UNITED REPUBLIC OF TANZANIA

TECHNOLOGY NEEDS ASSESSMENT REPORT

Climate Change Adaptation

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Technology Needs Assessment Report for the Climate Change Adaptation in the Agriculture and Water Sectors

Report I

Technology Needs Assessment Report

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

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

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

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

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

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

Sector) and Mr. Abdalla S. Shah (mitigation and adaptation, Forest Sector)

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

This report starts by explaining the basis of the TNA in Tanzania and gives an overview of institutions that are key for climate change policy making and implementation and roles performed under the TNA project. The report further gives the procedure and process of TNA, criteria, results and selection of sectors and technologies. The process of TNA has been following a participatory approach which included involvement of stakeholders through workshops and literature review.

The priority sectors chosen in the TNA project for adaptation are consistent with national development priorities, while taking into account the vulnerabilities of climate change impacts in the country. The sectoral consideration in the climate-development nexus of Tanzania is clearly revealed in its Initial National Communication under the UNFCCC, National Adaptation Programme of Action (NAPA) as well as many other developments focused such Kilimo Kwanza, Big Results Now. All these deal with climate change from a policy and strategic perspective, the TNA project brings complementarity in terms of nationally appropriate technology options.

The processes of prioritized technologies involved review of the existing literature, involvement of stakeholders, sector working groups and technical expertise in consultation with national TNA coordination office. The same actors also influenced the criteria and decision for sector and technology identification and prioritization. The identified sectors relevant for climate change adaptation were agriculture and food security, water, energy, forest and health. Agriculture and Water sectors were prioritized and are therefore covered in this TNA project for adaptation. Water is an important natural resource and is critical for sustainable development of practically all social and economic sectors as it is required for domestic purposes, agricultural and industrial development, energy generation and livestock. Agriculture is the mainstay of the economy in Tanzania and its vulnerability is due to it being rain fed.

After prioritization of sectors, the identification of technologies pertaining in the prioritized sectors followed. From consultation of stakeholders, sector ministries and working groups a long number of technologies options were identified. Basing on experts judgement, a short list of technology options were developed into a fact sheets. These technology fact sheets were shared with working groups and refined. After this, these technology options were subjected to prioritisation of technological options using a Multiple Criteria Analysis (MCA) framework. The criteria proposed by MCA4Climate were used in MCA, and indicators were defined by local stakeholders. The technologies that have been retained for developing the Technology Action Plan (TAP) are summarised below for each sector:

Summary of selected and prioritised technologies

Sector	**Technologies retained for TAP**
Agriculture	Improved variety seeds
	System of Rice Intensification
	Drip irrigation
Water	Rain water Harvesting from roof tops
	Water Leakage reduction programme
	Water re cycling and re use

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Acronyms

ASDP	Agriculture Sector Development Programme
CCFP	Climate change focal Point
COSTECH	Commission for Science and Technology
DAWASA	Dar es salaam Water and Sewerage Authority
ESTs	Environmentally Sound Technologies
GDP	Gross Development Product
GHG	Green House gas
INC	Initial National Communication
IWRMDP	Integrated Water Resources Management and Development Plans
LNBWO	Lake Nyasa Basin Water Office
LTBWO	Lake Tanganyika Basin Water office
NAMA	Nationally Appropriate Mitigation Actions
NAP	National Action Plans
NAPA	National Adaptation Programme of Action
PRBWO	Pangani River Basin Water Office
TNA	Technology Needs Assessment
UNFCCC	United Nations Framework for Convention on Climate Change
URT	United Republic of Tanzania
UWASA	Urban Water and Sewerage Authority
UWSA	Urban Water And Sewerage Authority
VPO	Vice President Office
WRWBO	Wami Ruvu Water Basin Office

CHAPTER 1: INTRODUCTION

Climate change and variability is rapidly emerging as one of the most challenging global problems that affect many sectors and livelihood in the world (Huq *et al.,* 2006). Concerns about climate change are global and real (Ngaire, 2007). During the past century the global climate warmed by about 0.7°C because of human activities, and is projected to rise by another 1.4 - 5.8°C in the next 100 years (IPCC, 2007). Signs of the impacts of climate change observed around the world include the increase in surface temperature, decrease in snow cover, sea-level rise and change in precipitation.

The IPCC (2001) report on the regional impacts of climate change declares, “Africa to be the most vulnerable continent to the impacts of climate change”. Africa is suffering more from impacts related to droughts and floods (Few et al., 2004). The projected climate change impacts on the African regions on different sectors by 2020 shows climate change is likely to expose around 90 million to 220 million people to increased water stress and this will magnify the conflicts already existing over water, decreased yield from rain fed agriculture due to shrinking of area of land suitable for agriculture, length of growing seasons and yield potential mostly on margins of semi-arid and arid areas indicating intensified food insecurity and malnutrition (IPCC, 2007).

International Efforts to address the climate change challenges resulted in establishment of the United Nations Framework Convention on Climate change (UNFCCC) in 1992. The treaty seeks to cooperatively consider what parties to the convention could do to limit average global temperature increases and the resulting climate change, and to cope with whatever impacts. It was until 2011, UNFCCC, recognized science and technology as important pillar to address climate change (Christiansen *et al*, 2011)

1.1 About the TNA project

Technology needs assessment (TNA) is a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of a particular country. Thus TNA projects are aiming at enabling developing countries to identify and determine their technology priorities for mitigating greenhouse gases and adapting to the adverse effects of climate change. TNA is an important process that allows developing countries to self-determine their technology needs in line with their national development priorities.

The current Technology Needs Assessment project follows the previously noted climate change technology needs assessment of Tanzania report of 2010. The previous report was guided by UNFCCC, particularly article 4.5 and was implemented through the United Nations Climate Change Enabling Activities Project (CCTNA, 2010). This Technology needs Assessment is a result of an agreement signed between the United Republic of Tanzania represented by the Vice President Office, Division of Environment and the United Nations

Environmental Program (UNEP) DTU Centre (URC), Denmark, and supported by the Global Environmental Facility (GEF) grant financing.

The project goes beyond prioritization and selection of technologies, it further goes at helping countries to come up with action plans that facilitate the transfer of Environment Sound Technologies (ESTs) by identifying critical barriers to the diffusion of these technologies and propose actions to remove the barriers.

TNA Project Objectives

The main objectives of the project are:

- To identify and prioritize through country-driven participatory processes, technologies that can contribute to adaptation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities (TNA).
- To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies.
- 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

1.2 Existing national policies related to technological innovation, adaptation to climate change and development priorities

Climate change is happening with significant long term impacts to livelihood, environment and the economy. Increased extreme weather events such as droughts and floods make poor countries such as Tanzania highly vulnerable due to poor/weak adaptive capacity. Technologies - if taken in conjunction with existing national development plans, priorities and programs could be a powerful solution to address climate change and promote sustainable, innovation-based growth. This section will introduce national policies, strategies and plans which are related to technological innovation and could be key in addressing adaptation and development priorities.

1.2.1 National Circumstances

Geographic location and administrative boundaries

United Republic of Tanzania is located in Eastern Africa comprising of two countries, administratively; she has 30 regions. It has an area of 945,000 km^2 which includes three major coastal islands of Mafia, Pemba, and Unguja, and a coastline that is about 800 km long. The country is located between longitude 29^0 and 41^{0}east, and Latitude 1^0 and 12^0 South.

Tanzania is bordered by the following countries; North: Kenya and Uganda, West: Rwanda, Burundi, and Democratic Republic of Congo, South West: Zambia and Malawi, South: Mozambique and East: Indian Ocean

Climate

The climate of Tanzania varies from place to place in accordance with geographical location, altitude; relief and vegetation cover (NAPA, 2007). Average temperatures range between 17°C and 27°C, depending on location. Average annual precipitation over the entire nation is 1,042 mm normally; the country has two rainfall regimes, bimodal and unimodal rainfall patterns. Bimodal rainfall which covers northeastern, northwestern (Lake Victoria basin) and the northern parts of the coastal belt has two major seasons, long rains (masika) between March-May and short rain (vuli) between October and December. A unimodal rainfall pattern, with most of the rainfall during December-April, is more typical of most of the southern, central, western, and southeastern parts of the country.

Population

The total Population of the United Republic of Tanzania according to the 2012 Census was 44,929,002 of which 43,625,434 reside in Tanzania Mainland and 1,303,568 are based in Tanzania Zanzibar. Some outstanding features of the population are; very youthful with 50% of it under 18 years, the growth rate is at 2.7% per annum, 70% of the population is rural based and 51% of the population comprise female of which 47.3% are in the reproductive age.

1.2.2 Policies and strategies related to climate change adaptation in Tanzania

In the efforts to address challenges to economic development and livelihood in the country as a result of impacts of climate change, the government of the United Republic of Tanzania (URT) has undertaken several initiatives. These include at international level, ratification to be party of the climate change convention and internally agree on frameworks of how to address the challenges. This section will outline some of the policies ,strategies, plans and programmes which address environment ,and climate change.

Initial National Communication

Among the earliest initiatives of the country to address climate change is the preparation of Tanzania's National Initial Communication to the UNFCCC in 2003. The National Communication documents sources of GHG emissions in Tanzania, and strategies to mitigate and adapt to climate change for Tanzania.

National Adaptation Programme of Action (NAPA)

To emphasize the need for adaptation on important sectors of economy, in 2007, Tanzania developed National Adaptation Programme of Action (NAPA) which reported on the country's climate change related vulnerabilities in various sectors including agriculture, water, health, energy and others which are important for the economy. Fundamentally, NAPA aimed at identifying activities that address urgent and immediate needs for adapting to the adverse impacts that are robust enough to lead to long term sustainable development in a changing climate. NAPA provided concise information oriented towards priority on the ground activities.

Environmental Management Act (2004)

The Environmental Management Act (EMA) of 2004 provides the legal and institutional framework for the sustainable management of the environment in mainland Tanzania. The Act under section 13-(1) provides the Minister responsible for environment, the overall responsibility for matters related to environment. Section 75(a) of EMA requires the same Minister in consultation with relevant sector ministries to take measures to address climate change particularly climate change adaptation. The Act in section 77 subsections 4(m) and section 111(i) respectively recognizes the role of technology in management of chemicals and preventing or reducing pollution of the environment.

National Environmental Policy 1997

Addressing cross-sectoral policies, the environment policy states that, science and technology have a central role in the exploitation, processing and utilization of natural resources, and in the resulting environmental impacts. The technology used has a bearing in the quality of a product and in the type and amount of the resulting waste and emissions. Environmentally sound technologies in the context of pollution are "process and product technologies" that generate low or no waste, for the prevention of pollution. They also cover "end-of-the pipe" technologies for treatment of pollution it has generated. The primary objective of the policy therefore, is the promotion of the use of environmentally sound technologies, i.e., technologies that protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residue wastes in a more acceptable manner than technologies for which they substitutes.

Zanzibar Environmental Policy 2013

The Zanzibar Environment Policy has outlined eight environmental pressures affecting the country the challenges and provide a way forward in addressing them. The policy recognizes adverse effects of climate change, depletion of fresh water resources, increased demands for land resources and associated land degradation and pollution and inadequate scientific research on environmental management and conservation; as among the challenges. The policy further gives a way forward of how the challenges can be addressed.

Furthermore, policy has taken into account the evolving international scenario in environmental Conventions and Protocols. Zanzibar is a part of the United Republic of Tanzania, but the environmental problems that the islands have are reminiscent of similar issues faced by other islands and Island States. Hence, the urgency to engage regional and international stakeholders and networks, participate in and promote relevant conventions, protocols and agreements and seek support in enforcing and implementation

National Climate Change Strategy

This strategy was developed in 2012 with the aim of enabling Tanzania mainland to effectively adapt to climate change and participate in global efforts to mitigate climate change with a view to achieving sustainable development in the context of the Tanzania Development Vision 2025, Five Years National Development plan. The strategy is facilitating strategic implementation of climate change activities that is different from the previous approach of projects and/or programmes. The strategy has the following objectives; a) To build the capacity of Tanzania to adapt to climate change impacts, b) To enhance resilience of ecosystems to the challenges posed by climate change, c) To enable accessibility and utilization of the available climate change opportunities through implementation d) To enhance participation in climate change mitigation activities that lead to sustainable development e) To enhance public awareness on climate change f) To enhance information management on climate change. g) To put in place a better institutional arrangement to adequately address climate change including climate finance.

Zanzibar Climate Change Strategy

This strategy was developed in 2014 with the aim of enabling, Zanzibar as a small island developing state, which is at risk from climate change to have a strategic framework to address her climate change responses. The islands have a development and economic vision built around sustainable development and poverty reduction, which aligns with the recent focus on green growth. The islands have numerous initiatives that are building the foundations for tackling climate change and developing a low carbon and sustainable society. The objectives of the Zanzibar Climate Change Strategy are: i. To provide a coherent and consistent view on the vulnerability and risks from current climate variability and future climate change on the islands, alongside possible opportunities for reduced emissions and low carbon sustainable development. ii. To establish a response framework to enhance Zanzibar's economic, social and environmental resilience to address these risks, and to enhance low carbon sustainable development opportunities. iii. To help build capacity and knowledge, raise awareness, and promote climate awareness and sustainable livelihoods practices for all of society, with a particular focus on local communities. iv. To guide the mainstreaming of climate change adaptation (and low carbon sustainable development) across government, and provide the enabling environment for all stakeholders (private sector, civil society and communities) to advance relevant activities. v. To strengthen institutional and coordination arrangements (including the policy and legal framework) for the effective implementation of the climate change strategy and mobilize internal and external financial support. Vi. To encourage the transfer, adoption and diffusion of technologies for increasing resilience and promoting low carbon sustainable development. vii. To guide the integration of climate change in the Zanzibar sustainable development goals, including future development plans.

National Climate Change Communication Strategy

The National Climate Change Communication Strategy (NCCCS, 2012) provides guidelines on management of information in fulfilling the national and international obligations on climate change issues. The strategy fulfils the international obligation, particularly article 6 of the United Nations Convention on Climate Change (UNFCCC) which addresses public awareness, education and training.

The emphasis of the communication strategy is for key actors to adhere to the key components of information management systems which include; people, culture, process, content, technology and storage. On technology, all possible tools would be explored and used in generating and communicating climate change issues while considering target audience, cultural setting, ethics and values.

National Science and technology Policy

The National Science and Technology Policy (1996), under paragraph 85, stresses the need for coordination of the various bodies and institutions with the view of smooth transfer and utilization of technology particularly with respect to imported goods. It also emphasizes on the need to increase awareness to establish and/or strengthen facilities for servicing and maintaining machinery and equipment. The policy recognize low capacity to operate and maintain technology as one of the barriers to technology transfer. As a pre-requisite for the transfer of technology on better terms and conditions, the development of a science and technology base, and the strengthening of research and development institutions in key sectors of the economy are emphasized by the policy.

The policy within its objectives provides guidelines to sectoral policy objectives to address issues related to environment. It emphasizes that sectoral policy need to ensure the maintenance of basic ecological processes upon which all productivity and regeneration on land and in the sea depend. The policy also emphasize on ensuring that the quality of life of the people of Tanzania present and future is not harmed by destruction, degradation or pollution of their environment.

1.3 Vulnerability assessments in the country

Adverse impacts of climate change are a major challenge to socio-economic development globally and Africa is the most vulnerable continent. This situation is further worsened by its poor state of economic development and low adaptive capacity. It is important to note that, existing climate trends for Tanzania are complex due to difference in ecological zones (ECA, 2009). Tanzania lies just south of the equator, at 1 to 11°S, and has a tropical climate that is predominantly highland, with exception of a narrow coastal strip. The greater part of Tanzania is a central plateau of around 900-1800m, punctuated with mountain ranges (which include Mount Kilimanjaro). The coastal regions of Tanzania are warm and humid, with temperatures 25 to 17°C through most of the year, dipping just below 25°C in the coolest months (June through to September, or 'JJAS'). The highland regions are more temperate, with temperatures around 20-23°C throughout the year, dropping by only a degree or so in JJAS. (McSweeney, C. *et al.* 2008).

Climate vulnerability in Tanzania has been manifested highly through increased hazards and disasters which are climate related. Ten years hazards records from 2005 to 2015 (table 1 below) shows that Tanzania suffered from both too much and too little rainfall, causing both drought and flooding events occurring on a number of occasions (CRED, 2016).

Table 1: Climate related natural hazards in Tanzania from 2004-2015

Date	Type	Total affected people/population
00--2006	Drought	3700000
00-08-2011	Drought	1000000
20-12-2011	Flood	50200
25-12-2009	Flood	50000
22-01-2014	Flood	20000
18-04-2014	Flood	20000
9-5-2006	Flood	19000
16-04-2005	Flood	10548
14-08-2015	Epidemic	9871
9-4-2011	Flood	9000

Source: CRED (2015)

Impacts of these extreme weather events have implications in agriculture, energy, water availability, health, livestock production etc. Table below summarizes results of climate change vulnerability assessments conducted in the country.

