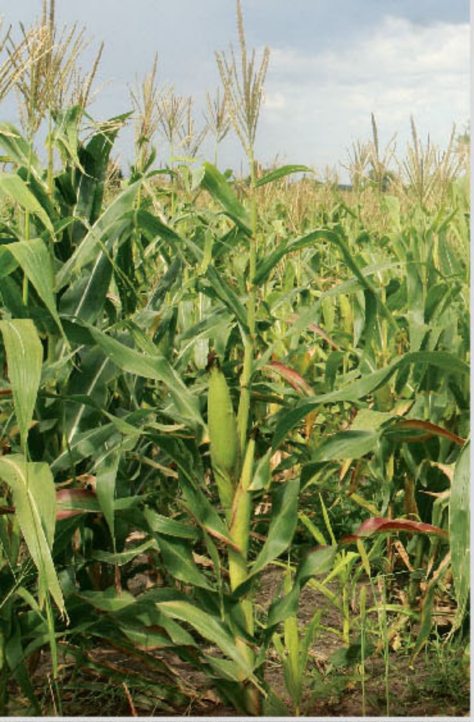
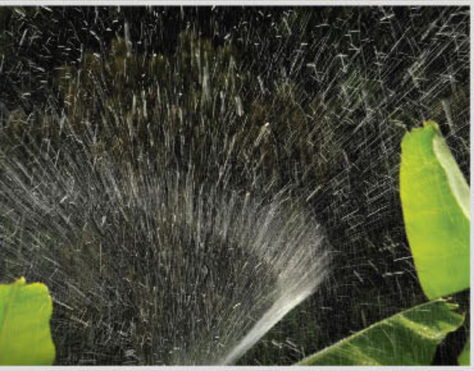
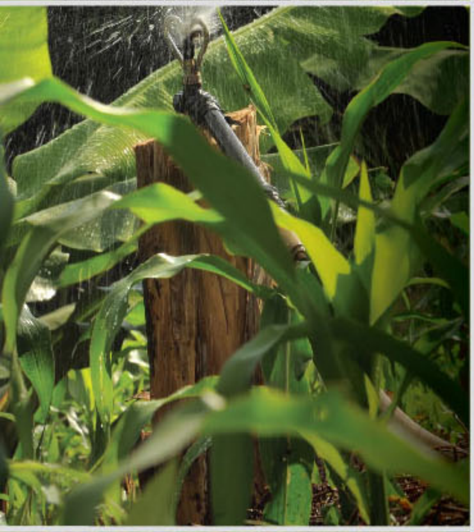


THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF AGRICULTURE LIVESTOCK AND FISHERIES

CLIMATE - SMART AGRICULTURE GUIDELINE





May, 2017

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THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF AGRICULTURE LIVESTOCK AND FISHERIES

CLIMATE - SMART AGRICULTURE GUIDELINE

May, 2017

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FOREWORD

Tanzania is already experiencing adverse impacts of climate change. Recently, climate change has become a bigger challenge suppressing and distorting efforts to improve productivity in the agricultural sector and subsequently affecting national food security and development initiatives.

In response to climate change, the country has been undertaking various efforts towards addressing climate change in accordance with its national context. For example, the National Climate Change Strategy (2012), aims to enhance Tanzania's adaptive capacity to climate change.

The Agriculture Climate Resilience Plan (2014-2019) identifies and responds to the most urgent impacts posed by climate variability and climate change on the crop subsector. The recently developed National Climate-Smart Agriculture Programme (2015 – 2025) aims to accelerate uptake of CSA in the country to increase productivity and climate resilience in the agriculture sector (crop, livestock and fisheries), but also in reduction of greenhouse gas emissions.

Tanzania is compliant to CAADP and Malabo Declaration as well as the 2011 Johannesburg Communiqué, which urges African countries to invest in facilitating adoption of CSA practices and approaches. In recognition of the CSA potential to contribute to a triple win for food security and climate change adaptation and mitigation, Tanzania is ready for implementing CSA practices and approaches. Development of the CSA guidelines is a step towards achieving the global and national goals of sustainable agriculture production in a changing climate.

The guideline is important to all stakeholders especially extension officers and smallholder farmers, as it will provide guidance for adaptation and mitigation in building resilience of agricultural farming enterprises; improving and increasing agricultural productivity and sustainability.

In this regard, it is our hope that the CSA guideline will go a long way in providing guidance for implementation of the agricultural sector's programmes and present a wide range of technologies and practices that are climate-smart with the intention to provide an opportunity for up-scaling the most promising ones in the country.

The Ministry would like to thank all those who participated in one way or another in developing this important document that would transform Tanzania agricultural sector through the climate-smart agriculture approach.

Hon. Dr Charles J. Tizeba (MP)

MINISTER FOR AGRICULTURE LIVESTOCK AND FISHERIES

ACKNOWLEDGEMENT

The preparation of the Climate-Smart Agriculture Guideline involved a number of individuals who worked determinedly to ensure that the preparation was a success.

I am equally indebted to all stakeholders and development partners at various stages during the preparation of this guideline. It is difficult to mention all their names but they provided valuable inputs in the course of further reshaping, editing and improving this guideline.

I also recognize and appreciate the tireless efforts of the Ministry of Agriculture Livestock and Fisheries (MALF) experts led by Ms S. Natai (Head of the Environment Management Unit) and coordinated by Prof H. Mahoo from Sokoine University of Agriculture (SUA); Mrs M. Majule, Mrs T. Massoy, Ms T. Malavanu, Ms Z. Sheuya, Mr S. Mbaga, Mr M. Malozo; Mr J. Mbogoni Ms L. Chacha, Mr R. Likiligo, Mr F. Banzi, and Mr M. Nzalawahe. Other experts include Dr L. Ssendi from President's Office-Regional Administration and Local Government (PO-RALG), Mr D. Nkondola Vice President's Office- Department of Environment (VPO-DoE), Mr M. Ndaki from Tanzania Meteorological Agency (TMA); Ms M Bura from Ministry of Water and Irrigation (MoWI) and Mr N. Mkarafuu from Ministry of Agriculture, Natural Resources Livestock and Fisheries (MANRLF) of Zanzibar. I would also like to thank experts from International Organizations; Dr A. Kimaro and Mr M. Mpanda from The World Agroforestry Centre (ICRAF); Dr J. Recha, Mr D. Lopa and Dr A. Kitalyi (Independent experts).

In a very special way, I would like to thank the respondents of the survey that was conducted as part of the process of developing this guideline. These include the District Executive Directors in all Local Government Authorities visited, District Agriculture officers, Ward and Village leaders and farmers.

Last but not least, I do acknowledge and appreciate the technical and financial support provided by the Food and Agriculture Organization of the United Nations (FAO) and VUNA Programme. Special thanks go to Ms K. Karttunen and Ms J. Rioux (FAO-Rome), Ms Joyce Mulila Mitti (FAO-SFS) and Ms M. Lwakatare and Mr D. Kalisa (FAO-Tanzania), Dr G. Wamukoya and Dr J. Recha (VUNA Programme) for their support during the development of this guideline.

Finally, I would like to take this opportunity to thank FAO for their great efforts in steering the development of the CSA Guideline and assure them of our heartfelt appreciation and that we value their cooperation and support.

Eng. Mathew Mtigumwe
PERMANENT SECRETARY

ACRONYMS

ACRP	-	Agriculture Climate Resilient Plan
AEZ	-	Agro-Ecological Zone
AEAs	-	Agricultural Extension Agents
ARI	-	Agriculture Research Institutes
ASDP	-	Agriculture Sector Development Programme
CA	-	Conservation Agriculture
CAADP	-	Comprehensive African Agriculture Development Programme
CBO	-	Community Based Organization
CARMATEC	-	Centre for Agricultural Mechanization and Rural Technology
CSA	-	Climate Smart- Agriculture
CSOs	-	Civil Society Organizations
DADPs	-	District Development Plans
DCC	-	District Consultative Council
EMU	-	Environment Management Unit
EWS	-	Early Warning System
FAO	-	Food and Agriculture Organization of the United Nations
FFS	-	Farmer Field Schools
FYM	-	Farm Yard Manure
GAP	-	Good Agricultural Practices
GCM	-	Global Circulation Model
GDP	-	Gross Development Product
GHGs	-	Green House Gases
ICRAF	-	International Centre for Research in Agroforestry
IK	-	Indigenous Knowledge
IPCC	-	Intergovernmental Panel on Climate Change
ISFM	-	Integrated Soil Fertility Management
M&E	-	Monitoring and Evaluation
MAFC	-	Ministry of Agriculture Food Security and Cooperatives
MALF	-	Ministry of Agriculture Livestock and Fisheries
MICCA	-	Mitigation of Climate Change in Agriculture
NAMA	-	National Appropriate Mitigation Actions
NAPA	-	National Adaption Programme of Actions
NARS	-	National Agricultural Research System
NGO	-	Non-Governmental Organization
PO-RALG	-	President's Office, Regional Administration and Local Government
RCP	-	Representative Concentration Pathways
RWH	-	Rain Water Harvesting
SPSS	-	Statistical Package for the Social Sciences
SRI	-	System of Rice Intensification
SUA	-	Sokoine University of Agriculture
TMA	-	Tanzania Meteorological Agency
ToR	-	Terms of Reference
VPO	-	Vice President's Office
URT	-	United Republic of Tanzania

GLOSSARY

Adaptation (to Climate Change)
Adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects.

Agricultural sector
"Agricultural sector" in this guideline includes crops, livestock and grasslands, agro-forestry, fisheries and aquaculture.

Agricultural Technology
Agricultural technology are the tools and machinery that are used primarily or entirely in order to support agricultural enterprises. Agricultural technology refers to highly productive, high quality, efficient and resource-saving (water, energy, labour, etc.) techniques and expertise for agricultural production. It also refers to techniques appropriate for the protection and improvement of the environment

Agricultural Practices
Agricultural practices refer to management activities at the farm and landscape level.

Agro-climatic zones
In the context of this Guideline, Agro-climate zones of Tanzania are based on the comparison between rainfall and the water requirements of the vegetation or crops using the amount of rainfall that can be expected to be reached.

Agro-ecological zones
Agro-Ecological Zones are defined as homogenous and contiguous areas with similar soil, land and climate characteristics. "Agro-Ecological Zones", is the standardized framework for the characterization of climate, soil and terrain conditions relevant to agricultural production.

Climate-Smart Agriculture
Climate-Smart Agriculture (CSA) is defined as 'Agriculture that sustainably increases productivity and income, increases the ability to adapt and build resilience to Climate Change and enhances food and nutrition security while achieving mitigation co-benefits in line with national development priorities. CSA includes both traditional and innovative practices, programmes, institutions, policies and finance. The techniques and practices are site-specific based on the farming systems, climatic impacts and farmers' livelihoods and socio-economic conditions.

Gender
Gender refers to the culturally and socially determined characteristics, values, norms, roles, attitudes and beliefs attributed to women and men through constructed identity in a society. Gender relationships differ from one social setting to another and can change from time to time. Gender roles are the 'social definition' of women and men (FAO, 2015). They vary among different societies and cultures, classes, ages and during different periods in history. Gender-specific roles and responsibilities are often conditioned by household structure, access to resources, specific impacts of the global economy, and other locally relevant factors such as ecological conditions. gender relations are the ways in which a culture or society defines rights, responsibilities, and the identities of men and women in relation to one another.

Livelihood
Livelihood is a means of making a living that encompasses people's capabilities, assets, income and activities required to secure the necessities of life.

Mitigation (of Climate Change)
Mitigation refers to efforts that seek to prevent or slow down the increase of atmospheric GHG concentrations by limiting current and future emissions and enhancing potential sinks for GHG

CHAPTER 1: INTRODUCTION

1.1 Climate Change Impact on Agriculture

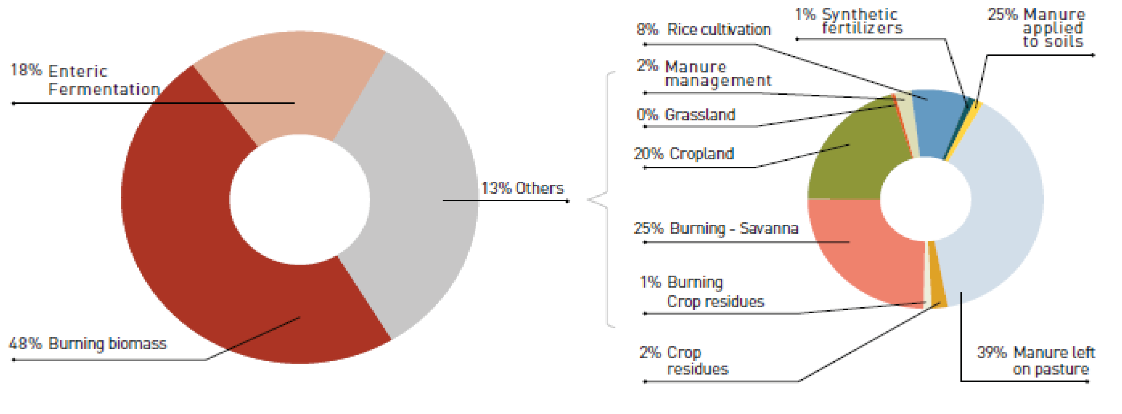
Agriculture in Tanzania is the largest sector in the economy, which accounts for about half of GDP and export earnings. The sector employs 77.5 per cent of the population, provides livelihood to more than 70 per cent of the population and contributes about 95 percent of the national food requirements (URT, 2014). Agricultural production however varies across food crops, cash crops and livestock while for 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. The recent annual average growth rates of export crops, food crops, and livestock was about 6, 4, and 3 percent respectively.

Although agriculture sector is key driver of social and economic development in Tanzania, it is hampered by low productivity and persistent poverty mainly because the majority of households still produce at subsistence level. Despite having a rich base of natural resources, agriculture in Tanzania is mainly rain fed hence more susceptible to climate change impacts. Globally, climate change has been occurring at increasing rates in the last 30 years, particularly in the last decade with significant impacts on natural resources and agriculture. Climate change has resulted into a general decline in agricultural productivity, including changes in agro-diversity. The prevalence of crop pests and diseases is also reported to have increased posing more challenges to agriculture. Studies by the Tanzania Meteorological Agency (TMA) indicated that some of the previous highly productive areas such as the southern and northern highlands will continue to be affected by declining rainfall, frequent droughts and significant increase in spatial and temporal variability of rainfall with long term implications in the agricultural sector planning and resource allocation and even the shifts in types of agricultural products (URT, 2009).

Observed changes in temperature and rainfall patterns in the agricultural sectors have led to degradation of water and land for agriculture. The magnitude of the impact of climate change and variability is contingent upon the vulnerability and adaptive capacity of the affected people and economic sectors. Tanzania like other developing countries has started to experience impacts of climate change and variability. The Agriculture Climate Resilient Plan (2014) has identified five key areas of concern for crop production: (i) Low rainfall areas (ii) Higher rainfall areas (iii) Pests and diseases (iv) land management and (v) Water availability.

1.2 Agriculture Impact on Climate Change

Land use changes significantly contribute to climate change. Large-scale changes such as deforestation contribute to increased carbon dioxide concentrations in the atmosphere. Soil erosion by water, wind and tillage affects both agriculture and the natural environment. Soil loss, and its associated impacts, is one of today's most important environmental problems. Tanzania currently has very low emissions of Greenhouse Gases (GHG), in total and per capita. The published inventory for 1994 puts per capita emissions at 1.3 tonnes of CO_2e (all GHGs) and 0.1 tonnes CO_2 (CO_2 only). However, if land use changes and forestry (including deforestation) are included, the per capita emission estimates rise to 2.67 tonnes (all GHGs) and 1.65 tonnes (CO_2 only). The key emitting sectors are forestry, due to deforestation (biomass burning 48percent), and agriculture, primarily from livestock (CH_4 from enteric fermentation 18percent) and others (mainly (N_2O) from animal manure left on pasture, burning savannah and cropland) (Fig. 1).



Source: FAOSTAT, 2012

Figure1: *GHG emissions from AFOLU sector in Tanzania (Rioux et al., 2016, based on FAOSTAT, 2014)*
Forestry and agriculture accounted for 93 percent of emissions in 1994 (forests - 70 percent, agriculture - 23 percent). In the future, it is inevitable that GHG emissions in Tanzania will increase under the planned current development baseline, as indicated by the increasing trend estimated since 1990 (Fig. 2).

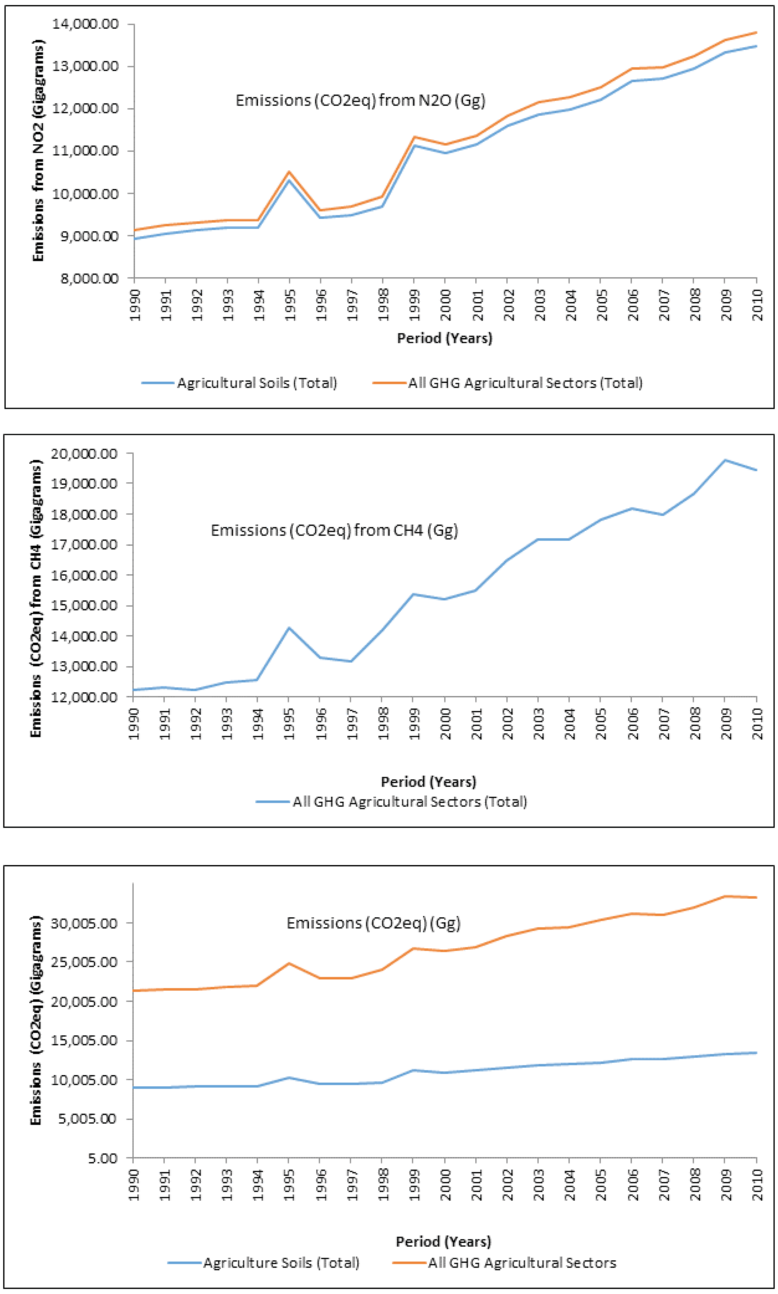


Figure 2: *Estimates of GHG emissions trend in agricultural sectors in Tanzania 1990 – 2010*
Source: FAO (2013). FAOSTAT Emissions Database (http://faostat.fao.org)

1.3 Adaptation and Mitigation in Agriculture

Climate change and its associated impacts on agriculture sectors is a major concern in Tanzania. Thus adaptation is the highest priority for the country. The National Climate Change Strategy (URT, 2012a) provides basis for identifying short, medium and long-term adaptation activities designed to address existing and emerging climate change threats.

