Rolling out an agroforestry programme will involve extension agents in providing training to farmers and may give the impetus to promote the technology.

4.1.4.1 Economic and Financial Barriers

There are no major financial barriers to this technology as the cost of purchasing seedlings is low and seedlings could also be grown by the farmer without any great difficulty. However, farmers often tend to have a mindset of thinking short term and not long term. Farmers do not prioritise using their income to buy seedlings for agroforestry. Farmers prioritise how they use their income and they may use it for activities which will provide immediate gains and agro forestry provides benefits in the long term, hence may not be deemed important for them. Limited access to agroforestry inputs such as seedlings could be a barrier for some. To remove this barrier, the programme recommends giving seedlings free of cost to beneficiary farmers.

4.1.4.2 Non-Financial Barriers

The non-financial barriers include inadequate awareness and capacity for agroforestry.

Table 24 Non-Financial Barriers for Agroforestry

Barriers	Explanation	Effects
Awareness Low awareness and impetus for investing in agroforestry	Farmers think of short-term benefits and agroforestry only accrues benefits in the long term. This mindset needs to be changed and can be changed through training and awareness raising.	Not having trees in farms is a lost opportunity for the benefits that could be received through agoforestry, such as improving soil conditions, provisiong of firewood, fruits and fodder and opportunity for honey production.
Capacity Agriculture Extension Officers promotion of agroforestry is inadequate	Extension agents are not promoting agroforestry enough. This could be due to knowledge gap or lack of impetus. Rolling out an agroforestry programme will involve extension agents in providing training to farmers and may give the motivation to promote the technology.	By not promoting agroforestry, farmers lose out on the potential benefits they could accrue.

4.1.5 Identified Measures for Agroforestry

Based on the stakeholder consultations and review of Rwanda's BAEF as well as ClimateTechWiki, the following measure was identified to overcome the barriers for Agroforestry technology.

Awareness and Capacity building

Measure: An agroforesry programme to be rolled out for training 20,000 farmers and providing free seedlings. The training should be conducted by Ministry of Agriculture's Extension Officers.

4.1.5.1 Enabling Framework for Agroforestry

The enabling framework fot this technology includes awareness and capacity building measures targeting farmers with involvement of extension workers.

Table 25 Enabling Framework for Agroforestry

Barriers	Measures	Economic consequence of measures	Other consequences of measures
Low awareness and impetus for investing in agroforestry	Training of 20,000 farmers from four regions. Providing free seedlings to 20,000 farmers	Training cost E3.9million	Mind-set can be changed from thinking short term to long term
Agriculture Extension Officers promotion of agroforestry is inadequate		Free seedlings (10 per farmer) cost E3 million	Involvement of Extension Officers in promoting Agroforestry will be greater

Mind-set of thinking short term and not long term. Farmers do not prioritise using their income to buy seedlings for agroforestry.	participating in the training. Training at all four regions to be conducted by Ministry of Agriculture's Extension Officers and NGOs working on the ground.		NGOs on the ground will also be involved thus becoming a participatory approach which builds capacity in the country

4.2 Conservation of Genetic Resources

4.2.1 General description of Conservation of Genetic Resources

Conservation of genetic resources arose from the thoughts of gene resource conservation which began in the 1910's by agriculturalists who wanted to use wild relatives of crops in breeding programs. This is in response to the worry that scientists had that the genetic diversity of plant and animal breeders was rapidly being lost. Conservation of genetic resources is important as even maintaining productivity requires constant input of new genetic material to over-come crop losses due to pests that become pesticide resistant. This also helps with climate change as higher diversity in crops will make the farmer more resilient to changing weather and climate patterns. This also helps improve yields and withstand shocks of climate change. This technology helps in conservation of biodiversity and reduces species extinction. It also helps farmers in building a pool of robust seeds which can withstand varying climatic conditions and thereby help in adaptation.

Swaziland has 464 species of trees and shrubs which are important not only for livelihoods but also for Swaziland's culture, which has entrenched biodiversity in its ceremonies and traditions (Dlamini and Lupupa, 1995). The benefits of conserving genetic diversity are manifold for Swaziland. There will be improved productivity in agriculture, forests and biodiversity sectors. This will boost the economy and livelihoods as well as well-being will improve. Other related sectors such as tourism will benefit from biodiversity conservation through conservation of genetic resources. Biodiversity will be maintained and productivity in agriculture and forestry sector will improve, which will provide ecosystem benefits. Forest genetic resources provide employment in the commercial forests. They are also used in addressing poverty by means of products sold in market and also addressing the food security problems. Commercial forests accounts for diversity of product that earns foreign revenue for Swaziland. The major forestry products include poles for fencing, construction and transmission lines, and sawn timber for furniture making, non-wood forestry products such as foliage, medicine, honey, edible fruits and nuts, mushrooms and silk worms.

Increased species of biodiversity will improve attraction of Swaziland for eco-tourism which will generate jobs and income. Improved productivity in farming will provide social and economic benefits to the sector. Collection of data and species names will help form a database for scientists and students who are interested to learn more on this. Parks which are conserved provide study sites for environmental students. There is more reliance on medicines derived from forest genetic resources for healthcare by a large population in the country. With climate change, biodiversity will be affected by the changing rainfall patterns and temperature. The need for conservation will increase and there is necessity for preserving genetic resources. Thus, this technology is useful in assisting agriculture, forests and biodiversity in effectively adapting to climate change.

In the late 80's and early 90's domestic production of seeds in Swaziland was developed. The Seed Multiplication Project began with an agreement between the Government of Swaziland and Pioneer-Hi-breed International (PHI) and a seed joint venture enterprise was formed. In 1991 a Seed company was established, which was responsible for the commercial production of Seeds. Through this, domestic

production of high-quality maize, beans, and sorghum seeds is being encouraged. Selling agents from South Africa have been providing vegetable seeds to Swaziland (Dlamini and Lupupa, 1995).

Swaziland's plant breeding programme is still young, hence use of genetic resources is small. The existing breeding programme is for cotton (*Gossypium*) and aims to improve the quality of cotton lint, to increase yield and to breed resistance to pests and diseases. Farmers are involved through on-farm trials, field days organized by the extension staff of agricultural Research Division. Swaziland Environment Authority (SEA) is mandated to look at environmental degradation including reduction or complete disappearance of species and a National Plant Genetic Resources Committee is in place to advise government on issues affecting Plant Genetic Resources. Furthermore, the University of Swaziland Agricultural Campus offers training in Plant and Soil Sciences which includes plant breeding as a subject. Swaziland does not have quarantine facilities in the country, however, the Plant Control Act 1981 seeks to control the importation and exportation of plant material without phyto-sanitary certification. Additionally, this Act prevents indigenous or protected flora from being exported as whole plants, seeds or parts thereof without permits from relevant authorities (Dlamini and Lupupa, 1995). Swaziland signed the International Convention on Biological Diversity in June, 1992, and is a member of the SADC Plant Genetic Resources Centre, which has been supported by Nordic countries since 1988. In addition, there is a network of the SADC Tree Seed Centres which focuses on genetic resources activities of trees.

The Swaziland National Plant Genetic Resources Centre (SPGRC) is located in Malkerns and was set up in 1989. This unit operates under the umbrella of the Agricultural Research Division of the Ministry of Agriculture and Cooperatives (MOAC) based at the Malkerns Research Station. It is responsible for collecting and conserving the country's plant genetic resources; to multiply and describe the characteristics of the collected material; to maintain the active collections and send duplicates to the base collection at the SPGRC; to document data on conserved material; to distribute and promote on-farm conservation of crop diversity through community seed banks; to raise awareness on the role and importance of plant genetic resources in ensuring food security in the SADC region and to promote conservation of vegetative propagated material in field gene banks. Currently, the Marula Project which is a brain child of Her Majesty the Queen Mother of the Kingdom of Swaziland, and run under MOAC is working towards commercialising marula (*Sclerocarya caffra*) production while also curbing the dangers that all other indigenous plants exposed to extreme weather events (SPGRC, 2017).