Table 2: Summarized results from climate change vulnerability assessments conducted in the country

Source	Vulnerability assessment records
INC (URT, 2003)	Reported certainty of future gradual warming in terms of temperature trends and gave variable results on future rainfall trends. Through Global Circulation models scenarios showed that there will be an increase in mean daily temperature as well as in the temperature of the warmest and coolest months. Mean daily temperature will rise by 3.5^0C throughout the country. The increase in temperature would be more during the cool months of June, July and August than during the warm months of December, January and February. In terms of rainfall, it was reported that there will be increased rainfall in some parts while other parts will experience decreased rainfall. The areas with two rainfall seasons i.e., the north eastern, the north western, the Lake Victoria basin and the northern part of the coastal belt would experience increase in rainfall for both seasons ranging from 5% to 45%. The other areas receiving unimodal rainfall pattern i.e., the southern, southwestern, western, central and eastern parts of the country will experience a decrease in annual rainfall by a range of between 5% and 15%. These areas will experience an increase in rainfall during the long rains and a decrease during the short rains. The southeastern parts are likely to experience an increase in annual rainfall by a range of between 5% and 45%.
NAPA (URT, 2006)	Reported a steady increase in temperature for the past 30 years throughout the country and unreliable rainfall trends. Analysis of total annual rainfall for 21 meteorological stations in selected regions of Tanzania indicated a decreasing trend for 13 stations whereas an increasing rainfall trend was observed in 7 stations and 1 station had almost a constant pattern. However, one common feature of the rainfall pattern was a greater variability in cycles. The NAPA further reports about observed impacts over the observed changes in temperature and rainfall.
Mc Sweeney, et al, (2008)	Reported that, Temperature • Mean annual temperature has increased by 1.0°C between 1960 and 2003; this increase in temperature has been most rapid in JF and slowest in JJAS. • Daily temperature observations show a small increasing trend in the number of hot days, and a larger increasing trend for hot nights. Hot nights, for example, have increased by 50 (equivalent to +14 %) between 1960 and 2003. Increases in both hot days and nights have been greatest in DJF. • The frequency of cold days has not changed; however, the frequency of cold nights has decreased in all seasons, amounting to 34 fewer days per year (equivalent to -9 %). The rate of decrease is most rapid in DJF. Precipitation • Rainfall over Tanzania show decreasing trends in annual rainfall, decreasing at an average rate of 2.8mm per month per decade (equivalent to -3 %), particularly in southern areas. • Observed decreases have also occurred in MAM and JJAS, decreasing by 4.0 and 0.8mm per month per decade, respectively (equivalent to -3 and -6 %). • There is no significant trend in the proportion of rainfall occurring in heavy events.
Mongi *et al* (2010)	Reports on vulnerability and adaptation of rain fed agriculture to climate change and variability in semi-arid Tanzania and concludes that there is strong evidence demonstrating the vulnerability of rain fed agriculture to negative impacts of climate change and variability in the study area. During the study,

	farmers reported recurrent drought, seasonal shift, dry spells and increasing temperatures and to their perception such changes have occurred in the recent ten years as compared to the previous decades. Therefore farmers in the study area depending on rain fed agriculture as sole livelihood activity are at risk of becoming food insecure. Analysis of livelihood activities during the study indicates that agricultural activities are mostly affected through decrease in rainfall which also influences loss of soil moisture. The study concludes that due to climate change, there is an increasing pests and diseases incidence that affects crops in the area. Adaptive measures taken by farmers to cope with the impact caused by climate change include; switch to more drought resistant crops such as sorghum and cassava, growing alternative crops such as sunflower and diversification to non-farm activities such as brick and charcoal making casual labour and carpentry.
Tobey et al (2011)	A study supported by USAID on village vulnerability assessment and climate change adaptation planning in Mlingotini and Kitonga Bagamoyo district gives highlights on the impacts of climate change in the two villages along the coast. The study highlights vulnerability to floods, drought, and sea level rise. The latter causing shoreline erosion, inundation, and salt water intrusion in fresh water aquifers. Furthermore, the focus groups highlighted that, the timing and intensity of the long and short rains are no longer reliable. In the past, early rains in the primary rainy season were heavy and these were followed later by small continuous rains which resulted in a good soaking of the soil. Presently early rains in the season are heavy and these are followed by dry conditions, which are not conducive to crop growth. For example, the drizzle that used to fall at the end of the rainy season has disappeared. This drizzle helped cassava to grow well. Now yield and quality of cassava has diminished. Rains in the short rainy season in October are now of short duration (barely not more than two weeks) and they are usually of low intensity compared with the past. Without predictable primary rainy season precipitation and smaller rainy season, agricultural planning under rain fed agriculture is difficult and food security is endangered.

1.4 Sector selection

1.4.1 An overview of expected climate change and its impacts in sectors vulnerable to climate change

Climate change is already affecting decadal efforts of development by countries and this necessitates countries to address their technology needs for adaptation. Technology needs assessment provides an opportunity to identify the need for new technology, equipment, knowledge and skills for reducing vulnerability to climate change. Vulnerability of sectors to climate change in Tanzania is based on analysis of how development priorities were affected by changing climate. This process involved consultation of many publications related to national development in Tanzania. The main national strategies consulted and explored were (1) The Tanzania National Vision 2025 (2) The Five years Development Plan (3) National Strategy for Growth and Reduction of Poverty (4) Tanzania Initial National Communications to the UNFCCC (5) National Adaptation Programme of Action (NAPA) (6) Tanzania National Climate Change Strategy. Exploring the national development strategies revealed the following sectors as most vulnerable to climate change, namely agriculture and food security (including livestock), water, forestry and health

Agriculture and food security: Agriculture is the most important economic sector to the economy of Tanzania being practiced by almost 80% of population. It provides source of food, employment, raw materials for industry and foreign currency. The country has a diversity of climate and agro ecological zones which allow for a wide range of food, cash crops, fruits, vegetables and spices. The sector contributes about 18.2% to the national GDP (The Economic Survey, 2008). It should be noted that agriculture sector in Tanzania is dominated by subsistence small holder farmers who largely depend on rain for harvest. Generally agriculture is characterized by low income resulting from low production, and the fact that agriculture is a seasonal activity dependent on weather, which is highly vulnerable to climate change (ASDP, 2011). Tanzania recognizes the impact of climate change globally, regionally and at country level including the fact that the agriculture sector is more vulnerable. Impacts of climate change includes decrease in agriculture production, change/shift of agro-ecological zones, increased pest and diseases and many other knock –on effects which brings about more challenges to the sector. Shift in rainfall patterns from bimodal to unimodal rainfall regime results into putting at risk a large population which depends on rain for food production.

Water resources: The availability of water is vital for supporting social and economic development of the country because the water sector strongly supports other sectors including agriculture, energy, health, water supply, manufacturing and environment. The impact of climate change on water resources is also a threat to other related sectors. Climate change is largely manifested through increased variability of rainfall and increased temperature. These factors largely result in decrease of water flow due to high transpiration. There has been dramatic decrease in flow of water into rivers and shrink water levels in lakes and dams which receive water. Such decrease constrains availability of water for domestic use, hydropower production, ecosystem services as well as industries.

Forest: Under climate change most of the forests across Tanzania are projected to shift towards drier regimes; from subtropical dry forest, subtropical wet forest, and subtropical thorn woodland to tropical very dry forest, tropical dry forest and small areas of tropical moist forest respectively (INC, 2003). Much of this projected change in distribution is attributed to an increase in ambient temperatures and a decline in precipitation in forested regions of the country. Some species shows high vulnerability than others, particularly those: that are drought/heat intolerant; with low germination rates; with low survival rate of seedlings; and with limited seed dispersal/migration capabilities. Climate change is impacting on forests and forest ecosystems and therefore livelihoods of forest dependent communities as well as national economic activities that depend on forest products and services. The problem is manifesting itself through, amongst others, unusually high temperatures, floods, droughts, massive land degradation,, poor crop yields, unreliable water supplies and increasing fire intensity.

Human Health: Climate change intensifies the impact of climate sensitive diseases such as malaria, cholera and Rift Valley Fever for livestock in Tanzania. Due to increased temperature, there have been reported cases of malaria on highlands of Lushoto in Tanga, Kilimanjaro, Njombe, Iringa, Kagera and Mbeya, among others where immunity to such disease is low. Such incidences increases high burden of diseases that a country is already experiencing. Generally, increased disease incidences due to climate change reduce labour productivity in various development undertakings undermining poverty alleviation efforts.

1.4.2 Process and results of sector selection

Consensus on the selection of the two sectors was based on exploration of the national development strategies of the country, contribution of the sector to national economy, its vulnerability to climate change and the prevailing socio-economic development priorities in relation to climate change. Some of the basic reports used included, the UNFCCC Initial National Communication (INC) (2003), National Adaptation Programme of Action (NAPA) (2007), Technology Needs Assessment Report (2010), National Climate Change Strategy (2012), the Zanzibar Climate Change Strategy (2014) and the Tanzania Intended National Determined Contribution (INDC) (2015).

The first study of climate change assessment of vulnerability and adaptation using Global Climate Change Scenarios in Tanzania was done from 1994 to 1997. Results of the study were published in 1998. The results indicated that several sectors were vulnerable. These sectors included agriculture, water resources, forestry, grasslands, livestock, coastal resources and wildlife and biodiversity. The study embarked on in depth assessment on water resources, crop production, grassland and livestock and coastal resources.

In 2007, National Adaptation Programme of Action (NAPA) was developed which focused on identifying immediate and urgent needs for adaptation for 7 sectors, Agriculture, Energy, Forestry and Wetlands, Health, Human Settlements, Coastal and marine and fresh water resources. Identification of vulnerabilities in each sector, key adaptation options and strategies that would best address those vulnerabilities were developed. The NAPA identified priority sectors for addressing adaptation in Tanzania; the prioritized sectors included agriculture and livestock, water resources, energy and forests.

Along with the development of INC and NAPA various other strategies were developed to address climate change anchored to National Climate Change Strategy (2012) and the Zanzibar Climate Change Strategy (2014) for implementation.

The Tanzania Intended National Determined Contribution (INDC) document of 2015 indicates that agriculture and water are priority sectors in addressing adaptation in the country stating that :

"Tanzania will embark on a climate resilient development pathway. In doing so the adaptation contributions will reduce climate related disasters from 70% to 50%, and significantly reduce the impacts of spatial and temporal variability of declining rainfall, frequent droughts and floods which have long term implications to all productive sectors and ecosystems, particularly the agricultural sector. Access to clean and safe water will be increased from 60% to 75% and, based on a conservative and a worst-case scenario of 50cm and 1m sea-level rise, the contributions will verifiably reduce the impacts of sea level rise to the island and coastal communities, infrastructure and ecosystems."

The process for sector selection in TNA for adaptation to climate change was carried out in a participatory and consultative manner, to ensure local stakeholder ownership of the project. The national inception workshop held to launch the Technology Needs Assessment (TNA) Project in Tanzania provided the forum for affirming the priority sectors for selection on the water and agriculture sectors. It was co-organized by the Vice President office, Division of Environment and COSTECH at Giraffe Hotel in Dar es Salaam on 30th Sept 2015. The workshop was attended by stakeholders drawn from various sectors, NGOs and private sector. The workshop aimed at facilitating enhanced awareness and active engagement of a broader group of stakeholders on the TNA process and addressing relevant issues relating to the TNA process such as affirming the choice of the sectors for the TNA.

The workshop benefitted from background of climate change situation in the country provided by the National Climate Change Focal Point (NCCFP). This emphasized the importance of the country to respond to climate change challenges and importance of Tanzania to focus on adaptation to enhance resilience to climate change and mitigation when sustainable development efforts are concerned for the TNA initiatives. When it came to the selection of sectors, two sectors were suggested by the stakeholders namely, water and agriculture. The two sectors are inter-linked as the availability of water in its various forms support agricultural practices; agricultural practices also stimulate efforts to ensure sustainable water availability. Impact in the two sectors water and agriculture needs to be effectively addressed to assure and sustain the socio-economic development of the nation.

The participants of the inception workshop also suggested that, despite of prioritized sectors, technology prioritization process should consider situation of other equally important sectors which are not prioritized in this phase of TNA.

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

2.1 Organizational Structure for TNA project

The United Republic of Tanzania (URT) ratified the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol in 1996 and 2002 respectively. At national level, the VPO, Division of Environment (DoE) - Tanzania mainland is responsible for all climate related activities. DoE is both the National Climate change Focal Point (NCCFP) and Designated National Authority (DNA) for clean development mechanism (CDM) under the Kyoto Protocol. The entity has the responsibility for international negotiations, preparation of national communications, etc. and in the future for Nationally Appropriate Mitigation Actions (NAMA) and National Adaptation Plans (NAPs) activities. However, given that Zanzibar is a Small Island Developing State (SIDS), Zanzibar has her own climate change architecture and governance.

According to the National Climate Strategy (2012), implementation of climate change issues in Tanzania is undertaken within the context of the National Environmental Policy (1997) and the EMA (2004) and other related policies and legislations.

Furthermore, EMA provides for establishment of various committees at both national and local levels. At national level, there is an established National climate change steering committee (NCCSC) chaired by Permanent Secretary of the VPO. This committee provides policy guidance to the NCCFP to ensure coordinated actions and participation within various sectors and institutions. There is also National Climate change Technical Committee (NCCTC) chaired by the Director of Environment which is geared to provide technical advice to the NCCFP, stimulate more coordinated actions of actors and broadens the participation of various actors in addressing climate change.

For TNA project, the overall coordination is done by the Vice President's Office (VPO), Division of Environment (DoE). The National TNA Team is responsible for day to day implementation of TNA activities. The TNA institutional arrangement is comprised of the National TNA Steering Committee, The National TNA Committee, the National TNA Team and Working Groups.

2.1.1 National Steering Committee

The National Steering Committee is composed of following members:

- Permanent Secretary Vice Presidents Office
- Permanent Secretary Ministry of Water and Irrigation
- Permanent Secretary Ministry of Energy and Minerals
- Permanent Secretary Ministry Natural Resources and Tourism
- Permanent Secretary Ministry of Agriculture, livestock and Fisheries
- Director General, Commission for Science and Technology

- Director, Institute of Natural Resource Assessment, University of Dar es Salaam

The Steering Committee is responsible for

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

2.1.2 National TNA Team

- The day to day implementation of the TNA is under the responsibility of the National TNA Team, which is comprised of:
- National TNA Committee,
- National Consultants /experts,
- Workgroups, and
- TNA coordinator.

2.1.3 National TNA Committee

It has eight members from different sectors as follows:

- Energy
- Water
- Agriculture
- Forest
- Environment
- University of Dar es Salaam
- Commission for Science and Technology
- The First Vice President Office – Zanzibar

2.1.4 Sectoral / Technological Workgroups

It involves technical people from the following four sectors

- Water
- Energy
- Agriculture and
- Forestry.

2.2 Stakeholder Engagement Process followed in the TNA – Overall assessment

Stakeholder Engagement is defined as "… the process used by an organization to engage relevant stakeholders for a purpose to achieve accepted outcomes." For TNA process Stakeholders' engagement is an important pillar to cement ownership of the process.

Engagement was done on different levels:

Stakeholder engagement for TNA was initiated in Arusha Tanzania in June 2015 through training where TNA consultants in the country were involved. During the training session, the TNA country consultants who formed a project team carried out stakeholders mapping exercise with the bottom-up approach in mind.

The coordinator prepared an introduction letter for consultants for enabling the consultation process. Consultants had face to face interview with experts to introduce the process and who have knowledge on various areas related to technologies in the water and agriculture sector also to gathering of various important literatures. Stakeholders ranged from research institutions, NGOs, Ministries and Ministries Department Agencies.

The inception and sector prioritization workshop on 29th and 30th of ?? 2015 for TNA process benefitted from the combination of TNA and CTCN stakeholders. For participants from the TNA stakeholders, consultants identified stakeholders and coordinator invited them to the workshop. The list included representatives from Ministries and sectors such as water, agriculture, energy, health, academia, civil society and representatives from Local Governments Authorities (LGAs) were also invited. Stakeholders prioritised sectors at the workshop on 29th and 30th September 2015.

After the workshop, the sector consultant developed technology factsheets (TFS) for technologies. The TFS contain relevant information on the technical aspects of the technology implementation, including its installation, operation and maintenance, efficiency, cost, and the benefits / opportunities, as well as the barriers for each short-listed adaptation technology. Individual meetings were also held with key stakeholders to collect information for the TFS on the market potential and status of the technologies in Tanzania, and to acquire technical information to estimate the incremental cost of the adaptation technologies.

The technology fact sheets were validated after members of the working group had been given ample opportunity to provide their comments and suggestions. Separate meetings were also held with key institutions before finalizing the technology selection and prioritisation.

On 24th November 2015 Stakeholders met as a working group in Tanzania mainland for agriculture and water sectors. They shared information which enriched the factsheets of technologies suggested. Stakeholders also identified institutions and individuals who are more informed and have experience on the ground.

On 25th November 2015 consultation was done in Zanzibar where stakeholders were introduced to the TNA process. After the presentation the stakeholders were allowed to work in groups to discuss guiding questions, the list of stakeholders already identified, types of technologies already identified and propose additional stakeholders and technologies.

On 7th March 2016 Stakeholders from Zanzibar and Mainland Tanzania met to prioritise technologies during the technology prioritization workshop in Dar es Salaam.

Thus the TNA process was through consultation of different stakeholders at different levels. Apart from the formal consultative meetings, there were also face to face interviews Details of the stakeholders consulted are attached as Annex II and Figure 1 and 2 shows stakeholders' involvement in different stages.

Figure 1: Stakeholders in the sector prioritization workshop

Figure 2: Stakeholders engagement in sector prioritization workshop

CHAPTER 3: TECHNOLOGY PRIORITISATION FOR AGRICULTURE SECTOR

3.1 Key climate change Vulnerabilities in agriculture sector and existing technologies for adaptation

As already stipulated in the previous chapter, agriculture sector in Tanzania is a major contributor to GDP and is a source of livelihood to approximate 80% of population. Despite its contribution to national development over the years the sector remains poorly developed with majority who continue to depend on rain fed subsistence food production using basic tools such as hand hoes. Climate change will continue to put pressure on Tanzanian farmers and the ecosystems as a whole – hitting harder on climate-sensitive sectors such as agriculture and water resources (Kulkarni, 2011). In the face of climate change, water scarcity and other natural resource constraints will make it even harder to intensify agricultural production.

3.2 Decision Context

Agriculture in Tanzania is the largest sector in the economy which accounts for about half of GDP and exports. This sector employs 77.5 per cent of the population, provides livelihood to more than 70 per cent of the population and contributes about 95 percent of the national food requirements (URT, 2014).

Agricultural growth has varied across food crops, cash crops and livestock. Within food crops, maize is the most important (accounting for over 20 percent of total agricultural GDP) followed by rice/paddy, beans, cassava, sorghum, and wheat. Within cash crops the most important by export value are coffee, cashew, cotton, tobacco and tea.