More than 80percent of the population in Tanzania depends on climate sensitive rain fed agriculture as source of livelihood. Reducing vulnerability of agriculture to climate change will significantly contribute to socio-economic development and ensure food security. Potential adaptation options that would help to integrate resilience in agricultural policy decisions, influence planning processes, and implement investments on the ground include improving agricultural land and water management; accelerating uptake of climate-smart agriculture; protecting the most vulnerable against climate-related shocks; and strengthening knowledge and systems to target climate action (URT, 2014)

The potential adaptation in the livestock sector include promoting climate change resilient traditional and modern knowledge on sustainable pasture and range management systems; promoting development and implementation of land use plans countrywide; and enhancing development of livestock infrastructure and services. Other adaptation options include promoting development of livestock insurance strategies; strengthening weather forecast information sharing for pastoralists; promoting livelihood diversification of livestock keepers; and promoting improved traditional livestock keeping systems.

In fisheries the strategic interventions include those for enhancing monitoring of fisheries habitat and species; facilitate enhancement and/or development of integrated data management systems in the fisheries sector; promoting aquaculture; and to enhancement of protection and conservation of aquatic ecosystems; and supporting alternative livelihood initiatives for fisheries community.

Climate change impacts affect forest and ecosystem processes. Protecting and conserving biodiversity through application of best practices in soil and water conservation; expanding forest cover and use of adaptive species as well as linking conservation areas are vital in adapting to climate change and ensuring continuity in the availability of ecosystem goods and services hence improving the livelihoods of Tanzanians.

Despite its negligible GHG emissions, Tanzania can participate in mitigation activities to contribute to its sustainable national development (URT, 2012). Agricultural sectors can contribute to mitigation as a consequence of improving productivity and sustainability. In agriculture, potential mitigation actions are promoting agro-forestry systems; enhancing management of agricultural wastes; promoting efficient fertilizer utilization; and promoting best agronomic practices and technologies. Potential mitigation interventions in livestock include promoting manure management practices; promoting appropriate technology for animal feed production; promoting waste management in abattoirs; and improving rangelands productivity and complementary activities.

Tanzania has high sequestration potential for GHG due to existing extensive forest cover. Addressing the drivers of deforestation and forest degradation will enhance the contribution of the forest sector to global GHG mitigation efforts and enhance sustainable development. Potential mitigation interventions in forestry include promoting afforestation and reforestation; supporting household energy plantations to reduce pressure on natural forests; supporting capacity building for community based forest carbon assessment; promoting reduction of emissions from deforestation; promoting reduction of emissions from forest degradation; promoting sustainable management of forest; enhancing and conservation of carbon stocks (REDD+ strategy) for forest management.

Therefore, it is important to put in place strategies aiming at adapting to climate change and reducing its impacts through research, awareness raising, advocacy, mobilization and empowerment of most vulnerable communities. Adaptive strategies have to be implemented from household, community, and national levels in order to enhance already existing adaptation strategies while designing new ones. One of these strategies is to promote Climate-Smart Agriculture.

1.4 Climate-Smart Agriculture

Climate-smart agriculture is "Agriculture that sustainably increases productivity, resilience (adaptation), reduces or removes Greenhouse Gases (GHGs) (mitigation), and enhances achievement of national food security and development goals" (FAO, 2010). However, in Tanzanian context, the adopted definition of Climate-Smart Agriculture is "agriculture that sustainably increases productivity and income, increases the ability to adapt and build resilience to Climate Change and enhances food and nutrition security while achieving mitigation co-benefits in line with national development priorities" (National Task Force Planning Workshop Report, 2016).

It ensures sustainable agriculture, based upon integrated management of water, land and ecosystems at landscape scale and includes techniques, such as mulching, intercropping, conservation agriculture, pasture and manure management, and innovative practices, programmes, and policies, such as improved crop varieties, better weather forecasting, and risk insurance. CSA emphasizes on agro-ecological approaches to soil, nutrient, water and ecosystem management with explicit attention to the importance of preserving genetic resources of crops and animals including wild relatives, which are critical in developing resilience to shocks.

Outstanding traditional technologies and practices, which follow the concept of CSA as documented by MALF include the Chagga (*Kihamba*) agroforestry system, the Haya (*Kibanja*) agro-forestry system, the *Luguru* ladder terraces and the *Matengo Ngoro* pits (soil and water conservation). The Chagga agroforestry system is among the oldest and most sustainable forms of upland farming that has been able to support one of the highest rural population densities in Africa (FAO, 2013). All these systems are among the essential agricultural technologies that require complementarities with other resources such as land and water.

Given the norms and traditions in relation to the roles of women in agricultural production as well as land tenure system, these technologies and practices face limitation when gender dimension are not taken into consideration. The inadequacy of access for women to essential agriculture development resources does not only increase hardships for women, but it places an extra burden on the entire agriculture sector, the broader economy and society as a whole.

1.4.1 Gender, Youth and Climate-Smart Agriculture

Gender and Climate Change are closely linked. Climate change affects different gender groups such as women, men, the youth, the old, the poor and rich differently; women are severely affected compared to men. This is because men and women are bound by distinct social economic roles and responsibilities, which give rise to differences in vulnerabilities and ability to adapt to climate change impacts. Men and women have varying abilities to adapt to climate shocks and longer-term climate change because of differentiated access to entitlements, assets, and decision-making; this ability to adapt is further complicated by gender and social differences. Youth and women have a different degree of vulnerability compared to that of men for many reasons, including their greater dependence on natural resources for livelihoods, responsibility for food production, water and fuel for their households, more limited assets, and social, cultural and political barriers.

With the impacts of climate change on the agriculture sector, the youth exacerbates the situation by engaging themselves in unsustainable activities such as deforestation for timber, farm expansion and charcoal making. Tanzania Agriculture Policy (2013), advocates for the creation of an enabling environment to attract youths in agriculture sectors. Youth strategy recognises the need to develop and promote on-farm and off-farm rural activities as engines of growth, innovation and attractive in terms of jobs for both women and men, in line with decent work concepts; youth-friendly skills development approaches and the creation of young farmer's organizations, in which CSA will be promoted.

Gender is pertinent to CSA hence the need to put emphasis on the importance and ultimate goal of integrating gender in CSA technologies and practices. The aim for integration is to reduce gender inequalities and ensure that men and women can equally benefit from any intervention in the agricultural sectors to reduce risks linked to climate change. Taking a gender responsive approach to CSA means that the particular needs, priorities and realities of men and women are recognized and adequately addressed in the design and application of CSA. Gender transformative

CSA interventions seek to transform gender roles and promote more gender-equitable relationships between men and women.

Climate-smart technologies and practices have substantial and highly context-specific implications for gender roles. Similarly, gender roles influence and drive the adoption of CSA technologies and practices. In order to support women's and men's equal uptake of and benefit of site specific CSA technologies and practices, gender analysis as well as equal participation and engagement of women and men are the key actions to be taken at the outset of any CSA interventions.

In general, capacity building of women and youth farmers should be emphasized as their contribution in the household economic activities is considerable. Awareness raising, provision of knowledge and access to information such as CSA information to women increases the ultimate effect in strengthening the resilience of households, communities, and food systems exposed to climate-related shocks and climate change. Women for example are at least as willing as men to adopt innovative climate-smart technologies, but they typically face different and often less visible obstacles such as formal legal or regulatory issues regarding women's land tenure (women without formal title to land cannot obtain credit to finance climate-smart innovations). Therefore, they should be helped to access land and tenure security to encourage investment.

Social cultural norms are other obstacles that limit women access to productive resources and advisory services. It is a priority to address these restrictions, because they limit women's ability to adopt new technologies and to build the climate resilience and adaptive capacity of their households and communities. Alternative CSA practices, which can easily be applied by women or disadvantaged people (being low cost, less labour demanding, simple), should be emphasized. Technologies with multiple benefits such as agroforestry, where multipurpose trees can provide for soil fertility improvement, fodder for livestock, and fruits for household nutrition and fuel wood for energy are among the CSA practices that are more attractive to women; however, they often need secured land tenure, or communal land to establish a tree nursery. Project implementers are encouraged to use new tools and approaches such as Women's Empowerment in Agriculture Index (WEAI) and to fill the knowledge gaps (IFPRI, 2012).

1.5 Policy and Legal Context

The Government of the United Republic of Tanzania has put in place sectoral policies, legislations, strategies and plans to enhance agricultural growth, natural resource management and climate change interventions. These include; The National Agriculture Policy (URT, 2013) which aims at developing an efficient, competitive and profitable agricultural industry that contributes to the improvement of the livelihoods of Tanzanians using agricultural practices that sustain the environment. It also strives to improve adaptation measures to climate change effects and deal with all the risks involved as well as up-scaling of practices that enhance the carbon storage capacity such as conservation agriculture and agro-forestry. Furthermore, both the Livestock and Fisheries policies (URT, 2006 and URT, 1997) respectively emphasize on productive and environmentally friendly livestock and fisheries husbandry systems. Fertilizers Act, Cap. 378 (2009) provides regulation on utilization of agricultural fertilizers and prohibit the use of fertilizers in a manner that it has adverse impacts on the environment. Plant Protection Act, Cap. 133 (1997) among other things provides for safeguards against pollution of groundwater and the natural environment by plant protection substances. The Tobacco Industry Act (2001) provides regulatory functions for controlling and prescribing measures for the preservation of the environment including avoidance of land degradation through compulsory reforestation and economical use of wood fuel programmes. Finally, the National Irrigation Policy (2010) provides the basis for a focused development of the irrigation sector by ensuring sustainability of water for irrigation and its efficient use for enhanced crop productivity and profitability in order to contribute to food security and poverty reduction.

The National Climate Change Strategy (URT, 2012) sets out strategic interventions for climate change adaptation measures and greenhouse gas emissions reductions. The goal is to enable Tanzania to effectively adapt to and participate in global efforts to mitigate climate change with a view to achieving sustainable economic growth in the context of the Tanzania's national development blueprint, Vision 2025; Five Years National Development Plan; and national cross-sectoral policies in line with established international policy frameworks. The National Climate Change Strategy has outlined objectives for all sectors and proposed strategic interventions in those sectors and themes that are highly vulnerable to climate change such as agriculture.

The Agriculture Climate Resilience Plan (URT, 2014) has been developed to implement strategic adaptation and mitigation actions in the crops sub-sector. It presents a wide range of adaptation options including, but not limited to: improving agricultural land and water management, accelerating uptake of CSA, reducing impacts of climate-related shocks through risk management, and strengthening knowledge and systems to targeted climate action.

The Climate-Smart Agriculture Programme for Tanzania (2015 – 2025) has the Vision to have an "*Agricultural sector that sustainably increases productivity, enhances climate resilience and food security for the national economic development"* (URT, 2015). This vision is in line with Tanzania National Development Vision 2025. The Climate-smart Agriculture Programme aims to build resilience of agricultural farming systems for enhanced food and nutrition security through six programmatic result areas namely: Improved productivity and incomes; building resilience and associated mitigation co-benefits; value chain integration; research for development and innovations; improving and sustaining agricultural advisory services; and improved institutional coordination. The CSA programme enhances the implementation of the Comprehensive African Agriculture Development Programme (CAADP) and responds to the 23rd Ordinary African Union Assembly Decisions and Declaration (Malabo Declaration), This CSA guideline has therefore been developed to support the implementation of Tanzania CSA programme.

CHAPTER 2: CLIMATE CHANGE AND AGRICULTURAL RISKS IN TANZANIA

2.1 Variability in precipitation and future projections

Several studies have been conducted on precipitation projections in Tanzania. For example according to Agrawal et al. (2003), annual precipitation over the whole country is projected to increase by 10percent by 2100. However, seasonal declines of 6percent are projected for June, July, and August, and increases of 16.7percent for December, January, February (Agrawal et al., 2003). Rainfall is projected to increase under A1B scenario (Mourice et al., 2016). This is based on four General Circulation Models (GCMs) that were considered in the study, which were CNRM-CM3, CSIRO-MK3, ECHAM5 and MIROC3.2 medium resolution Global models (CIMP3). On the basis of this study, rainfall amount, duration, distribution and intensity will increase.

Other rainfall projections show the increase during the middle of the rainy season (November-April) with all other months is projected to decrease in precipitation (Figure 2.1).

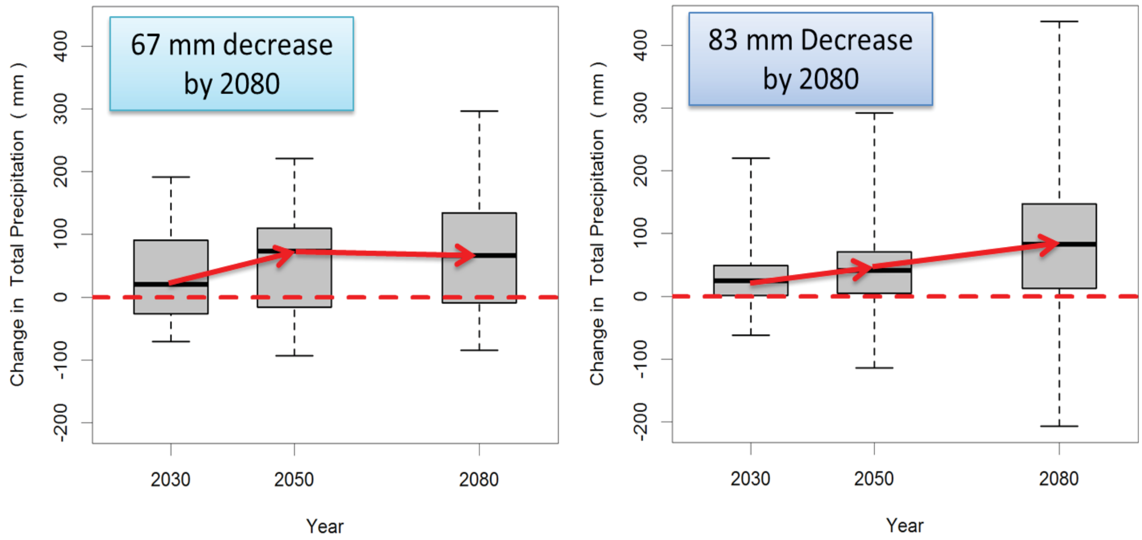


Figure 2.1: *Changes in precipitation in Tanzania with respect to lower (RCP 4.5) and higher (RCP 8.5) greenhouse gas emissions scenarios (Source: Adapted from URT, 2015)*

This would result in the rainy season becoming shorter but more intense, and the dry season becoming drier (Figure 2.2)

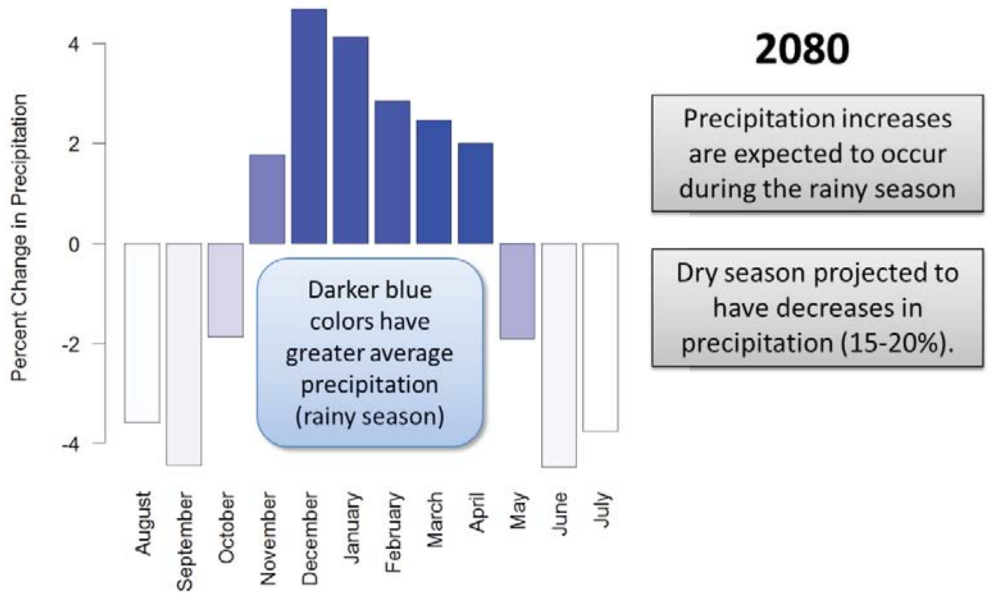


Figure 2.2: *Percent change in precipitation in Tanzania by 2080 under the higher RCP 8.5 greenhouse gas emissions scenario based on an ensemble of 19 climate models from the IPCC Fifth Assessment Report (Source: Adapted from URT, 2015).*

Analysis of historical trends of rainfall for most meteorological stations has revealed a decreasing trend in the mean annual rainfall. These decreasing trends have been observed in Arusha, Zanzibar, Iringa and Singida by Matari et al. (2008). A study by Enfors and Gordon (2007) of rainfall records from the Same Meteorological Station from 1957 to 2004 showed that the long rainy season (*masika)* had non-significant declining trend whereas the short rainy season (*vuli)* rainfall, although highly variable, did not seem to change. The significant change was observed in the dry-spell events of 21 days or longer, which were observed to increase over time. Analysis of rainfall data in the Ngerengere and Morogoro river catchments showed a declining trend in October-January rainfall and increasing trends in April-June rainfall (Ludovick, 2012).

2.2 Temperature

Climate trends of monthly temperature across Tanzania have increased by 1 °C over the past decades between the baseline periods of 1961 - 1999 (URT, 2007). An ensemble of the GCM and emission scenarios have projected increase of average annual temperature to 3ºC above the baseline period by the 2050s (Figure 2.3), with the latest projections indicating a high certainty of a 1 °C rise across the country.