There are two major alternatives for the conservation of genetic resources and they are in situ and ex situ. In situ conservation refers to the conservation of important genetic resources in wild populations and land races, and it is often associated with traditional subsistence agriculture. Ex situ conservation refers to the conservation of genetic resources off-site in gene banks, often in long-term storage as seed. The focus of conservation of genetic resources in Swaziland is in the forestry sector. In situ conservation and ex situ conservation can be done and the focus in the country is on in situ conservation. Stakeholders at the workshop also suggested in situ conservation which they felt would benefit the local farmer and land user. Furthermore, establishing seed banks and undertaking research would be expensive and not entirely necessary considering Swaziland's neighbour South Africa has capacity to do this and are currently doing it. Stakeholders at the BAEF workshop and in bilateral interview stated that there is need to strengthen and

establish in situ methods of genetic conservation. This can be in the form of establishment of botanic gardens and reserves as well as field gene banks. There is also need to train adequate manpower in Plant Genetic Resources Management, Plant Ecology, Plant Taxonomy and Ethno botany to carry out the above activities.

Swaziland is a signatory to a number of regional and international conventions, protocols and agreements. These include the United Nations Convention on Biological Diversity (UNCBD), The United Nations Convention to Combat Desertification (UNCCD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) etc. There are also several legal instruments that were put in place as a result of the international and regional conventions, protocols and agreements in which the country is a signatory to. These include the Environment Management Act, 2002, the Flora Protection Act, 2001 and the Plant Control Act, 1981. Furthermore, the Sustainable Development Goal Target 2.5 states " By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed" (SDSN, 2017). Hence, this technology is in line with these regulations and there is endorsement for preserving genetic diversity in Swaziland.

4.2.2 Economic Analysis

The following measures are envisaged for Conservation of Genetic Resources in Swaziland.
Measure 1: Establishment of a Botanical Garden and Field Gene Bank.
The Botanical Garden for Swaziland would be a garden dedicated to the collection, cultivation and display of a wide range of indigenous plants labelled with their botanical names. The Field Gene Bank would be an area within the Botanical Garden where the plant genetic resources are kept as live plants that undergo continuous growth. The plants would require continuous maintenance. Field Gene Bank will provide an easy and ready access to the plant genetic resources, and the same material is conserved in the form of seeds. However, both the Botanical Garden and the Field Gene Banks require labour and inputs as well as land and are at risk from natural disasters and adverse environmental conditions like drought, floods or attacks from pests and diseases. The cost for establishment of Botanical Garden and Field Gene Bank is estimated by the Department of Forestry to be $6,000,000.

The proposal for development of a National Botanical Garden was developed by the Department of Forestry. It is proposed to be located at Ngwane Park in the Manzini region on Portion 17 of Farm No.6. This site is very suitable and ideal for the project as it is located near the two main cities; furthermore, it os close to University campuses, schools and /colleges of Manzini and Hhohho regions. The site has the Mhlaleni /Nhlangano road on the West and Nazarene and Two Sticks Township on the East, Ngwane Park Complex on the South and Mhobodleni/Mhlaleni on the Northern side. The climate and altitude of the site allows most plants of the Highveld, Middleveld and the Lowveld to be accommodated in the garden. The site covers an area of about one hundred and sixty-four (164) hectares. The site has been generously

provided by the Government of Swaziland and it has already been declared a protected site for the Botanical Garden and Herbarium through a government gazette.

Stakeholders and relevant institutions consulted for development of the proposal for Botanical garden were, Botanic Gardens Conservation International, KEW Botanic Gardens, Southern African Biodiversity Network, South African National Botanical Institute, Swaziland's Ministry of Economic Planning and Development and Ministry of Pubilc Works and Transport. The Botanical Garden will include Arboretum, Nurseries, Protected plant species sections, Economic garden section, Medicinal and indigenous edible plant section, Ornamental section, Water feature, Geological section displaying the soils and rocks of the country with their unique features found within the garden area, Grass lawns, Sporting facilities, a Dam, Display house, Amphitheatre and chalets. Infrastructural Buildings such as Administrative Building and offices, Entrance ticket office, Security Gate and Fencing, Herbarium Building, Seed bank, Storerooms, Restaurant, Park bay, Kitchen, Book store and, Training and conference centre will also be built.

This centre will act as a training hub for farmers (who, when trained will aid in preserving genetic diversity through use of diversified seeds);

- Genetic diversity of Swaziland will be preserved; and
- The centre will generate income as a tourist centre and educational centre.

Measure 2: Training.
Train adequate manpower in Plant Genetic Resources Management, Plant Ecology, and Plant Taxonomy and Ethno botany to carry out the above activities. This can be achieved by sending the staff of SPGRC and Swaziland Environment Authority for further training. Through scholarships offered by Government of Swaziland, training could be provided and hence this is not costed.

4.2.3 Preliminary targets for technology transfer and diffusion

In the context of Swaziland's national roadmap and vision 2022, the environment and biodiversity are essential to achieving the UN Sustainable Development Goals hence the efforts to create an enabling place for such to be realized. This technology supports Swaziland's Vision 2022 and the various conventions and protocols that Swaziland is signatory to including the Convention on Biological Diversity, United Nations Framework Conventions on Climate Change (UNFCCC), Convention on International Trade in Endangered Species of the Wild Fauna and Flora (CITES), Convention to Combat Desertification (CCD), Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture. Establishing a Botanical Garden and Field Gene Bank will build capacity of officers in SPGRC, SEA as well as farmers of Swaziland. The existing Herbarium of Swaziland contains 7200 plant specimens and this would be the minimum that can be preserved through the measures proposed here. There will be opportunity for in-situ and ex-situ conservation of plant genetic materials. The measure proposed is for the establishment of a National Botanic Garden (Conservation garden) to serve to fulfil Swaziland's national and international goals for plant conservation and sustainable development by providing a refuge for plants which are threatened by development, human expansion, over exploitation

and other related pressures. It will also promote awareness on flora conservation through educational programmes offered by the institution. There will be opportunity to create awareness amongst farmers to collect seeds and multiply them through field days at the Botanical Garden and Field Gene Bank. Farmers are chosen as benefitiaries because they can collect seeds and undertake seed multiplication on their own after the training and thereby contributing to attaining the targets of conservation of genetic resources in Swaziland.

The idea of a Botanical Garden precedes the observed loss of biodiversity in the country and lack of information on the flora existing in Swaziland. International participation in conservation focused goals, conventions and associations necessitates the need of ground work in Swaziland's conservation efforts. On a wider biodiversity scale, the country has a number of wildlife sanctuaries and game reserves/parks but lack the deliverables provided by a Botanical Garden. There has not been a botanical garden at a National or Regional level in the country.

4.2.4 Identification of barriers for Conservation of Genetic Resources

4.2.4.1 Economic and Financial Barriers

The major economic and financial barrier is provided in table below.

Table 26 Economic and Financial Barriers for Conservation of Genetic Resources

Barriers	Cost for country	Remarks	Effects
Inadequate funds for establishment of a national botanical garden and field gene bank.	The estimate for establishing this according to Department of Forestry is $6,000,000.	Often when more pressing sectors need funds such as health and education, the internal country funds are not allocated for projects such as botanical garden which is not seen as an urgent need, but rather a "desirable" one.	Swaziland's indigenous flora is not conserved adequately.

4.2.4.2 Non-Financial Barriers

Non financial barriers include low awareness and weak capacity in plant genetics resources management.

Table 27 Non-Financial Barriers for Conservation of Genetic Resources

Barriers	Cost for country	Remarks	Effects

Awareness Inadequate seed multiplication done by farmers as they would prefer to purchase Genetically Modified seeds	Loss of genetic diversity and indigenous seeds.	Setting up Field Gene Banks will help preserve genetic diversity of flora in Swaziland	Some species will get extinct if they are not collected as seeds, muliplied and planted.
Lack of a National Botanical Garden where farmers and environmental manager can view and learn about Swaziland's indigenous flora.	Setting up a National Botanical Garden and Field Gene Bank will cost approximately $6,000,000	The Botanical Grden and Field Gene Bank will help in preserving live samples of Swaziland's flora	Genetic diversity will be preserved and the center will also act as an educational/field school and can raise funds as a tourist attraction.
Capacity Inadequate capacity in plant genetic resources management in the country	Training of staff of SEA and SPGRC in Plant Genetic Resources Management, Plant Ecology, Plant Taxonomy and Ethnobotany	Capacity building in country will help ensure sustainable utilisation of the Botanical Garden and Field Gene Banks.	The officers trained can train others in the country as well as hold training sessions for farmers.

4.2.5 Identified Measures for Conservation of Genetic Resources

Awareness

Measure 1: Establish a national Botanical Garden and Field Gene Bank.

Measure 2: Create awareness amongst farmers to collect seeds and multiply them through field days at the Botanical Garden and Field Gene Bank.