Though the Tanzanian economy and the agriculture sector have experienced economic gains, little of those gains have been translated to the poor who still depend on rudimentary technologies and erratic rainfall for their livelihood and food security (ACRP, 2014). These factors influence the impact climate variability and climate change will have on the agriculture sector, as well as the capacity to adapt to current and changing conditions.

The strategic direction of the agriculture sector is to modernize through promoting large-scale commercial farms, irrigation expansion, strengthening value chains, and improving linkages with smallholders. Rural poverty reduction, economic growth, and food self-sufficiency are anticipated, but this will add pressure on natural resources that already face high levels of management inefficiency and degradation due to agriculture, as well as competing uses. NAPs has identified a number of adaptation options but the increase in irrigation by using appropriate water efficient technologies to boost crop production in all areas was ranked to be priority number one. Also the Agriculture Climate Resilient Plan (ACRP) identifies many potential interventions that could build climate resilience through improved agricultural land and water management. The ACRP has proposed adaptation measures that are a mix of strategies to ensure better adaptation. These include methods to harvest and store rainwater runoff, and better management of land and catchment areas.

3.3 Overview of Existing Technologies in Agriculture sector

This section gives an overview of existing technologies in the agriculture sector. The following are some of the likely adaptation options assessed from the vulnerability studies done. NAPA which resulted from assessment that was carried throughout the country, recommended the following as prioritized options for agriculture sector (URT, 2006):

- Increase irrigation by using appropriate water efficient technologies (e.g. drip irrigation) to boost crop production in all areas.
- Promote alternative farming systems (such as crop rotation, zero grazing and growing of crops that need little water, such as millet and sorghum and drought-resistant varieties of maize) and relocation of water sources including wells along the low lying coastal areas.
- Develop water harvesting and storage programs for rural communities particularly those in dry lands.
- Develop community based catchments conservation and management programs.
- Promote water harvesting and recycling.
- Establish good land tenure system and facilitate sustainable human settlements.

3.4 Adaptation Technology Options for agriculture sector and their main adaptation benefits

This section gives overview of options of technologies that addresses adaptation in the agriculture sector.

i) Tractor and draft animals (ox-plough)

This is a widely used technology for land preparations but also in some cases it is used in weeding. These technologies are mostly used for ploughing and planting, while in some instances they are also used for ferrying equipment/implements to farms and crop produce from farms back home. For the case of Climate Smart Agriculture (CSA), these technologies can be used for zero tillage using implements such as rippers to break soil hard pans.

ii) Improved seeds

One key technology is improved seeds which are early maturing and drought tolerant crop varieties. It is noted that farmers understand and are using improved seeds in their crop production with the main objective to grow high yielding varieties as an adaptation strategy to climate change.

iii) Farm yard Manure

Farm yard manure (FYM) and compost is an appropriate technology to enhance nutrient availability for ensuring high yields. FYM is also good for maintaining soil structure and control evaporation. Use of farm yard manure increases crop–livestock integration such that crop residues from well managed crops are fed to livestock. The livestock manure is then returned to the fields at the start of the cropping season.

iv) Industrial/inorganic Fertilizers

Farmers in Tanzania use inorganic fertilizers for increasing crop yields. It is advised that use of fertilizer should be under the concept of integrated soil fertility management (ISFM) which is a set of agricultural practices adapted to local conditions to maximize the efficiency of nutrient and water use and improve agricultural productivity (Woomer, et al ,2009). ISFM strategies emphasize on the combined use of mineral fertilizers and locally available soil amendments (such as lime and rock phosphate) and organic matter (crop residues, compost and green manure) to replenish lost soil nutrients. This improves both soil quality and the efficiency of fertilizers and other agro-inputs. In addition, ISFM promotes improved germ-plasm, agroforestry and the use of crop rotation and/or intercropping with legumes (a crop which also improves soil fertility). Farmers who have adopted ISFM technologies have more than doubled their agricultural production and increased their farm-level incomes by 20 to 50 percent (ibid).

v) System of Rice Intensification (SRI)

The System of Rice Intensification (SRI) is a methodology aimed at increasing the yield of rice produced under irrigation. It is a low water, labor-intensive, and organic method that uses younger seedlings singly spaced and typically hand weeded with special tools. It is a climate-smart, agro-ecological methodology for increasing the productivity of rice and more recently other crops by changing the management of plants. SRI is now well used by farmers in Mcholi 1 ward in Ruvuma river basin and Dakawa in Wami River basin.

vi) Water pumping technology

Water pumps are widely being applied for irrigation especially in vegetable production in both rural and urban areas like Temeke in Dar es Salaam. These are widely used due to the challenges related to rainfed agriculture. This has compelled farmers to always dig wells or boreholes to get water for various uses including agricultural production. The water pumps are then connected with polyvinylchloride (PVC) pipes to help supply water to the gardens and/or farms. The PVC pipes are sometimes connected with sprinklers to apply the water in the gardens. Other people use canals instead of PVCs pipes to supply water to the gardens.

vii) Water harvesting and storage structures (e.g. water pans)

Rainwater harvesting (RWH) is defined as a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions (Boers and Ben Asher, 1982). In crop production systems, RWH is composed of a runoff producing area normally called the catchment area (CA) and a runoff utilization area normally called cropped basin (CB) (Hatibu and Mahoo, 1999). Rainwater harvesting systems for crop production are divided into different categories basically determined by the distance between CA and CB as follows:

- In-situ rain water harvesting such as majaluba is a method to increase the amount of water stored in the soil profile by trapping or holding the rain where it falls,
- Internal (Micro) catchment is a system where there is a distinct division of CA and CB but the areas are adjacent to each other,

- External (Macro) catchment such as water dam is a system that involves the collection of runoff from large areas which are at an appreciable distance from where it is being used.

viii) Improved irrigation (e.g. drip irrigation)

Drip irrigation, also known as trickle irrigation, is an irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. Drip irrigation is an efficient method of irrigating. It is easy to design, install and much less water is wasted during irrigation. The farmers can use low cost drip irrigation system which will enable them to produce high value crops especially vegetables.

ix) Lined Irrigation

Lined irrigation is an improved system whereby both secondary and tertiary canals are lined with cement to reduce water loss. Lined irrigation ensures efficient water utilization and minimum water loss. An important reason for lining a canal that is used for irrigation is that it can reduce water losses, as water losses in unlined irrigation canals can be high.

x) Terracing

Terracing refers to a technique of landscaping sloped land into a series of successively receding flat surfaces or platforms, which resemble steps, for the purposes of more effective farming. The principal objective of terracing is generally to reduce the runoff and the loss of soil, but it also contributes to increasing the soil moisture content through improved infiltration and to reducing peak discharge rates of rivers. Graduated terrace steps are commonly used to farm on hilly or mountainous terrain.

From the existing technologies listed above, below is a summarized table indicating adaptation benefits that exist in each of the stated adaptation option.

Table 3: Summary of adaptation benefits from identified adaptation options

Category	No.	Technologies	Adaptation benefit
Soil Management	1.	Tractor/Ox-plough	Improved farming system/improved productivity' using mechanized systems not human labour/power
	2.	Industrial /inorganic fertilizers	Boost production by promoting growth rate when properly used hence more income
	3.	Farm Yard manure	organic fertilizer; less environmental pollution from inorganic fertilizers"?
Sustainable Crop Management	4.	Improved seeds	Drought and disease tolerant, fast maturity, more yield
	5.	System of Rice intensification	Ensure efficient water use and increase in rice production
Water use and management	6.	Water pumping technology	Ensure adequate water availability for use in areas with no adequate surface water
	7.	Water harvesting and storage structures	Ensure adequate water availability for use during dry season
	8.	Drip irrigation	Ensure efficient water use
	9.	Lined irrigation	Reduce water loss
	10	Terracing	Reduce soil erosion and improve moisture retention

3.5 Criteria and process of technology prioritization for agriculture sector

Prioritization process which had two phases considered the scenario of the United Republic of Tanzania which is comprised of mainland Tanzania and Revolution Government of Zanzibar (RGZ). Initial consultations compelled presence of two working groups one from each part of the country. However, consultation for prioritization using the MCA tool was done with one working group that combined the two groups from both parts of the country.

In the first phase, the consultant introduced the fact sheets to the stakeholders and indicated the amount of information needed for prioritization and gave list of preferred technologies. The first two meetings of working groups were held in November 2015 which were used to agree and enrich information found on the fact sheets and ranked the technologies. Each of the working group agreed on criteria and equally weighed the criteria.

The second phase of prioritization was done by combining the two working groups from mainland Tanzania and RGZ, where criteria for prioritizing technologies were developed and agreed by stakeholders and the Multi Criteria Analysis Tool (MCA) was used to prioritize the technologies. MCA facilitates the participation of stakeholders and hence allows normative judgments, while incorporating technical expertise in the adaptation technology assessment (UNEP-DTU 2015). This prioritization indicates which technologies should be implemented first. Stakeholders were introduced to the use of the MCA as main tool for prioritization. According to the MCA guidance on adaptation the following steps were followed:

Step 1: Identify the options from long list of existing technologies on adaptation in the sector.

The technology fact sheets were circulated to all members of the sector working group for familiarization with the technology options prior to the MCA prioritization process. This was done through sharing of facts sheets with the working group members before the meeting. Stakeholders were consulted to select technologies that were to be included in the MCA process.

Step 2: Identify the criteria against which technologies will be ranked.

This was a clear and transparent process. The consultant developed a long list of criteria and shared with the working group during the workshop. These criteria had variation across technologies. Most of the criteria were based on objectives and goals of the specified sector. Criteria were discussed and agreed based on information from the existing national and local priorities, plans, and ongoing projects in the context where the technologies are going to be transferred and diffused. Also, criteria was agreed based on identified potential gaps from the overview of the existing technologies in the sector provided from fact sheets shared by the consultant among the stakeholders, and these were

i. Income generation and job creation, this criterion assesses the effect of technologies in achieving poverty reduction of the communities and households affected if the climate technology is implemented. Although the effect may not be direct, it is important to ensure that effects are at least not causing more households to fall under the poverty line, and at best bringing people out of poverty.

ii. Capital costs, this criterion looks at the costs of set-up of the technology often incurred during start-up phase. Set- up costs can often involve associated costs of importing a technology, installing it or with technologies already in country these could be costs of replicating in other areas.

iii. Food and nutrition security: this aligned with implementation of NAP, NAPA, INDC and aligns with development goals set by a country.

iv. Sustainable production, this criterion assesses how the given technology contributes to supporting ecosystem services - broadly categorized into provisioning, regulating, supporting and cultural services. Provisioning services relate to the production of food and water. Regulating services relate to regulation of climate and disease/pest control. Supporting services relate to nutrient cycles, seed dispersal, and pollination, where cultural ecosystem services relate to the spiritual and recreational benefits.

v. Social acceptability (including gender), this criterion asses how chosen technology should aim to reduce inequity between social classes, gender, ethnic groups etc. In particular it looks at income disparities and differences in access to resources between these groups.

vi. Accessibility of technology: This criterion covers whether the technology is available in the country. Can users (physically) access it easily e.g. found in local shops. It also incorporates transaction costs associated with the research, design, support and monitoring of the technology.

vii. Maturity of a technology: The maturity of a technology will closely link to how efficient and effective the technology is in achieving the desired results. Technologies which have been tried and tested in other regions can often be less problematic to implement in other regions.

viii. Level of capacity: Having the technical capacity in-country to set up and implement a technology would be advantageous and dismiss the need for hiring costly external experts.

The technical working group members involved in the MCA process discussed on the meaning of the criteria and how criteria were framed as well as the implied trade-offs and chose the most agreeable criteria. Table below, gives a summary of criterion agreed and their category.

Table 4: MCA process: Agreed criteria and category in agriculture sector

Criterion	**Criteria category**
Income generation and job creation	Socio-economic
Food and Nutrition security	Socio-economic
sustainable production	environment/climate related
capital costs	Financial/ economic
social acceptability	social
maturity of the technology	Technical and economic
Availability and accessibility of tech	Institutional
level of capacity	Institutional

Step 3: The consultant and working group worked on description of the expected performance of each option against the criteria.

Table 5: MCA process: Description of the expected performance

Criterion	Criterion Category	Unit Chosen	Value Preferred
Income generation	Socio-economic	Tsh	High
Food and Nutrition security	Socio-economic	Kcal	High
Sustainable production	Environmental/climate related	Scale of 1-5	High
Capital Cost	Economic/financial	Scale of 1-5	Low
Social acceptability	social	Scale of 1-5	High
Maturity of a technology	Institutional	Scale of 1-5	High
Availability and accessibility	Institutional	Scale of 1-4	High
Level of capacity	Public financing needs	Scale of 1-4	High

Step 4: 'Weighting' process assign weights for each of the criteria to reflect their relative importance to the decision

It was agreed during consultation with the technical group that, the weighting process should be technically led by the ministry of Agriculture. This session followed after step 3 which had all the technology options scored against all criteria, however, the scores had to be compared because preference of one criterion does not necessarily equal the preference of another criterion. Therefore, each criterion was assigned a weight to reflect the weight of importance that stakeholders assign. Once the criteria have been weighted, the scores against all criteria can be compared. The weighting process was done as follows: First, the final list of criteria was arranged in order of relative importance. Then weight was assigned between 1 and 100 to each criterion, making sure that the sum of all weights totals 100.

Table 6: MCA process: Weighting of criterion

Criterion	Allocation of Budget (total=100)	Weight %
Income generation and job creation	15	15%
Food and nutrition security	25	25%
Sustainable Production	10	10%
Capital Cost	15	15%
Social acceptability	5	5%
Maturity of the technology	10	10%
Availability and accessibility of technology	10	10%
Level of capacity	10	10%
Total Allocated	**100**	

Step 5: Combine the weights and scores for each of the options to derive and overall value.

Table 7: MCA process: Results of the ranking in agriculture sector

Option/Criterion	**Income generation and job creation**	**Food and Nutrition**	**sustainable production**	**capital costs**	**social acceptability**	**maturity of the technology**	**availability and accesibility of tech**	**level of capacity**
Units	Tshs	Kcal	scale of 1-5	Tshs	scale of 1-5	scale of 1-5	scale of 1-5	scale of 1-5
Preferred value	High	High	High	Low	High	High	High	High
Conservation agriculture	4	4	5	5	4	3	3	3
Improved seed varieties	5	5	4	2	3	3	4	3
Terracing	4	4	3	5	5	3	5	4
System of rice intensification	5	4	4	3	3	4	4	4
Lined irrigation	4	4	3	5	4	3	3	3
Drip irrigation	4	4	5	2	3	3	3	4
Rainwater harvesting	3	4	4	2	4	3	4	4

3.6 Results of technology prioritization

The table below shows the results of technology prioritization following MCA process. The technologies with the highest scores are improved seed varieties, system of rice intensification and drip irrigation with score of 65%, 55% and 42.5% respectively. These were selected for further analysis, development and adoption. The results from other technologies are as shown from the table below.

Table 8: Results of technology prioritization in Agriculture Sector

Rank	**Option**	**Weighted Score**
1	Improved seed varieties	65.0
2	System of Rice Intensification	55.0
3	Drip Irrigation	42.5
4	Rainwater harvesting	37.5
5	Terracing	32.5
6	Conservation agriculture	20.0
7	Lined irrigation	10.0

CHAPTER 4: TECHNOLOGY PRIORITIZATION FOR WATER SECTOR

Water is a shared common resource fundamental to life and in sustaining the environment and plays a central role in the social and economic development. Water is important for many aspects of life including domestic, agriculture, livestock, fisheries, wildlife, industry, energy, recreation and other social and economic activities. Thus it is an important ingredient for sustainable socio-economic development and plays a pivotal role in poverty alleviation through enhancing food security, domestic hygienic security, hydropower, industrial development, mining, navigation, and the environment for sustenance of ecosystems. This section aims at providing information on technology prioritization process for the water sector.

4.1 Key Climate change Vulnerabilities in Water Sector

Climate change threatens the productivity and sustainability of rivers and lake basins' resources and socio-economic activities, thus affecting water supply for ecosystem, power generation, irrigation, domestic and industrial use. Many lake basins which form important components of the ecosystem have also been affected by climate change adverse impacts. The high temporal and spatial variability in rainfall has resulted in endemic drought in some parts of the country and occasional floods in other parts, and has far reaching consequences on water resources management. High variability in flows in the rivers poses very difficult conditions for managing large irrigation and hydropower reservoirs. (NWSDS, 2006)

The importance of water sector to support other sectors to realize projected development goals have attracted a number of vulnerability assessment studies. Some of these studies were general for the whole country and some for specific rivers. Among the early initiatives includes projections by Mwandosya et al. (1998) which reported that by 2015 high temperatures and less rainfall during dry months would lead to reduction of annual river flows for the Pangani and Ruvu river basins by 9% and 10 %, respectively. Another study by, Agrawala et al (2003) using MAGICC/SCENGEN model projected a likelihood of general increase in precipitation by 10% by 2100 throughout the country while a seasonal decline by 6% was projected for June, July and August and seasonal increases by 16.7% was projected for December, January and February during the same period. These long-term projections however, had high standard deviations, which is an indication of low confidence in projections. Further studies by Valimba (2011) gives projections indicating predicted changes of annual rainfall to vary between the highest decrease of 30% (Pangani, Rufiji, Ruvuma-Southern Coast and Wami-Ruvu basins) and the highest increase of 40% (Lake Victoria and Pangani basins).

Pangani basin is one of Tanzania's most agriculturally productive areas and is an important hydropower production region. River Ruvu is important source of water for domestic and industrial uses in the city of Dar es Salaam. Reduced runoff of Pangani and Ruvu rivers, which are economically important for supplying water and hydroelectricity to major towns, where industrial activities are highest in the country, would adversely affect socio-economic activities in the country.(INC, URT 2003)

4.2 Decision Context

The water sector touches all spheres of life including domestic, agriculture, livestock, fisheries, industry, energy, recreation, and other social and economic activities.