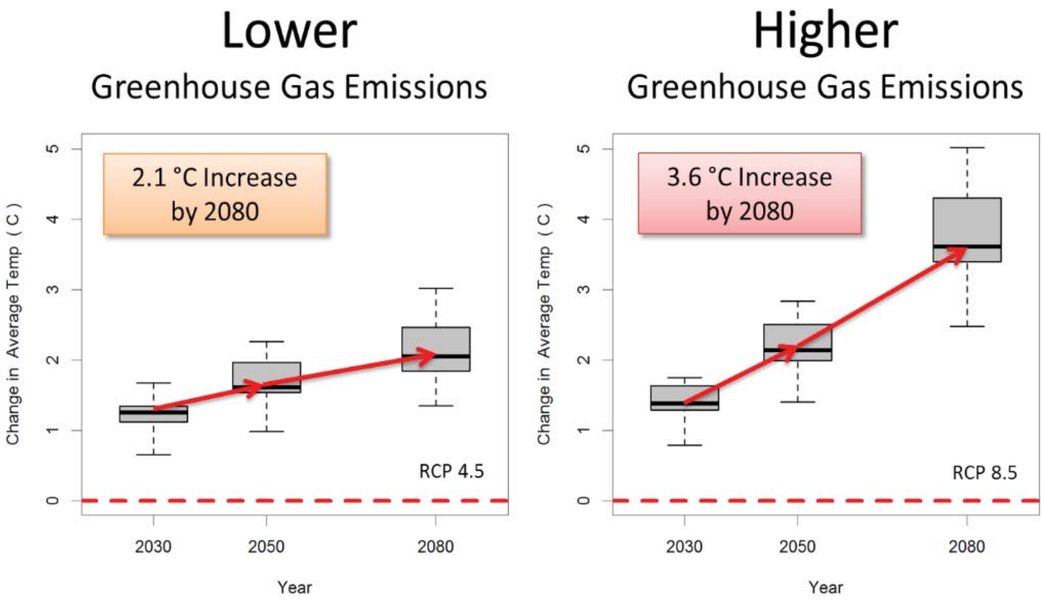
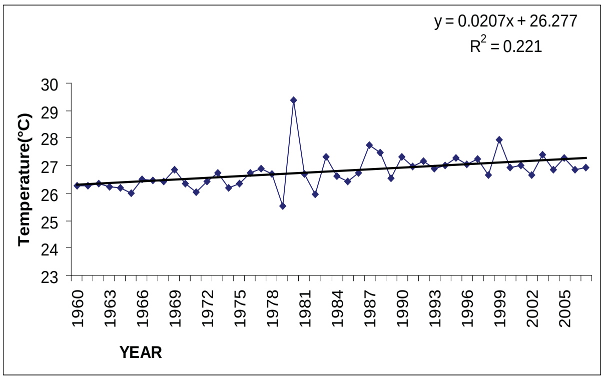
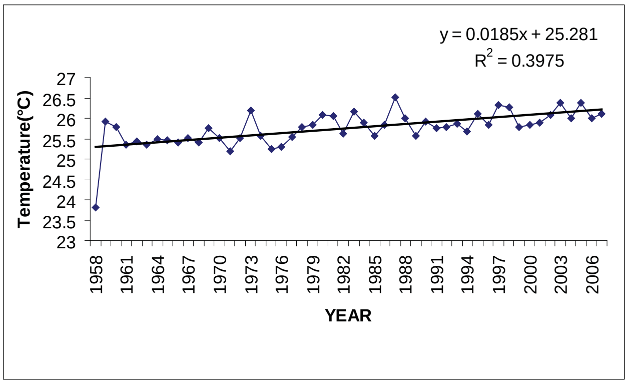


Figure 2.3: *Changes in temperature in Tanzania with respect to lower (RCP 4.5) and higher (RCP 8.5) greenhouse gas emissions scenarios (Source: Adapted from URT, 2015)*

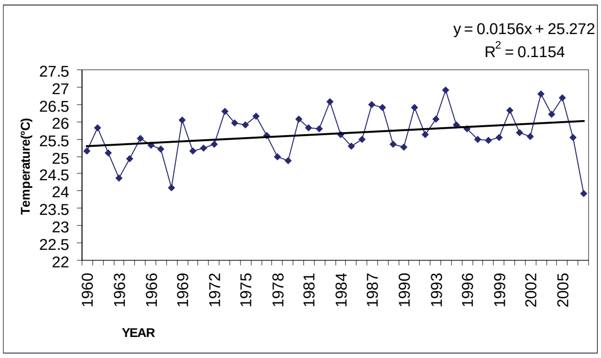
Analysis of historical trends of temperature by (Matari et al. 2008) using climatological records from 1961 to 2010 in several locations in Tanzania found that across the country, the mean annual maximum and minimum temperatures showed increasing trends. The increasing trend is more pronounced in mean annual minimum temperature as compared to mean annual maximum temperature. For example, the mean annual maximum temperatures for Arusha, Zanzibar, Mbeya and Dodoma show an increasing trend; with Arusha and Mbeya having higher gradient compared to Dodoma and Zanzibar (URT, 2013). Analysis of climatological data from the Same Meteorological Station for the years 1958 to 2007 revealed a pronounced increasing trend of mean annual minimum temperature but a decreasing trend of maximum temperature (Mnimbo, 2013). The Tanzania Meteorological Agency reported increasing trend of mean annual maximum temperature for four Meteorological stations of Songea, Bukoba, Arusha and Zanzibar (Figure 2.4) for the year 1958-2005 (TMA. 2007).



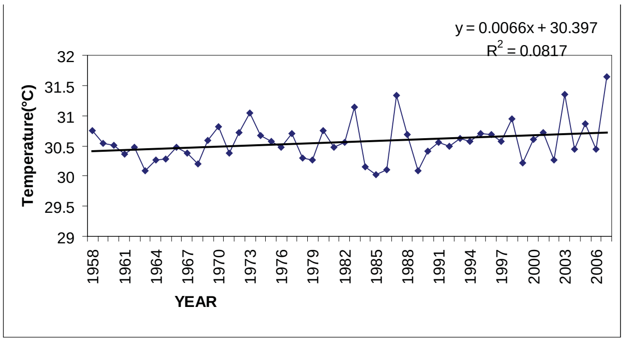
a) Songea station



b) Bukoba station



c) Arusha station



d) Zanzibar station

Figure 2.4: *Mean annual maximum temperature time series for Songea, Bukoba, Arusha and Zanzibar stations (Source: Adapted from TMA, 2007)*

2.3 Extreme events

Climate change is also expected to increase the severity, duration and frequencies of weather related extreme events such as drought and floods. Drought and floods account for up to 70percent of all recorded natural calamities for the last 100 years (Chang'a and Nduganda, 2008). Drought and floods cause large scale famine, diseases and deaths to human beings, plants and animals.

Drought events are classified into four major classes. Meteorological drought involves the period below normal rainfall and above normal temperature; hydrological drought is the period of below normal stream flow and depleted reservoir storage; agricultural drought is the period during which soil moisture is insufficient to support crops; and socio-economic drought is the type where there is low water availability below society's productive and consumptive demand. According to Chang'a and Nduganda (2008), meteorological drought was reported in Tanzania for the period from 1961-2006, where severe drought (Si>3 Pedya Index) frequency was at 2-8.7percent. The October–December months are reported to experience more severe drought frequency than the March–May months. Compared to the period between 1961 and 1980, the years between 1980 and 2006; experienced more frequent and severe drought events. These events occurred five times (1983, 1987, 1993, 2003, and 2005) during the later period (Chang'a and Nduganda, 2008).

As a result of severe drought, annual and perennial crops are affected. For example, maize livelihood zones face a general yield decline (URT, 2007) with up to 84percent yield drop in the central regions, 22percent decline in North-Eastern highlands, 17percent decline in the Lake Victoria region, and 10 – 15percent decline in the Southern highlands.

Based on the Pedya index (Si), extremely wet condition, which translates into flood, has Si less or equal to -3. Most extremely wet conditions in Tanzania can be linked to El-Nino episodes of 1961, 1968 and 1997 (Chang'a and Nduganda, 2008). However, with projected rainfall changes due to climate change, floods are expected to increase.

2.4 Shifting of Agro-Ecological Zones

Impacts of climate change and variability are expected to lead to seasonal shifts. According to URT (2007) increase in temperature by 2-4 degree centigrade will alter the distribution of the agro ecological zones (AEZ). As result, areas that used to grow perennial crops will be suitable for annual crops. These shifts will accelerate plant growth and hence the length of growing seasons. Reductions in crop yield in some parts of the country may be attributed to shifting of the AEZ. In some areas, there is a shift in rainfall patterns from bimodal to unimodal rainfall regimes in some areas. For example Manyara and some parts of Morogoro and Kigoma Regions which have long been characterized by bimodal rainfall distribution are now experiencing a shift towards unimodal rainfall regime (URT, 2008).

Productivity of most crops seems to have declined due to changing climate, particularly due to the increasing unreliability of rainfall. However, the production of some crops seems to have improved with the changing climate. For example, the productivity of mangoes and oil palm in the western plateau of Tanzania has increased considerably during the last 20 years (Kahimba et al., 2015). Previously mango and oil palm trees produced only flowers without bearing fruits in the same areas because of cold weather; but today reasonable harvests can be realized from these crops (Kangalawe et al., 2009). Warming of the environment has favoured production of both mango and oil palm in these highland areas.

2.5 Crop Production

Regional predictions indicate that Tanzania may suffer a loss of over 10percent of its grain production by the year 2080 (Parry et al., 1999). The cultivation of maize is likely to be most negatively affected. There is considerable uncertainty regarding the effects of climate change on the yields of most important cash crops such as coffee and cotton. However, according to Tanzania Initial National Communication (2003), the two cash crops are projected to experience increases in yield. In fact, coffee output had a steady increase in the period 2003/04 to 2008/09 followed by two pronounced decreases in 2009/10 and 2011/12, which cannot be explained by the biological cycle of coffee plants.

These drops in output (in a permanent crop as coffee) can only be attributed to production (yield) problems, drought, and/or pest attacks. Previous reduction in crop production was most likely associated with the lengthy periods of depressed market with low and unstable prices. In 2003/04, however, the fall in production was also driven by drought problems.

Estimates from Crop Environment Resource Synthesis Model (CERES-Maize) (Jones and Kiniry, 1986) show that the average yield decrease over the entire country would be 33percent. However, simulations have indicated that decreases could be as high as 84percent in the central regions of Dodoma and Tabora when the carbon dioxide concentration is doubled. Yields in the north-eastern highlands showed decreases of 22percent, while in the Lake Victoria region decreases of 17percent were indicated. The southern highland areas of Mbeya and Songea were estimated to have decreases of 10-15percent. These reductions are mainly due to decrease in rainfall and increase in temperature that shorten the length of the growing season. Consequently, the continued reliance on maize as a staple food crop over wide areas of the country could be a risk. Change of staple crops to millet and cassava may be necessary in the hinterland.

Large-scale extreme events, such as the 1997/98 El Niño, illustrate ways in which many communities are already suffering from less predictable and more extreme weather patterns. The 1997/98 El Niño, for example, resulted in cereal deficit at 916,000 metric tons in Tanzania. The La-Niña event of 1996/97 was responsible for the severe drought that occurred in most parts of Tanzania leading to widespread crop failure.

In 2005 the agricultural sector grew by only 5.2percent compared to 5.8percent growth in 2004 and GDP was targeted to grow by 6.9percent, but it grew by 6.8percent. This was attributed to severe drought that affected most parts of the country, triggering food shortage and power crisis (URT, 2005).

According to the Agriculture Climate Resilient Plan (URT, 2014), the potential impacts of higher temperatures on crop agriculture is largely on water availability and pests and diseases, including possible expansion of pest and disease ranges and significant impacts on soil moisture and fertility due to increasing evaporative losses. Studies by Perfect and Majule (2010) also indicated that climate change and variability pose a serious challenge to irrigated agriculture and water sectors, which requires specific interventions to sustain productivity.

2.6 Livestock Production and Aquaculture

Climate change is expected to further shrink the rangelands which are important for livestock production in Tanzania. Impacts of climate change and variability are expected to lead to pasture and water shortages. According to Coulibaly *et al*., (2015), 40percent of pastoralists in Arusha and 26percent of agro-pastoralists in Kiteto and Longido districts identified climate variability and extreme climate events, especially drought, as the major challenge to sustained livestock productivity due to water scarcity and lack of adequate good quality pasture. Because of drought, livestock deaths are frequent in these pastoral districts, forcing them to migrate to other areas in search of pasture and/or sell part of their herds to cope with food insecurity.

The impacts on aquaculture from climate change will likely be both positive and negative arising from direct and indirect impacts on natural resources required for aquaculture; the major issues being water, land, fish seed, feed and energy. Increased temperature brings about associated changes in the hydrology of water bodies, exacerbates the occurrence of algal blooms and red tides etc. These factors can have important impacts on aquaculture. The potential indirect impacts are associated with global warming, sea level rising, ocean productivity and changes in circulation patterns, changes in monsoon and occurrence of extreme climatic events (e.g. floods, changes in monsoonal rain patterns and storminess), water stress and changes in hydrological regimes in inland waters.

Unlike other farmed animals, all cultured aquatic animal species and plants for human consumption are poikilothermic (their internal temperatures varies considerably). Consequently, any rise and/or decrease of the habitat temperatures would have a significant influence on general metabolism and hence the rate of growth and therefore total production; reproduction; seasonality and even reproductive efficacy (relative fecundity and number of spawning); increased susceptibility to diseases and toxicants. Climate change induces temperature variations that impacts on spatial distribution of aquatic species.

Aquaculture occurs in fresh water, marine and brackish water, each suited to particular group of aquatic species with particular physiological traits. Climate change is likely to bring significant changes with respect to salinity and temperatures in brackish waters and therefore may influence aquaculture production in such environment. The most obvious and commonly indirect impact of climate change on aquaculture is related to fishmeal and fish oil supplies and their concurrent usage in aquaculture. These are important if aquaculture is considered to promote food security.

2.7 Biophysical Drivers of Vulnerability

2.7.1 Infrastructure

In Tanzania, land based road travel is the dominant mode of transport and accounts for over 80percent of passenger traffic and over 95percent of freight traffic. The road network density in Tanzania is 96.5 metres per square km (or 5.0 metres per square km for paved roads). Tanzania has one of the lowest road densities in Africa, meaning that a large part of Tanzania is inaccessible. On the other hand, the railway network operates erratically. For example the TAZARA Railway which operates between Dar es Salaam and Zambia faces this challenge.

The inaccessibility, especially in the rural areas makes travel burdensome, transport costs become too high, and crop markets become too far. The magnitude of each of these problems is felt more during the long rains than in short rains. Thus transport becomes a major driver of vulnerability to climate change in the country.

2.7.2 Water Resources

Increasing rainfall variability and prolonged droughts lead to pressure on the country's available water resources. Severe and recurrent droughts in the past few years triggered a decrease in water flows in rivers, hence shrinkage of receiving lakes, declines of water levels in satellite lakes and hydropower dams. Furthermore, some of the perennial rivers have changed to seasonal rivers and some wetlands have dried up (URT 2007).

Thus, water as a finite resource is under pressure because of climate change and variability, degradation due to pollution, over-abstraction, and encroachment of water catchments for various land uses including agriculture. This scarcity and vulnerability has negative impacts on crop production by making it have lower yields over time.

Increased population in major watersheds will put pressure on water resources as a result of climate change in terms of the quantity abstracted and also siltation and sedimentation of rivers as a result of soil erosion. Socially, the impacts of climate change on water resources are felt by the whole society regardless of gender. However, where water sources are depleted or quality compromised, women and children are the most affected due to their vulnerability.

2.7.3 Soil Erosion and Land Degradation

Climate change will have two-fold effects on soil erosion on the landscape (Adhikari et al., 2015). Direct effect of climate change is in the event of increased precipitation, in terms of amounts and intensity which translates into high erosivity. In the event of decreased precipitation and increased temperature as a result of climate change, soil moisture content is decreased, thus the landscape becomes incapable of supporting dense vegetation that becomes sparse with time.

Therefore, insufficient vegetation cover may accelerate soil erosion and its negative effects to the community. Land use change as an adaptation strategy to climate change may affect the rate at which a growing crop covers the ground and hence affect the runoff. Poor farmers who are not motivated to adopt soil conservation methods will be on high risk of losing their productive surface soil to erosion. The latter will be worsened by nutrient mining where the extraction of mineral nutrients through crop removal is higher than replenishment through fertilizers and organic matter. According to National Sample Census of Agriculture (Small Holder Agriculture Volume II) the number of households reported to have soil erosion problem was 779,563 accounting for 13percent of total agricultural households involved. In coffee-banana farming systems, soil erosion is less severe than in other systems for two reasons; first is the continuous vegetation cover unlike in other systems and; second is that in coffee-banana system the in-and-out flows of nutrients is somewhat balanced unlike in other systems where harvesting involves pulling the whole plants with their roots such that the field does not benefit from nutrient recycling (Kaihura *et al.,* 2001). In pastoral livelihood zone (e.g. Loliondo) and semi-arid sorghum livestock livelihood zone (e.g. Dodoma) where soil cover is virtually non-existent, soil erosion is widespread, resulting in huge gullies, thus reducing land productivity.

2.7.4 Pests and Diseases

Warmer temperatures, wetter climates and increased carbon dioxide levels are also projected to favour increase in insect pests and fungi leading to increase in the use of pesticides and fungicides, which may negatively affect human health and the environment. The severity of crop pests or diseases and emergence of new invasive pests or diseases is also changing. For example, African army worm moth (*Spodoptera exempta* Walk.) (Lepidoptera: Noctuidae) outbreak follows a prolonged drought period and its lifecycle depends on the prevailing temperature. Banana *Xanthomonas* wilt, (BXW), a new deadly banana wilt pathogen, is thought to have emerged due to climate change and is posing a threat to banana production in coffee-banana livelihood zones. Mongi *et al*. (2010) reported that farmers had the perception that food security problems were caused by prevalence of crop pest and disease due to climate change in the cotton-paddy-cattle livelihood zone. FAO (2008) Climate Change and Food Security Framework document points out that meteorological conditions as a result of climate change may become favourable for some animal and plant pests and diseases and unfavourable for others, thus enabling pests and diseases to establish in new areas that were previously unsuitable. Also new animal or plant pests and diseases may emerge due to natural selection by, and adaptation to new meteorological conditions. Although the effects of climate change on animal/plant pest and pathogen species distribution, severity and frequency of incidence of pest and disease has not been well documented in Tanzania, there is a general perception that the increase in temperature or rainfall will affect pests and disease dynamics. Nonetheless, pest and diseases intensity is higher in wet and humid livelihood zones than in arid and less humid livelihoods.

2.8 Socio-Economic Drivers of Vulnerability

2.8.1 Population

Based on the 2002 Population and Housing Census, Tanzania was reported to have a population of about 34,569, 232, with 33,584,607 from mainland with an annual average growth rate (1988 to 2002) of 2.9percent (URT, 2002). By 2012 the country had about 44.5 million people (of which 21.9 million were male and 22.6 million female) (URT, 2013). The average household size was estimated at 4.9 and the population density was estimated to be 39 persons per sq.km.