Capacity

Measure 2: Provide training to staff of SEA and SPGRC in in Plant Genetic Resources Management, Plant Ecology, Plant Taxonomy and Ethnobotany through providing scholarships for further studies.

4.2.6 Enabling Framework for Conservation of Genetic Resources

Given below are a set of measures that will form the enabling framework for conservation of genetic resources.

Table 28 Enabling Framework for Conservation of Genetic Resources

Barriers	**Measures**	**Economic consequence of measures**	**Other consequences of measures**
Lack of a Botanical Garden where farmers and environmental manager can view and learn about Swaziland's indigenous flora.	Set up a Botanical Garden and Field Gene Bank.	Cost to set up the centre is $6,000,000	The centre will attract tourists and can act as an education centre for farmers and university students
Farmers find it convenient to purchase Genetically Modified seeds from South Africa as it is affordable	Create awareness amongst farmers to collect seeds and multiply them through field days at the Botanical Garden and Field Gene Bank.	The cost of holding field schools for farmers at the Botanical Garden and Field Gene Bank is only the cost of transport and refreshments for farmers who could make a day trip to the centre. Farmers who come from far would need to be provided accommodation.	Due to the fact that seed collection and multiplication takes effort, farmers may continue opting for Genetically Modified seeds due to its short term benefits.
Inadequate seed multiplication done by farmers as they would prefer to purchase Genetically Modified seeds			
Inadequate capacity in plant genetic resources management in the country	Provide training to staff of SEA and SPGRC in in Plant Genetic Resources Management, Plant Ecology, Plant Taxonomy and Ethnobotany through providing scholarships for further studies.	This can be covered through Government scholarships.	The trained officers can impart training to other colleagues and capacity development within Swaziland will be improved.

4.3 Invasive Alien Species Management

4.3.1 General description of Invasive Alien Species Management

Alien (non-native) species have been introduced both accidentally and intentionally in Swaziland. Intentional introductions are, and have been, motivated by economic, environmental and social considerations. It is important to control invasive species as their impacts are immense, insidious and usually irreversible, and they may be as damaging to native species and ecosystems through loss and degradation of habitats. The cost of reversing their impact is large. Although some species have invaded habitats through natural ways, human activity such as exploration, colonization, trade and tourism has dramatically increased the diversity and scale of invasions by alien species. Invasive species contribute to land degradation through soil erosion and the drawing down of water resources, reducing resources available to people and indigenous plants. Others produce leaf litter which poisons the soil, suppressing the growth of other plants, and in particular that of the understorey. They may alter the environment in directions that are more favourable for them but less favourable to native species. This could include altering geomorphic processes (soil erosion rates, for instance, or sediment accretion), biogeochemical cycling, hydrological cycles, or fire or light regimes. Swaziland declared a national emergency on proliferation of invasive species in year 2005, as they were said to threaten food security and thus the economy of the country. SNTC and its partners have been collecting data, researching, mapping and compiling information materials on invasive species. A number of programmes and projects in Swaziland has already included elements of invasive species control (for example Lower Usutu Sustainable Land Management and the Strengthening the National Protected Areas System of Swaziland or SNPAS).

Some of the invasive species such as eucalyptus and guava are beneficial to people and so support from communities to control those species may be difficult to receive. Data collection, research and mapping of invasive species require specialized personnel. Swaziland has to put in place systems for evaluating the risks and benefits associated with alien species, and for deciding when to use them and when to prevent their introduction or eradicate them. This entails considering the economic, development, environment and human well-being costs and benefits, and recognizing the close relationship between sectors. Second, Africa faces the challenges of how to translate its policy objectives into effective management practice. When species are identified as a threat, appropriate responses may include establishing systems for their eradication, as well as for controlling and monitoring their introduction. When alien species are used, developing early warning and assessment systems regarding their behaviour as well as effective response systems is essential. Swaziland National Trust Commission (SNTC), Swaziland Environment Authority (SEA) and its partners have already embarked on such programmes. Some species such as the eucalyptus provide benefits which reduce the need to completely eradicate them form the country. Invasive species control is a continuous activity as invasive species are propagated by seeds blown by wind, carried by fauna and deliberately planted by humans. Data collection and mapping need to be done at regular intervals to assess extent of spread of invasive species. There is a strong political endorsement through the Ministry of Tourism and Environmental Affairs and Government of Swaziland declared an emergency of invasive species, indicative of the solid commitment to this cause.

UNEP has declared that invasive species is a substantial threat to ecosystems. The Millennium Ecosystem Assessment (MEA) found that trends in species introductions, as well as modelling predictions, strongly suggest that biological invasions will continue to increase in number and impact (MEA, 2005). With climate change, temperature variations and rainfall variations may promote growth of some species of alien invasive plants. Due to these species, farmers are losing productive arable land used to produce cash crops and pastures where domesticated and wild animals graze. Invasive species may out-compete native species, repressing or excluding them. Controlling invasive species therefore allows indigenous species to thrive which has multiple benefits of provisioning of productive ecosystem services such as food, fibres and medicinal plants. Habitat loss reduction helps in maintaining biodiversity and use of land for productive purposes such as agriculture. Invasive species use excess water compared to indigenous species so controlling them has indirect positive benefits on water resources. Invasive species such as the Wattle (originally from Australia, but introduced in Southern Africa for wood fuel security) has the tendency to take over grazing land and convert to bush. When such species which take over arable and grazing land are controlled the benefits are felt in agriculture and livestock rearing through improved land and yields.

In Swaziland, the sugar and forestry industries are struggling to save their farms from these alien plants and thousands of hectares of developed land in which they have invested expensive irrigation infrastructure (see figure below). The plants have clearly demonstrated their ability to change permanently our ecosystem and impact negatively on economic development. Furthermore, invasive species such as the Guava are planted by individuals for fruits and therefore there is need for greater awareness raising to prevent people planting the invasive species. Controlling invasive species will help the agriculture, forests and biodiversity sectors and indirectly aid in climate change adaptation (SEA, 2017).

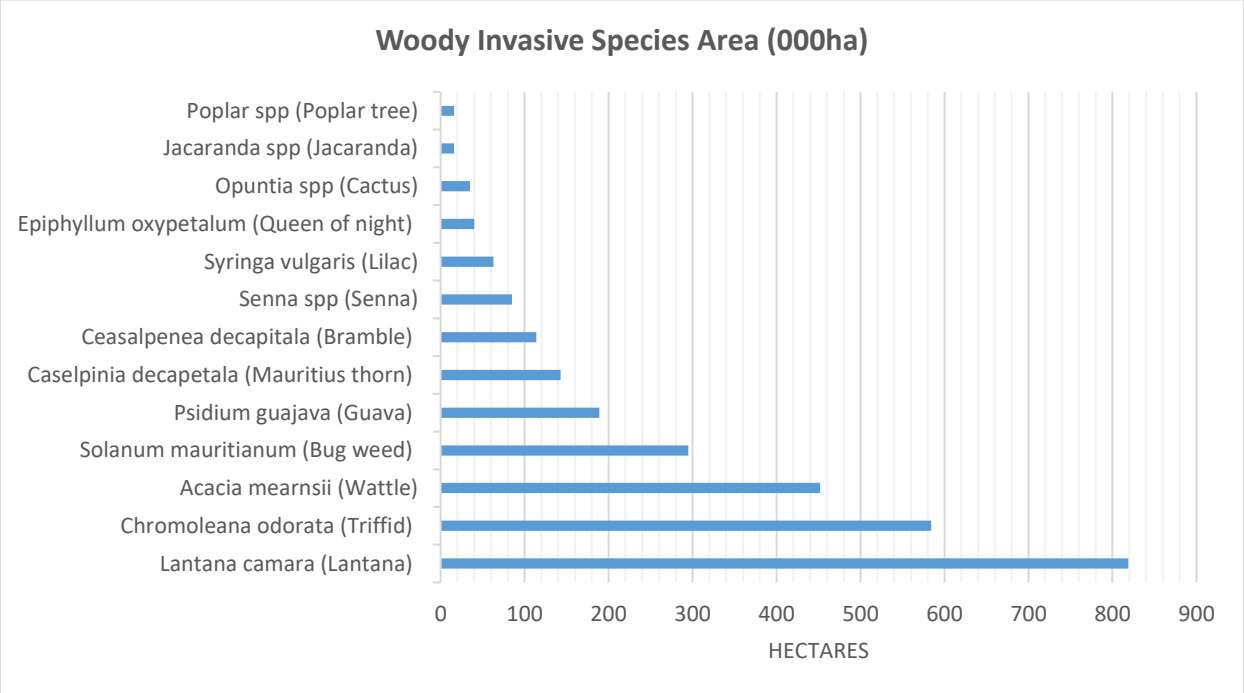

Figure 10 Total Forest Area Affected by Woody Invasive Species in 2010

(Source: SEA, 2014)

When implementing this technology, there will be substantial costs of data collection, mapping, awareness raising, and field activities in controlling invasive species. There will also be continuous costs of database updating, regular publishing of research results and maps and activities on the field such as awareness raising as well as removal and destruction of invasive species. However, this will be offset by benefits accrued in prevention of land being taken over by invasive species. Benefits of controlling invasive species are myriad. This includes being able to use land productively, increasing agricultural yields and enhancing biodiversity. Habitat loss is prevented and therefore there are benefits to wildlife. This will help the tourism sector.