In Tanzania, water plays a pivotal role in poverty alleviation through enhancing food security and domestic hygiene security, and the environment for sustenance of ecosystems (National Water Sector Development Strategy, 2006-2015). Furthermore, availability of adequate water supply with good quality reduces time in fetching water and facilitates increased health standards among the people in the community.

The water sector has been identified to be among priority sectors in national development programmes including the National Strategy for Growth and Reduction of Poverty (NSGRP/MKUKUTA). The sector has also been included among the five priority sectors in acceleration of the implementation of the vision 2025 through the Big Results Now (BRN) development program in 2013. Three result areas were identified under the sector and were to be achieved by 2015. These areas are;

- Sustaining water supply to 15.2Million people
- Restoring water supply to 5.3 Million People
- Extending water supply to 7 Million new users

The impact of climate change on water resources is also a threat to other related sectors. Therefore, threats on other sectors posed by the impacts of climate change on water resources need to be addressed. To address this, Tanzania has prepared National Climate Change Strategy (2012) and a Climate Change Adaptation Strategic Intervention Plan for Water Resources Management; other climate change adaptation measures in water sector at different levels have also been formulated.

4.3 Overview of Existing Technologies in water sector

The Climate Change Adaptation Strategic Intervention Plan for Water Resources Management (MoW, 2013) identifies several strategies and techniques that exists and geared towards enhancing adaptation in the water sector and these include:

i. Integrated Water Resources Management and Development Plans (IWRMDP)

All nine basins in Tanzania are preparing Integrated Water Resources and Development Plan (IWRMDP) with climate change adaptation strategy as one of the objectives. The plans are anticipated to borrow and improve already existing climate change adaptation measures applied in different areas of the country.

ii. Water storage and conservation techniques

This has been addressed at different levels. At a basin scale and Urban Water and Sanitation Authorities (UWSA), there are plans to develop and rehabilitate water storage dams in order to increase water supply for domestic water supply, environmental flows, irrigation, and hydropower generation. Examples of dams planned for construction include Kidunda in Wami-Ruvu River Basin to improve water supply for Dar es Salaam, Ndembera in Rufiji River Basin to improve environmental flows for the Ruaha River and provide water for irrigation and possibly hydropower. Other planned dams include Farkwa for Internal Drainage Basin, Maluluma in Rufiji, Borenga in Mara River, Itobo, Uchama, Nkiniziwa in Nzega (IDB), Elenywe and Enguikument in Monduli and Four potential dam sites upstream of Mandera Bridge in Wami-Ruvu River Basin.

In semi-arid areas of Tanzania there is a widely used technique for water storage using charcoal dams[1]. This technique is widely used for domestic, livestock and farming water storage. Several charco dams have been constructed under Agriculture Sector Development Plan (ASDP) to provide water for small scale irrigation. (ASDP, 2010). Dams account for 3% of the irrigation water used in the ASDP-supported schemes. According to the water sector status report (ASDP, 2010), there are 633 dams in Tanzania but not all of them are used for irrigation. About 21% of the dams experience spillage and twelve dams have silted up.

Other techniques used includes protection of groundwater catchments to enhance groundwater recharge capacity; restriction of human activities closer to water sources to avoid environmental degradation, and planting water friendly trees and other vegetation around the water sources.This suggests most of the dams need rehabilitation.

iii. Efficiency in water-use and irrigation

Increasing efficiency of water use through leakage and non-revenue water reduction is one of the planned climate change adaptation activities by most UWASAs such as DAWASA and IRUWASA, which is yet to be implemented. In terms of irrigation, drip irrigation is considered the most efficient irrigation system worldwide. Drip irrigation is 40% more efficient than gravity and 25% more efficient than overhead or sprinkler irrigation systems HBST, 2012). However, the use of drip irrigation in Tanzania is only localized to specific applications for individual organisations and locations. For example, USAID funded project under Tanzania Agriculture Productivity Program (TAPP) is supporting vegetable farmers using drip irrigation with training on good agricultural practices. There have also been attempts to introduce SRI in rice farming for instance in rice irrigation schemes in Iringa, Morogoro, Kilimanjaro but implementation is at early stages to be able to determine their

[1] Charcodams are natural depressions where rainwater either flows or accumulates during rainy seasons. The soil should, preferably, be deep clay, silt or Black Cotton Soil.

effectiveness in water use and saving. The other activity under this climate change adaptation initiative is training of district agricultural staff on irrigation water use efficiency in the Pangani River Basin under the Pangani River Basin Management Project.

iv. Rain water harvesting and storage systems

Rainwater harvesting in Tanzania is practiced on household basis for domestic, agriculture and livestock uses. For domestic water uses, tanks are used to store rainwater harvested from tiled or corrugated galvanized iron sheet roofs. Moreover, water harvesting and storage systems for agriculture and livestock use are very common in semi-arid areas of Tanzania and they exist in different types such as Ndiva, Malambo or charco dams, and Sand dams. Ndiva, which store water overnight are common in mountainous districts such as Same and Lushoto and are used on communal basis. Malambo are man-made ponds, dug on relatively flat land areas and strategically located to harvest as much runoff as possible from the surrounding terrain. They are common in the semiarid parts of the country especially in Dodoma, Singida, Tabora, Mwanza, and Shinyanga regions. Sand dams are dug at the bottom of seasonal rivers to store water. This practice is common in Dodoma, Mwanza, Shinyanga and Tabora regions. The Pangani River Basin Management Project which was implemented in the Pangani River Basin by the PRBWO and IUCN in collaboration with the Climate Change and Development Project (CCDP) and the Global Water Initiative (GWI) supported rain water harvesting as one of the adaptation measures in Meru District.

v. Technical measures to increase water supply

Although water storage and conservation techniques and rainwater harvesting system may aim at increasing water supply, there have been specific climate change adaptation measures to increase water supply to meet the demand of water in urban due to population increase and climate change. The adaptation measures include increasing water availabilty (e.g. DAWASA water supply expansion in Lower and Upper Ruvu), identification and development of groundwater resources for domestic and irrigation use. Gravity and boreholes water supply schemes have been developed in a number of UWASAs and District Councils under the Water Sector Development Programme (WSDP-I).

vi. Flood protection measures

Flood protection adaptation measures such as raised dykes, reservoir enlargement and river training are not implemented in the water basins but are at the planning stage in IDWB, PBWO, WRWBO, LTBWB, RBWO and LNBWO. For example, the dam planned to be constructed along trans-boundary Songwe River in Lake Nyasa Basin will have multipurpose functions including hydropower production, water supply, fishing, irrigation, navigation and flood control through river training in order to stabilise the River. In terms of flood control through upgrading drainage systems, some of the urban LGAs such as Moshi Municipal Council and Dodoma Municipal Council have constructed and upgraded storm water drainage infrastructures to control floods.

Other climate change adaptation measures which are either planned or considered effective but are not yet implemented by the Water Basins and Urban Water Authorities include floodplain restoration, proper land use plan, restriction of settlement development in flood prone areas, and improving forecasting and information dissemination on flood hazards.

4.4 Adaptation technology Options for water sector and their main adaptation benefits

The following section will give a summary of ten technology options for water sector and their main adaptation benefits:

1. Water re-claim and reuse

Water reclaim and reuse is one among the integrated approach that consider municipal wastewater as a vital resource for appropriate applications, including agricultural and other irrigation, industrial and domestic uses. In this technology Water reclamation involve treatment or processing of wastewater to make it reusable with definable treatment reliability and meeting appropriate water quality criteria, while water reuse is the use of treated wastewater for a beneficial purpose. Water reclamation and reuse contributes to climate change adaptation by allowing water resources to be diversified and conserved also using reclaimed water for applications that do not require potable water like irrigating, flushing and construction can result in greatly decreased depletion of protected water sources and prolong their useful lifespan.

2. Water recycling and reuse

Water recycling and reuse involves using untreated and uncontaminated wastewater for a second time. This water may come from bathtubs, showers, bathroom washbasins, clothes washing machines and laundry tubs for an appropriate purpose. This water recycling and reuse also offer cost-effective and multi- benefit solution. The technology requires the installation of dual plumbing so as to avoid confusion of mixing between recycled water and clean. Water to be recycled is carried in pipes with different colors (purple color is recommended) from the point of production or collection to the point of reuse or storage tank. Filters can also be installed to remove large particles before water is stored or reused. Use of recycled water will contribute to reducing household water demand and ease pressure on the main water supply, reducing upstream energy and environmental costs.

3. Rain water harvesting from roofs

Rainwater harvesting is the capturing and storing of rainwater for use before it reaches the aquifer. Rooftop catchments is the most basic form of this technology and include collection of rainwater in gutters which drain to the collection vessel through down-pipes constructed for this purpose and/or the diversion of rainwater from the gutters to containers for settling particulates before the domestic use. In Tanzania most precipitation that falls on human settlements is lost to the atmosphere through evapotranspiration or runs into rivers away from settlements before it can be used. However, if the rain is collected by using appropriate infrastructure, it can contribute greatly to the volume of freshwater available for human use.

This can greatly decrease the time spent fetching water or queuing at water points also rainwater harvesting can reduce exposure to waterborne pathogens by providing improved potable water quality and high quality water for other household purposes including hygiene, bathing and washing.

4. Rainwater Collection from Ground Surfaces—Small Reservoirs and Dams

Rainwater collection from Ground Surfaces by the use of small Reservoirs and Dams can be a suitable technology in Tanzania to overcome the challenges of climate change in water sector. Collection and storage of rainwater can provide a convenient and reliable water supply during seasonal dry periods and droughts. Additionally, widespread rainwater storage capacity can greatly reduce land erosion and flood inflow to major rivers. Rainwater collection can also contribute greatly to the stabilization of declining groundwater tables.

5. Increasing the Use of Water-efficient Fixtures and Appliances

In Tanzania the use of available water is not efficient, since massive amounts of water are lost daily due to use of inefficient appliances in different areas as well as households. Thus the use of water efficient appliances and fixtures in homes, industries and hospitals, learning institutions, hotels and mosques can contribute greatly to water conservation efforts as well as adaptation efforts to climate change impacts in water sector. Water efficiency means using less water to provide the same level of service or to get the same result while water efficient appliances are those that use less water to operate, such as fewer gallons per flush with a toilet. This technology will help to reduce the amount of clean water used in households and community in general consequently contributes to climate change mitigation by decreasing energy consumption and greenhouse gas emissions. Water conservation can lead to large savings in the energy used to transport, treat and distribute water.

6. Borehole drilling

A borehole is simply a deep narrow well usually driven by an electric pump that taps into the underground stores of water held in permeable rock known as aquifers. Boreholes can provide clean potable water supply in Tanzania though their numbers are still inadequate due to high drilling cost. Increasing access to groundwater is a key strategy for household water supply (both potable and non-potable) during drought. Boreholes have much greater resilience to drought than traditional water supplies including springs, hand dug wells and surface water sources.

7. Household Drinking Water Treatment and Safe Storage (HWTS)

HWTS increases resilience to water quality degradation by enabling users to improve water quality at the point of use. Degradation of water quality is expected to be one of the key impacts of climate change on water resources and water supply (IPCC, 2007). For centuries, households have used a variety of methods for improving the appearance and taste of drinking-water. Even before germ theory was well established, successive generations were taught to boil water, expose it to the sun or store it in metal containers with biocide properties, all in an effort to make it safer to drink.

8. Leakage Reduction Program

Leakage is a way for fluid to escape a container or fluid-containing system, such as a tank or a pipe. Leaks are usually unintended and therefore undesired. Physical leak detection is the technique that uses electronic listening equipment to detect the sounds of leakage. As pressurized water is forced out through a pipe, a leak loses energy to the pipe wall and to the surrounding soil area. This energy creates audible sound waves that can be sensed and amplified by electronic transducers/ piezoelectric sensors. The sound waves are evaluated to determine the exact location of the leak.

9. Improving the Resilience of Protected Wells to Flooding by Building an Apron Slab

An apron slab is a smooth impermeable surface constructed around a water point to prevent spilt water soaking into the ground. Its purpose is to prevent pollution of the groundwater supply and prevent the development of puddles or muddy conditions that are unpleasant and can attract mosquitoes, flies and lead to the transmission of disease. The apron slab should have a raised edge that extends at least 1-3 m below ground to prevent infiltration of contaminants. Protecting wells by building apron slabs can prevent contamination of drinking water that results to water borne diseases and Ensuring continuous access to drinking water during floods.

10. Desalination of water

Desalination refers to those processes which reduce the quantity of dissolved substances in the water. The desalination process essentially separates saline water into two parts, one that has a low concentration of salt (treated water or product water) and the other with a much higher concentration than the original feed water, usually referred as brine concentrate or simply concentrate. Solar distillation and reverse osmosis are the two suggested technologies to be introduced in Tanzania. Desalination technologies provides resilience to water quality degradation and will increase access to an adequate supply of freshwater for drinking, household, commercial and industrial use which is essential for health, wellbeing and economic development.

Below is a Summary of available technologies for adaptation in the water sector:

Table 9: Available Technologies for Adaptation in the Water Sector

Challenge of water related to climate change	Adaptation option	Technology
Greater precipitation variability and drying of water sources	Establishment of other sources of water such as groundwater	Borehole Drilling
Decrease of water quality that resulted to increase in eruption of water borne diseases	Create Resilience to Water Quality Degradation	Household Water Treatment and Safe Storage(HWTS)
Increase of precipitation intensity due to climate change that results to risk of flooding and contamination of water supplies and the environment.	Improving the Resilience of Protected Wells to Flooding	Protecting wells by building apron slabs
Decrease of water quality	Water Conservation option by Detection and repair of leaks in water systems.	Leakage Reduction Program by passive observation and Physical leak detection
Decrease of water levels in ground waters and surface water excluding sea	Diversification of Water Supply	Desalination of Water
i. Water scarcity and drought **ii. Intrusion of sea water to fresh water sources**	i. Diversification of Water Supply ii. Ground- water Recharge iii. Resilience to Water Quality Degradation iv. Storm water Control and Capture	Rainwater Collection from Ground Surfaces—Small Reservoirs and Dams
Decrease of water levels(surface and ground)	i. Diversification of Water Supply	Water recycling and reuse
i. Excessive water contamination due to drought and floods **ii. Sedimentation due to increased runoff and flooding**	i. Diversification of Water Supply ii. Ground- water Recharge	Rain water harvesting from roof
Decrease of water levels(surface and ground)	i. Diversification of Water Supply ii. Ground- water Recharge iii. Resilience to Water Quality degradation	Water reclaim and reuse
Water scarcity and drought	i. Water Conservation	Increasing the Use of Water-efficient Fixtures and Appliances

4.5 Criteria and process of technology prioritization

A similar process used for prioritization in the agriculture sector was followed in this sector. However, during the MCA process due to differences in nature of the two sectors, some of the criteria differed. MCA facilitates the participation of stakeholders and hence allows normative judgments, while incorporating technical expertise in the adaptation technology assessment (UNEP-DTU 2015). This prioritization indicates which technologies should be implemented first. Stakeholders were introduced to the use of the MCA as main tool for prioritization. According to the MCA guidance on Adaptation same steps that were followed during agriculture sector technology prioritization were followed for the technology prioritization of the water sector:

Step 1: Identify the options

This was done by sharing technology fact sheets with the technical working group developed by the consultant prior the ranking workshop. Stakeholders were asked to select priority options to be used in the MCA process.

Step 2: Identify the criteria

This was a clear and transparent process. The consultant developed a long list of criteria and shared with the working group during the workshop. These criteria had variation across technologies. Most of the criteria based on objectives and goals of water sector. Criteria were discussed and agreed basing on information from the existing national and local priorities, plans, and ongoing projects in the context where the technologies are going to be transferred and diffused. Also, criteria agreed based on identified potential gaps from the overview of the existing technologies in the sector provided from fact sheets shared by the consultant among the stakeholders, and these were:

i. Job creation, this criterion assesses the effect of technologies in achieving poverty reduction of the communities and households affected if the climate technology is implemented. Although the effect may not be direct, it is important to ensure that effects are at least not causing more households to fall under the poverty line, and at best bringing people out of poverty.

ii. Capital costs, this criterion looks at the costs of set-up of the technology often incurred during start-up phase. Set- up costs can often involve associated costs of importing a technology, installing it or with technologies already in country these could be costs of replicating in other areas.

iii. Availability and Accessibility of tech: This criterion covers whether the technology is available in the country. Can users (physically) access it easily e.g. found in local shops. It also incorporates transaction costs associated with the research, design, support and monitoring of the technology.

iv. Maturity of a technology: The maturity of a technology will closely link to how efficient and effective the technology is in achieving the desired results. Technologies which have been tried and tested in other regions can often be less problematic to implement in other regions.

v. Level of capacity: Having the technical capacity in-country to set up and implement a technology would be advantageous and dismiss the need for hiring costly external experts.

vi. Water efficiency: This criterion is an essential criterion when evaluating climate technologies in general, the achievement of joint adaptation and mitigation benefits from any given climate technology is advantageous. This is therefore considered an important criterion in the evaluation of alternatives, as the opportunity to achieve adaptation and reduce emission of GHGs. Furthermore it also aligned with implementation of NAP, NAPA, INDCs and aligns with development goals set by a country.

vii. Environmental Sustainability: Technologies can often affect surrounding natural resources and oftentimes draw on these resources to function effectively e.g. rainwater harvesting technologies could affect the natural water cycle affecting groundwater levels. The environmental quality and integrity therefore needs to remain intact, and at best improved following the introduction of the technology.

viii. Social acceptability (including gender), this criterion asses how, chosen technology should aim to reduce inequity between social classes, gender, ethnic groups etc. In particular it looks at income disparities and differences in access to resources between these groups.

The technical working group members involved in the MCA process discussed on the meaning of the criteria and how criteria were framed as well as the implied trade-offs and chose the most agreeable criteria. Table below, gives a summary of criterion agreed and their category.

Table 10: MCA process: Criteria agreed and categories in the water sector

Criterion	Criteria category
Job creation	Socio-economic
Water efficiency	Technical
Environment sustainability	environmental
Capital costs	Financial/economic
Social acceptability	social
Maturity of the technology	Techno-economic
Availability and accessibility of tech	Institutional
Level of capacity	Institutional

Step 3: Describe the expected performance of each option against the criteria.