Rapid urbanization is taking place in the country. Whilst the urban population was only 4percent of the national population at independence in 1961, it rose to 23percent in the 2002 national population census. With this trend, it is estimated that by the year 2030, 50percent of the national population will be urbanized through natural growth, inward migration and transformation of rural settlements into urban centers. History shows that over the years of pre- and post-independence of many developing countries, the difference in livelihood between urban and rural areas has catalyzed rural-urban migration. Recently, climate change and other extreme weather events have caused instability in peasant farmer activities in rural areas hence aggravating rural to urban migration.

One factor for gradual growth in urban areas compared to rural areas may be failure of the agricultural system, causing rural populations to migrate into urban centres in search of alternative livelihood strategies. Although total population growth rate has been decreasing in Tanzania, there is dissimilarity between urban and rural population growth rates.

2.8.2 Conflicts

Many conflicts emanate from trans-boundary resource competition, either between pastoralists and crop producers or wildlife and pastoralists or crop producers. Conflicts are a result of combined effects of climate change, where rangelands cannot sustain wildlife population in terms of water and forage due to droughts and high temperature or loss of habitat. Change in forage species composition, and habitat characteristics may force wild animals to seek alternatives from human settlements and hence cause conflicts. On the other hand, anthropogenic factors such as encroachment, land fragmentation and destruction may cause conflicts. For example, increased water abstraction for rice cultivation in the Katuma river system of the maize-rice farming system has been reported to cause water shortage problems for wildlife in Katavi National Park (Elisa *et al.,* 2011).

Prolonged dry season and increased rainfall variability negatively impact on forage and water availability for livestock, compelling pastoralists to migrate to distant areas in search of water and pasture. As a result, conflicts between crop producers and pastoralists arise and sometimes with severe human casualties, for example in the sugarcane farming regions of Morogoro, Kagera and Kilimanjaro, and sisal farming regions of Morogoro, Tanga, Coast and Lindi in which also pastoralists are found.

Major conflict prone regions include those which harbor large herds of cattle, especially rice farming zone in the Usangu plains where large herds of livestock from elsewhere have migrated into for the water and pasture. Since models predict that southern Tanzania is projected to receive increased precipitation than central and northern parts of the country (Mourice et al., 2016), there is a potential conflict between livestock herders and crop producers. This is because water and forage supply may not be adequate for large population of livestock as a result of influx into the southern region from other parts of the country.

CHAPTER 3: OBJECTIVES AND METHODOLOGY

3.1 Rationale and History of the Guideline

Climate-Smart Agriculture contributes to a cross-cutting range of development goals. The CSA guideline opens up many opportunities for capturing synergies between the pillars of climate-smart agriculture and for being aware of the potential trade-offs. CSA is a multi-sectoral approach as it involves sectors such as crop, livestock, fishery, land, forestry, and water. The guideline provides a platform for application of sustainable approaches and practices across the agricultural, food security and climate change related policies at all levels. The Agricultural sector must become climate-smart to successfully tackle current food security and climate change challenges. Agriculture, including crop, livestock, forestry and fisheries, is crucial for food security and rural incomes as well as other essential products, such as energy, fibre, feed and a range of ecosystem services.

Some effective climate-smart practices already exist and could be scaled-up. This can only be done with serious investments in building the knowledge base and developing suitable technology and approaches. Early action is needed to identify pilot and scale-up best practices, strengthen institutional capacities, and build experiences that can help stakeholders to make informed decisions to adopt climate-smart agricultural practices. The CSA guideline will provide an avenue for having shared approaches and strategies.

The idea to prepare the CSA guideline started during the development of Agriculture Climate Resilient Plan (ACRP 2014 - 2019) in 2014. The preparation of the ACRP is also a result of the Ministry's initiatives for the implementation of the National Climate Change Strategy. The Ministry through the ACRP recognises that the development of a CSA guideline would assist in the successful implementation of CSA practices in the country. This initiative is in line with the Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods through Harnessing Opportunities for Inclusive Growth and Sustainable Development. It is expected that the CSA guideline will assist in the planning of sustainable use of natural resources and enhance ecosystem management, which in turn will result in improvement of peoples' livelihoods and poverty alleviation in the country.

In October 2014, by then Ministry of Agriculture Food Security and Cooperatives (MAFC), in collaboration with the Food and Agriculture Organization of the United Nations (FAO), the World Agro-forestry Centre in Tanzania (ICRAF) and CARE-Tanzania organized a National Climate Change and Agriculture Workshop. The purpose of the workshop was to share evidence and experience on Climate-Smart Agriculture in Tanzania in order to build the case for accelerating the adoption of CSA in the country. The workshop was conducted as a final output of the MICCA project led by FAO and jointly implemented by FAO, ICRAF and CARE-Tanzania (Rioux *et al.,* 2016).

In line with this event, MALF by then MAFC presented the Agriculture Climate Resilience Plan (ACRP 2014 - 2019) that intends to implement strategic interventions for adaptation and mitigation of Climate Change and its impacts. Increasing yield through CSA is among the four Priority Resilience Actions proposed in the ACRP.

Other actions are: Improvement of Agricultural Land and Water; Protecting the most vulnerable against climate related shocks; and strengthening the Knowledge Systems to target Climate Actions. During the national workshop, participants recommended the development of a CSA guideline. The stakeholders clearly pointed out the need to develop the guideline to inform implementation and up-scaling of CSA practices in Tanzania. The guideline, once developed would streamline the implementation process. A team of experts was therefore formed to lead the process.

3.2 Objectives of the Guideline

i. To guide identification of suitable technologies and practices for successful implementation of CSA to enhance agricultural production;
ii. To guide in identification of approaches and key requirements for successful CSA implementation; and
iii. To facilitate planning for implementation and up-scaling of CSA.

3.3 Target Audience and Uses of the Guideline

The scope of this guideline is first and foremost to describe the CSA technologies and practices to help users understand them. The primary users of the guideline are the districts development planners and extension agents. The guideline also targets policy makers and private sectors engaging in agricultural related activities, practitioners such as researchers from private and public sectors, farmers and also the CSOs (NGOs, FBOs and CBOs). The guideline takes into consideration the agro-ecological zones in Tanzania to facilitate the identification and up-scaling of CSA technologies and practices.

This guideline is developed for guiding different people in promoting and adopting climate-smart agriculture practices in Tanzania. It is therefore useful for planners and extension agents. Planners will use this guideline to plan and budget for agricultural development by considering the current climate change and climate variability.

Planners can also use this guideline to facilitate community level planning. For extension agents, this guideline will aim to sensitize, mobilize, train and supervise smallholder farmers to adopt agricultural practices considered climate-smart. This guideline is a strategic document to implement the ACRP Action 2 of *Accelerating uptake of CSA* and the Tanzania CSA programme (2015 - 2025). Therefore, it is also addressed to policy and decision makers who will use it to make evidence-informed decisions and programming.

Additionally, the guideline can be used for the following purposes:

i. Informing policy makers to formulate policies and regulations and support strategies, programmes, plans and related incentives for CSA implementation and up-scaling;
ii. Guiding development actors, extension services, research institutions and private sector to promote CSA practices and technologies;
iii. Create awareness, building knowledge and capacity on CSA as an approach for climate change mainstreaming and environmental management in the agriculture sector; and
iv. Monitoring of CSA implementation.

3.4 Methodology

3.4.1 Task Team Formation and Tasks Undertaken

MAFC through the Environment Management Unit (EMU) formed a task team of 18 members to prepare the CSA guideline under the leadership of the Head of the Environment Management Unit (HEMU). The Task team (Annex 1) was composed of people from different sectors including public and private as well as CSOs. The team comprised experts from agriculture, environment, climate and development and related sectors. The main activities of the Task Team were to prepare and organize an inception workshop; Information seeking and data gathering; data analysis and drafting of the CSA Guideline; preparation of a consultative stakeholders' workshop; presentation of the findings and the Draft CSA Guideline during the consultative stakeholders' workshop; incorporation of comments and recommendations provided by the stakeholders and finalization of the CSA Guidelines.

3.4.2 Inception Workshop

The inception workshop was organized to review the Terms of Reference of the task team. In addition, it also paved the way for the preparation of the implementation road map towards developing the CSA guideline. The inception workshop also directed the processes and the tools for developing the guideline. During the inception workshop, the action plan was developed for gathering and analysing data and information, compiling findings and drafting the guideline. Then the task team was divided into four small groups for conducting field work in selected agro-climatic and agro-ecological zones to gather the required information for preparing the guideline. The team also drafted the content outline of the CSA Guideline. This was intended to guide the data collection exercise during the baseline survey.

3.4.3 Baseline Survey

The baseline survey was conducted to document current agricultural technologies and practices in the country based on the livelihood and agro-ecological zones (AEZ). The country has 16 livelihood zones in 18 regions that overlay 64 AEZ (Annex 2). The criteria for site selection were a purposive selection based on agro-climatic zones (Annex 3), livelihood zones and AEZ (Table 1). Description of the study sites are shown in Annex 4.

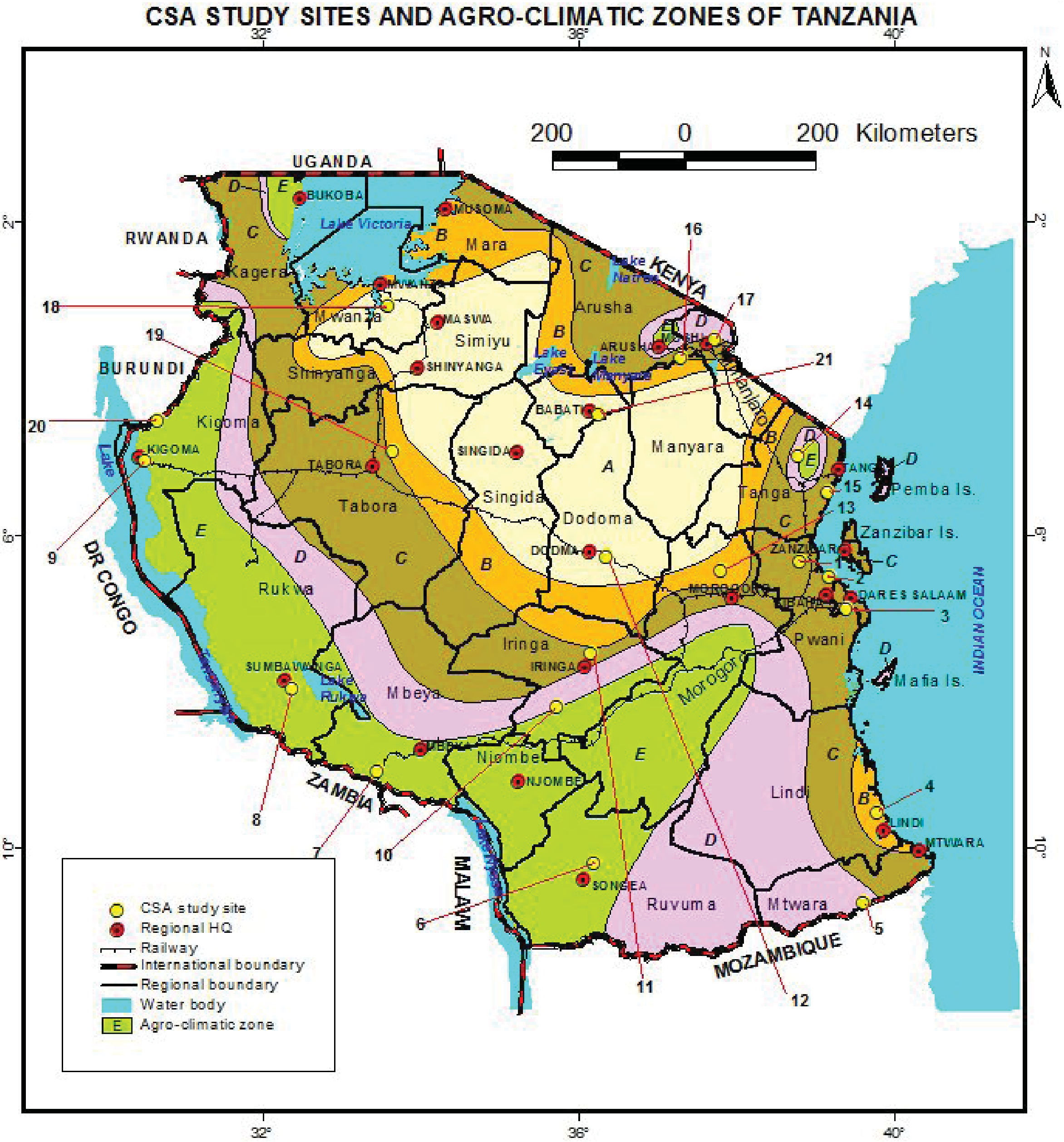
Small groups of the task team members visited selected agro-ecological zones to gather information by using semi-structured questionnaires. The team interviewed 600 farmers, 25 extension agents, 6 civil society organizations, 2 programme leaders, 12 research institutions, 9 private sector representatives and 35 district officers (refer MAFC - CSA Baseline Survey Report, 2015). The task team then continued with the analysis of the information gathered and thereafter compiled findings for the preparation of the CSA guideline. The location of the study sites within the agro-climatic and agro-ecological zones are shown in Figure 3.1 and Figure 3.2 respectively.

The methods used for conducting the survey included preparation of checklists, questionnaires, observations and conversations with district officials. The type of information collected were mainly on existing livelihoods, existing technologies and practices and their climate-smart potential, climate change impacts and climate information services available, situation analysis and institutional framework that govern implementation of agricultural technologies and practices. The types of tools used were: face to face semi-structured questionnaires, Focus Group Discussions, and secondary data. The respondents involved in the study were: farmers, extension officers, private sector, civil society organizations and higher learning institutions and researchers. The survey was conducted in the villages of the chosen District Councils.

Table 1: Study Sites in Agro-climatic and Livelihood Zones

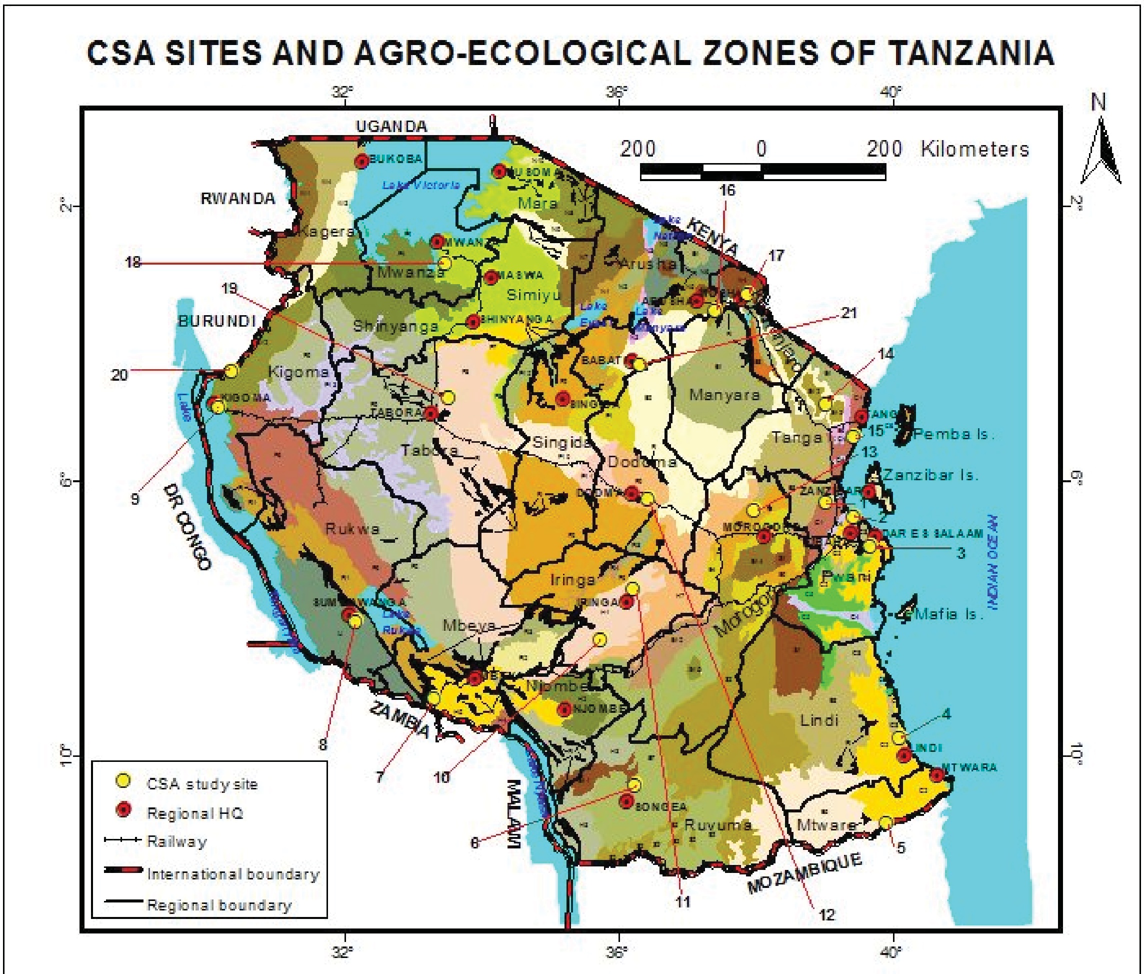
Agro-Climatic Zone	Region/District	Ward/Village	AEZ	Livelihood Zone*
C	Pwani – Bagamoyo	Kiwangwa	C1	Tree crops fishing coastal
C	Pwani - Bagamoyo	Zinga	C2/C3	Tree crops fishing coastal
C	Dar-es-salaam - Temeke	Chamazi	C2	Tree crops fishing coastal
B	Lindi	Mchinga	C2/C3	Tree crops fishing coastal
C	Tanga - Pangani	Madanga	C4/C1	Tree crops fishing coastal
D	Tanga - Korogwe	Magoma	E2	Sisal Sugarcane cattle
D	Mtwara - Newala	Chikwedu – Mcholi I	E5	Maize cassava cashew and sesame
B	Morogoro - Mvomero	Dakawa	E9	Sisal sugarcane cattle
C	Kilimanjaro - Moshi	Iwa – Kirua Vunjo I	N4	Coffee Banana Humid Highlands
C	Arusha - Arumeru	Makiba	N5	Pastoral
A	Manyara - Babati	Gedamar - Gallapo	E2	Pastoral
A	Dodoma	Chololo – Kikombo	P9	Semi-Arid Sorghum Livestock
E	Kigoma – Kigoma Ujiji	Kagera and Kibirizi	W2	Lake Tanganyika Fishing Maize Sunflower
B	Tabora - Nzega	Usagari - Magengati	P3	Cotton-Paddy Rice-Cattle Midlands
A	Mwanza – Misungwi	Nange – Igokelo	P8	
E	Ruvuma - Namtumbo	Msindo	E7	Maize Tobacco
E	Kigoma – Buhigwe	Mwayaya	W2	Coffee Banana Humid Highlands
D	Iringa - Mufindi	Mafinga – Lyasa	H1	Tree Plantation with Pyrethrum and Tea
C	Iringa Urban	Kising'a - Igingilangi	H1	Rice Maize Bimodal
E	Songwe - Mbozi	Ihanda	H5	Coffee Banana Humid Highlands
E	Rukwa - Sumbawanga	Mollo – Ulinji	U	Rice Maize Bimodal