Programmes and projects that control invasive species employ people to physically remove the plants and thus jobs are created. Higher level jobs are created for data collection, research, capacity building and mapping of plants. Increased research and data collection as well as mapping of invasive plants help provide botanists and students with more information. Capacity building at village level on types of invasive species and their impacts help increase knowledge amongst communities.

There is opportunity in including control of invasive species into current and ongoing as well as future environmental, forestry, agricultural and water projects in the country. This problem affects all these sectors. Beneficial invasive plants such as wattle, guava and eucalyptus are used by communities and industries and may be difficult to remove from Swaziland. But, there are alien species which are not beneficial, such as weeds. The Swaziland National History Society, notes that an invasive species known locally as demonica weed was blown into Swaziland by a cyclone in 1984; this has subsequently rendered large areas of formerly productive agricultural land useless (SEA, 2017). Local stakeholders understand to some extent the negative impacts of invasive species. The challenge may be for controlling of species which are beneficial to humans.

Ministry of Tourism and Environmental Affairs, Swaziland Environment Authority, Swaziland National Trust Commission, All Out Africa and Natural History Society of Swaziland are all working towards studying, compiling data and physically removing these alien species. A project was carried out in 2003/4 by Swaziland Environmental Authority, to compile existing data on alien invasive plants of Swaziland. One product of this project was the creation of an online database of Swaziland's alien/non-indigenous plants, with distribution maps and photographs or illustrations. Furthermore, the Luhlanyeni Chiefdom community were one of the first to receive training on clearing and controlling invasive alien species. They cleared 50ha of rangeland taken over by lantana by physically removing the lantana and subsequently spraying using chemicals provided by the Ministry of Tourism and Environmental Affairs. This community gave feedback that due to the clearing of rangeland, they are benefitting from improved livestock management. They also pointed out that the commitment for removal of invasive alien species takes 4-5 years and work is extremely strenuous, leading to many members of the community opting out due to ill health (IFAD, 2014).

Some progress has been made with regard to managing invasive alien species in the country. Swaziland Environment Authority spearheaded the National Alien Invasive Plant Species Control and Management

Strategy which aims to promote cooperative, coordinated and integrated management and control of alien invasive plant species to reduce their ecological, economic and social impacts on human and natural resources. Through this programme, survey and mapping of distribution and intensity of infestation of selected invasive alien plant species was done by the department of forestry. In the GEF-UNEP funded project on Strengthening the National Protected Areas System of Swaziland, the element of managing invasive alien species was included SEA (2014).

4.3.1 Cost benefit Analysis

According to an assessment done on IASPs in 2010, Pine, Eucalyptus and Chromolaena has the highest average density amongst invasives. Lantana covers the greatest area, followed by Chromolaena and Black Wattle. In total 80% of Swaziland is invaded at different densities, or 10.68% is invaded at a 100% density (condensed) which covers 184 995 hectares. This area will cost approximately E665 million to be cleared once (Kotzé et al. 2010).

Swaziland already has a National Strategy for the Control and Management of Invasive Alien Plant Species. This is under review through the SNPAS programme. The implementation strategy with monitoring and evaluation is the responsibility of the Forestry Department in the Ministry of Tourism and Environmental Affairs.The strategy document has a plan for activities with a detailed budget for the institution (personnel and equipment) and budget for the clearing of IAPS (Government of Swaziland, 2010). The grand total costs comes to E141,404,591 (141 million) for five years, which at 2017 adjusted by 10% from 2010 budget would amount to E275,557,544.5 (276 million) for five years. The budget includes a 100 teams with 25 combatants per team, working 20 days a month, chemicals for combat, cost of clearing land (cutting IASPs), transport costs, public awareness and research costs.

For a comparison, the IASPs management programme of South Africa was taken. South Africa has the largest programme on IASPs in the region called the “Working for Water” programme, which strives to control invasive alien species (until recently only plants), and in so doing to protect essential ecosystem services. They have a 3-year budget of R7.8 billion, arguably the most generous funding for an environmental problem that South Africa has ever seen (van Wilgen et al., 2012). For Swaziland, the budget for IASPs control would need detailed site specific analysis.

4.3.2 Preliminary targets for technology transfer and diffusion

Invasive Alien Species (IASPs) are a threat to biodiversity, water, agriculture and forestry. Managing IASPs helps Swaziland achieve its commitments for the Convention on Biological Diversity. The Convention on Biological Diversity (CBD) seeks to ensure the conservation of biological diversity, expects the country to undertake number of provisions aimed at safeguarding biodiversity and requires Government to develop national strategies, plans and or programmes for achieving this. Managing IASPs helps Swaziland achieve its sectoral goals as IAPSs affect the sectors. For example, Swaziland wants to safeguard its water resources and grazing lands because it is important for livelihoods, however IASPs wreak havock in wetlands and are

taking over grazing lands, thereby affecting these sectors. Swaziland's INDC has also prioritised IASPs management. Furthermore, this is backed up by the National Forest Policy and the Plant Control Act of 1981 which provides for the control, movement and growing of plants and matters incidental thereof. It prohibits importation of plants, insects and alien animals without a permit or otherwise in accordance with the conditions attached to a permit issued by the Principal Secretary of the Ministry of Agriculture and Cooperatives.

The priorities for Swaziland with regard to IASPs is that the following invasive plants need removal: *Chromolaena odorata, Solanum mauritianum, Lantana camara, Caesalpinea decapeta, Eucalyptus species, Rubus species, Psidium guajava, Jacaranda mimosifolia, Caesalpinia decapetala, Opuntia species, Pinus species, Cereus jamacaru, Ricinus communis, Senna didymobotrya, Sesbania punicea, Melia azedarach and Acacia mearnsii. Pathenium hystorophorus* (Government of Swaziland, 2010).
The National Forest Policy recognizes the following species as priority IAPS: *Chromolaena odorata, Lantana camara, Solanum mauritianum, Pathenium hystorophorus.* The strategy states that the following invasive plants species are of economic use and should be kept within management level at all times: Eucalyptus species, *Psidium guajava, Acacia mearnsii and Jacaranda mimosifolia*. Land owners should keep these plants within their planted areas and they should be stopped from spreading to other areas. The ambition is taken from the National Strategy for Control and Management of Invasive Alien Species (Government of Swaziland, 2010), and is as follows:

- Target area for first clearing is 563,325.3 hectares and 15000 hectares for follow up clearing.
- At least 100 combat teams should be engaged in IAPS clearing on SNL.
- Each combat team is expected to clear 70 hectares per month.

When implementing IASPs management, training will need to be provided to personnel and this would need to be incorporated into the management programme. Lessons could be learnt from South Africa' Working for Water programme which manages IASPs in South Africa. Recognizing that IASPs waste a lot of water from ecosystems and are a threat to biodiversity, South Africa embarked on one of the most successful project in the region to manage IASPs. Working for Water currently runs over 300 projects in all 9 South African provinces. Mechanical and chemical methods as well as biological and integrated control methods are used and the programme provides employment for many. It is hailed as a success. But in Swaziland, IASPs management is being promoted using "Management by Utilization method" and is currently being implemented in its Protected Areas with funding from UNDP through the Strengthening the National Protected Areas Systems of Swaziland (SNPAS) Project. This approach is useful as it uses an integrated land and natural resource management approach and at same time enhances vulnerable communities' livelihoods, in particular those adjacent to the Protected Areas.

4.3.3 Identification of barriers for Invasive Alien Species Management

From literature review and based on the stakeholder consultations as well as the consultant's own knowledge, the barriers for management of invasive alien species are described here. Problem and solution tree method and brainstorming was used for developing and to identify barriers for this technology.