Table 11: MCA process: Description of the expected performance

Criterion	Criteria category	Unit Chosen	Value Preferred
Job creation	Socio-economic	Number of jobs created	High
Water efficiency	Political	Scale of 1-5	High
Environment sustainability	environmental	Scale of 1-5	High
Capital costs	Public financing needs	Scale of 1-5	Low
Social acceptability	social	Scale of 1-5	High
Maturity of the technology	Institutional	Scale of 1-5	High
Availability and accessibility of tech	Institutional	Scale of 1-4	High
Level of capacity	Public financing needs	Scale of 1-4	High

Step 4: ‘Weighting’: Assign weights for each of the criteria to reflect their relative importance to the decision

Decision of weighing was done collectively in the technical working group led by a representative from the Water ministry. Having all the technology options scored against all criteria, the scores had to be compared because preference of one criterion does not necessarily equal the preference on another criterion. Therefore, each criterion was assigned a weight to reflect the weight of importance that stakeholders assign to each of the specific criterion. When the criteria have been weighted, the scores against all criteria can be compared. The Weighting process was done as follows: First, the final list of criteria was arranged in order of relative importance. Then weight was assigned between 1 and 100 to each criterion, making sure that the sum of all weights totals 100.

Table 12: MCA process: Weighing of available options

Criterion	Allocation of Budget (total=100)	Weight %
Water efficiency	25	25%
Job creation	15	15%
Capital Cost	15	15%
Environmental sustainability	10	10%
Maturity of the technology	10	10%
Social acceptability	10	10%
Availability and accessibility of technology	10	10%
Level of capacity	5	5%
Total Allocated	100	

Step 5: Combine the weights and scores for each of the options to derive and overall value.

High scoring scale was 5 and 1 the lowest. In all the criteria high scoring was preferred except for cost. Options were provided from fact sheets shared by the consultant, criteria were agreed among the stakeholders, these were efficiency use of water, capital cost, job creation, maturity of the technology, environmental sustainability, social acceptability (including gender), availability of the technology and capacity available for use of technology. Results of the ranking are shown on the table below:

Table 13: Ranks for technology prioritization in the water sector

Option/Criterion	water efficiency	capital cost	Job creation	Maturity of the tech	Environmental sustainability	Social acceptability	Availability	Capacity
Units	scale of 1-5	Tsh	Number of jobs	scale of 1-5	scale of 1-5	scale of 1-5	scale of 1-5	scale of 1-5
Preferred value	High	Low	High	High	High	High	High	High
Use of efficient fixtures and appliances	5	5	3	2	5	5	2	2
Water harvesting from roof top	5	3	3	2	5	5	5	3
Water recycling and re use	5	5	4	5	5	5	2	2
Household drinking water and safe storage	5	4	3	1	3	3	2	2
Leakage reduction programme	5	4	3	3	4	5	5	4
Desalination of water	5	5	3	1	5	5	1	1
Water reclaim and re use	5	5	1	1	5	5	1	1
Borehole drilling	4	5	3	3	3	5	3	2

4.6 Results of technology prioritization

Table 5 below shows the results of technology prioritization following MCA analysis. The technologies with the highest scores are water harvesting from roof top, leakage reduction programme and water recycling and re use with score of 87.5%, 76.7% and 74.2% respectively. These were selected for further analysis, development and adoption. The results from other technologies are as shown from the table below.

Table 14: MCA results after prioritization of water sector technologies

Table 14: MCA results after prioritization of water sector technologies

Rank	Option	Weighted Score
1	Water harvesting from roof top	87.5
2	Leakage reduction programme	76.7
3	Water recycling and re use	74.2
4	Use of efficient fixtures and appliances	63.3
5	Desalination of water	56.7
6	Water reclaim and re use	50.0
7	Household drinking water and safe storage	43.3

8	Borehole drilling	28.3

CHAPTER 5: SUMMARY AND CONCLUSIONS

The TNA report on adaptation was prepared through consultation of stakeholders at different levels. This multi-stakeholder process has been crucial to cement allowed prioritization in adaptation for water and agriculture sectors. It further allowed for identifying climate change technology options for the priority sectors. The sectors that have been retained for the TNA project in adaptation are: water and agriculture. These two sectors were prioritized basing on the vulnerability to climate change and their contribution to the country's development agenda.

MCA tool was used to prioritize and rank technologies. The results are summarized as follows:

Table 15: Summary of prioritized technologies in agriculture and water sector

Sector	Technologies retained for TAP
Agriculture	Improved variety seeds
	System of Rice Intensification
	Drip irrigation
Water	Rain water Harvesting from roof top
	Leakage reduction programme
	Water re cycling and re use

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ANNEX I: TECHNOLOGY FACT SHEETS FOR SELECTED TECHNOLOGIES IN THE AGRICULTURE SECTOR

Technology 1: Rainwater Harvest

Introduction

Rain water harvesting is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams. Commonly used systems are constructed of three principal components; namely, the catchment area, the collection device, and the conveyance system. When the rain is collected using appropriate infrastructure, it can contribute greatly to the volume of freshwater available for human use. This is particularly relevant in arid and semi-arid regions, where the little rainfall received is usually very intense and often seasonal

Technology

Rainwater harvesting is the accumulating and storing of rainwater for reuse before it reaches the aquifer. Rooftop catchments is the most basic form of this technology and include collection of rain water in gutters which drain to the collection vessel through down-pipes constructed for this purpose, and/or the diversion of rainwater from the gutters to containers for settling particulates before being conveyed to the storage container for the domestic use (Pacey &Cullis, 1986). As the rooftop is the main catchment area, the amount and quality of rainwater collected depends on the area and type of roofing materials

Cost to implement adaptation options

Currently, to install one cubic meter in rooftop rainwater harvesting system costs: With plastic tank: $ 230 while with stone and concrete tank: $ 220. The installation of one cubic meter in a small sized (240 m3). Moreover the gross margin analysis for paddy rice production in Maswa District (Bukangilija Village) shows positive average gross margin of TShs 138,814 per hectare. Returns to labour for rice came out to be TShs 868 per person-day. Returns to labour in rice production was lower than the opportunity cost of labour in the area. The results were however not significantly lower ($p = 0.05$, $n = 30$). About 13% of the farmers in Bukangilija obtained zero grain yields from their bunded basins (Majaluba). The main reason for this was failure to harvest enough rainwater to cover the whole growing period.

Potential development impacts, benefits

The technology will enhance availability of drinking water for domestic and agricultural water for arid and semi-arid areas, contribute job creation and result in reduction of public and private expenditures associated with water infrastructure. Roof rainwater harvesting will contribute to increased availability of freshwater and hence lead to enhanced growth of social structures and women empowerment. It will also reduce overexploitation of ground and service water with consequent environmental benefits

Status in the country

Rain water harvest spread all over the semi-arid central zone of Tanzania including Dodoma, Singida, Tabora and Parts of Shinyanga. It is also a common technology in the semi-arid districts of Same and Mwanga in the North-eastern highlands zone. Pilots installations have already took place in some areas of the country under the support of AAP-VPO-UNDP where water scarcity is critical. This gives the technology the possibility of up scaled to other areas of similar water constraints immediately.

Timeframe

Rainwater harvest can be implemented and became operational within one year period

Institutional capacity

To implement this technology, the government through the Ministry of Agriculture food security and cooperatives, and Ministry of water in collaboration with LGAs would play a key role in providing for equipment purchases by making the technology accessible to a larger number of farmers, particularly small-scale farmers, who have problems raising capital investment funds. The technology is simple to install and operate and does not imply any specific organizational requirements

Adequacy for current climate

Climate change projection for Tanzania indicates general rainfall decrease in most part of the country, which together with population growth is bound to impact serious freshwater sources of the country. Collection and storage of rainwater can provide a convenient and reliable water supply during seasonal dry periods and droughts.

Barriers

The cost of rooftop rainwater harvesting systems is relatively high to small scale farmers, lack of National Policy on rainwater harvesting as well as inadequate technical assistance in maintaining communally- owned systems. The disadvantages of rainwater harvesting technologies are mainly due to the limited supply and uncertainty of rainfall. Rainwater is not a reliable water source in dry periods or in time of prolonged drought. Low storage capacity will limit rainwater harvesting potential, whereas increasing storage capacity will add to construction and operating costs making the technology less economically viable. The effectiveness of storage can be limited by the evaporation that occurs between.

Acceptability to local stakeholders

The technology is well known by the population and can be easily accepted. With improved water supply through rooftop rain water harvesting and runoff pond systems, households and small- scale farmers are able to not only feed their families better, but also earn extra income from selling their produce at local markets. Rainwater harvesting reduces demand on rivers and groundwater that could be used for domestick purposes as well as farm activities. Large-scale collection of rainwater can reduce run-off and therefore the risk of flooding is minimized.

Endorsement by experts

Harvesting rainwater from rooftops, constructions of Chaco dams provide water for both domestic and livestock use and therefore enhance community adaptive capacity to adverse impacts of climate change. Different studies have indicated significant use of water conservation and harvesting for crop production for example in Dodoma region. With adoption of water harvesting for crop production, there is a clear evidence of increased farmers' income and poverty reduction. MAFC promote rainwater harvesting in different form that can serve for small scale irrigation on vegetable production as well as domestic uses such as RWH with reservoir storage for supplementary irrigation in Hombolo Dodoma (SWMRG, 1995). The Government of Tanzania has also formulated a number of strategies and policies to guide interventions in the agricultural and water sectors, and in rural development and poverty alleviation with much emphasis on water harvesting and irrigation. The Agriculture Climate Resilient Plan identified many potential interventions that could build climate resilience through improved agricultural water and land management. Some of these includes the increase in water harvesting and storage capacity (dams/weirs, chaco-dams, raised beds) and designing of water storage facilities to accommodate multiple users (ACRP, 2014).

Technology 2: Conservation Agriculture

Introduction

Conservation agriculture is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes.

Technology characteristics

The technology is guided by three major principles which includes reduction of the intensity of soil tillage, or suppress it altogether, cover the soil surface adequately if possible completely and continuously throughout the year and diversification of crop rotations. Most CA practices have been historically practiced (soft technologies) and adapting CA to some crops may require specific machinery for seeding. Also CA induces a decrease in machinery use, fuel and time-saving in operations. It is suitable for arid and semi arid regions, to areas with soils suffering from low organic matter content and for areas prone to desertification and CA should be avoided in soils with high clay content, in humid areas with shallow water table, in saline soils and for crops with no residues left.

Costs

Weed control, accessibility to appropriate tools and equipment, and competition for crop residue have influenced rate and extent of adoption. Slowly, however, farmers have been integrating various components. Weed control is a critical problem during the first two years of converting to conservation agriculture—the transition period. Soil cover in the long term helps reduce weed intensity and hence saves the energy, time and materials that would have been needed for weeding. Although herbicides are seen as a good investment and reduce labour during weeding and land preparation activities such as clearing, ploughing and burning residue, few can afford them. A liter of Round-Up costs around TZS 8500 (USD 85), while hiring labour for one acre for each weeding costs TZS 8000–10,000 (USD 80–100), with up to three weeding required. Therefore, those who can afford to apply herbicides save time and reduce costs.

Institutional and organizational requirement

More research and trial should be done in different agriculture zones, namely in arid regions. Capacity building and knowledge transfer is required for the adaptation option to be implemented where CA deployment is successful.

Potential development impacts, benefits

Increasingly, farmers are pointing to soil degradation as a key issue among the factors constraining crop production. Poor and declining farm outputs, and especially the instability in yields that even minor climatic changes bring on, virtually immediately affect food security and farm incomes adversely. Managing its natural resources sustainably needs to be an integral part of its agenda for agricultural productivity. Thus it is promoting conservation agriculture, especially in the Arusha region, as a combination of crop and crop–livestock production practices that make land more productive even as it improves the resilience of natural resources. Conservation agriculture is gaining recognition as a way to farm that boosts agricultural performance. Increase in crop yield in Mbeya maize yield increased 26–100%, sunflower by 360%; in Arumeru and Karatu the increase was 60–70%. Less labour needed: hand-hoe planting takes 3 people a day to plant 1 acre while one person using a hand jab planter takes 3–4 hours to plant the same area, Less labour for preparing land: in conventional agriculture operations are slashing, collecting and burning trash, and ploughing; in conservation agriculture slashing is the only operation. Soil erosion reduced: hence gullying and land degradation lessened, Soil fertility and structure improved: also improved water-holding capacity, High and stable yields: for example, conservation agriculture farmers in Babati went from 4 to 24 bags per acre; in the LAMP project, from 3–6 to 15–20 bags per acre and ARI-Uyole from 5–8 to 10–17 bags, Social interaction increased.

Status of technology in the country

CA is now adopted by over 10,000 farmers across the country. About 14,200 acres are currently under CA in Tanzania (mainly Northern Zone, Lake Zone, Southern Highlands, Southern Zone and Eastern Zone). Conservation Agriculture practices currently used by farmers in 2014 included, minimum soil disturbance (ripping, sub soiling); planting of soil cover crops (e.g. *Dolichos lablab,* Pigeon pea etc.)

Barriers

Main challenge has been availability of CA implements in the market and associated prices for farmers to afford. Adoption of conservation agriculture practices has been slow, with farmers adopting certain components only, such as covering the soil by mulching. Components adopted are partly based on what farmers see as feasible in their particular circumstances. In drier areas, drought, free-range grazing and harvesting of crop residue for various uses have made soil cover difficult to maintain.

Acceptability to local stakeholders

CA reduces soil erosion, regenerates soil fertility, increase food production income and food security and farmer's livelihood improvement. In areas where farmers have adopted CA, yields have increased, family welfare improved tremendously. Crop failures are a history for CA practitioners.

Endorsement by experts

MAFC in collaboration with FAO initiated a pilot project to introduce Conservation Agriculture for Sustainable Agriculture and Rural Development (CA-SARD) and a Technical Cooperation Project in six districts. Farm

Mechanization and Conservation Agriculture for Sustainable Intensification launched 4 years project. All these are in line with sector policy and vision 2025. There are other actors who have introduced CA in various parts of the country in collaboration with LGAs such as CARE international and CARITAS

Timeframe

Institutional capacity

Government extension staff serves vast areas, though they are expected to be in touchwith farmers regularly. They are hindered by inadequate knowledge on conservation agriculture, leaving the responsibility to the few with extensive knowledge. Yet they could greatly contribute in spreading and monitoring conservation agriculture as a daily duty. Conservation agriculture is a new technology as far as climate change impacts are concerned and the knowledge needs to be widely spread to enhance its adoption.

Adequacy for current climate

Droughts and/or long dry spells which currently are associated with climate change ispredicted to jeopardize food security in many communities that depends on rain-fed agriculture. However, the urgent measures to be taken to boost and sustain productivity and mitigate climate change impacts is conservation agriculture that will boost agricultural productivity by embracing minimum soil disturbance; maintenance of a permanent soil cover with mulch or cover crops; and practicing crop associations or rotations.

Size of beneficiaries group

CA has reached several stakeholders from different districts such as Kilosa, Mvomero, Mbeya, Arumeru, Karatu and Bukoba rural

Technology 3: System of Rice Intensification (SRI)

Introduction

The System of Rice Intensification (SRI) is a methodology aimed at increasing the yield of rice produced.It is a set of practices that change the way we manage the environment where rice is grown. This environment comprises of soil, water, and nutrients, and how they interact with the rice plant in order to improve its yield.SRI is NOT a new type of rice, nor does it modify the genetic make-up of rice. It is simply a combination of agricultural practices especially developed to improve the productivity of rice grown in paddies.

Technology

It is characterised by transplanting single younger seedlings at 8-12 days old with wide plant spacing of 25x25cm, minimum water applications during vegetative growth period, keeping soils moist but well-drained and aerated, frequent weeding with a simple mechanical hand weeder, and application of organic matter, in preference to chemical fertilizer.Unlike the conventional method of continuous flooding of paddy fields, SRI involves intermittent wetting and drying of paddies as well as specific soil and agronomic management practices.

Costs

This technology requires 70-90% less rice seeds, 20-25% less nitrogen fertilizer and chemicals than normal while increasing 10-15% of productivity. SRI helps to control pests and diseases (such as sheath blight, golden snail, root rots, etc.) while strengthening resistance to pathogens, and as a result, reducing costs of pesticide. Based on the CBA, SRI system is a promising Water Use Technology for smallholder farmers in SAGCOT with paying back all investment costs in the first year.Returns to land for improved traditional (Mkindo) under SRI tallied with the conventional scheme (Dakawa) at USD 700/ha – compared to unimproved traditional of about USD 300/ha (Evans *et al.* 2012).

Status

The System of Rice Intensification (SRI) is now gaining popularity among rice farmers in Tanzania. It has spread along the SAGCOT areas where irrigation rice production is common. These areas include Kilombero Plantations Limited, Mkindo and Dakawa in Morogoro However the SRI is also practiced in some isolated pockets in the Mwanza and Kilimanjaro regions. Following the successful implementation of SRI in these regions, there seems to be a growing interest to upscale SRI in other parts of the country

Potential development impacts, benefits

SRI methods are particularly accessible to and beneficial for the poor, who need to get the maximum benefit from their limited land, labor, water and capital. It gives higher yields more tons of rice per hectare; saves on inputs – over 75% less seed; about 25-50% less water; about 40-50% less fertilizer depending on the fertility status of the soil; makes use of what the farmer has. SRI ensures more water is available to more farmers and other beneficial uses

Barrier

The system is labor intensive especially for weeding. In small scale farmers family labour can be made effectively more productive through SRI. Also with respect to irrigation water requirement, SRI requires less water, but the water has to be available at regular intervals (every 5 to 7 days). SRI therefore requires complete control of irrigation which is not the case in most Tanzanian irrigation schemes (Katambara et al., 2013). Another complication is that if water is not available when the seedlings are ready for transplanting (8-12 days after sowing), then farmers will have to wait. In this case the farmers will have to use old seedling (up to 30 days or more) causing sub-optimal conditions for plant establishment. Another challenge is to organize the farmers within a particular irrigation scheme, and make them follow a uniform planting calendar, use of improved variety and use of proper fertilization Farmers attached to irrigation schemes will irrigate their rice when water is available. Introduction of SRI will be a challenge in cases of water shortage as the non-SRI farmers are likely to use most of the available water unless there are some agreements in the irrigation scheme. It is easier to introduce SRI if all the farmers in the scheme agree to practice intermittent flooding.