** (Source: Perfect and Majule, 2010)*



SYMBOL	DESCRIPTION	NAME OF CSA SITE
A	Rainfall surplus in 0-1 months	Chololo, Nange, Gedamar
B	Rainfall surplus in 1-2 months	Mchinga, Wami Dakawa, Usagari
C	Rainfall surplus in 2-3 months	Kiwangwa, Zinga, Chamazi, Igingilanyi, Madanga, Makiba, Iwa
D	Rainfall surplus in 3-4 months	Chikwedu, Lyasa, Magoma,
E	Rainfall siurplus in over 4 months	Msindo, Ihanda, Ulinji, Mwayaya, Kagera

Figure 3.1: *The study sites in the agro climatic zones and regions based on Pidwirny, 2006*



No	NAME OF SITE	WARD	DISTRICT	REGION	AEZ
1	Kiwangwa	Kiwangwa	Bagamoyo	Pwani	C1
2	Zinga	Zinga	Bagamoyo	Pwani	C2/C3
3	Chamazi	Chamazi	Temeke	DSM	C2
4	Mchinga	Mchinga	Lindi	Lindi	C2/C3
5	Chikwedu	Mcholi I	Newala	Mtwara	E5
6	Msindo	Msindo	Namtumbo	Ruvuma	E7
7	Ihanda	Ihanda	Mbozi	Mbeya	H5
8	Ulinji	Mollo	Sumbawanga	Rukwa	U
9	Kagera	Kagera	Kigoma Ujiji	Kigoma	W2
10	Lyasa	Mafinga	Mufindi	Iringa	H1
11	Igingilanyi	Kising'a	Iringa Urban	Iringa	H1
12	Chololo	Kikombo	Dodoma	Dodoma	P9
13	Wami Dakawa, Kwamhuzi	Dakawa	Mvomero	Morogoro	E9
14	Magoma	Magoma	Korogwe	Tanga	E2
15	Madanga, Jaila	Madanga	Pangani	Tanga	C4/C1
16	Makiba	Makiba	Arumeru	Arusha	N5
17	Iwa	Kirua Vunjo West	Moshi Rural	Kilimanjaro	N4
18	Nange	Igokelo	Misungwi	Mwanza	P8
19	Usagari	Magengati	Nzega	Tabora	P3
20	Mwayaya	Mwayaya	Buhigwe	Kigoma	W2
21	Gedamar	Gallapo	Babati	Manyara	E2

Figure 3.2: *The study sites in the agro-ecological zones based on De Pauw, 1984*

3.4.4 Compilation of the CSA Guideline

Different sections of the Guideline were drafted by smaller groups of the task team and later compiled all together. The smaller groups reviewed the findings from the field baseline survey and also crosschecked them with information from various literature and expert knowledge to prepare the zero draft. The zero draft was then shared with stakeholders for inputs and further reviewed by the team to incorporate the comments from the stakeholders.

3.4.5 Stakeholders Workshop and Validation

A stakeholders' workshop was convened, in which the Final Draft of CSA Guideline was presented. The finalization of the guideline was done by incorporating inputs from the validation workshop; sharing of the refined draft with stakeholders; production of the final draft; presentation of the final draft to MALF management team for ownership; presentation of the document to the Minister of Agriculture Livestock and Fisheries for endorsement and approval. Thereafter, CSA Guideline dissemination plan was developed.

3.4.6 Limitations

One of the major limitations was that the team could not cover all the 64 AEZ in the country, and only 16 were covered. This Guideline is therefore a first attempt and it should be updated from time to time in order to cover other regions and AEZ of the country.

CHAPTER 4: CLIMATE CHANGE ADAPTATION STRATEGIES, CSA PRACTICES AND TECHNOLOGIES

4.1 Climate Change Impacts and Farmers' Adaptation Strategies

4.1.1 Perceptions

Results from the baseline survey show that climate change has already occurred and has caused negative impacts on agriculture. In all agro-climatic zones visited, 60-100 per cent of farmers reported perceiving impacts of climate change (Annex 5). To a great extent farmers are knowledgeable on issues related to climate change in Tanzania. Findings from the baseline survey indicated that farmers also had some knowledge (though limited) on climate-smart agriculture. The local farmers for example noted changes in temperature, rainfall and wind, which they associated with climate change. The changes have affected their livelihood activities especially agriculture and livestock keeping. This shows that local farmers understand climate change in terms of its impacts and that they are the ones hardest hit by climate change.

In various places, as noted also by scholars, crops have failed due to prolonged droughts or extreme precipitation. This was pointed out by various categories of respondents, who were interviewed including farmers, extension officers, NGOs, private sector and researchers from Agricultural Research Institutes (ARIs) and Universities. All the respondents perceived that the impacts of climate change are evident in their areas. Responses from majority of farmers admitted that climate change has already occurred and the impacts have affected them. Although the impacts varied from one place to another, the most common impacts observed and witnessed include changes in rainfall amount and distribution, temperature rises and change in wind patterns. Other impacts stated were shift in agricultural seasons and increase in rainfall variability, incidence of pests and diseases and frequency of extreme weather events, particularly drought.

Similarly, researchers, extension officers, NGOs and private sector also acknowledged that climate change is real and the impacts have caused challenges in agricultural production among smallholder farmers. According to agriculture extension officers, climate change has negatively impacted the agriculture sector due to its high dependency on rainfall. They insisted that changes in weather are affecting the agriculture sector especially crop production and livestock keeping.

4.1.2 Adaptation Strategies

In view of the observed impacts, different strategies are being employed to adapt to the changing climate. Although the strategies varied from place to place, in most places they included early land preparation, early planting, dry planting, planting of drought tolerant crops, planting of early maturing crops, mulching, irrigation, tree planting, and the use of indigenous knowledge (Annex 4). Other strategies include replanting, intercropping, crop rotation, minimum tillage, use of water harvesting pits, digging irrigation trenches and terracing. Livestock farmers also adapt by growing grasses and perennial fodders, using farm by products and doing additional activities such as crop farming.

In addition to farmers' initiatives, extension agents build the capacity of farmers to adapt to climate change impacts by promoting the use of improved seeds (short maturing and drought resistant crop varieties) and adoption of improved agricultural practices that conserve soils and water (such as intercropping, minimum tillage and water harvesting technologies), ridging and agroforestry. They also promote appropriate use of fertilizers, manure application, crop rotation, ox-ploughing, drip irrigation, agro-processing, mushroom cultivation, mulching and use of water harvesting pits. In livestock production, extension agents promote use of improved livestock breed, improved livestock management, artificial insemination, milk value addition, improved fodder and supplemental feeding of concentrates. Also they have been training farmers through Farmer Field Schools (FFS), demonstrations, study tours, field/exchange visits and exhibitions. Livestock keepers are encouraged to practice crop farming in addition to keeping animals and these strategies are promoted through group training and follow up, engaging with policy makers and using of research institutions for demonstrations.

Research institutions such as SUA and ARIs are promoting different climate related technologies/practices including System of Rice Intensification (SRI), use of water harvesting pits, pocket/kitchen gardens, rain water harvesting, use of weather information through knowledge sharing, face to face meetings, village meetings, workshops and training. ARIs are also conducting various climate change research initiatives and develop various improved seeds and breeds (crops, livestock and fish) that are highly productive, drought tolerant and disease resistant.

NGOs promote climate-smart technologies and practices through training, radios, seminars, demonstrations, FFS and integrating approaches. In crop production, they promote CSA technologies and practices such as Conservation Agriculture (minimum tillage, soil cover and crop rotation). Other crop technologies and practices promoted include application of organic fertilizers, use of bio-pesticides; use of early maturing varieties, drought tolerant crop varieties particularly Open Pollinated Varieties (OPVs) which farmers can recycle for a number of years; and improved crop varieties (e.g. root crops - orange flesh sweet potatoes). NGOs also promote improved livestock production technologies and practices including cross breeding of local chicken, goats, sheep, pigs and cattle. Other technologies promoted are artificial insemination, livestock processing, introduction of dairy goats and cattle; pest and disease control through dipping and use of hand sprayers to control ticks. Livestock intensive and semi-intensive systems as well as crop-livestock integration are also promoted as they reduce movement of livestock and increase production. In some areas they also promote improved fodder. In fisheries, NGOs promote aquaculture and sustainable fishing as a measure to adapt and mitigate the impacts of climate change in fisheries (e.g. in Pangani District).

4.2 CSA Practices and Technologies

Using the information gathered during the baseline survey, combined with expert knowledge and literature review, the suitable CSA technologies and practices were identified and summarised. Table 2 contains the 'Recommended CSA packages of technologies and practices' that will guide implementation of CSA activities in the different study sites. The current practices and technologies used by farmers surveyed during the baseline are summarized in Annex 5. These shows the current status of "CSA-readiness" of farmers, and what CSA practices and technologies could be suitable and adopted.

4.2.1 Crop Subsector Practices and Technologies

4.2.1.1 Rain Water Harvesting and Storage Practices and Technologies

a. Rain Water Harvesting and Storage Structures

Rain water harvesting (RWH) is a method for inducing, collecting, storing and conserving local surface runoff for agriculture (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 utilisation 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* (Bunded basins) 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 a 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. In areas where traditional water harvesting technologies exist, they should be improved and promoted e.g. Ndiva system in Pare Mountains, or Kitivo in Usambara Mountains.

In essence, in situ rainwater harvesting technologies are soil management strategies that aim at maximum infiltration and minimum surface runoff to achieve better yields where soil moisture is a constraint. This technology often serves primarily to recharge soil water for crop and other vegetation growth in the landscape. On the other hand, as the storage systems of ex - situ systems often are wells, dams, ponds or cisterns, water can be abstracted easily for multiple uses including irrigation or domestic, public and commercial uses through centralized or decentralized distribution systems. Increase in water availability will improve agricultural yield and farmers' livelihood at scale. Through this, adaptation to climate change impacts will therefore be possible.

Water shortage affects more rural women since it is their cultural role to provide water. They are more concerned with rainwater harvesting as compared to men. Therefore, small-scale rainwater harvesting can ensure a significant and steady supply of water for farming even in times of drought, and permit year-round vegetable cultivation with significant nutritional impacts on families. Small-scale rainwater harvesting systems can also reduce the time that women and girls spend collecting water and increase time and energy available for education and productive work.

b) Chololo Pits

Chololo pit is an in-situ rain water (runoff) harvesting technology initiated by a farmer in Chololo village, Dodoma. Chololo pits consist of pits of about 0.2 – 0.25m deep and 0.2-0.25m diameter dug in a line across the slope spaced at 0.5m within line and about 1.0m between lines. The adjacent line of pits is set such that the pits are dug in a middle position to the ones above so as to tap runoff that has drained through the first line of pits. They are made during land preparation (before rains) and the soil is heaped below the pit. Crop seeds (millet seeds) are planted in the pits and part of the soil (sometimes mixed with manure) is returned to cover the seeds. The pit holds and conserves runoff water during the growing season. Contour bunds are constructed on the upper side of the farm to control excessive runoff.

4.2.1.2 Irrigation Practices and Technologies

a. Drip/Trickle Irrigation

Due to climate change, more attention should be placed on using water efficiently, reducing evaporation and enhancing infiltration and moisture retention in the soil profile through soil organic matter (SOM) management combined with the use of more drought-resilient species.

Drip irrigation, also known as trickle irrigation, is an irrigation method that saves water and fertilizer by allowing water to drip slowly to the plant roots, 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.

Drip irrigation can improve water use efficiency. A well-designed drip irrigation system reduces water run-off through deep percolation or evaporation to almost zero. If water consumption is reduced, production costs are lowered. Also, conditions may be less favourable for the onset of diseases including fungus. Irrigation scheduling can be managed precisely to meet crop demands, holding the promise of increased yield and quality. Agricultural chemicals can be applied more efficiently and precisely with drip irrigation. Since only the crop root zone is irrigated, nitrogen that is already in the soil is less subject to leaching losses. In the case of insecticides, fewer products might be needed. Fertiliser costs and nitrate losses can be reduced. Nutrient applications can be better timed to meet plants' needs.

Drip irrigation is a versatile technology suitable for application in a wide range of contexts. It can be implemented at small or large scales and with low-cost or more sophisticated components. This technology can be employed in conjunction with other adaptation measures such as the establishment of water user boards, multi-cropping and fertiliser management. Promoting drip irrigation contributes to efficient water use, reduces requirements for fertilisers and increases water productivity. It is particularly suitable in areas with permanent or seasonal water scarcity, since crop varieties can also be adaptable to these conditions.

Drip irrigation reduces the irrigation water volume required to grow crops, which can lower the risk of water supply shortages for irrigation. It allows for flexibility in the timing and amounts of applied water according to the evapo-transpiration/plant demand; and because less water is applied, nutrient leaching is reduced. Nutrient applications can also be better timed to meet plant needs. Application of fertilizers in irrigation water means the nutrients can be delivered directly to the root zone. Drip irrigation allows for the use of polyethylene mulch, which helps soil-water conservation and reduces fertilizer leaching from rainfall.

b. System of Rice Intensification (SRI)

The System of Rice Intensification (SRI) is a methodology for increasing the productivity of irrigated rice by changing the management of plants, soil, water and nutrients. SRI is a low water, labour-intensive, and organic method that uses younger seedlings singly spaced and typically hand weeded with hand tools such as push-weeders. SRI leads to healthier soil and plants supported by greater root growth and the nurturing of soil microbial abundance and diversity. It is a climate-smart and agro-ecological methodology for increasing the productivity of rice and more recently of 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.

SRI is a water saving technology for lowland (paddy) rice farmers; it involves controlled irrigation, (rice fields are alternately flooded and dried and fields monitored via simple, perforated tubes). It improves farmers' livelihoods; decreases costs of (water-related) inputs and increases resilience to both price shocks (e.g., increased energy costs) and weather variability. Paddy rice cultivation is a primary source of non-CO_2 GHG emissions from the agriculture sector. Therefore, SRI is widely accepted as climate-smart technology for its potential to significantly reduce methane emissions and increasing yields.

c. Irrigation Canal Lining

Canal lining is the process of reducing seepage loss of irrigation water by adding an impermeable layer to the edges of the trench. Seepage can result in losses of 30 to 50 percent of irrigation water from canals, so adding lining can make irrigation systems more efficient. Canal linings are also used to prevent weed growth, which can spread throughout an irrigation system and reduce water flow. Lining a canal can also prevent water logging around low lying areas of the canal. The most commonly used types of lining include: concrete; concrete blocks, bricks or stone masonry; sand cement; plastic; and compacted clay.

4.2.1.3 Soil and Water Conservation Practices and Technologies

Soil and water conservation structures reduce run-off and eventually soil erosion, conserve the soil productivity and therefore help to increase yields, especially on sloping farmlands. There are different types of soil and water conservation practices, which can be used under specific conditions such as low rainfall, high rainfall, steep slopes, gentle slopes, deep soil, shallow soil etc.

a. Ridging

Ridging is the farming practice of ploughing or placing stones across the slope following its contour line for the purpose of controlling soil erosion and enhancing water infiltration. This practice is mostly adopted in gentle slopes to control run-off and retain moisture and nutrients. Ridging creates a water break, which reduces the formation of rills and gullies during the times of heavy water runoff which is a major cause of soil erosion. The ridges should traverse the slope to capture the rainfall rather than running downhill, channelling water and soil away.

b. Tie-Ridging

Tie-ridging is a soil and water conservation practice used mainly to conserve soil moisture in areas receiving insufficient rainfall. Small earth ties are made within the ridge/furrow to collect and store runoff in the soil to be used by crops planted on the ridges

c. Water Retaining/Harvesting Pits

Water-retaining pits trap runoff and allow it to seep into the soil. A series of pits are dug into the ground where runoff normally occurs. The soil from the pit is used to make banks around the pits. Furrows carry excess water from one pit to the next. Traditionally, this system is mainly practiced by the Matengo tribe of Mbinga District, living on the steep slopes of the Matengo highlands. The pits are locally called Matengo pits or *Ngoro.* The system is suitable for steep slopes of 20percent - 50percent, which are prone to erosion.

Ngoro is a pit that is surrounded by four ridges that are tied together. The purpose of this pit is to intercept and prevent destructive effects of surface runoff on the cultivated steep slopes. This is a two-year cultivation system, where by one cycle of crop alternate with a short fallow period. The construction starts at the end of the wet season (March - April) when soils are wet and rains are about to end. Prior to cultivation, grass is cut (not burned) and once dried it is piled into ridges on vertically and horizontally square grids traditionally about 2m x 2m. Soil is then dug (0.5 m deep) from the centre of each square and placed to cover the dried grass to form four bunds surrounding each pit.

Some of the benefits of Matengo pits are: to minimize soil erosion, water runoff and nutrient loss, it improves soil fertility due to its combination with anti-erosion mechanism maintenance techniques, helps in water conservation because of the pit that is surrounded by four ridges that are tied together, the system has enabled people to farm intensively in the steep areas without deterioration of land and without a decline in crop production and contributes to pest control due to crop rotation. One major challenge affecting the practice is the non-availability of sufficient labour to work on the fields and inadequate supply of composting material. This practice was developed since the 18th century has also been acclaimed as an effective soil conservation measure.

d. Terraces

Terrace farming is a method of farming using "steps" that are built into the side of a mountain or hill. On each level, various crops are planted. When it rains, instead of washing away all of the nutrients in the soil, the nutrients are carried down to the next level. Additionally, these steps prevent a free flowing avalanche of water that would take plants with it and destroy the crops on the hillside. Terraces are pieces of sloped plane that have been cut 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. Terrace farming is common in mountainous areas of Uluguru and Lushoto (URT, 2014)

Terraced fields decrease both erosion and surface runoff, and may be used to support growing crops that require irrigation. Small terraces with the size of a ladder are dug on steep slopes for the purpose of breaking the slope and controlling soil erosion. They are used for growing mainly vegetable crops such as cabbage, onions, green pea and beans. There are different types of terraces such as the following: -

- **Fanya Juu Terraces**
  Fanya Juu terraces are made by digging a trench along the contour and throwing the soil uphill to form an embankment.
  The embankments are stabilized with fodder grasses and in between cultivated portions. Over time, the *Fanya Juu* develops into bench terraces. They are useful in semi-arid areas in harvesting and conserving water. The measure is suitable for soil too shallow for level bench terracing and moderate slopes below 20percent. However, they are not applicable on stony soils. *Fanya Juu* is a very versatile technology - ideally suited to smallholder farms, especially in sub-humid areas where the land is sloping and erosion a threat. Fodder grasses may be planted on the bunds and fed to livestock. In the dry areas, water harvested from roads is directed into the trenches which allow production of bananas and fruits.