4.3.3.1 Economic and financial barriers

Stakeholders at the BAEF workshop identified the high cost associated with management and control of IASPs to be a major challenge. There is need for expensive chemicals and tools as well as labour when uprooting or burning the plants. Often the chemicals are imported and local production may be research intensive and costly. The control measures are often labour intensive and require rapid action and follow up programs. The labourers involved must also be trained well and provided with protective clothing. There are more urgent priorities for Swaziland Government and hence adequate budgetary support for IASPs control may be lacking. As a result, IASPs continue to spread in the country.

Table 29 List of economic and financial barriers for IASPs management, costs for the country and effects of the barriers

Barriers	Cost for country	Remarks	Effects
High cost assosciated with IASP management and control chemicals and tools	Cost of importing chemicals for IASP management	Due to high cost involved, budgetary support for IASPs management is limited and IASPs management is being done at project levels with support from development partners (UNDP)	Competing government priorities may cause reduction in the scale at which IASPs management is done
High cost of labour for IASP management	Cost of training people for IASPs management, cost of protective clothing	IASPs management is labour intensive and needs skilled labour	Unless ongoing monitoring and follow up is done, IASPs control efforts may be futile

Table above gives a list of economic and financial barriers for management of IASPs.

4.3.3.2 Non-financial barriers

Non-financial barriers for IASP management include poor awareness and understanding on IASPs and their impacts and weak political, strategic and legislative framework for IASPs management. The National Alien Invasive Plant Species Control and Management Strategy aims to promote cooperative, coordinated and integrated management and control of alien invasive plant species to reduce their ecological, economic and social impacts on human and natural resources (SEA, 2017). Although Swaziland has a good strategy for control of IASP, the awareness is low. Stakeholders at the BAEF stated that there are insufficient awareness campaigns regarding IASP and they are not fully integrated into school curriculum. This could be due to it being a fairly new topic and teachers may not be conversant with the subject. It leads to weak understanding and people may promote IASPs by planting them in their gardens, as some of them are beneficial, i.e. guava for fruits and wattle for fuel wood. This will cause IASPs to continue to spread and become more difficult to control and may also threaten grazing land and croplands.

Table 30A participant presenting the problem tree for IASPs on behalf of his group at the BAEF workshop

The cross sectoral nature of IASPs provides a challenge of developing a legislative framework specific for the issue. Stakeholders also noted that there is inadequate action politically for management of IASPs. The larger negative impacts of IASPs spreading in the country influences water availability, as some species grow in wetlands. IASPs spreading into croplands and grazing land have negative economic impacts. Habitat loss due to proliferation of IASPs may cause species loss and negative biodiversity impacts.

Table 31 Non-financial Barriers, costs to country and effects of IASPs

Barriers	Cost for country	Remarks	Effects
Political Weak political, strategic and legislative framework for IASPs	When IASPs continue to spread, water sources are affected, biodiversity is affected and productive lands may be impacted by IASPs invasion.	There is an IASP Strategy developed by Ministry of Tourism and Environmental Affairs in 2010. This is under review through the SNPAS programme.	Inadequate action politically for IASPs management.
Awareness Limited understanding of IASPs	Cost of creating awareness through IEC materials and campaigns.	IASPs management is not fully integrated into school curricula and there is insufficient awareness.	People may promote planting of IASPs due to low awareness levels.

4.3.3.3 Identified measures

Swaziland's National Development Strategy (Vision 2022) and other international obligations such as the Aichi Targets under the auspices of the Convention on Biological Diversity have set targets for the conservation of its ecosystems and species. IASPs are a threat to Swaziland's ecosystems, therefore it is imperative that the country manages the spread of IASPs. Stakeholders suggested that Swaziland should use the approach of "Management by Utilization" to deal with IASPs. Economic exploitation of notorious invasive species has been found to be a good way to manage their spread and was found to be successful in countries such as Sudan, Ethiopia, India, Senegal, Mali, Nigeria and the Gambia (Borokini and Babalola, 2012). The measures discussed below were identified by stakeholders during consultation on management of IASPs. There was consensus that IASPs should be "managed by utilization". This is in line with Government priorities and a UNDP GEF funded project currently being implemented in Swaziland called "Strengthening the National Protected Areas Systems of Swaziland" or (SNPAS) Project.

4.3.3.4 Economic and Financial measures

Measure 1: Exempt all IASP management and control chemicals from import duty. This will reduce the cost of usage of such chemicals for IASP management programme, thereby reducing its overall budget.

4.3.3.5 Non-financial measures

Awareness

Measure 1: Improve awareness of IASPs and its impact on the environment and all the sectors affected. This can be done through awareness campaigns and road shows.

Capacity

Measure 2: Improve skills in IASPs management by providing training to IASPs field officers responsible in SEA.

Political

Measure 3: Prepare a policy brief on impact of IASPs on sectors in Swaziland. This will help create further awareness amongst all policymakers of various sectors and they will be motivated to include IASPs management into their programmes.

Legislative

Measure 4: Revise the IASPs Management Strategy to make it more robust for implementation. Remove any weaknesses and grey areas that may cause confusion in the strategy. Include stricter controls on cross-border movement of IASPs, planting of IASPs and managing IASPs. This can be in the form of fines for offenders.

4.3.3.6 Enabling framework for IASPs management

The enabling framework for IASPs management was developed by stakeholders and includes multiple sectoral responses. The table below gives the enabling framework for IASPs management.

Table 32 Enabling framework for IASPs management in Swaziland

Barriers	Measures	Economic consequence of measures	Other consequences of measures
Financial High cost of IASPs management chemicals and tools	Exempt all IASPs management and control chemicals and tools from tax.	Loss of tax revenues for Government, but this will be offset by the gains in controlling loss of productive lands and water resources from damaging impacts of IASPs.	This tax incentive could be misused by people who may buy in Swaziland and export to neighbouring countries.
Capacity Skilled labour needed for IASPs management	Training to be provided to IASPs management field officers. This must be ongoing, as trained officers may leave the organization or may need refresher trainings from time to time.	It will be costly for Government to train personnel on a regular basis and so training funds may be sought from development partners	Trained personnel may seek jobs elsewhere thereby causing leakage in the system.

Legislative The IASPs management strategic plan is not being implemented effectively. Include stricter controls on of cross-border movement of IASPs, planting of IASPs and managing IASPs.	Revision of IASPs Management Strategic plan and enaction	Revision of IASPs strategic plan will involve conducting stakeholder consultations and experts working on revising the documents. This will involve costs. Government may seek support from international agencies that support policy development such as UNDP for funding this.	Enaction of revised strategy requires many sectors and players to work together. This may take time and extensive consultations, during which IASPs growth and spread will continue.
Awareness Many people are not aware of the devastation caused by IASPs in Swaziland. People have planted IASPs in their farms and households due to poor awareness about them.	An awareness campaign needs to be done about impacts of IASPs and identifying the species. This will discourage people promoting them accidentally or intentionally. Awareness raising will need to be done for policy makers too.	Cost of creating awareness through IEC materials, policy brief and campaigns.	Beneficial IASPs such as guava, pine, wattle may be continually used by people and they may resist the move to control their spread.

4.3.4 Linkages between barriers and complementarities between technologies in Forestry and Biodiversity Sector

In the forestry and biodiversity sector, weak capacity and low awareness were linked to all three technologies prioritised. Inadequate funding was linked to both conservation of genetic resources and IASPs management as hindrances for these technologies not reaching scale. There are complementarities between the technologies, as control of IASPs will support conservation of genetic resources, as IASPs are a threat to indigenous species in some areas. Capacity building in conservation of genetic resources and IASPs are complementary to each other as they have overlaps. Furthermore, awareness raising can be complementary if conducted in a wholistic manner with messages that touch on all three technologies.

5. Chapter : SWOT Analysis of Measures

Here measures are analysed and compared to enable political decision making. A SWOT analysis of measures is performed and in the next section, overall strategy to overcome barriers been designed.