Acceptability to local stakeholder

SRI is most easily visualized in terms of certain practices that are recommended to farmers for trying out on their own rice fields to improve the productivity of their rice crop. These practices are based upon important insights and principles that constitute SRI. The current initiative to promote the adoption of SRI in Tanzania is a multi-stakeholder, participatory project combining research, capacity building and outreach activities.

Endorsement by experts

SRI promotes the growth and health of rice plant roots so that they grow larger and deeper, not degenerating for lack of oxygen in the soil, and also promotes abundance, diversity and activity of soil organisms bacteria, fungi, earthworms and other soil biota that improve soil fertility and contribute to plant growth and health

Institutional capacity

Despite the advantages associated with SRI, there are challenges related to technological, institutional, and financial and policy issues. Nearly 90 % of the farmers in Tanzania are smallholders and produce for own household consumption. One of the challenges is to transplant young seedlings in 25x25 cm grids within 20 minutes after uprooting. In a situation where the seedbed is distant from the rice field, it is sometimes a challenge for the seedlings to be transplanted within this short period. In addition, the seeds are vulnerable to rodents and other pests and therefore integrated pest management is necessary during the rice growing period.

Adequacy for current climate

Rice is one of the priority crops for agricultural development. Rice production in Tanzania is expected to reach 1.2 million ton of milled rice whereas the consumption needs are about 1.39 million ton.Rice in Tanzania is mainly grown under upland rain fed conditions (about 80-90 %), and about 10-20 % is grown in irrigation schemes. Given the impacts of climate change on water availability SRI has been introduced in order to enable farmers to adapt to climate change impacts and build resilience

Technology 4: Improved Seed Varieties

Introduction

Impacts of climate change such as prolonged dry spell, inadequate rainfall and persistence of pest and diseases has necessitated many farming communities to shift from the locally known seed varieties to improved ones. Drought is a major constraint to rain- fed crop production. Yield losses vary according to severity and type of drought. Prolonged drought at any stage and eruption of pest load and diseases has been resulting crop failure.

Technology characteristics

Improved seed varieties are characterized by early maturing, pests and drought tolerant meant to enhance resilience of crops to climate change hazards, particularly drought, extreme heat and shorter rain seasons. The technology reduces the risk of total crop failure and provides the producers with chances of dealing with the uncertainty created by climate change because they require relatively little rainfall

Status of the Technology in the Country

The technology has been developed and adopted by farmers in the country. However, the adoption studies have been on and are still on-going. Farmers are already using the drought tolerant varieties in drought prone areas to improve crop production under drought conditions. Government extension agents and NGOs such as CARITAS are promoting drought tolerant seed varieties for food security and Various research institutions such as Uyole=Mbeya and KATRIN- Ifakara are working out with different drought tolerant varieties of beans, maize and rice respectively so as to ensure resilience and food security in the country. Farmers using Farmers Field Schools have been promoting and practicing the use of improve seed varieties in order to scale up utilization, for example, the Eco-village in Chololo where improved seed variety of sorghum is being promoted. Generally, proportion of farmers who are aware of the new improved seed such as sorghum varieties ranges from about 16% in Lindi (Southern Tanzania), to as high as 80 % in Dodoma (Central Tanzania). Those with experience in growing these varieties also ranged from as low as 6% (Lindi) to as high as 6 2 % in Dodoma.

Barriers

Several factors can be identified that contribute to the low adoption rate (World Bank, 2012). First, despite the liberalized environment, a number of policy-level hurdles remain in the seed industry. Only recently did a government directive lift a restriction prohibiting private companies from producing their own foundation seed from public varieties, and local seed companies have difficulties accessing foundation seed from public varieties in a timely manner. Despite the passage of the new Seeds Act, the certification and release of new seed varieties is still slow, taking up to three years. Seed regulation is still weak in Tanzania and that monitoring is inadequate; fake seed can be found in the market. The other problem faced by local companies interested in investing in seed production in Tanzania relates to the high taxes on imports of packaging materials. Further, farmers still lack awareness about improved seed and their higher yields. Finally, certified seed is expensive: the seed-to-grain price ratio for hybrids is ten, the highest in East Africa, where the average is eight (Erenstein et al., 2011).

Acceptability to local stakeholders

Improved seed varieties are utilised by farmers aiming at incresing productivity and resilience towards climate change mpacts. Some of the improved seed varieties commonly used by farmers in the country includes Maize (TMV1, STUKA and KITO), Rice (NERICA1, NERICA 2), beans (Uyole), Sorghum (PATO, MARCIA etc). Various farmers have different opinions regarding these improved seed varieties. For example sorghum which is Africa's oldest food crop full of energy – giving nutrients, can replace maize flour in making stiff porridge (ugali). They have high nutritional value because when processed and packaged, they do not lose their nutritive value very fast, hence preferred by farming communities in highly drought affected areas. The direct and indirect benefits of drought tolerant seed varieties are water use efficiency improved; expands arable land; reduce soil erosion, improvement of soil fertility and improvement in food security.

Endorsement by experts

MAFC acknowledges that, increased use of modern inputs such as improved seeds is a pre-requisite for achieving sufficient agricultural production and growth to meet economic development, poverty reduction and food security and nutrition goals. And also private sector participation in multiplication of pre-basic and basic seed shall be promoted

Timeframe

Effects of improved seed varieties can be seen within two cropping season by observing both long and short rain seasons.

Institutional capacity

Tanzania enacted a new Seeds Act in 2003, with subsequent regulation signed in 2007, which encouraged private sector seed production and distribution (World Bank, 2012). The act established TOSCI (Tanzania Official Seed Certification Institute), now the sole agency for seed certification, quality control and other regulatory tasks. Other important recent legislation in Tanzania includes the Protection of New Plant Varieties (Plant Breeders Rights) Act of 2002 which established a plant variety protection (PVP) system based on the International Union for the Protection of New Varieties of Plants. However, these Acts are old enough to be reviewed and incorporate contemporary issues related to climate change impacts

Climate Change Adaptation Benefits

Improved seed varieties (citing sorghum as an example) requires relatively less rainfall. Comparing to other cereals such as maize, sorghum is less affected by pests. Sorghum grows well in arid and semi arid areas. Sorghum is not only drought tolerant but it is also adaptable to most of Tanzania's climatic zones and soils.

Size of beneficiaries group

Improved seed varieties are widely used for production of food crop in Tanzania. They are widely grown in three of the country's six zones, i.e. the Central, Western, and Lake Zones. In other zones cultivation of improved seeds such as sorghum is more localized but is nevertheless important in some districts, particularly in the Southern Zone. Sorghum and to a lesser extend millets are the main food security cereals in the central high plateau (Singida and Dodoma), and second in importance only to maize in the Western, Lake, and Southern Zones (Monyo et al. 2004). Sorghum is grown in low-potential areas unsuitable for maize and other cereals. Other seed varieties as mentioned earlier are widely grown throughout the country

Technology 5: Drip Irrigation

Introduction

Changes in climate have a significant impact on water quantity and quality. As a result, sectors that depend heavily on water, such as agriculture must find ways to adapt and use limited resources more efficiently. Drip irrigation can protect community from changing climate conditions, improve productivity and help in the more efficient use of threatened resources such as water.

Drip irrigation is one means used by farmers to effectively use water for agriculture as means of adaptation to deal with draught. Adoption of drip irrigation technology contributes to increase in net sown area, net irrigated area and thereby helping in achieving higher cropping intensity and irrigation intensity

Technology characteristics

Drip irrigation sometimes called trickle irrigation involves dripping water onto the soil at very low rates (2-20 liters/hour) from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants so that only part of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile. With drip irrigation water, applications are more frequent (usually every 1-3 days) than with other methods and this provides a very favourable high moisture level in the soil in which plants can flourish.

A typical drip irrigation system consists of the following components; Pump unit, Control head, main and sub-main lines, Laterals and emitters or drippers.

The pump unit takes water from the source and provides the right pressure for delivery into the pipe system.

The control head consists of valves to control the discharge and pressure In the entire system. It may also have filters to clear the water. Common types of filter include screen filters and graded sand filters which remove fine material suspended in the water. Some control head units contain a fertilizer or nutrient tank. These slowly add a measured dose of fertilizer into the water during irrigation. This is one of the major advantages of drip irrigation over other methods.

Mainlines, sub-mains and laterals supply water from the control head into the fields. They are usually made from PVC or polyethylene hose and should be buried below ground because they easily degrade when exposed to direct solar radiation. Lateral pipes are usually 13-32 mm diameter.

Emitters or drippers are devices used to control the discharge of water from the lateral to the plants. They are usually spaced more than 1 metre apart with one or more emitters used for a single plant such as a tree. For row crops more closely spaced emitters may be used to wet a strip of soil. Many different emitter designs have been produced in recent years. The basis of design is to produce an emitter which will provide a specified constant discharge which does not vary much with pressure changes, and does not block easily.

Status of technology in Tanzania

In Tanzania the technology in some areas is imported from Israel and Germany by various private companies in Tanzania which, markets the product and assists farmers with installation. The technology costs about US$450 for a 500 square meters system and there are also much cheaper low-head drip kits for even smaller plot sizes. In this case, drip irrigation seems to be gaining in popularity because of its low water use and minimum labour requirements and many districts dry regions have ambitious plans to promote it.

Drip irrigation technology has also been adopted in improving tea production for small scale farmers. Compared to rain-feeding, small scale drip irrigation improved tea yield by 40% and increased tea production from 1000Kg of tea/ha/year under rain-fed regime in 2010 to 4000Kg of tea/ha/year in 2012.

Potential development impacts and benefits

Economic, Costs, employment, and investment

Drip irrigation is expensive on investment, however, once initiated it can operate at a minmum cost in energy usage as it require low pressure and efficient use of fertilizer. Yield is at maximum.

It reduces the cost of cultivation mainly due to savings in labour costs and energy savings. There is a reduction in labour costs due to reduced costs of weeding.

The system reduces electricity costs as well because the same output can be obtained by using a low HP motor run for a short period of time every day. According to some estimates, the system can save electricity of 278 kWhr/ha for wide spaced orchard crops and 100 kWhr/ha for closely grown crops.

Social and

Drip irrigation has received considerable attention from policy makers because of its significant contribution towards resource saving, enhanced agricultural productivity and environmental sustainability.

The drip system technology is adaptable to terrains where other systems cannot work well due to climatic or soil conditions. Drip irrigation technology can be adapted to lands with different topographies and crops growing in a wide range of soil characteristics (including salty soils). It has been particularly efficient in sandy areas with permanent crops such as citric, olives, apples and vegetables.

Another significant social benefit of drip irrigation is real saving in irrigation water. This is mainly in the view of the scarcity value of the resource being acutely felt especially in semi and arid areas with growing competition from other sectors such as industry and urban drinking, in addition to that from farmers in other areas. Non-adoption of drip irrigation would force the farmers to use other means to sustain the income from crop production or led to conflicts.

Environmental Benefits

The drip irrigation helps in improving the soil surface and the environment.

It allows pretreated coal bed methane waters to flow into the root zone of an agricultural field which minimized environmental impacts by storing detrimental salts in the vadose zone.

It reduces off-farm movements of fertilizers and pollutants and improves the water use efficiency of irrigated agriculture. It offers potential water and nitrate fertilizer efficient and decrease ground water contamination by NO_3.

It helps prevent diseases that can set in when plants come into contact with too much water on their stems or leaves. This is because drip irrigation systems only release water by the plants roots and also reduces the chance of weed growth because the rows between stay dry.

Therefore by adopting drip water irrigation, smallholder farmers are able to increase the variety of crops on their farms and produce higher yields, resulting in greater food security and income opportunities.

Barriers

There is still lack of appropriate research and affordable technology geared towards poor farmers on small plots. This provides limited technical knowhow by the farmers regarding the use of this technology.

Pest attraction: Being the only green spot, especially during the prolonged dry spells, insects, rodents, squirrels etc find refuge in the drip raised crops.

Because of on-going maintenance, drip irrigation is notoriously considered high maintenance cost. This is particularly due to the land-scape maintenance practices surrounding the component surface systems in particular are susceptible to vandalism.

Cost to implement/adopt the system:

The system poses high cost of initial installation and the cost estimate includes:

- Costs for local material / equipment delivery to and service provider transportation to and from the job site.
- Costs to prepare the worksite for Drip Irrigation Installation, including costs to protect existing structure(s), finishes, materials and components.
- Costs for job cleanup and debris removal at project completion.
- Labor setup time, mobilization time and minimum hourly charges that are commonly included for small Drip Irrigation Installation jobs.

Technology 6: Terracing

Introduction

Terracing refers to a technique of landscaping a piece of sloped land into a series of successively receding flat surfaces or platforms, which resemble steps, for the purposes of more effective farming. This type of landscaping, therefore, is called terracing. Graduated terrace steps are commonly used to farm on hilly or mountainous terrain. Terraced fields decrease erosion and surface runoff retaining soil nutrients. Terraces contribute to increase in the farm productivity, fight against erosion and also contributed to poverty reduction (Mupenzi et al; 2012). The principal objective of terracing is generally to reduce the runoff and the loss of soil, but it also contributes to increasing the soil moisture content through improved infiltration and to reducing peak discharge rates of rivers.

Technology

Three types of terraces commonly used are bench terraces, contour terraces, and parallel terraces (Keirle, 2002; NRCS, 2004), although this subdivision mixes different criteria. Contour terraces follow exactly the contour lines of the terrain. Parallel terraces eliminate the production losses associated with contour terraces because they are constructed parallel to each other and, where possible, to the direction of field operations. Bench terraces usually consist of a series of level or nearly level platforms constructed along the contour lines of terraced slope (Ramos et al., 2007; Tenge et al., 2005.) Platforms are separated by embankments known as risers. The main task of level platforms (also known as benches) is to reduce the length of the slope and its steepness, so the amount and velocity of surface runoff is also being reduced and the nearly level platforms retain surface water and allow infiltration into top soils. Thus the erosion control and increased infiltration of rain water as well as limiting soil fertility loss are possible. Bench terraces also allow mechanized farming operations and improvement water management (irrigation).

Costs

Potential development impacts, benefits

Terracing reduces overland flow and contributes to water and nutrient conservation. It has been traditionally practiced in Tanzania but there have been modifications in techniques. Terraces have several environmental benefits which include; soil erosion control soil moisture improvement and maintenance; soil fertility improvement and maintenance biodiversity conservation and natural hazards (land slide) prevention. Stone terracing is an efficient and sustainable agriculture technique for smallholder farmers. It helps in soil-water retention and reduces erosion. The terraces also protect the crops from stray animals. A few cows could severely damage crops if they crossed a field which has not been stone-terraced. Local conditions and the dimensions, form and stability of the terraces determine the efficacy of terraces (Rufino, 1989). The efficiency of a terrace system increases by applying additional conservation practices such as appropriate land preparation (contour ploughing and sowing), appropriate cultivation of crops (e.g. strip cropping) and maintaining a permanent soil cover. Bench terraces appeared to be the most successful of the tested manners in retaining soil moisture, during both short and long rains. The mean soil moisture for bench terraces was 35.9% for short rains and 34.3% for long rains, while values noted for *Fanya juu* terraces, grass stripes and no-conservation were, respectively, 32.9% and 27.1%, 29.2% and 26.0% and finally 28.5% and 25.7% for short and long rains (Valentin et al., 2005).

Status

Contour terraces are commonly practiced in mountainous areas such as Uluguru-matombo, mgeta, Lushoto-Usambara Mountains and currently promoted in villages of Same District (Bangalala, Chome, Kwainka, Malindi, Tae and Vudee Juu) as well as. In addition to the contour terraces also contour irrigation ponds can be constructed to have water available also during the dry season as where community or villages are prone to crop failure

Barrier

The main observed barrier is the construction and maintenance costs as well as observed reduction of cropping area (Ramos et al., 2007), difficult access to credit by local farmers and the technology takes time to give returns. Terraces are labor-intensive and are mostly constructed by men. They may be communally or individually managed, and have tenure implications because they alter the landscape. They are limited mostly to hilly areas.

Acceptability to local stakeholder

Construction of bench terraces in some cases is inappropriate because the top soil remains to be too thin so that the construction exposed the infertile subsoil. In addition, the bench terraces hold back too much water and induced landslides. Luuk and Freddy (1997), recommend that if terraces are necessary to protect an area, a study should be carried out on the nature of the soils. However, contour terracing has proven to be successful to various farmers.

Endorsement by experts

Terraces are recommended by various stakeholders and promoted to be used with conservation agriculture practices that can lead to increased food security community resilience and environmental safeguard. D-LUP promote creation of a water break which reduces the formation of rills and gullies during times of heavy water run-off in a farm; which is a major cause of soil erosion. The water break also allows more time for the water to settle into the soil.

MAFC through department of Land Use Planning (D-LUP) recommend terraces.

Institutional capacity

MAFC consist of D-LUP which in collaboration with EMU are capable of implementing and promoting terracing in the country.

Adequacy for current climate

Water conservation in various ways including terracing system has repeatedly been identified as a priority measure for climate adaptation and increasing productivity of smallholder agriculture. This will enhance resilience to farmers and community at large.