- **Fanya Chini Terraces**
  Fanya Chini terraces are made by digging a trench along the contour and the soil is put on the lower side of the contour trench. It is used to conserve soil and divert water. The embankment can be used to grow fodder. This is applicable on slopes of up to 20percent.

- **Bench Terraces**
  Bench terraces are level or nearly level steps constructed or formed on the contour and separated by embankments known as risers. They are formed by excavation or developed from grass strips or *Fanya Juu* terraces. They are suitable on slopes up to 55percent.

- **Stone Terraces**
  Stone terraces are useful in areas with steep slopes but high population density and scarce land. The terrace risers are made of stones collected from the land. Stone terraces are suitable where there is abundant availability of stones.

4.2.1.4 Agroforestry Practices and Technologies

Agroforestry is a dynamic, ecologically based, natural resource management system that, through integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits. Agroforestry systems include both traditional and modern land-use systems where trees are managed together with crops and/or animal production systems in agricultural settings.

Agroforestry systems play important roles in increasing the resilience to climate change impacts for small scale farmers and in larger landscape approaches. Trees help fight climate change by storing carbon. Carbon, sequestered by trees intercropped with food and fodder crops and stored in above ground biomass and soil, contributes to reducing greenhouse gas concentrations in the atmosphere. Trees buffer against weather-related production losses, such as reducing soil erosion through e.g. hedgerow and contour planting - thus enhancing resilience against climate impacts. Trees bring nutrients from deeper soil layers, or in case of legume trees, through nitrogen fixation, and decomposition of leaf litter into fertilizer for crops. And trees on farms provide additional income and diversity of food sources through tree-based products. The combination of trees, crops and livestock mitigates environmental risk, creates a permanent soil cover against erosion and minimizes damage from flooding and acts as water storage, benefitting crops and pastures.

Agroforestry serves to enrich farmers through the harvesting of diverse products at different times of the year. It also brings job opportunities from the processing of tree products, expanding the economic benefits to rural communities and national economies.

Agroforestry is increasingly acknowledged as a climate-smart production system which through provisions of sustainable environmental and socio-economic benefits helps to increase resilience of farming systems and the adaptive capacity of farmers to impacts of climate change (Kimaro *et al.* 2015). Recent studies in Mwanga Kilimanjaro, Tanzania (Charles et al., 2013) and Western Kenya (Thorlakson and Neufeldt, 2012) revealed that agroforestry practitioners have more diversified sources of food, fodder, wood fuel, and income; increasing their adaptive capacity to climate change than non-Agroforestry practitioners. According to Sanou *et al.,* (2011), amelioration of temperature and light conditions under baobabs tree canopy improved millet and taro production by 39percent and 50percent, respectively under semiarid conditions in the Sahel. It has been noted that inclusion of trees in farmlands also enhances efficiency use of fertilizer and precipitation for crop production (Sileshi *et al.,* 2011 and Kimaro *et al.,* 2015). Mulch or green manure from tree leaves add soil nutrients, improve infiltration and decrease evaporation from soils and hence improving soil moisture retention. Moreover, the presence of trees/shrubs in the farmland enhance the ability of the land to capture rainfall, store and make it available to crops through the build-up of soil organic matter by maintaining a leaf canopy during the dry season (Sileshi *et al.,* 2011; Kimaro *et al.,* 2015).

Some of the common agroforestry practices found in the field during the baseline survey were boundary tree planting and intercropping with nitrogen-fixing trees. Other agroforestry practices include improved fallows, woodlots, coffee home-gardens with fruit and shade trees and livestock based agroforestry practices, including *ngitili* and zero grazing.

Agroforestry practices for replenishing soil fertility are attractive to women farmers because they involve low inputs but high returns. Agroforestry with Indigenous fruits trees can also provide women with significant income. For example, in Tabora Region, women are generating income through processing and selling of jam, wine and juice from indigenous fruits. Among the widely promoted agroforestry practices include; trees in cropland, woodlots, improved fallows and fodder banks. Others include; boundary planting live fence and bee keeping.

a. Tree in Crop Land

This is the practice of growing crops in association with trees left during land preparation or planted for their economic, social or cultural value. Among the common values include production of fruits, fuelwood, timber, medicine, and shade or soil fertility improvement. Some of the common species found on cropped lands are Afzelia quanzensis (Timber, fuel wood), *Parinari curatellifolia* (Fruit), *Pterocarpus angolensis* (Soil fertility, timber), *Faidherbia albida* (soil fertility, fodder), *Piliostigma thonningii* (soil fertility, fodder)

b. Rotational Woodlot

The rotational woodlot is an agroforestry practice which involves alternating arable crops with improved tree fallow on the same piece of land over time (Otsyina *et al,* 1998). The practice is intended to simulate the effects of shifting cultivation systems, with tree species carefully selected for their fast growth rates, high wood yields, and/or soil enrichment capacity (Young, 1989). The practice involves three phases namely; tree establishment phase (crop and young trees), fallow phase (woodlot) and the post-fallow phase (clearing for cultivation) (Otsyina *et al* 1994, Chidumayo 1988). Some of the recommended tree species (for soil fertility improvement) include; Leucaena spp, *Acacia polyacantha, Gliricidia sepium, Albizialebbeck.*

c. Improved Fallow

This is a practice of improving a farm which after continuous cultivation is rested (fallowed) for one or two seasons to regain fertility by introducing fast growing, high fertility enriching plants normally herbaceous legumes, grasses and/or shrubs. Some of the species used to improve fallow land are; *Sesbania sesban* (sesbania), *Tephrosia vogeli* (utupa), *Cajanus cajan* (mbaazi), sun hemp (Marejea), and herbaceous legumes like Lablab purpureus.

d. Fodder Bank

The practice involves growing of high quality fast-growing and high-yielding trees, shrubs, grass and herbaceous legumes in small homestead plots in order to provide low cost fodder supply to alleviate shortages of fodder and nutrition deficiencies and consequently, increase and sustain livestock production. The animals are given supplements of protein-rich feedstuffs during the dry season when other good-quality fodder is scarce. The fodder may be cut, carried and fed to livestock in their enclosure (kraal). The kraal manure in turn is applied to crops thus enhancing nutrient cycle (soil resilience). The amount and quality of manure increase with good feeding of the animals. Alternatively, livestock can be allowed to graze on the fodder bank, although not all fodder species tolerate this well. Some species used in fodder bank include; *Leucaena leucocephala*, *Panicum maximum*, Acacia *spp*

e. Tree Planting / Afforestation

Tree planting is the process of transplanting tree seedlings, generally for forestry, land reclamation, or landscaping purpose. The activity is known as reforestation, or afforestation, depending on whether the area being planted has or has not recently been forested. It involves planting seedlings over an area of land where the forest has been harvested or damaged by fire or disease or insects. Tree planting is grounded in forest science, and if performed properly can result in the successful regeneration of a deforested area.

Trees contribute to climate change adaption by reducing wind speed, and decreasing damage to crops and degradation/erosion to the soil. They contribute to climate change mitigation by removing CO2 from the atmosphere. Trees provide shades to mitigate the impact of climate induced temperature rise. Reforestation provides other benefits by reducing land degradation and soil erosion, and improving water infiltration. Practices that promote sustainable management of forests for their role in climate stabilisation can simultaneously provide multiple benefits for local communities. Forests produce wood and non-wood products, fruits, fibre, medicines and honey, all of which can be important for the livelihood.

Local people often prefer indigenous species for a variety of uses such as charcoal, furniture, housing material, and medicine. Examples include: *Afzelia Quanzensis, Khaya Annthotheca, Milicia Exelsa, Pterocarpus Angolensis, Gmelina Arbores, Terminalia Superba, Terminalia Ivorensis* and *Trichilia Emetica*. Exotic tree species are planted because they are fast growing species that serve a variety of uses such as fuel wood, timber, and fodder in order to relieve pressure on existing forests. Examples of exotic tree species are *Eucalyptus Camaldulensis, Eucalyptus Citrodora, Eucalyptus Tereticornis, Casuarinas Equisetifolia, Cedrella Odorata, Acacia Mangium* and *Tectona Grandis*.

Tree planting initiatives that specifically enlist participation of women have had great success. For example, the "Late Wangari Mathais' Greenbelt Movement Women Tree Planting Initiative" is one of the World best practices. Tree planting was linked to women economic empowerment which helped the women earn carbon credit.

4.2.1.5 Conservation Agriculture Practices and Technologies

Conservation Agriculture (CA) is a set of soil management practices that minimize the disruption of the soil structure, composition and natural biodiversity and has a potential to improve crop yields, while improving the long-term environmental and financial sustainability of farming. It encompasses farming practices which have three key characteristics: First, minimal mechanical soil disturbance (i.e. no tillage and direct seeding); second, maintenance of a mulch of carbon-rich organic matter covering and feeding the soil (e.g. straw and/or other crop residues including cover crops); and third, rotations or sequences and associations of crops including trees and legumes which are nitrogen-fixing.

CA offers climate change adaptation and mitigation solutions while improving food security through sustainable production intensification and enhanced productivity of resource use. Management of soil fertility and organic matter, and improvement of the efficiency of nutrient inputs, enable more to be produced with proportionally less fertilizers. It also saves on energy use in farming and reduces emissions from the burning of crop residues. Moreover, it helps to sequester carbon in soil. Conservation Agriculture also contributes to adaptation to climate change by reducing crop vulnerability. Conservation Agriculture also contributes to protect crops from extreme temperatures. Hence, CA offers opportunities for climate change adaptation and mitigation solutions, while improving food security through sustainable production intensification and enhanced productivity

a. Cover Cropping;

Cover cropping is a technology that aims to maintain or cover soil surface during and between cropping operations. It is well known by farmers and extension agents. It can be achieved by, for example, planting leafy legumes between the plants of the main crop, providing shade, suppressing weeds, reducing ground temperature and evapo-transpiration, and thereby retaining soil moisture (URT, 2014). It has also been used for reducing effects of raindrop impact and aggregate disintegration from slaking. Ground cover also prevents raindrops from directly striking the soil surface and allows rainfall to slowly penetrate the soil surface. Ground cover helps to sequester carbon dioxide in the soils but also control soil erosion.

b. Mulching

Mulching is a technology of applying a protective covering, usually of organic matter such as grass, leaves, straw, or peat, around plants or on the surface of the soil. Mulching helps to conserve moisture, improve the fertility and health of the soil and reduce weed growth. When applied correctly, mulching can dramatically improve soil productivity. Maintenance of a mulch layer provides a substrate for soil-inhabiting microorganisms which helps to improve and maintain water and nutrients in the soil. This also contributes to net increase of soil organic matter - derived from carbon dioxide captured by photosynthesis in plants, whose residues above and below the surface are subsequently transformed and sequestered by soil biota.

From the baseline survey, farmers know and adopt mulching in their farms to cover soils and thus protect the soils from direct contact with the Sun and therefore control water losses by evaporation. Also by suppressing weed, mulching reduces the cost of weeding, and therefore reduces overall cost of production.

c. Crop Rotation

Crop rotation is a technology of growing different crops in a field each year or season. The new crop planted during the succeeding season will be from a different family. The idea behind this is to change what soil nutrients the crop uses, and the insects it attracts. So, the pests never get used to one field because crops are constantly changed. In terms of soils, each crop needs different nutrients. Changing the crop every year prevents depletion of any one nutrient in the field. Crop rotation is also effective in suppressing weeds because of regular changes in the root zone composition and patterns of nutrient absorption. Rotations and crop associations that include legumes are capable of hosting nitrogen-fixing bacteria in their roots, which contributes to optimum plant growth without increased gas emissions induced by fertiliser's production. Crop rotation over several seasons also minimises the outbreak of pests and diseases.

d. Intercropping

Intercropping is a multiple cropping technology involving growing two or more crops in proximity in the same field. The farmers commonly use a cereal-legume intercrop, mixing of crops for example millet, sorghum or maize with cowpeas or groundnuts (Chololo Eco-village 2011-2014 Project). Farmers acknowledge leguminous crops such as beans, cowpeas, lablab and pigeon peas are suitable for intercropping as they contribute nutrients to the soils by biological nitrogen fixation. In this case, intercropping reduces depletion of individual soil nutrients (Ibid). It can also involve new crop varieties (e.g. drought resistant).

The most common goal of intercropping is to produce higher yields on a given piece of land by making use of resources that would otherwise not be utilized by a single crop. It provides a family with a balanced diet of staple grains, protein-rich beans, and green leaves for essential vitamins. It also reduces risk of total crop failure by having two crops instead of one. Also intercropping increase resilience to drought and reduced pest and diseases incidences.

e. Minimum / Zero Tillage

Minimum Tillage (MT) means reducing tillage operations required to plant a crop (Conservation Farming Unit -CFU, 2007). Minimum Tillage usually involves scratching or ripping along the row where the crop is to be planted and leaving the rest of the land untouched until weeding is required. Alternatively, farmers may just dig holes or pits where the seed will be sown (such as *chololo* pits in Dodoma and basins in Newala). Minimum tillage is one of key conservation agriculture (CA) practices that minimizes run-off and increases infiltration rates. It actually ensures enough moisture is stored in the soil for plant growth.

Avoidance of tillage minimises occurrence of net losses of carbon dioxide by microbial respiration and oxidation of the soil organic matter and builds soil structure and bio-pores through soil biota and roots. Zero tillage has many advantages among others including minimal soil disturbance; retention of crop residues; seeds planted directly into previous crop's residue; and crop rotation. It reduces erosion; improves soil quality and structure, soil biota; reduces evaporation of water, helps retain nutrients. In addition, depending on rotation, no-till reduces greenhouse gas emissions of nitrous oxides.

f. Crop Residue Management

Crop residues management is the practice where by crop residues are left in the field /farm after the crops have been harvested. These residues include sticks and stubble/stems, leaves and seed pots. Crop residues can also be used as animal feed outside the crop field. The protective soil cover of leaves stems and stalks from the previous crop protect the soil surface from heat, wind and rain, keeps the soil cooler and reduces moisture losses by evaporation. In drier conditions, it reduces crop water requirements, makes better use of soil water and facilitates deeper rooting of crops. In extremely wet conditions, crop residues management facilitates rain water infiltration, reducing soil erosion and the risk of downstream flooding.

4.2.1.6 Soil Fertility Management Practices and Technologies

A healthy soil is fundamental for sustained agricultural productivity and the maintenance of other vital soil-mediated ecosystem processes. To cope with climate change, specific management practices need to be adapted taking into account: the types of crop, grazing and forest systems, the diversity and current status of soils (e.g. sand/loam/clay soils, peat soils, sodic soils, shallow soils, nutrient depleted soils), terrain (e.g. steep/flat lands, wetlands) and climatic conditions (e.g. short rains seasons, erratic rains, high temperatures and storms).

Management practices that increase soil organic carbon (SOC) content from year to year through organic matter management will bring benefits. Productive soils that are rich in carbon require fewer chemical inputs and will maintain vital ecosystem functions such as the hydrological and nutrient cycles. A shift away from specialised high input systems towards the design and adoption of more integrated production systems (crop-livestock, agroforestry, agro-pastoral) will reduce inorganic fertiliser use and resulting in lesser GHG emissions.

a. Manuring

- ***Farm Yard Manure***

  Farm Yard Manure (FYM) is an appropriate technology to enhance nutrient availability for ensuring high yields. FYM is also good for improving 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.

  A large proportion of the mitigation potential of agriculture (excluding bio-energy) arises from soil carbon sequestration, which has strong synergies with sustainable agriculture and generally reduces vulnerability to climate change (IPCC, 2007). With regard to CO_2 sequestration in soils, use of FYM can achieve high carbon and improve soil structure and quality, because the accumulated carbon is in the organic form of humus. This will improve climate adaptation by reducing the impacts of flooding, droughts, water shortages and desertification, thereby also improving food and water security.

- ***Compost Manure***

  Composting is a partially controlled and accelerated bio-oxidative process through which highly diverse and heterogeneous organic material is decomposed and transformed into unified material. Composition of the raw materials to be composted determines CO_2 evolution during composting, and residual carbon levels in finished compost. Compost refers to a mixture of organic matter, from leaves and manure that has decayed or has been digested by organisms, and can be used to improve soil structure and provide nutrients. It helps dry soil to absorb and retain more water, compacted soils to regain their elasticity and poor soils to bring forth abundant farm produce; they provide plants with nutrients which they require to grow to their full potential.

  Action to raise soil carbon levels through more widespread adoption of organic farming practices and grass-based and mixed farming systems can make a significant and immediate contribution to greenhouse gas mitigation. Harvesting crops removes carbon from the soil that would otherwise return to the soil when the plant dies and decomposes. Compost returns organic matter to the soil. The nitrogen in compost can increase soil productivity, which can lead to increased crop residues and an increased return of carbon to the soil. Composting increases the formation of stable carbon that remains bound in the soil for long periods of time. Applying organic matter to soils is one of the most effective ways to divert CO2 from the atmosphere and convert it into organic carbon in the soil.

  Compost use can supply at least some of the mineral nitrogen that would otherwise have to be provided through mineral fertilisers, as well as most, if not all, of the crop's phosphorous, potassium and trace element requirements. Substituting the use of mineral fertiliser through compost use offers an opportunity of reducing GHG emissions caused by the manufacturing and transportation of fertilisers.

b. Efficient Use of Fertilizer (Micro Dosing)

Micro-dosing of fertiliser is a highly efficient technique that minimises the application of and over-reliance on fertilizers. Fertiliser micro-dosing involves the application of small and affordable, quantities of fertiliser onto or close to the seed at planting time, or a few weeks after emergence. This can be done by filling a soda bottle cap with fertiliser and applying it directly to the root of the crop. The micro-dosing technique increases the efficiency of fertilizer use, and helps improve productivity.

c. Integrated Soil Fertility Management

Integrated Soil Fertility Management (ISFM) aims to make available required soil nutrients by balancing different on-farm soil organic sources (amendments) with nutrients from mineral fertilizers (to address deficiencies) and reducing nutrient losses through soil and water conservation. It is advised that use of fertilizers should be under the concept of integrated soil fertility management (ISFM) which is a set of agricultural practices adapted to local conditions to optimise the efficiency of nutrient and water use and improve agricultural productivity (Sanginga and Woomer, 2009).

ISFM aims to optimise the use of organic matter that provides nutrients, sequesters C and enhances water storage (e.g. compost, animal manures or green manures); and enhance nutrient efficiency through crop rotations or intercropping with nitrogen-fixing crops and judicious/precision use of inorganic fertilizer to reduce losses. Also ISFM minimize GHGs emissions (reduced traffic and tillage and efficient use of organic and inorganic fertilizers).

ISFM strategies centre 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.

ISFM improves resilience of soils and agricultural production to weather variability; increases soil organic matter and soil organic carbon; improves soil health and fertility leading to increased yields and; lowers potential for nitrogen leaching and greenhouse gas emissions, potentially increases soil carbon. Other soil fertility management practices include; mulching, crop rotation (see under conservation agriculture).