Table 33 SWOT analysis of measures

Technology	Measures	Strengths	Weaknesses	Opportunities	Threats	Proceed to TAP stage?
Integrated River Basin Management (IRBM)	Develop proposals to raise funds from international and regional institutions/opportunities.	Rivers originating in Swaziland are shared with Mozambique and South Africa and hence there are regional agreements already in place, hence preparing proposals will become better guided and focus on practical activities	Swaziland is a middle income country, therefore getting funds allocated for lower income countries is not possible.	Since Swaziland is the riparian country for majority of the rivers, there is opportunity for Swaziland to develop infrastructure such as dams and roads which will provide employment for Swazis and help with economic development in the Kingdom.	Project and development terms must be negotiated carefully such that equitable share of resources is done and such that economic giant such as South Africa does not take majority of benefits.	Yes
Integrated River Basin Management (IRBM)	Raise funds at national level through Public Private Partnerships (PPP).	Raising funds through a PPP would be beneficial to the country's economy as the private sector partner and Government will both benefit through the partnership.	For transboundary resources national projects would have to be carefully designed such that transboundary resource management agreements such as the SADC shared water courses is adhered to.	The sugar industry if Swaziland and Eco-Tourism sector would be possible private sector partners that can benefit through PPP.	Any national level PPPs affecting shared water resources would be subjected to scrutiny by the countries using the shared water courses. This may impose certain restrictions on use and loss of control in the PPP.	No. This is due to agreements Swaziland has signed with regard to shared water courses.

Integrated River Basin Management (IRBM)	Establish a "Funds Coordination Platform" within Swaziland with members from development partners, private sector, Government and non-state actors.	The Funds Coordination Platform will promote transparency, create synergies and promote sharing of funds, thereby being better "value for money" and will enhance ability to do more with same funds.	Since it will be a voluntary mechanism, it will be based on initiative and interest of members.	Opportunities to share resources such as vehicles, "piggybacking" on workshops to include additional capacity building initiatives and create deeper impact with projects.	Some development partners may not be willing to share their resources and may have policies that prevent them to share resources. Lack of trust may also prevent some agencies to openly divulge their resource plans and work together with other partners.	Yes
Integrated River Basin Management (IRBM)	Build capacity of officers responsible for implementing relevant legislations (such as the Water Act) through providing them training, technical support and equipment where needed.	Officers whose capacity is built will become champions in IRBM and provide impetus at national level. Building capacity nationally is an investment for the country.	There are no weaknesses anticipated from building capacity of officers.	There will be opportunity to train officers in the latest technologies which will help the sector improve.	Officers whose capacity is built may leave the country in pursuit of better career prospects.	Yes
Integrated River Basin Management (IRBM)	Create awareness amongst stakeholders about IRBM and water	An aware society will be stewards of the environment. Awareness raising amongst local communities will trigger	Communities have been involved in many awareness raising sessions for several projects and there could	There is opportunities to incorporate awareness raising with national and international commemoration days	Local communities whose mind-set that "water is free" and "from God" may oppose when	Yes

	resources management.	local champions who will carry forward good environmental management activities long after the project has ended.	be fatigue from attending too many meetings and awareness sessions.	(such as World Water Day, World Wetlands Day).	awareness raising sessions talk about need to manage resources which are beginning to be affected by scarcity.	
Integrated River Basin Management (IRBM)	Build capacity of institutions responsible, such as the River Basin Authorities through filling vacancies and adding more staff where needed (such as for water quality checks and leakage management).	Building capacity of institutions in Swaziland is an investment for the country. Having strong institutions within the country will help the sector.	There may not be sustained funding to fill new positions. Long term funding is needed before hiring new personnel.	Opportunity to hire highly skilled personnel who will add value to the institutions. Opportunity to look for personnel with skills in using latest technology and modernise the institutions.	New recruits may leave the organization in pursuit of career opportunities elsewhere.	No. This Can be looked at when long term funding is available, so that sustainable capacity building can be done.
Integrated River Basin Management (IRBM)	Create a Participatory Forum, where traditional authority and relevant stakeholders can be given a voice in decision making.	Improving participation and dialogue between stakeholders including traditional authority will be beneficial for success of any project, as local authorities have powers at local level and can influence the outcome of projects.	Collective dialogue and participatory decision making is usually a long and time consuming process. Quick results and outputs could not be expected.	Opportunity to include traditional authorities in decision making will reduce conflicts in resource use and provide a voice to communities.	Traditional authorities may be resistant to dialogue and collective decision making.	Yes

Wetland Restoration and Protection (WRP)	Set a funds coordination mechanism involving stakeholders where meetings are held regularly and synergies in usage of funds for wetlands restoration and protection by agencies working in same areas are realised.	The Funds Coordination Mechanism will promote coordination and better usage of funds for WRP	This is a voluntary stakeholder forum and depends on initiative of members	Projects related to environmental management may have wetlands restoration and protection aspects. This mechanism will allow for synergistic use of funds	There could be development partners who are not interested to join this mechanism as they prefer full autonomy on their resrouces.	Yes
Wetland Restoration and Protection (WRP)	Proposal development for wetlands restoration and protection for shortlisted wetlands Mlawula, Ubombo, Ndlotane, Mangwenya and Shovella.	Since these wetlands have already been identified in a previous study and this technology has been noted as helping with adaptation in Government documents, this indicates Government's support for implementing this technology. Thus proposal development has a strong justification.	Proposal development requires time and since Swaziland is a middle income country, funds for low income countries are unavailable.	There is opportunity to include wetlands rehabilitation under other larger environmental and developmental projects. There is also opportunity to undertake community lead programmes such as Community Based Natural Resource Management (CBNRM) projects to include wetlands protection.	By the time proposals are developed and funds raised, the wetlands may have been over exploited and degraded.	Yes
Wetland Restoration and	Create awareness of importance of wetlands through	This will motivate communities living near the wetlands to	Community members may not be available at the meetings, or may not	Opportunities for sustainable use of wetlands for enhancing	When awareness is raised on sustainable use of wetlands,	Yes

Protection (WRP)	community level meetings and site visits for communities living near wetlands.	participate in its protection.	take the meetings seriously.	community livelihoods could be explored at these meetings.	which includes restrictions on unsustainable harvesting, communities may resist this.	
Wetland Restoration and Protection (WRP)	Create a wetlands monitoring system to be implemented and published regularly by Swaziland Environment Authority on an ongoing basis.	Measuring wetlands health is the first step towards managing them. Data is important to make evidence based decisions.	Monitoring using remote sensing may miss out on nuances that are site specific and can be obtained only through discussions with communities in the area.	There is opportunity to monitor health of all wetlands in the country as well as look at other pressures on the environment, such as deforestation happening in other areas.	There are no threats identified for this measure.	Yes
Wetland Restoration and Protection (WRP)	At the funds coordination mechanism meetings grey areas in roles and responsibilities can be discussed and better clarity arrived at.	Clearing confusions in roles and responsibilities and removing duplications and overlaps will help in better utilisation of funds.	The funds coordination mechanism is a voluntary imitative and so it is difficult to hold people to account for outcomes/outputs.	There is opportunity to look at overlaps/confusions and create greater synergies.	Institutions may not agree to divide responsibilities and may want to maintain status quo.	Yes
Rooftop Rain water harvesting	Government could subsidise RWH tanks (by 50% of its cost) by providing vouchers to selected households.	One major barrier that prevented people to invest in RWH was the price of the tank. This measure will overcome that barrier.	This measure has a weakness of not being able to cover all households in the country.	There is opportunity for utilising harvested rainwater for household gardens which will contribute to improved nutrition.	Some people may buy the subsidised tank and resell at greater price.	Yes