Technology 7: Lined Irrigation

Introduction

Irrigation is an agricultural operation, supplying the need of a plant for water. Irrigation is necessary in a dry climate where natural rainfall does not meet plant water requirements during all or part of the year. Water resources are becoming scarcer and arable land has decreased tremendously due to population increase, unreliable rainfall caused by periodic droughts and lack of appropriate technologies to cope with the situation. Persistent droughts due to climate change have led to persistent threat of household food security and exacerbated poverty in the country. The importance of irrigation and efficient use water due to water scarcity is being addressed through development of more efficient irrigation systems. There is a wide variety of irrigation systems used in our country. This includes Surface Irrigation, Conventional Sprinkler Irrigation and Drip Irrigation. The predominant one is surface irrigation

Technology characteristics

It is characterized by the application of a specific amount of water at a particular location in order to meet the requirements of a crop growing at that location in amounts that are appropriate to the crop's stage of growth. Surface irrigation is common for large, medium to small holders; distribution is usually by lined and unlined canals. Lined irrigation ensures efficient water utilization and minimum water loss. Included in this category is the water harvesting or use of flood recession, which although informal but it's still considered as surface method. Furrows and basins are widely used in this. This system does give rise to salinity, but once attention is paid to adequate drainage, the problem is overcome.

Costs, including cost to implement adaptation options and cost of not modifying the project

Potential development impacts, benefits

Irrigation farming plays a significant role in food security and income generation as well as providing buffer to the local communities during drought periods which are currently frequent. Development of irrigation activities will transform agriculture into a stable, highly productive, modernized, commercial, and competitive that will generates higher incomes; increases food security and stimulates economic growth.

Status

The country has high potential of surface as well as ground water resources. For the purpose of effective management, planning and development of the water resources, the country is divided into nine water basins namely: Rufiji, Pangani, Ruvuma, Wami/Ruvu, Internal Drainage, Lake Rukwa, Lake Nyasa, Lake Tanganyika and Lake Victoria. These basins hold all the surface and groundwater in the country for all uses of water, including irrigation.

Barrier

Lack of well-articulated policy and strategy framework, poor understanding of the real resource endowment of the country, Low level of irrigation skills of the farmers; Low production and inefficient marketing systems to absorb the produce from irrigation farming; inadequate funding; low irrigation water use efficiency; ineffective and inefficient control of irrigation water which limits the application of the principles of Water Markets and Socio-Economic Mobility of Water use permit; inadequate irrigation production support services that is supported by research and technical innovation; inadequate farm power for various farm operations; inadequate data base for irrigation development; inadequate storage of water for irrigation; competing demand for water with other users such as Hydropower, domestic use, livestock and wild life and changes in river flow patterns as a result of catchment degradation and climatic changes.

Acceptability to local stakeholders

Rain-fed agriculture is affected by the vagaries of weather (droughts and floods) and will become exacerbated by climate changes that impact significantly on both the national economy and the vulnerability of smallholder farmers to food insecurity. Furthermore, food security and agricultural development are closely linked to availability and utilization of land and water resources through irrigation practices. Due to increasing pressure of population on food supplies, expansion of cultivated land and/or crop intensification particularly for irrigated agriculture is eminent. Tanzanian farmers are facing serious low crop production as a result of over dependence on rainfall which is inadequate and erratic. Irrigation development is therefore one of the means to solve this problem and will continue to be an important intervention for increased crop production for food security and economic growth.

Endorsement by experts

Existence of the institutional set up with qualified personnel with different disciplines related to irrigation such as Irrigation Engineers, Sociologists, Soil Scientists, Water Resources Engineers, Hydrologists, Environmentalist, Agronomists, Economists, Land Surveyors, Mechanical Engineers, and Irrigation Technicians. However, the number of personnel is inadequate. The Government is now giving high priority to irrigation development which is emphasized within the National policy frameworks. The Government is also giving high priority to the management of the nation's water resources. This offers strong synergies with irrigation development.

Institutional capacity

The existing institutions responsible for irrigation development in Tanzania are characterized by inadequate and weak data base; low skills and awareness on the roles and responsibilities of the stakeholders; inadequate financing; weak enforcement of by-laws; inadequate equipment, facilities and number of qualified staff as well as absence of irrigation legal framework. Linkages between relevant institutions are weak and their respective roles and responsibilities are not clearly defined to the detriment of effective irrigation development. However establishment of the Irrigation Commission which was launched 2015 might be part of the solution.

Adequacy for current climate

Rain-fed agriculture is affected by the prolonged drought and will become exacerbated by climate changes that impact significantly on both the national economy and the vulnerability of smallholder farmers to food insecurity. Adaptation option identified includes utilization of identified irrigation potential area amounting to 29.4 million hectares for sustainable irrigation development. Irrigation interventions have vital input in crop production and productivity to increase resilience, ensuring food security and increased income

Size of beneficiaries group

The development of irrigation sector has an unprecedented opportunity to facilitate the Tanzania agriculture sector to be transformed from subsistence to a modern and highly commercial sector. Therefore promotion of irrigation is considered to reach majority of farmers in the country.

ANNEX II: TECHNOLOGY FACTSHEETS FOR SELECTED TECHNOLOGIES IN WATER SECTOR

Technology 1: Increasing the Use of Water-Efficient Fixtures and Appliances

Technology: **Increasing the Use of Water-efficient Fixtures and Appliances**	
Introduction	In Tanzania the use of available water is not in efficiency manner, in view of the fact that massive amount of water in litters are lost daily due to use of inefficient appliances in different areas as well as households. Thus the use of water efficient appliances and fixtures in homes, industries, hospitals, learning institutions, hotels and mosques can contribute greatly to water conservation efforts as well as adaptation efforts to climate change impacts in water sector.
Technology characteristics	Water efficiency in the households or any building means using less water to provide the same level of service or to get the same result. While water efficient appliances are those that use less water to operate, such as fewer gallons per flush with a toilet. Water efficient appliances can be purchased or older appliances can be retrofitted to conserve water. The most common water efficient appliances include dishwashers and clothes washing machines; popular fixtures include toilets, showerheads, taps and faucets. However in order to insure this technology is adopted the following strategies are needed to be undertaken: • Mandates – mandating water efficiency standards for new construction and replacement of old fixtures and appliances; mandating use of water efficient products in government facilities. • Labeling – certification systems for water efficient products; adding the estimated cost of use, also called the "second price tag," to labels. • Tax incentives – for purchasing and installing efficient products; for retro-fitting and replacing older fixtures.
Costs including	
cost to implement adaptation options	Establishing a functioning certification process may be costly depending on existing capacity. The costs for individual households are generally small and may be fully recovered by water savings over the lifetime of the product. However the cost for establishing this technology will differ according to the kind of water efficiency appliance to be used.
Climate change adaptation benefit	This technology will help to reduce the amount ofclean water used in households and community in general consequently contributes to climate change mitigation by decreasing energy consumption and greenhouse gas emissions. Water conservation can lead to large savings in the energy used to transport, treat and distribute water
Economic benefits	Reduces public expenditures to household, community and institutions others that resulted from high water bills.
Social and Environmental benefits	The technology will result in reduction in the loss of water consequently reducing energy consumption and GHG emission.
Status of Technology in Tanzania	The technology is not well adopted in Tanzania, Only few large buildings in large cities like Dar es salaam and Arusha currently use this technology.
Barriers	The technology may be faced with the challenge of misrepresentation or corruption in a certification and labeling process. Establishing a functioning certification process may be costly depending on existing capacity of a country.

Acceptability to local stakeholders	It's expected that the technology will be accepted in a community and other sectors since water problems are affecting many communities both In rural and urban. Also through ongoing water campaign many citizen have been educated on the importance of water resource conservation and they are able to change behaviors and perception on water.
Endorsement by experts	Many experts like engineers, environmentalist and conservationist are supporting the technology as a means of ensuring the efficiency use of available water as well as adapting to changing climate.
Time frame	2 years
Institutional capacity	Standards could be adopted to introduce water efficiency appliances. Policy makers and residents must be educated. Also some Initiatives to promote water conservation by the use of efficiency appliance must be practiced in schools, industries, mosques, hotels and industries through media and by other means. Branding and marketing is necessary for any certification system so that residents know the label and associate it with quality and efficiency
Adequacy for current climate	The technology is very suitable for both current variability and future climate change. It empowers communities to adapt appropriately to water shortage influenced by seasonal and short duration rainfall conditions now and in the future.
Size of beneficiaries group	Local communities, industries, hotels, mosques and the country in general will benefit from this technology.

Technology 2: Water Reclaim and Reuse

Technology: Water reclaim and reuse	
Introduction	Demand of water in Tanzania quickly expands to exceed available supply. This quick increase is influenced more by the increasing population, industrial activities, agricultural sector and domestic uses. Water reclaim and reuse is one among of the integrated approach that consider municipal wastewater as a vital resource for appropriate applications, including agricultural and other irrigation, industrial and domestic uses. In this technology Water reclamation involve treatment or processing of wastewater to make it reusable with definable treatment reliability and meeting appropriate water quality criteria, while water reuse is the use of treated wastewater for a beneficial purpose.
Technology characteristics	Water reclamation and reuse approaches utilize the same treatment technologies as conventional wastewater treatment, including secondary clarifiers, filtration basins of various designs, membranes, and disinfection basins. Though it is likely that each and every water reclamation treatment scheme will require some degree of customization. The technology consist of the following applications during treatment of water;- first is sedimentation, second is biological oxidation and disinfection, and lastly include chemical coagulation, filtration and disinfection.
Costs including	
Cost to implement adaptation options	The financial requirements for implementing water reclamation and reuse programs will vary significantly based on the type of application that is planned for the reclaimed water. The approximate costs for application of pilot project will be around 600,000–800,000 USD.
Operation and maintenance cost over 10 years	Operational and maintenance costs will be around 200,000-250,000 USD per year.
Potential development impacts, benefits	

Climate Change Adaptation Benefits	This technology contributes to climate change adaptation at the sector level primarily through two mechanisms: • Water reclamation and reuse contributes to climate change adaptation by allowing water resources to be diversified and conserved. • Using reclaimed water for applications that do not require potable water like irrigating, flashing and constructing can result in greatly decreased depletion of protected water sources and prolong their useful lifespan. In addition, reclaimed water can be applied to permeable land surfaces or directly injected into the ground for the purpose of recharging groundwater aquifers and preventing saline intrusion in coastal areas
Economic benefits	• Reclaiming and reusing water in sector or country level can reduces the enormous cost of energy required to import water to different areas this will bring economic benefits. • Also users of reclaimed water can gain benefits through reduced water bills. This will result in additional water for irrigation thus the potential to promote development.
Social and Environmental benefits	• The reclaimed water can also contribute to productive and economic livelihood purposes. • Diversifying sources of water supplies. • Reducing energy consumption and GHG emission • Reclaiming and reusing water may allow communities to have alternative water source thus reduce pressure to fresh water sources.
Status of Technology in Tanzania	This technology is not well adopted in Tanzania. Collected waste water by municipals is usually either discharged into the nearby water bodies (ocean) or stored in the waste ponds. However very few institutions like Sokoine University of Agriculture (SUA) and Ardhi University are conducting this technology.
Barriers	• Weak institutional capacity and policy to allow implementation of the same. • Low awareness of environmental protection. • Lack of confidence in the quality of reclaimed water. • Lack of communication and collaboration between stakeholders • Many technologies are still under research; therefore the technology has not been fully commercialized.
Acceptability to local stakeholders	It is expected that through conducting a series of public education and campaign about advantage and safety of the reclaimed water, the technology will be accepted by the community. But these strategies must be done before installation of the technology.
Endorsement by experts	A number of research institutes are using it, Endorsed by water experts to Climate Change adaptation method.
Timeframe	3 years
Institutional capacity	A number of key capacity building elements are needed to ensure this technology well adopted in Tanzania, these are; • Human resources: Implementation of water reclamation and reuse approaches requires the strengthening of local water and wastewater personnel's technical and managerial ability to evaluate limitations of current practice, potential benefits and requirements of wastewater reuse as well as the fostering their capacity to implement new programs. • Policy and regulatory framework: It will be necessary for policies and legal frameworks that facilitate safe and appropriate reclamation and reuse programs to either be created or aligned in order to ensure protection of human health and the environment. • Institutions: National, regional, and local institutions will likely need to be supported in their efforts to identify ways in which they can improve effectiveness in regulating and managing water reclamation and reuse

	programs. • Financing: Financing opportunities and services for water reclamation and reuse initiatives will need to be expanded in order to facilitate such initiatives. It is also likely that the capability of utilities and potential users to understand and access these services will need to be improved. • Participation: Since public perception often determines the success or failure of water reclamation and reuse initiatives,civil society will need to be educated about the benefits of water reclamation and reuse as well as encouraged to participate in the decision-making process and implementation of such programs.
Adequacy for current climate	The technology is very suitable for both current variability and future climate change.
Size of beneficiaries group	Institutions such as hotels, universities, hospitals, prisons, industries can benefit from this technology. More than one /institution may use one reclamation system. It is estimated that at least 300 Sectors/institutes in the country could benefit from this technology, but it is suggested to start with a 'pilot' introduction of 100 sectors/institute.

Technology 3: Water Recycling and Reuse

Technology: Water recycling and reuse	
Introduction	Tanzania has the potential to recycle enough water to meet or reduce the requirements in different areas like households, industry, hotels or mosques were the use of water is in high rate. This is because more than half of the water used in these areas is suitable for reuse. Water recycling and reuse involves using untreated and uncontaminated wastewater for a second time. This water may come from bathtubs, showers, bathroom washbasins, clothes washing machines and laundry tubs for an appropriate purpose. This water recycling and reuse also offer cost-effective and multi- benefit solution. Recycled water in the community can be used for different purposes including outdoor irrigation, toilet flushing and commercial and industrial processes.
Technology characteristics	The technology requires the installation of dual plumbing so as to avoid confusion of mixing between recycled water and crean .Water to be recycled is carried in a pipes with different color (purple color is recommended) from the point of production or collection to the point of reuse or storage tank. Filters can also be installed to remove large particles and waste before water stored or reused. Several households may share one medium to large storage tank. Also major cities in Tanzania where new construction and buildings are substantially remodeled this technology may be introduced by installing the dual plumbing systems for recycled water.. The plumbing system can be connected to the city collection and storage infrastructure.
Costs including	
cost to implement adaptation options	A particular building/household will need to have specified plumbing system, where by purple pipes suggested to be used. If a household/building already has a suitable plumbing system for use as a collection system, storage containers are the major expense if needed. Estimated installation and maintenance cost are Cost per unit established = USD 1500 Total costs (35 000 units)= USD 5,250,000 The cost of recycled water may exceed that of fresh water but it is justified by the series of benefits water recycling provides
Potential development impacts, benefits	
Climate Change	Use of recycled water will contribute to reducing household water demand and

Adaptation Benefits	ease pressure on the main water supply, reducing upstream energy and environmental costs. less water usage and also reduce incidences of water shortage
Economic benefits	• Recycling existing water supplies can be less expensive than purchasing new supplies. Recycling and reusing water in sector or country level can reduces the enormous cost of energy required to import water to different areas this will bring economic benefits. • Also users of recycled water can gain benefits through reduced water bills. This will result in additional water for irrigation thus the potential to promote development.
Social and Environmental benefits	• The reycled water can also contribute to productive and economic livelihood purposes. • Diversifying sources of water supplies. • Reducing energy consumption and GHG emission • it saves high quality water for drinking, • it reduces the amount of polluted water released to the environment, it may have a quality making it suitable for specific uses (e.g. relative high nutrient contents may provide fertilizers through its use for irrigation.
Status of Technology in Tanzania	The use of recycled water in Tanzania for irrigation, toilet flushing, commercial, industrial processes and other purposes is applied but not common. Collected used water is usually discharged into the nearby water bodies. However, in some urban areas uncontrolled irrigation of vegetable gardens for commercial purposes, sometimes using untreated (recycled) wastewater, even though sometimes the use of this recycled water raise public health concerns. This technology has been done in the lower Moshi area reported to increased availability of water for paddy irrigation schemes.
Barriers	• Institutional capacity and policy is not strong; there are many overlapping views in the policies and cannot meet the fact. • Low awareness of environmental protection. • Lack of confidence in the quality of reused water. • Lack of communication and collaboration between stakeholders • Many technologies are still under research; therefore the technology has not been fully commercialized.
Acceptability to local stakeholders	It is expected that the technology will be accepted since in some urban areas uncontrolled irrigation of vegetable gardens for commercial purposes is conducted by using recycled water. However public education campaign can be conducted before installation of the technology and advice use of the recycled water by the community that will influence many people to accept the technology.
Endorsement by experts	Many experts including environmentalist and conservationist are supporting the technology as a means of ensuring the efficiency use of available water as well as adapting to changing climate.
Timeframe	2 years
Institutional capacity	• Institutions: National, regional, and local institutions will likely need to be supported in their efforts to identify ways in which they can improve effectiveness in regulating and managing water recycling and reuse programs. • Financing: Financing opportunities and services for water recycling and reuse initiatives will need to be expanded in order to facilitate such initiatives. It is also likely that the capability of utilities and potential users to understand and access these services will need to be improved. • Participation: Since public perception often determines the success or failure of water recycling and reuse initiatives, civil society will need to be educated about the benefits of water recycling and reuse as well as encouraged to participate in the decision-making process and implementation

Adequacy for current climate	The technology is very suitable for both current variability and future climate change. It empowers communities to adapt appropriately to water shortage influenced by seasonal and short duration rainfall conditions now and in the future.
Size of beneficiaries group	Several buildings, fields and institutions like Universities, industries, mosques, hotels, agricultural and households will benefit from this technology. It is estimated that at least 35,000 buildings/institutions in the country could benefit from this technology, but it is suggested to start with a 'pilot' introduction of 300 buildings/institutions.