4.2.1.7 Crop Management Practices and Technologies

a. Adapted crops and crop varieties (Improved seeds, high yielding, fast maturing, drought tolerant, salinity tolerant, flood tolerant)

Climate change affects the agricultural yield directly through changes in temperature and precipitation, and indirectly through changes in soil quality, pests and diseases. Drought is the principal constraint of crop production in dry land areas. It may be defined as periods in the natural cycle of stress and renewal during which the amount of moisture in the soil no longer meets the needs of a particular crop. Drought occurs frequently in dry lands, partly because average rainfall is low, ranging across locations and years from an average of about 300 to 800 mm per annum, but also because it may be highly erratic, followed by long dry spells. Improved crop varieties provide one of the key technologies for addressing climate change impacts especially in areas where rainfall is expected to be more erratic or to decrease (Lobell *et al.,* 2008).

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. Improved, high-yielding varieties include grain, legume, fruit, and vegetable varieties that have been bred to improve and increase yields. Early maturing crop varieties enable the crop to escape stress at the end of the season and are ideal for intercropping as they provide less competition for moisture, light, and nutrients as compared to late maturing varieties. In addition, they offer flexibility in planting dates, which enables multiple plantings in a season to avoid risk of losing a single crop due to drought and avoidance of known terminal drought periods during the cropping season. These advantages make the early maturing crop varieties more remunerative and less risky to climate change impacts. Drought tolerant crops bred specifically to be adapted to climate challenges in a particular region escape drought through early maturity.

b. Integrated Pest and Diseases Management (IPM)

Integrated pest management (IPM), also known as Integrated Pest Control (IPC) is a broad-based approach that integrates practices for economic control of pests. IPM aims to suppress pest populations below the Economic Injury Level (EIL). It is a strategy that promotes a safer and more sustainable management of pesticides. IPM lies at the centre of insect, disease, and weed control. The combination of farming strategies, biological control agents, and necessary pesticide and herbicide use can help farmers address pest problems using a variety of methods.

IPM reduces the need for pesticides by using several pest management methods; shields the environment from excessive or unnecessary pesticide applications; fosters clean water supplies; and promotes sound structures and healthy plants.

IPM contributes to climate change adaptation by providing a healthy and balanced ecosystem in which the vulnerability of plants to pests and diseases is decreased. By promoting a diversified farming system, the practice of IPM builds farmers' resilience to potential risks posed by climate change, such as damage to crop yields caused by newly emerging pests and diseases.

However, the multiple impacts of climate change could significantly reduce the effectiveness of current IPM strategies, leading to higher crop losses. Better knowledge and understanding of pest behaviour under different projected scenarios are required to adopt and develop new IPM technologies to respond to threats resulting from climate change.

c. Timely/Early Planting/Sowing

Timely land preparation and early planting/sowing (in some places also dry sowing) is a practice of adapting to climate change. The practice ensures optimal use of the short rain season and makes efficient use of accumulated nutrients from organic sources during the dry season (nitrogen flush). The use of this practice can be strengthened by climate services through timely provision of weather information.

4.2.1.8 Crop Insurance

Safety nets are a form of social insurance comprising programmes supported by the public sector or NGOs that provide transfers to prevent the poor from falling below a certain poverty level. These programmes include cash transfers, food distribution, seeds and tools distributions, or conditional cash transfers (Devereaux, 2002). Several new initiatives for safety net programmes have recently emerged, including Ethiopia's Productive Safety Net Programme (wfp, 2012) and the Kenya Hunger Safety Net Programme (Oxfam, 2010). There has been a continuing debate about the role of such programmes visà-vis development activities. However, recent evidence indicates trade-offs between protection and development are not pronounced (Ravallion, 2006). Instead, safety net programmes can actually be a form of social investment into human capital (e.g. nutrition, education) and productive capital (e.g. allowing households to adopt higher risk and higher productivity strategies; (SOFI, 2010). Safety nets are increasingly being linked to rights based approaches to food security moving from a charity to entitlements.

4.2.2 Livestock Subsector Practices and Technologies

4.2.2.1 Improved Livestock Breeds

One key technology is improving the genetic potential of cattle, chicken, pigs, sheep and goats to produce livestock which grow bigger and faster but also are resistant to drought and diseases. This can be done through cross-breeding of indigenous breeds with improved or exotic breeds to combine the high yield and early maturity of the exotic breeds with the hardiness, disease resistance, and adaptability of local breeds. The aim of cross-breeding is to improve local breeds to improve production of meat, milk and eggs, while reducing time to maturity. This way livestock keepers gain increased incomes on selling more produce, more often.

4.2.2.2 Adapted Livestock

Different livestock types and breeds require specific environmental conditions. Climate determines the type and quality of pasture, availability of water, livestock pests and diseases and therefore overall livestock types and their productivity. Adapted livestock types and breeds often survive and do well under extreme climatic conditions. Under the changing climate, care should be taken in deciding on the appropriate livestock enterprise for any particular area.

4.2.2.3 Improved Feeding

This entails storing animal feeds (stover, grass, grain) and making better use of feed (by combining types of feed), growing grass varieties specifically suited to the agro-ecological zone, and many other practices, such as fodder conservation and animal fattening.

Livestock production can be enhanced by adopting improved feeding strategies such as cut and carry, rotational grazing by paddocks, fodder crops, and grassland restoration and conservation. This also involves livestock keepers managing paddocks and/or pastures for ensuring enough fodder for livestock. It can also involve cutting and carrying fodder for feeding livestock at home especially under zero grazing. Keeping animals in paddocks helps also in improving the manure management practices.

Livestock feed can be altered to improve its digestibility and provide needed nutrients. Examples of feed supplements are urea–molasses multi-nutrient blocks, low bypass protein, lipids, and calcium hydroxide. Stover mixtures for feed can also be designed to improve digestibility. In addition to providing direct nutrients, urea is converted and synthesized during digestion so that it can provide more protein. Stover from different varieties of the same crop species" is mixed in feed and offers a wide range of digestibility.
Concentrates are livestock feeds for providing basic nutrients required for animal production, including energy, proteins and amino acids (macro-nutrients), and minerals, vitamins and other micro-nutrients. Concentrates may be fed in raw or milled forms as individual feeds (sometimes referred to as straights), or may be blended or formulated into balanced rations for particular production purposes (compound feeds). Compound feeds may be mixed on-farm but are also produced by the commercial feed compounding industry. Other than nutrients, concentrates increase livestock productivity including outputs of livestock products that are achieved from fewer animals.

Seed cake such as sunflower seed cake is a by-product from sunflower oil processing and can be used to feed livestock. The seedcake can be blended with grass or leguminous pastures, or even crop residues to produce supplementary feed for livestock. This can contribute to development of zero grazing system and enhance productivity as well. This will therefore control extensive use of pastureland hence control associated problems such as soil erosion.

Although primarily a mitigation strategy, improving livestock feed also offers adaptive benefits by increasing both the effectiveness of feed and the resilience of livestock. As food resources face increased strain in a changing climate, improving the nutrient quality of available feed will help ranchers maintain herd numbers with less feed. Nutrients also help animals cope with extreme conditions. For instance, animals facing heat stress need a specific diet to maintain normal levels of meat or milk production.

One primary co-benefits of improving livestock feed is a reduction in methane (CH_4) emissions. Climate change mitigation benefits result from a more efficient absorption of nutrients, with a consequent reduction in gaseous losses, and the ability to produce comparable amounts of dairy and meat with fewer animals.

a. Traditional in-situ Fodder Conservation System

Like farmers, livestock keepers (pastoralists) have a rich indigenous knowledge in regard to natural resources management, human and animal diseases relative to their environment. The communities control resource use pattern, and conservation using the traditional knowledge of the ecosystem and the biological diversity of the areas. Among such age old livestock management systems are fodder conservation and grazing land management. Apart from conserving fodder, these systems have other benefits which contribute to climate change resilience such as soil conservation; restoration of land from degradation; regulation of local climate of an area and conservation of biodiversity.

b. Ngitili

This is a traditional fodder conservation system that was developed by the *Wasukuma* agro-pastoralists (Shinyanga) as means of alleviating acute dry season fodder shortage. *Ngitili* encompasses retaining of an area of standing hay until the rainy season ends, the area remains closed to livestock and other activities at the onset of the rainy season and is opened up at the peak of the dry season to allow the livestock get dry season fodder. Grazing under *ngitili* normally starts from July/August after crop residues and forage in fallow areas has been depleted; and animals are removed from *ngitili* after all the fodder is exhausted or when fodder becomes available outside the *ngitili*.

c. Olelii

This is a traditional fodder conservation system developed by the Maasai pastoralists (Arusha) as means of conserving fodder for the dry season or for the calves, sick animals and/or milking herd. The vegetation is left to grow and regenerate during wet season and livestock are allowed to graze in dry season. The elder groups oversee and direct the management and use of resources such as grazing pattern and conservation of fodder for dry season grazing. The Traditional ecological and farming knowledge (TEK) systems such as grassland and forest conservation and use, uses of biological diversity (including ethno-veterinary, nutritional and medicinal uses) is practiced and passed from one generation to another through the traditional institutions.

d. Alternative Source of Water for Livestock

In semi-arid areas, water content of forages is very low during the dry season and due to high evaporation rates, water sources may contain high concentrations of salt. Succulent plants can offer an alternative source of water as well as feed to grazing animals. Some are sufficiently palatable to be preferred, even when drinking water is available, e.g. the juicy herb *Commelina* and the swollen stems of *Pyrenacantha malvifolia*, Water melons (*Citrullus vulgaris*) are available in appreciable quantities in some villages of semi-arid Central Tanzania and are used by livestock as a source of water during the dry season.

e. Zero Grazing

A zero-grazing system is where grass is mechanically mown and brought to cattle. Its appeal is that it allows cattle to consume fresh grass from fields that are too far away, or are separated by busy road, to be included in the grazing rotation. Zero-grazing can also play a role when utilising fields too wet for grazing, provided the machines employed have sufficiently wide wheels to safely distribute their load.

f. Pasture Management

Pasture management is a practice of growing healthy grass and related plants to profitably sustain forage availability and livestock production while ensuring ecological health. Pasture management can provide significant benefits including improved forage yields, lower feed costs and improve livestock performance.

Pasture management tends to decrease carbon levels in pastures, releasing it to the atmosphere. The key to preventing GHG creation is to maintain healthy, high quality pastures. High quality feed means higher feed efficiency and more nutrients absorbed by the animal. The rate of consumption by animal (e.g. cattle) is improved with high quality forage, increasing the efficiency of digestion and reducing the amount of time needed to graze. Faster digestion and greater feed use efficiency means less creation of GHG emissions.

Pastures also have numerous indirect benefits to reduce GHG production from animal production. Perennial forages trap atmospheric CO_2 with their extensive roots systems, storing carbon (C) meters below ground. Grasses and alfalfa not only improve the soil by increasing organic C, but are capable of absorbing excess water, lowering the water table and helping to control soil salinity. Reducing soil moisture also limits the risk of N losses by de-nitrification, cutting down the amount of nitrous oxide (N_2O) creation. Pastures also provide soil cover, protecting against erosion, and maintain or improve water quality.

4.2.2.4 Manure Management

Major emissions from manure come in the form of methane (CH_4) from anaerobic decomposition of manure during storage, and N_2O formed during storage and application. The creation of these gases is influenced by a variety of factors: temperature, oxygen level, moisture or amount of nutrients. In turn, these factors are affected by manure type, animal diet, the type of manure storage and handling and manure application techniques. To help reduce GHGs creation and work with large amounts of excess manure, it is important that manure management in the province concentrates on disposing manure in an environmentally and economically friendly manner.

Objectives for manure management should focus on maintaining or improving local water and air quality by limiting unpleasant odours, reducing nitrogen (N) and phosphorus (P) concentrations in manure and efficiently spreading manure. Although many management technologies exist, not all are realistic or cheap enough for farmers to implement. Different nutrient management strategies will work better for different farms.

a. On Farm Biogas Production

This is a method to reduce Greenhouse Gases (GHGs) emissions and develop more sustainable livestock operations. The GHGs are reduced by production of renewable energy as a substitute for fossil fuels via reduction of fugitive GHGs emissions from stored and land applied manures, as well as by reduction in use of chemical fertilizers in crop production. Utilization of livestock residue in this way is important not only for energy recovery and material recycling but also for preventing environmental pollution.

4.2.3 Fishing and Aquaculture Enterprises

4.2.3.1 Pond Aquaculture/Fish Ponds

This is a common technology used in aquaculture for fish farming. Farmers use fish ponds to farm or raise fish for domestic or market purposes. It is very common in areas with easy access to water though in some dry areas farmers also try to develop fish ponds, often as a seasonal activity during the rainy season. The great bulk of aquaculture in the country is finfish culture. The dominant form of inland finfish aquaculture is in ponds, the size of which range from a few hundred square meters to a few hectares which are often shallow ponds.

Polyculture is the practice of culturing more than one species of fish in the same pond. Fish yield under polyculture can be higher and foods in the pond can be properly utilized, since the different fish species exploit food at different trophic levels.

Fish pond management is critical to environmental impacts. It requires proper management gears at reducing noxious gases production and mitigate high risks of diseases. However, it is important to use fish species which can easily adapt and are tolerant to a particular situation. Some of the farmed and fresh water fish are tolerant to low oxygen levels, high temperature and saline conditions. Such species include Nile Tilapia and catfish. In Marine ecologies, milk fish is known to be tolerant to low oxygen levels, high temperature and poor water quality. In brackish waters, Mozambique tilapia, catfish are extremely tolerant to poor water quality (high level of ammonia, nitrate, nitrite and turbidity), Fish species that can adapt saline water to the level of brackish water are Nile tilapia and Mozambique tilapia.

Pond plan and management basing on knowledge of climate impacts such as flooding: the most important challenge to fish production is feeding, pond management, pond site selection and aquatic disease management. These are very important when considering minimizing climate change impacts.

4.2.3.2 Mariculture

Mariculture is a specialized branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean, or in tanks, ponds or raceways which are filled with seawater. Aqua-silviculture, the integration of aquaculture and mangrove forestry is an environmentally-friendly and GHGs mitigating mariculture system. Such systems not only sequester carbon, but they are also more resilient to shocks and extreme events and also lead to increased production due to improved ecosystem services.

4.2.3.3 Integrated Aquaculture and Cage Culture

a. Integrated aquaculture

Integrated aquaculture is a practice that may take many forms: rice cum fish culture and/or aquaculture integration with animal husbandry. All these forms are traditional practices, conducted on small-scale, often single unit family operations. In general, fish species cultured are those feeding low in the trophic chain.

The potential climatic change impact lies in the fact that an increase in water temperature could occur, albeit to less significant levels than in temperate climates. Overall therefore, climatic change influences on integrated aquaculture could be minimal and perhaps as an adaptive measure these practices, which help carbon sequestration, should be further popularized and encouraged and developed to meet the food safety standards.

b. Cage culture

Globally cage aquaculture is becoming an increasingly important facet of aquaculture development in inland and marine waters and will continue to do so for the foreseeable future. This trend is driven through utilizing existing inland waters for food fish production; in the marine environment to fulfil the increasing demands for higher quality/valued food fish; and also inland cage culture is considered an important means of providing alternative livelihoods for people.

4.2.3.4 Sustainable Fishing

Well-designed and responsibly-used passive fishing gears such as gill nets, pots, hook and lines and traps can reduce the requirement for fossil fuel consumption by as much as 30-40 percent over conventional active fishing gears, such as trawls. Moreover, the use of bio-degradable materials can minimize the amount of ghost fishing when fishing gears are inadvertently lost as a result of bad weather. New designs of selective fishing gear can reduce the capture of juveniles and other forms of by catch as well as reducing discards. Innovative technologies such as echo-sounders can also be used to ensure that fishing gears are not set on vulnerable or sensitive habitats.

a. Seaweed Farming

Globally, the farming of seaweed has expanded rapidly in recent decades as demand has outstripped the supply available from natural resources. In Tanzania seaweed farming is practiced in Zanzibar and along the Indian Ocean coastal belt. The culture of seaweed requires minimal energy inputs and, therefore, has a relatively small carbon footprint. Moreover, the rapid turnover in seaweed culture, approximately three months per crop (in the tropics), far exceeds the potential carbon uptake that could be obtained through other agricultural activity for a comparable area. Additionally, such systems can filter nutrients and provide a “cleaning service” to coastal marine environments.

4.2.4 Other Practices and Technologies

4.2.4.1 Bee-Keeping

Traditional beehives are hung on trees close to a nearby forest. To make a hive, a tree is felled and cut into cylindrical logs which are carefully scooped out to form hollows. They are then sealed, leaving some small holes for exit and entry. The hive is split into halves, which the beekeeper attaches together before baiting and installation. At harvest time, beekeepers make a fire near the hive to create smoke and dismantle the whole beehive. Before dismantling the beehive, it is difficult to know whether there is honey in the hives. The halves are then re-joined for the bees to start the next honey crop. However, this method is tedious in the sense that it is labour intensive and time consuming.

The Tanzanian transitional long hive is a single-box rectangular hive that uses frames instead of top-bars. Usually it contains 27 to 33 frames. All the frames are patterned after the Langstroth type, but the dimensions differ to suit the tropical African bees. Modern hives have straws to test whether the honey is ready for harvesting. By opening the hive and taking out the straw, the farmer will know whether the honey is ready to harvest. This method helps beekeepers to increase production capacity.

4.2.4.2 Climate Information Services

Smallholder farmers in the developing world are especially vulnerable to climate fluctuations and weather extremes, and are expected to suffer disproportionately from climate change. With institutional support and policies, advisories and climate information (historical, monitored, predicted) offer great potential to enable farmers to make informed decisions, better manage risk, take advantage of favourable climate conditions, and adapt to change. Yet a substantial body of research also shows that the availability of information is not sufficient for these smallholder farmers to benefit.

Timely communication of climate information helps prevent the economic setbacks and humanitarian disasters that can result from climate extremes and long term climate change. Climate information also plays a crucial role in national development planning, for managing development opportunities and risks and for mitigation and adaptation. Efficient application of climate services requires that climate information become integrated into various sectors' policies.

4.2.4.3 Improved Cooking Stoves

Improved cooking stoves (ICS) are a mature energy technology for the efficient conversion of energy from biomass to heat. They can influence agricultural practices because they require less wood, which can reduce women's workload and the time needed to prepare food.

Improved cooking stoves can offer the following key benefits to local communities over traditional stoves or 3-stones fire place: more fuel efficient as money and time is saved in acquiring fuel, and; reduced amounts of smoke and indoor air pollution. Furthermore, other wider social benefits are less pressure on forest and energy resources; reduction of disease caused by indoor air pollution; and, skill development and job creation in the community.

Many of today's more efficient cooking stoves have been shown to reduce fuel use by 30-60percent, resulting in fewer greenhouse gas emissions and reduced impacts on forests, habitats, and biodiversity. Recent evidence also demonstrates that advanced (efficient and low emission) cooking stoves and fuels can reduce black carbon emissions by 50-90percent (Global Alliance for Clean Stoves, 2013-2016).