Rooftop Rain water harvesting	Introducing RWH technology in tertiary schools, and providing skills training.	Tertiary institutions will find it beneficial to include this practical technology training. This will provide skills to youth, which is sustainable for the long run in making RWH popular and viable.	This is dependent on the cooperation and support of tertiary institutions.	Availability of skilled personnel will bring down cost of installation of RWH systems.	Tertiary institutions may not take this as a priority and may resist the inclusion into curricula.	No
Rooftop Rain water harvesting	Legislative measures may help in improved adoption of RWH technology.	Legislative measure will give legal mandate to implement RWH technology. A policy to promote RWH or it could be amended into the Building Control, Water and Public Health Acts of the country.	Making a technology compulsory may not be fair for poor households. It is also costly to enforce such legislation.	Amending RWH technology into building control regulations, water and public health acts will provide opportunity to design projects right from beginning with RWH technology incorporated into them.	People may protest enforcement measure.	No
Rooftop Rain water harvesting	SWASA needs to make RWH standards and link it to building standards.	Having good RWH standards will ensure proper installation of RWH systems thereby increasing confidence of people in these systems.	This is dependent on revision of building standards.	Linking RWH standards to building standards will provide opportunities for construction companies and personnel to know more about this technology.	No threat envisaged.	No
Rooftop Rain water harvesting	Improving awareness. Setting up a RWH Forum under Water Sanitation and Hygiene (WASH) forum	The WASH forum is well established in Swaziland and including RWH under this forum will ensure good information gathering and dissemination.	RWH may not be considered a priority when more important issues are being discussed such as water contamination, drought	Opportunity to include RWH into WASH forum entails no further costs. Information on rainfall data and simple methods of calculating size of RWH tanks, could be	No threat envisaged.	Yes

			and related health impacts.	shared with general public though awareness campaigns, which may include television shows, radio broadcasts, posters and flyers.		
Rooftop Rain water harvesting	Demonstration projects may be set up in prominent places in the country.	Demonstration projects are useful in providing practical training for installers and for raising awareness amongst general public.	If demonstration systems are not well managed, it may cause loss of confidence in technology.	Opportunity to use existing RWH systems in institutions such as schools and churches.	There is threat of vandalism of RWH systems.	Yes
Rooftop Rain water harvesting	School curricula needs to be revised to include RWH with a practical approach and hands on training at tertiary level.	Revision of curricula to include RWH will ensure that it will be taught.	Theoretical knowledge alone is not enough, practical sessions and visits to demonstration sites will help.	Opportunities are there in schools which have already implemented RWH and can act as demonstration sites.	Curriculum review may take time	No, giving subsidy vouchers will be a more effective measure.
Livestock and Poultry selective breeding	Awareness on the technology to be improved through training of farmers.	Farmers are the users of this technology and raising awareness amongst them will help adoption of this technology.	This technology should not compete with indigenous knowledge, but rather work together with local and indigenous knowledge.	This will help change mind-set of farmers to consider livestock farming as a business and use correct breeding techniques to maximise benefits for adaptation.	If technology is not implemented properly, there could be weaknesses in breeds.	Yes
Livestock and Poultry selective breeding	Conduct research on markets spread, gaps and improve value chain by creating new	With demand from markets for well-bred livestock and poultry, farmers will respond to the demand.	Creating new markets is dependent on people using the markets.	Research on markets spread will help increase breeding opportunities as farmers can buy livestock and poultry to breed from the markets.	There could be resistance for creation of new markets.	Yes

	markets where needed.					
Livestock and Poultry selective breeding	Promote indigenous chickens by enhancing capacity of Department of Livestock extension services. Ministry of Agriculture promotes indigenous chickens, but this needs to be up-scaled further.	The indigenous chickens programme is already being implemented by Department of Livestock extension services, hence we need to build on this.	Extension officers have resource limitations to carry out their duties.	Opportunity in developing capacity of existing personnel of Department of Livestock extension services.	No threats identified	Yes
Conservation Agriculture	Create awareness amongst farmers through setting up demonstration sites and conducting site visits.	The demonstration sites will promote peer to peer education.	The success of demonstration sites depend on the farmers and is not in control of the technology promoters.	Site visits can be conducted during commemoration days, such as Labour Day.	If the demosntration sites are not successful, people will lose faith in the technology.	Yes
Conservation Agriculture	Provide 50% subsidy of cost for planter equipments to 20,000 farmers.	This will address the main barrier in adopting this technology which is that of farmers not being able to afford planters.	Careful selection of the 20,000 farmers in an equitable manner is needed. If farmers are incorrectly chosen, then they may not use the planters and the	There are opportunities to combine this measure with agroforestry technology.	Some farmers may buy the planter and resell.	Yes

			technology adoption may fail.			
Micro and Drip irrigation	Tax cuts for local manufacture of drip and micro irrigation kits.	Tax cuts for local manufacturers will be an incentive for producing micro irrigation equipment in the country. This will address the barrier of micro and drip irrigation kits being too expensive, as locally manufactures items will be more cost effective than importing.	This measure will reduce tax revenue.	Promoting local manufacture will create employment in the country influencing positive socio-economic change.	Competition from South African manufacturers will be there, as they are larger companies with greater economies of scale.	No. Subsidising the micro and drip kits may be better value for funds than effecting tax cuts for local manufacturing.
Micro and Drip irrigation	Subsidise drip and micro irrigation kit for 20,000 farmers. Government can subsidise micro and drip irrigation kits (by 50%) for farmers and encourage purchase of kits by farmer groups.	This will make the micro and drip irrigation kits affordable and widely used.	This measure requires funds to be made available for subsidy. Furthermore, selection of farmers should be done carefully and equitably to avoid conflicts.	There is opportunity to improve food production through usage of irrigation kits, which has multiple benefits of improving food security and nutrition, as well as helping with climate change adaptation for the sector.	There could be people who will purchase the subsidised kits for resale.	Yes
Micro and Drip irrigation	Set up an Irrigation Act which should contain incentives for efficient use of irrigation water	Having an Irrigation Act will give provision for efficient use of water for irrigation, which is the largest water usage in the country.	Setting up an Act is a time consuming process.	There is opportunity to make the Irrigation Act in alignment with latest Government priorities and to align with climate change strategy.	No threat ideintified.	No. This measure will take time, rather the focus could be on

	and fines and penalties for wastage of water.					providing subsidy whic will help up-scale the technology faster
Micro and Drip irrigation	Capacitate the National Water Authority through providing training to staff, providing improved facilities and information technology infrastructure.	Capacity building of the National Water Authority will be benefitial in the long run as they are mandated to ensure efficient use of water.	There are no weaknesses anticipated from capacity building measure.	There is opportunity to include latest technologies in the training.	Officers trained may leave the institution for career prospects.	Yes
Micro and Drip irrigation	Create awareness of the benefits of drip and micro irrigation technologies.	Creating awareness will help change negative beliefs such as assosciating visible wet soil to irrigation, whereas drip irrigation technology does not wet the soil externally.	No weaknesses anticipated from creating awareness of water efficient irrigation technologies.	Creating awareness will entice more farmers to adopt this technology, thereby contributing to efficiency in water use.	No threats anticipated.	Yes
Micro and Drip irrigation	Create a pool of skilled labour through providing training at vocational schools on drip and micro irrigation installation.	Targetting youth for training will be a sustainable way to promote this technology.	The success of this measure is dependent on vocational schools being open to including this training.	There is opportunity for youth to get work as micro and drip irrigation installers.	No threat anticipated.	No. For up-scaling this technology, subsidy would be most effective.

Agroforestry	An agroforesry programme to be rolled out for training 20,000 farmers and providing free seedlings.	The training would be done by Ministry of Agriculture's Extension Officers, who are mandated for this.	Identifying 20,000 farmers in an equitable manner from all four regions may be a challenge.	There is opportunity to piggyback the training with other trainings for farmers, such as Conservation Agriculture.	No threats identified	Yes
Conservation of genetic resources	Establish a Botanical Garden and Field Gene Bank.	This measure will provide multiple benefits of being a training center and field seed bank.	This measure required continuous maintenance and care to be running successfully.	There is opportunity to use information from Department of Forestry's already developed proposal for National Botanical Garden	There is threat of vandalism and collapse if maintenance is not done.	Yes
Conservation of genetic resources	Provide training to staff of SEA and SPGRC in in Plant Genetic Resources Management, Plant Ecology, Plant Taxonomy and Ethnobotany through providing scholarships for futher studies.	Developing capacity of SEA and SPGRC staff will help them effectively carry out their duties.	Sending officers for training for long term may cause staff shortages in the institutions.	There is opportunity for the officers trained to share their knowledge and train other staff members.	Staff trained may leave for better career prospects.	Yes
Conservation of genetic resources	Create awareness amongst farmers to collect seeds and multiply them through field days at the Botanical Garden and Field Gene Bank.	Field days are powerful way of practical demosntrations and peer to peer education.	The field days have to be organized well and logistics organized in order for it to be successful.	There is opportunity to conduct this on environemntal commemmoration days and therefore pool resources allocated for that.	Farmers may boycott such field days if they feel it is not beneficial for them.	Yes