Technology 4: Rain Water Harvesting From Roof

Technology: Rain water harvesting from roof	
Introduction	Climate variability and change threaten water supply in many ways, especially through climate stress on water availability, quality as well as water supply infrastructure. Rain water harvesting from roof can be a good method for households and institutions to confront the challenge of water availability. In Tanzania most precipitation that falls on human settlements is lost to the atmosphere through evapotranspiration or runs into rivers away from settlements before it can be used. However, if the rain is collected by using appropriate infrastructure, it can contribute greatly to the volume of freshwater available for human use.
Technology characteristics	Rainwater harvesting is the accumulating and storing of rainwater for use before it reaches the aquifer. Rooftop catchments is the most basic form of this technology and include collection of rainwater in gutters which drain to the collection vessel through down-pipes constructed for this purpose and/or the diversion of rainwater from the gutters to containers for settling particulates before the domestic use. The rooftop is the main catchment area, the amount and quality of rainwater collected depends on the area and type of roofing material. The salient features of rainwater harvesting from roof systems include: • A catchment surface where precipitation lands; • A conveyance system of gutters and pipes to transport and direct the water • A container to store the water for later use. Incorporating water quality protection adds one or more additional elements to system. Additionally water quality can be protected by adding one or more of the following: filtration/screening, chemical disinfection, or a "first flush" system. First flush systems discard the initial volume of a precipitation event in order to protect water quality
Cost Including	
cost to implement adaptation options	If a household or building already has a suitable hard roof for use as a catchment surface, storage container is the major expense. However two or more close households/building can share one large storage container so as to minimize cost, so the technology would require about USD 2,500cost to establish in one unit. The total required cost will be USD 6,000,000.
Additional cost to implement adaptation option, compared to "business as usual" (extra storage capacity)	Additional cost per unit = USD 10 Total additional costs = USD
Potential development impacts, benefits	
Climate Change	The technology contributes to climate change adaptation at the household and

Adaptation Benefits	institutional level primarily through two mechanisms: (1) Diversification of household water supply (2) Increased resilience to water quality degradation. It can also reduce the pressure on surface and groundwater resources (e.g. the reservoir or aquifer used for piped water supply) by decreasing household demand and has been used as a means to recharge groundwater aquifers. Another possible benefit of this technology is mitigation of flooding by capturing rooftop runoff during rainstorms. And the use of storage tank helps to reduce loss of water to the atmosphere through evaporation.
Economic benefits	• Creation of jobs to support construction of RWH systems and to provide training to users/households. • Can create investments in production of storage Containers • Reduce public and private expenditures associated with water infrastructure.
Social and Environmental benefits	• The use of this technology can provide significant savings for households that are sometimes forced to purchase vended or bottled water. • Stored rainwater is a convenient, inexpensive water supply close to the home. This can greatly decrease the time spent fetching water or queuing at water points. • Rainwater harvesting can reduce exposure to waterborne pathogens by providing improved potable water quality and high quality water for other household purposes including hygiene, bathing and washing. • It will also reduce overexploitation of ground and service water with consequent environmental benefits
Status of Technology in Tanzania	Rainwater harvesting particularly from rooftops is not a new technology in Tanzania. Although the size of intervention in individual household, community and zonal is very low the technology is used to increase source of water in many parts of the country especially in urban areas like Dar es Salaam and Dodoma where there is water scarcity. The applicability of this technology is limited in Tanzania due to lack of capital for construction of reservoirs, buying gutters and pipes for its installation. In rural areas this technology is not common although few institutions such as schools, hospitals, mosques and churches have facilities for rainwater harvesting.
Barriers	• Lack of proper operation and maintenance of the systems due to inadequate skills of the users. • Costs and affordability: Poor communities cannot afford construction of storage tanks. • Harvested rainwater quality is affected by the roofing material on the catchment surface
Acceptability to local stakeholders	It's expected that the technology will be accepted since it not new in eyes of the citizen. There is a wealth of experience on rainwater harvesting in the country and several donor-funded projects have done research in this area.
Endorsement by experts	This technology has been certified by many experts as a means of ensuring the continuous availability of clean water in the dry season for both rural and urban communities.
Timeframe	2 Years
Institutional capacity	Basic RWH involves collection, management and use by individual households/institutions and there are few if any institutional requirements. However, storage containers usually show strong economies of scale. Therefore, groups of households can often benefit by directing rainfall to one

	or larger, shared storage containers.
Adequacy for current climate	The technology is Very suitable for both current variability and future climate change.
Size of beneficiaries group	It is estimated that at least 3,000 buildings including Universities, industries, mosques, hospitals and hotels apart from households will benefit from this technology.

Technology 5: Borehole Drilling

Technology: Borehole drilling	
Introduction	A borehole is simply a deep narrow well usually driven by an electric pump that taps into the underground stores of water held in permeable rock known as aquifers. Boreholes are one of source of potable water supply in Tanzania though their numbers are still inadequate due to high drilling cost. Increasing access to groundwater is a key strategy for household water supply (both potable and non-potable) during drought. Some of the existing ones have concrete protection against contamination from flood waters.
Technology characteristics	The borehole is completed by installing a vertical pipe (casing) and well screen to keep the borehole from caving, this also prevent surface contaminants from entering the borehole and protects any installed pump from drawing in sand and sediment. Protected wells can potentially provide a water supply that is highly resilient to flooding and ensure that clean water is available to communities during dry periods.
Status of technology in Tanzania	Tanzania has a high potential for boreholes in terms of hydrology, the technical range of groundwater abstraction is quite wide. A high percentage of sites are suitable for dug-wells and hand-augered boreholes, Drilling equipment ranges from very lightweight rigs to large truck mounted rigs. Boreholes drilled for domestic water supplies indicate variable yields. Some boreholes in the Dodoma plain have exceptionally high yields of about 460m^3 /hr. The average yield of boreholes (excluding Dar es Salaam and dry boreholes) is 11m^3 /hr. The average static water level of productive boreholes is about 17 meters and the average total depth 62 m^3.
Potential development impacts and benefits	
Economic,	- Can create employment opportunities
Social and Environmental	- Availability of good quality water for domestic use. - Reduce consumption costs of vended water. - Promotes health by reducing water borne diseases. - Saves time spent by women in search of water. - Reduces risk of children skipping school
Barriers	- There is insufficient number of well trained drillers and hydro-geologists. - Drilling operators have not been able to make sufficient investments into new equipment. The equipment is ancient and unreliable. Frequent breakdowns slow down the performance. - Lack of private sector consultants: The market for Technical Service Providers and private consulting companies is still very young. It will take some time before a consulting capacity

	emerges that meets the demands and needs of District Water Engineers. - Lack of capital: Nearly all drillers have not enough cash and not enough confidence into the market to invest in new equipment.
cost to implement adaptation options	Costs of drilling a boreholes vary widely depending aquifer depths and design of a borehole in a specific geological formation. However, in Tanzania the average cost of drilling and installing a borehole per unit on dry area is US$ 48,500.
Adequacy for current climate	Boreholes have much greater resilience to drought than traditional water supplies including springs, hand dug wells and surface water sources. In many regions, groundwater is the only perennial source of water supply.
Size of beneficiaries group	One borehole can be shared by several households, hospitals, schools and industries if it yields enough water per hour and the storage tank is large.

Technology 6: Household Drinking Water Treatment and Safe Storage (HWTS)

Technology: Household Drinking Water Treatment and Safe Storage(HWTS)	
Introduction	HWTS increases resilience to water quality degradation by enabling users to improve water quality at the point of use. Degradation of water quality is expected to be one of the key impacts of climate change on water resources and water supply. For centuries, households have used a variety of methods for improving the appearance and taste of drinking-water. Even before germ theory was well established, successive generations were taught to boil water, expose it to the sun or store it in metal containers with biocide properties, all in an effort to make it safer to drink.
Technology characteristics	The best way to reduce the risks associated with drinking unsafe water is by using the multi-barrier approach. Each step in this approach, from source protection, through water treatment to safe storage, provides an incremental protection against unsafe drinking-water. The concept of the multi-barrier approach is also addressed as part of water safety plans, the principles of which can be applied at both community and household levels. Both community and household systems follow the same basic water treatment process: sedimentation, filtration and disinfection. A typical community-level system that relies on surface water, for example, may incorporate source protection (drawing water from a deep inlet away from shore), assisted sedimentation (using coagulants), filtration (rapid sand) and disinfection (with ozone and chlorine to minimize recontamination during distribution).
Status of technology in Tanzania	Household water treatment such as boiling and filtration (using cloth material) is highly practiced in Tanzania. Popular treatment technologies used in Tanzania include chemical disinfectants, biological sand filters and boiling. Tanzania's efforts to achieve this include introducing incentives for HWTS products, integrating HWTS into existing interventions such as school health programs, conducting a national campaign advocating for HWTS and establishing performance evaluations for HWTS products (MoH, 2012).
Potential development impacts and benefits	
Economic	- Creates business opportunities to people selling water disinfectants and storage vessels.

Social	- Availability of good quality water for domestic use. - Promotes health by reducing water borne diseases.
Environmental	- HWTS increases resilience to water quality degradation by enabling users to improve water quality at the point of use.
Barriers	- Expenses of buying water treatment disinfectants - Shortage of awareness towards water users on how to treat and store drinking water.
Cost to implement adaptation options	
Initial purchase cost	Free or low cost since households can use any container estimated as US$ 100 per unit.
Operating cost	On-going cost to buy chemical coagulants and to repair • Filters once they are worn out as they are used US$ 30 for concrete filters; US$ 75 for plastic filters. • On-going cost to buy chlorine products; US$ 50 depending on product Total cost to adopt this technology will be US$10,000
Institutional capacity	Drinking water treatment and safe storage provides a means to improve the quality of water for those with unsafe drinking water by treating it in the home therefore awareness should be provided to people on how to treat and store drinking water as well as protecting water sources
Adequacy for current climate	Degradation of water quality is expected to be one of the key impacts of climate change on water resources and water supply therefore HWTS will increase resilience to water quality degradation by enabling users to improve water quality at the point of use.
Size of beneficiaries group	Currently water treatment is conducted in some households but this technology needs to be intensified to schools and hospital so as they may access potable water for students and patients. Therefore it is suggested to start with a pilot introduction of 500 schools and 100 hospitals in all regions.

Technology 7: Leakage Reduction Program

Technology: Leakage Reduction Program	
Introduction	Leakage is a way for fluid to escape a container or fluid-containing system, such as a tank or a pipe. Leaks are usually unintended and therefore undesired, leakage can happen in three different ways such as: *Leaks*; refers to water lost through leaks on the pipe network before the customer's meter. *Bursts*; refers to the water lost through bursts in the pipe network. *Over Flows and Leaks at Storage Tanks*; refers to the water lost through leaking overflows and or leakage of water storage facilities. A warmer climate is highly likely to result in more frequent drought. Additionally, growing population will push many countries into water stress and water scarcity in the coming decades. Detection and repair of leaks in water systems is an important part of comprehensive strategies to reduce pressure on existing water resources. Reducing water use in municipal systems also contributes to climate change mitigation by decreasing greenhouse gas emissions.
Technology characteristics	**1.Passive observation** This method has been the most practiced in Tanzania, It includes;

	• Responding to running or spouting water • Responding to low pressure identified by customers or during routine inspections. • It is useful to locate only obvious leaks or breaks (e.g. break of sufficient size or duration that water reaches the surface) A leak identification team should have a team leader and plumbers. Tasks to be carried out by the leak detection team encompasses: Leak searching by combing of the whole network to identify any visible leaks and Sketching the leaks identified and reporting to the leak repair/maintenance team. **2.Physical leak detection** This technique uses electronic listening equipment to detect the sounds of leakage. The equipment has a piezoelectric sensor, a high fidelity earphone set, a receiver box and a mechanical component in combination with the sensor power rating. As pressurized water is forced out through a pipe, a leak loses energy to the pipe wall and to the surrounding soil area. This energy creates audible sound waves that can be sensed and amplified by electronic transducers/ piezoelectric sensor. The sound waves are evaluated to determine the exact location of the leak. Audible sound transducer is placed in contact with ground surface to assist in locating where the sound of leakage is loudest.
Status of technology in Tanzania	The major problem for water provisioning in Tanzania is that large amount of water are lost physically in pipe leakages. Common causes of leakage in Tanzania • Aging pipes • Corrosion of internal and external surfaces of pipe network. • Poor design (materials selection, sizing, layout). • Damage to exposed pipes especially during roads construction, it is worsened if the pipes are on the surface or less than 3 feet deep.
Potential development impacts and benefits	
Economic, Social and Environmental	- Reduced Operational costs– less travels to the field to repair leaks / bursts. - Reduces water losses - More water available for consumption and therefore increased revenue. - Reliability of water supply – minimized water supply interruption due to repairs - Provision of reliable water quality as water cannot get contaminated.
Barriers	It is very expensive to conduct leak detection process and requires skilled and trained personnel.
cost to implement adaptation options	The costs of leak management, detection and repair include staff training, management, labor and equipment. Cost for initial assessment is estimated to be 300,000 US$. Operational and maintenance costs will be around 15,000 US$.
Size of beneficiaries group	All connected users including households, mosques, hospitals and industries will benefit from municipal water that will be saved from leakage and supplied to users.

Technology 8: Desalination of Water

Technology: Desalination of water	
Introduction	Over 97% of the water on earth is unsuitable for human consumption due to its salinity. The vast majority (about 99%) of this is seawater, with most of the remainder consisting of saline groundwater. Purification of this saline water holds the promise of nearly unlimited water resources for human civilizations in coastal regions. Desalination refers to those processes which reduce the quantity of dissolved substances in the water. We all know that sea water tastes excessively salty and that in normal circumstances it cannot be drunk or used for normal domestic purposes such as washing and cooking. However, if this salt content could be reduced it would then be possible to produce water suitable for drinking and other domestic purposes. Water scarcity and quality issues pose significant burdens to sustainable development in Africa. Although the continent receives 3991 km3 of renewable freshwater resources per year, 300 million people (a third of Africa's population) are living under conditions of water scarcity (Garrity et al., 2005). However desalination is a promising technology that can alleviate the water scarce issues because it can reduce salt dissolved compounds to a quality that can be used by the community.
Technology Characteristics	A desalination process essentially separates saline water into two parts, one that has a low concentration of salt (treated water or product water) and the other with a much higher concentration than the original feed water, usually referred as brine concentrate or simply concentrate. Solar distillation and reverse osmosis are the two suggested technologies to be introduced in Tanzania; Solar distillation: has been around for many years and is simple technology suitable only for small outputs. Heat from the sun warms the sea water in a glass-covered tank causing some to evaporate. The vapor is condensed on a glass cover and the resultants fresh water is collected. A well maintained solar still produces about 8 liters for every square meter of glass, so the area required for about 4 people would be 130-260 square meters. Reverse Osmosis: in this technique seawater is pumped under pressure across the surface of the membrane, water molecules diffuse through the membrane leaving a concentrated brine solution on the feed side of the membrane and fresh water on the low pressure product side. Reverse osmosis membranes are manufactured from modern plastic materials in either sheets or hollow fibers
Status of the technology in Tanzania	Plans are underway for water authorities in Dar es Salaam to work with an Israeli consortium in constructing two reverse osmosis desalination plants to alleviate water shortage. The plant will supply 100 million cubic meters of desalinated water per day. The plants will be the first among desalination plants to be built in the country. The initiative to venture into building desalination plants aims to reduce over dependence on water from the Ruvu River. The company had already submitted its report after undertaking thorough investigations and a contemporary analysis. The surveyed areas are Mbezi-Ununio and Kigamboni, places that they recommended the desalination plants to be built(MoWI 2011)
Potential development impacts and benefits	
Economic	Access to an adequate supply of freshwater for drinking, household, commercial and industrial use is essential for health, well being and economic development.
Social	Saves time spent by women and reduces risk of children skipping school in search

	of water. Reduces water borne diseases.
Environmental	Desalination technologies also provide resilience to water quality degradation because they can usually produce very pure product water, even from highly contaminated source waters.
Barriers	It is expensive therefore only few households will afford to use it. Solar distillation is not suitable for large scale production of water. There is insufficient number of well trained personnel to establish desalination technology.
cost to implement adaptation options	Costs of installing a desalination plant vary widely depending energy, scale of the plant and salt content present in water. However, in Tanzania the average estimated cost of a unit desalination plant is US$ 500,000,this includes initial installation and maintainance cost.
Adequacy for current climate	Desalination can greatly aid climate change adaptation, primarily through diversification of water supply and resilience to water quality degradation. Diversification of water supply can provide alternative or supplementary sources of water in drought times.
Size of beneficiaries group	Solar Distillation is suitable for few households whereby 5 households can organize and share a single glass-covered tank which will help in treatment. Reverse Osmosis plants can be used either in the home or on small ships to large industries and municipal units for

ANNEX III: LIST OF STAKEHOLDERS INVOLVED AND THEIR CONTACTS

SN	Name	Contacts	Approach of consultation
1	Shakwanaande Natai	Ministry of Agriculture Environmental Management Unit aikarua@gmail.com	Meeting
2	Remegius Rushomesa	Ministry of Agriculture Irrigation Commission rushoman@yahoo.com	Meeting
3	Godwin Mubi	Ministry of Agriculture Department of Mechanization god_mubi@yahoo.com	Meeting
4	Charles Yongolo	Ministry of Agriculture Department of Reserch and Development csyongolo@yahoo.co.uk	Meeting
5	Godfrey Edward	Ministry of Agriculture Department of training Godfreyedward9@gmail.com	Meeting
6	Miccah Songaleli Sethi	Mikocheni Agriculture Research Institute (MARI) micahgunah@gmail.com	Interview
7	Andrew Ngereza	Mikocheni Agriculture Research Institute (MARI) jngereza@yahoo.com	Interview
8	Onasimbo A. Ntikha	Ministry of Agriculture Food Security & Cooperatives Principal Economist onasimbo.ntikha@gmail.com	Interview
9	Eng S. Kissina	Ministry of water Environment Unit Kissinas90@yahoo.com	Interview
10	Henschel Christian	GIZ Tanzania christian.henschel@giz.de	Interview
11	Conrad Ndomba	Min of Livestock development, and Fisheries conradndomba@yahoo.com	Interview

List of Stakeholders Workshop on Climate Change Technology Needs Assessment-Sector Prioritization held at Giraffe Ocean View Hotel, Dar es salaam on 29th – 30th September, 2015.

S/NO	Names	Institution	Contact
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