Invasive Alien Species Management	Exempt all IASP management and control chemicals from import duty.	Import duty exemption will reduce cost of chemicals and budgets for IASPs management will be extended.	This may affect the country's overall Gross National Income.	There will be opportunity to expand the IASPs management programme when budget is more.	Some importers of such chemicals may misuse this exemption.	No This may be difficult to monitor.
Invasive Alien Species Management	Improve awareness of IASPs, its impact on the environment and all the sectors affected. This can be done through awareness campaigns including road shows.	Awareness raising as a measure is helpful in mobilising public support and generating several local initiatives to control IASPs.	If messages are not designed suitably in IEC materials, there could be misunderstandings.	There is opportunity to include awareness raising measures during commemoration of environmental days	No threats identified	Yes
Invasive Alien Species Management	Improve skills in IASPs management by providing training to IASPs field officers responsible in SEA.	Skills improvement such as learning new technologies available will help in effective IASPs management.	Field officers may be trained in new skills, but if resources are unavailable for them to implement techniques learnt, they may become demotivated.	There are opportunities to collaborate and undertake training on various related aspects, such as wetlands restoration and IASPs management. This will bring out synergies and optimal use of training sessions.	Knowledge on IASPs is constantly changing as new invasive species get introduced.	Yes
Invasive Alien Species Management	Prepare a policy brief on impact of IASPs on sectors in Swaziland.	Policy briefs will provide policy makers with userfreindly data to make evidence based decisions and policies.	Policy brief is short and therefore not able to depict a lot of information.	There is opportunities for the policy brief to link impact of IASPs to all sectors affected and indicate how it will impact economy of country	No threats identified	Yes

Invasive Alien Species Management	Revise the IASPs Management Strategy to make it more robust for implementation.	The IASPs Management strategy is already in place but needs revision.	The IASPs Management Strategy is not a legal instrument such as an Act and needs revision as identified by stakeholders	There is opportunity to update the strategy and remove any weaknesses or confusion in the strategy.	No threats identified	No, as the revision of the strategy is included in the SNPAS programme

Overall strategy for overcoming barriers in each technology is given below.

Table 34 Overall strategy for overcoming barriers

Technology	**Strategy**
Integrated River Basin Management (IRBM)	The overall strategy for implementing this technology is to develop proposals for raising funds to implement programmes for River Basin Authorities, establish a "Funds Coordination Platform" where synergies in usage of funds can be realised, to build capacity of officers responsible for implementing relevant legislations and create awareness amongst stakeholders about IRBM and water resources management.
Wetland Restoration and Protection (WRP)	The overall strategy for wetlands restoration and protection will include a suite of actions including setting up a funds coordination mechanism for identifiying syenrgies in funds usage with related programmes, developing proposals for restoration of selected wetlands, creating awareness of importance of wetlands creating a wetlands monitoring system.
Rooftop Rain water harvesting	Ths strategy to up-scale this technology is by subsidising RWH tanks (by 50% of its cost) and improving awareness.
Livestock and Poultry selective breeding	To improve breeding of livestock and poultry, awareness raising, researching on gaps in the market and enhancing capacity of extension staff to promote this technology.
Conservation Agriculture	Creating awareness through demonstration farms and providing subisides for planters will help up-scale this technology.
Micro and Drip irrigation	The overall strategy for up-scaling this technology is to make it more affordable to farmers and this will be done through providing subsidies. Furthermore, capacity building of officers responsible and creating awareness amongst farmers will help in widespread use of this technology.
Agroforestry	The strategy for this technology is simple, that of training 20,000 farmers and providing free seedlings.
Conservation of genetic resources	The strategy for this technology is multipronged. Establishing a botanical garden and field gene bank, providing training to relevant officers and creating awareness amongst farmers will help in the technology being utilised in Swaziland.

Invasive Alien Species Management	The oversall strategy for this technology includes raising funds for IASPs management, improving awareness and skills in IASPs management as well as revising the IASPs Management Strategy and preparing a policy brief to get support from policymakers.

6. Chapter 6 Linkages between barriers and complementarities between technologies

During the analysis for BAEF report, linkages of barriers between technologies were identified. The most common barrier for all the nine technologies was inadequate funds, weak capacity and low awareness. A funds coordination mechanism was suggested as a measure for IRBM and WRP.

Technologies	**Barriers**			**Measures**		
	Inadequate funding	Weak Capacity	Low awareness	Funds Coordination mechanism	Capacity building	Awareness raising
Integrated River Basin Management (IRBM)	✓	✓	✓	✓	✓	✓
Wetland Restoration and Protection (WRP)	✓	✓	✓	✓	✓	✓
Rooftop Rain water harvesting	✓	✓	✓		✓	✓
Livestock and Poultry selective breeding		✓	✓		✓	✓
Conservation Agriculture	✓	✓	✓		✓	✓
Micro and Drip irrigation	✓	✓	✓		✓	✓
Agroforestry		✓	✓		✓	✓
Conservation of genetic resources	✓	✓	✓	✓	✓	✓
Invasive Alien Species Management	✓	✓	✓	✓	✓	✓

Complementarities can be established between all the nine prioritized technologies. IRBM and WRP will enhance the ecosystem health, leading to improved water quality and reduced flooding, which will be beneficial for agriculture and forestry sectors. A good agroforestry programme not only has adaptation benefits, but mitigation benefits of carbon sequestration too. Furthermore, it helps in enhancing livelihoods

of farmers by providing additional incomes. Efficient use of water by humans will allow water for environmental needs which will be beneficial to conserve biodiversity and habitats. Similarly conserving genetic resources will not only provide benefits to farmers, but also help with preserving Swaziland's biodiversity. Invasive alien species management provides benefits to all three sectors, and enhances ecosystem health. When developing proposals for raising funds, integrating more than one technology into the proposal will help generate concerted effort. Funds coordination mechanism was suggested for three technologies and there is scope for combined effect. Capacity building and awareness raising was something that was suggested as measure for all technologies. Here too there is scope for collaborative efforts and greater synergies. When cross-cutting measures such as improving funds coordination, providing awareness and building capacity is implemented, there are synergies that could be derived from the sectors working together. Integrated development efforts will benefit Swaziland more than siloed sectoral approaches.

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LIST OF PARTICIPANTS FOR STAKEHOLDER CONSULTATIONS

List of stakeholders involved for first BAEF workshop

BAEF workshop 1 – August 2016

	Name	Institution
1	Jabulani Tsabedze	Swaziland National Agricultural Union
2	Sandile Simelane	Wundersight Investments
3	Mzwandile Thwala	Ministry of Natural Resources and Energy, Energy Department
4	Mduduzi Dlamini	Swaziland Environment Authority
5	Titus Dlamini	Ministry of Agriculture, UNCCD
6	Bongani Sigudla	Ministry of Health, Environmental Health Department
7	Lemohang Mtshali	Matsapha Town Council
8	Mthunzi Fakudze	Ministry of Public Works and Transport, Roads Department
9	Bongani Mvubu	Ministry of agriculture, Malkerns Agricultural Research Centre
10	Bafana Simelane	Department of Meteorology
11	Vusi Matsebula	Ezulwini Municipality
12	Minky Groenewald	Department of Meteorology
13	Glory T. Mdluli	Ministry of Tourism and Environmental Affairs
14	Edward Mswane	Ministry of Natural Resources and Energy , Department of Water affairs
15	Thamsanqa Nkambule	Ministry of Tinkhundla , Administration and Development
16	Stanley Simelane	University of Swaziland
17	Hlobsile Sikhosana	Ministry of Tourism and Environmental affairs
18	Deepa Pullanikkatil	Coordinating Assembly for Non- Governmental Organisations
19	Mduduzi Mathunjwa	UNISWA
20	Bothwell Batidzirai	ERC- University of Capetown
21	Mvezi Dlamini	Peak Timbers
22	Dennis Mkhonta	Department of Meteorology - Forecasting
23	Thembinkosi Ndzimandze	Ministry of Natural Resources and Energy, Department of Energy
24	Sanelisiwe Mamba	Ministry of Tourism and Environmental Affairs
25	Mzwandile Msibi	Swaziland Energy Regulatory Authority

26	Mbhekeni Wilfred Nxumalo	Department of Forestry
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28	Nomkhosi Khoza	Eclipse Environmental Solutions
29	Duduzile Nhlengethwa Masina	Department of Meteorology
30	Sifiso Nzalo	Department of Meteorology
31	Sipho Matsebula	Swaziland Environment Authority
32	Andile Zwane	Swaziland Standards Authority
33	Mbongeni Hlophe	Swaziland Environment Authority
34	Sipho Simelane	Swaziland Water Services Corporation
35	Mandla Mdlovu	Ministry Of Agriculture
36	Khetsiwe Khumalo	Department of Meteorology

List of participants for the second BAEF workshop (March 2017) will be appended as soon as it is made available.

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