4.2.4.4 Improved Post-Harvest

Post-harvest practices such as improved storage and processing methods, reduce food losses and women's workloads and improve food safety. Utilizing improved postharvest practices often results in reduced food losses, improved overall quality and food safety, and higher profits for growers and marketers. Some of the commonly used postharvest practices includes winnowing, drying using either solar driers especially for horticultural products or direct sun as in maize and rice using tarpaulin or heavy polythene, concrete slab to maintain the quality,

Table 2: CSA packages of technologies and practices in the study regions

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
1 & 2	Bagamoyo District, Pwani	C1, (other similar AEZ C2, C3, C5, C6, C7)	C	Weakly bimodal / unimodal with rainfall ranging from 1000 to 1200 mm	Mainly Loamy sands, sandy loams or sand clay loam on sloping lands of low natural fertility and low WHC; and Sand clay loam, sand clay or clay of medium fertility and WHC on valleys, bottom lands	– Low natural soil fertility and Low WHC in sloping areas – Slope (in places) – Moderate soil fertility and WHC on valleys and bottom lands.	Maize, cassava, paddy, pineapple, cashew nut, coconut, livestock, poultry and fishing	• Ridge cultivation on slopping land supported with application of manure, cover cropping, orchards • Irrigation with high water use efficient technologies and practices on valleys and gardening (vegetable) • Use of adapted crop varieties, application of appropriate organic and inorganic fertilizers, and good agronomic practices including integrated pest management; appropriate agro-forestry practices that integrate crops and livestock • Use of adapted livestock breeds and improved livestock management practices • Aquaculture or integrated aquaculture and cage farming	• Capacity building to women and youth farmers • Orchards are perennials thus require gender analysis to understand inter and intra-household dynamics in terms of land access and control. The same applies to other AEZs • Gender inclusiveness in selection of crop varieties or livestock breeds is crucial because women are the custodians of household granaries, but also the managers of vegetable gardens. This applies to similar practices in the other AEZs • Introduction of improved livestock breeds e.g dairy require gender analysis to understand socio-cultural norms and practices in term of livestock management, division of labour and sharing of benefits from the different enterprises.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
3	Temeke district, Dar es Salaam	C2 (other similar AEZ C1, C3, C5, C6, C7)	C	Weakly bimodal/ Unimodal with rainfall ranging from 800 to 1000 mm	Mainly Loamy sands, sandy loams or sand clay loam on sloping lands of low natural fertility and low WHC; and deep, moderately well drained usually calcareous, black, dark grey or brown cracking clays of moderate natural fertility on valleys, bottom lands	– Low natural soil fertility and Low WHC in sloping areas – Slope (in places) – Moderate soil fertility and WHC on valleys and bottom lands.	Vegetable, paddy, cassava, maize, pineapple, livestock and fish farming	• Ridge cultivation on slopping land supported with application of manure, cover cropping, orchards; agro-forestry • Irrigation with water use efficient technologies and practices on valleys and gardening (vegetable) • Use of adapted crop varieties, application of appropriate organic and inorganic fertilizers, and good agronomic practices including integrated pest management • Use of adapted livestock breeds and improved livestock management practices • Aquaculture or integrated aquaculture and cage farming	• Enhance women and youth capacity to adapt • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
4	Lindi district, Lindi	C2, (other similar AEZ C1, C3, C5, C6, C7)	B	Unimodal with rainfall ranging from 800 to 1200 mm	Soils are deep, well drained, reddish and yellowish sandy clay loams and sandy clays, with low natural fertility; and complex of rock outcrops, surface ironstone, stony and shallow soils; and moderately well drained, shallow, usually calcareous, dark grey or black, cracking clays with moderately natural fertility.	– Low natural soil fertility and Low WHC in sloping areas – Slope (in places) – Moderate soil fertility and WHC on valleys and bottom lands.	*Cassava, sesame, sorghum, maize, coastal fishing and livestock*	• Ridge cultivation on slopping land supported with application of manure, cover cropping, orchards • Use of conservation agriculture practices and technologies • Use of adapted crop varieties, application of appropriate organic and inorganic fertilizers, and good agronomic practices including integrated pest management • Use of adapted livestock breeds and improved livestock management • Use of appropriate fishing practices (and gears)	• Capacity building to women and youth farmers • Potential for women to benefit from increased productivity • Labour intensive interventions such as Conservation Agriculture where terracing may require heavy labour, careful attention to gender heterogeneity of household needs and constraints is important for adapting CA to maximise benefits at the individual and household level.
13	Mvomero district, Morogoro	E9, (other similar AEZ C4, E10)	B	Unimodal with Rainfall range from 800 – 1000 mm. Variable	Flat alluvial plains with homogenous sedimentation pattern. Major soils are deep, imperfectly to poorly drained, dark grey or grey brown, often mottled clays (clay 40-70percent), more compact and contain fewer sandy strata. Natural fertility status is low to moderate	– Moderate soil fertility – Drainage (in places) – Rainfall variability	Paddy, maize, sunflower and livestock	• Irrigation with water use efficient technologies and practices (e.g. SRI) • Use adapted crop varieties, Application of appropriate organic and inorganic fertilizers, and good agronomic practices including integrated pest management • Use of conservation agriculture practices and technologies • Use of adapted livestock breeds and improved livestock management practices	• Enhance women and youth capacity to adapt • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
4	Newala district, Mtwara	E2, other similar AEZ E2, E3, E4, E8, N1, N2, N5, N7, N8, N9, N10, P1, P9)	B	Unimodal with Rainfall range from 800 – 1000 mm.	soils are moderately deep to deep, well drained, reddish and yellowish sandy loams and sandy clays; and moderately deep to deep well drained, dark red to red, friable clays with low natural fertility	– Inadequate rainfall – Low natural soil fertility – Low soil water holding capacity – Slope (in places)	Cashew nut, cassava, sunflower, sorghum, pigeon pea, sesame and livestock	• Use of soil and water conservation technologies (tie ridging, contour ridges); appropriate agro-forestry practices • Use of conservation agricultural practices with emphasis of minimum tillage, cover crops, manuring and crop rotation • Use of adapted crop varieties (drought tolerant and early maturing) supported with good agronomic practices including integrated pest management • Use of adapted livestock breeds and improved livestock management	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial.
14	Magoma in Korogwe district, Tanga	E2, other similar AEZ E2, E3, E4, E8, N1, N2, N5, N7, N8, N9, N10, P1, P9)	D	Unimodal with Rainfall range from 800 – 1000 mm.	Mainly deep, well drained, dark reddish brown, yellowish red or red sandy clay loams and sandy clays with low natural fertility; and deep, moderately well to imperfectly drained, brown, pale yellow, light grey sands and loamy sands with very low natural fertility	– Inadequate rainfall – Very low to moderate natural soil fertility – Low soil water holding capacity – Slope (inplaces)	Maize, paddy, cassava, fruit, vegetable and livestock	• Irrigation with water use efficient technologies and practices (e.g. SRI) • Use of conservation agricultural practices with emphasis of minimum tillage, cover crops, manuring and crop rotation; appropriate agro-forestry practices • Use of adapted crop varieties supported with good agronomic practices including integrated pest management • Aquaculture or integrated aquaculture and cage farming • Use of adapted livestock breeds and improved livestock management.	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
15	Madanga in Pangani districts, Tanga	C1, (other similar AEZ C2, C3, C5, C6, C7)	C	Bimodal with Rainfall range from 100 – 1200 mm.	Major soils are moderately deep to deep, well drained, red, yellowish red or orange sands and loamy sands with very low natural fertility; and shallow to deep, moderately well to imperfectly drained, calcareous, black, dark grey or brown cracking clays with moderate natural fertility.	– Low natural soil fertility and Low WHC in sloping areas – Slope (in places) – Moderate soil fertility and WHC on valleys and bottom lands.	Cashew, coconut, maize, cassava, sesame, fruits, livestock and coastal fishing	• Ridge cultivation on slopping land supported with application of manure, cover cropping, orchards • Irrigation with water use efficient technologies and practices on valleys and gardening (vegetable) • Use of adapted crop varieties, application of appropriate organic and inorganic fertilizers, and good agronomic practices including integrated pest management; appropriate agro-forestry practices • Use of adapted livestock breeds and improved livestock management practices • Use off appropriate fishing practices (and gears)	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
19	Nzega district, Tabora	P3, (other similar AEZ P4, P5, P6, P7, P8, P9, P13)	B	Unimodal with rainfall ranging from 600 - 1000	Major soils are deep, well drained, red, yellowish red or orange loamy sands, gravely sandy loams and sandy clay loams, with very low natural fertility and low WHC; and shallow, stony, rock outcrops, or surface ironstone; and imperfectly drained, shallow to deep often calcareous, black, dark grey or brown cracking clays with high natural fertility	– Moderate slope (in places) – Moderate natural soil fertility – Low to moderate soil water holding capacity,) – Shallow soil depth in places.	Tobacco, cotton, maize, paddy, cassava, sorghum and livestock	• Ridge cultivation on slopping land (tie ridges, pit cultivation, Fanya Juu – Fanya Chini ridges) supported with application of manure, cover cropping • Use of appropriate rain water harvesting and storage practices • Use of adapted crop varieties and good agronomic practices including integrated pest management on slopping lands • Use of conservation agricultural practices with emphasis of minimum tillage, cover crops and crop rotation • Use of agroforestry and improved bee keeping • improved bans in tobacco curing • Use of adapted livestock breeds and improved livestock management.	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • Heavy labour demand in Conservation Agriculture gender analysis a prerequisite to maximise benefits at the individual and household level.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
9 & 20	Kigoma Ujiji and Buhigwe Districts, Kigoma	W2, (other similar AEZ W1, W3, W4)	E	Unimodal with rainfall ranging from 1000 - 1500	Soils are deep, well drained, yellowish or reddish sandy clays to clays with very low to low natural fertility; and deep, well drained, yellowish or reddish sandy clays to clays with moderate natural fertility.	– Moderate to very low natural soil fertility – Low soil water holding capacity – Steep slopes (in places) – Shallow soil depth in places	Palm oil, maize, *cassava, banana*, tea, cotton, beans, sweet potatoes, coffee, livestock and fishing	• Soil and water conservation technologies and practices (terracing, Fanya Juu – Fanya Chini) • Permanent soil cover crops (fruit, vegetable, agroforestry) in combination with, application of appropriate organic and inorganic fertilizers, and good agronomic practices including integrated pest management • Use of adapted crop varieties and good agronomic practices including integrated pest management on slopping lands • Use of adapted livestock breeds and improved livestock management. • Use of appropriate fishing practices (and gears) • Aquaculture or integrated aquaculture and cage farming	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
18	Igokelo in Misungwi district, Mwanza	P8, (other similar AEZ P3, P4, P5, P6, P7, P9, 13)	A	Unimodal with rainfall ranging from 600 - 1000	Major soils are shallow, imperfectly drained, dark grey or brown sands to sandy clays with hardpan within 50 cm depth, calcareous and sodic in the subsoil with moderate natural fertility; and shallow to deep, imperfectly drained, calcareous, black, dark grey or brown cracking clays with high natural fertility; and moderately deep, well drained, red or brown gravely, sandy loams and sandy clay loams, with low natural fertility.	– Moderate slope (in places) – Moderate natural soil fertility – Low to moderate soil water holding capacity,) – Shallow soil depth in places.	Cotton, paddy, maize, fishing and livestock	• Ridge cultivation on slopping land (tie ridge cultivation, Fanya Juu – Fanya Chini ridges) supported with application of manure, cover cropping • Use of adapted crop varieties and good agronomic practices including integrated pest management • Use of conservation agricultural practices with emphasis of minimum tillage, cover crops and crop rotation • Use of agroforestry and improved bee keeping • Use of adapted livestock breeds and improved livestock management. • Use of appropriate fishing practices (and gears)	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
7	Ihanda in Mbozi district Mbeya	H5, (other similar AEZ H1, H2, H3, H6, H7, R1, R2, R3	E	Unimodal with rainfall ranging from 1000 – 2000	Major soils are deep, well drained, dark grey brown loamy sands, sandy loams and loams with high natural fertility; and deep, well drained, yellowish or reddish sandy clays to clays with moderate natural fertility.	– Steep slope (high erosion risk), – Moderate to Low natural soil fertility,	Maize, Beans, Paddy, Cocoa, Banana, Coffee, Sunflower Livestock and fish farming	• Soil and water conservation technologies and practices (terracing, Fanyajuu – fanyachini) • Use of agroforestry (fruit crops, vegetable) with improved bee keeping in combination with, application of appropriate organic and inorganic fertilizers, and good agronomic practices including integrated pest management • Use of adapted livestock breeds and improved livestock management • Aquaculture or integrated aquaculture and cage farming	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
10	Mufindi district, Iringa	H1, (other similar AEZ, H2, H3, H6, H7, R1, R2, R3)	D	Unimodal with rainfall ranging from 600 – 1600 mm	Major soils are deep, well drained, yellowish or reddish sandy clays to clays with moderate natural fertility; and moderately deep to deep, well drained, reddish and yellowish sandy loams and sandy clays, with low natural fertility.	– Steep slope (high erosion risk), – Moderate to Low natural soil fertility,	Maize, Sorghum, Sunflower, Tobacco, Tea, Rice, Beans, Fruits, Vegetables and livestock	• Soil and water conservation technologies and practices (ridging (contour ridges, Fanya Juu – Fanya Chini ridges etc) • Use of conservation agricultural practices with emphasis of minimum tillage, cover crops, manuring and crop rotation • Use of agroforestry (fruit crops, vegetable) with improved bee keeping in combination with, application of appropriate organic and inorganic fertilizers, and good agronomic practices including integrated pest management • Use of improved tobacco and tea curing bans • Use of adapted livestock breeds and improved livestock management	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial. • In tobacco farming use of child labour has been a major concern and thus the need for gender responsive interventions.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
6	Namtumbo district, Ruvuma	E7, (other similar AEZ, E10, E11, E12, E13, E14, E15)	E	Unimodal with rainfall ranging from 800 – 1000 mm	Major soils are deep to moderately deep, well drained, dark red to red to friable (acidic) clays with low to moderate natural soil	– Steep slope (high erosion risk), – Moderate to Low natural soil fertility,	Maize, Cassava, Yam, Sweet potatoes, Paddy, Tobacco and livestock	• Ridge cultivation on slopping land (tie ridges, pit cultivation, Fanya Juu – Fanya Chini ridges) supported with application of manure, cover cropping • Use of adapted crop varieties and good agronomic practices including integrated pest management on slopping lands • Use of conservation agricultural practices with emphasis of minimum tillage, cover crops and crop rotation • Use of agroforestry and improved bee keeping • improved bans in tobacco curing • Use of adapted livestock breeds and improved livestock management.	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial. • Gender responsive interventions in the tobacco farming communities.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
8	Sumbawanga district, Rukwa	U, (associated AEZ, R1),	E	Unimodal with rainfall ranging from 800 – 1000 mm	Major soils are moderately deep to deep, well drained, reddish and yellowish sandy clay loams and sandy clays with low natural fertility; and moderately deep to deep, well drained, red, yellowish red or orange sands and loamy sands with very low natural fertility and low WHC;	– Very low to moderate natural soil fertility – Low soil water holding capacity – Slope (in places) – Shallow soil depth in places	Maize, beans, cassava, wheat, sunflower, livestock and fish farming	• Ridge cultivation on slopping land (tie ridge cultivation, Fanya Juu – Fanya Chini ridges) supported with application of manure, cover cropping • Use of adapted crop varieties and good agronomic practices including IPM on slopping lands • Use of conservation agricultural practices with emphasis of minimum tillage, cover crops and crop rotation • Use of agroforestry and improved bee keeping • Use of adapted livestock breeds and improved livestock management • Aquaculture or integrated aquaculture and cage farming (with adapted species) • Fishing using appropriate fishing gears	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards, use of adapted crops and livestock. Gender analysis is crucial.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
17	Moshi Rural district, Kilimanjaro	N4, (other similar AEZ, N2, N5, N6)	C	Unimodal with rainfall ranging from 500 – 1400 mm	Major soils are deep, well drained, reddish clay loams and clays with high natural fertility and accumulation of partly decayed plant material in permanent swamps .	– Steep slope – Limited soil depth (stony) in places	Maize, Coffee, Banana, beans, fruits, vegetable and livestock	• Soil and water conservation technologies and practices (terracing or contour ridges, Fanya Juu – Fanya Chini ridges etc) • Use of agroforestry (fruit crops, vegetable) with improved bee keeping in combination with, application of appropriate organic and inorganic fertilizers, and good agronomic practices including integrated pest management • Use of adapted livestock breeds and improved livestock management • Aquaculture or integrated aquaculture and cage farming (with adapted species)	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards and other agroforestry practices, use of adapted crops and livestock. Gender analysis is crucial.

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
16	Arumeru district, Arusha	N5, (other similar AEZ, N2, N4, N6)	C	Unimodal with rainfall ranging from 600 – 1200 mm	Major soils are shallow to deep, well drained, dark brown or dark grey calcareous sandy loams with moderate natural fertility; and deep, well drained, dark grey or brown loamy sands, sandy loams and loams with high natural fertility.	– Low to moderate natural soil fertility – Low soil water holding capacity – Slope (in places) – Shallow soil depth in places	Coffee, banana, vegetable, avocado and round potato, Maize, Cassava, Beans, fruits, Vegetable and Livestock	• Soil and water conservation technologies and practices (terracing or contour ridges, Fanya Juu – Fanya Chini ridges etc) supported with application of manure, cover cropping • Use of agroforestry (fruit crops, vegetable) with improved bee keeping in combination with, application of appropriate organic and inorganic fertilizers, and good agronomic practices including IPM • Use of adapted livestock breeds and improved livestock management • Aquaculture or integrated aquaculture and cage farming (with adapted species) • Irrigation with water use efficient technologies and practices on valleys and gardening (vegetable) • Use of adapted livestock breeds and improved livestock management	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
12	Kikombo Ward in Dodoma district, Dodoma	**Semi-Arid** P9, (other similar E2, E3, E4, E8, N1, N2, N5, N7, N8, N9, N10, P1, P2, P10, P12, S1, S2,	A	Unimodal with rainfall ranging from 800 – 1000 mm	Major soils are deep, imperfectly to poorly drained, dark grey or grey brown, clays with low to moderate natural fertility.	– Moderate soil fertility – Drainage (in places) – Rainfall variability	Sorghum, Sunflower, Groundnut, Bulrush Millet, Maize, Sesame Livestock and beekeeping	• Use of appropriate rain water harvesting and storage practices example Chololo pits) • Use of conservation agricultural practices with emphasis of minimum tillage, cover crops, manuring and crop rotation • Use of adapted crop varieties (drought tolerant and early maturing) supported with good agronomic practices including integrated pest management • Use of agroforestry and improved bee keeping practices • Use of adapted livestock breeds and improved livestock management.	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity

Study sites	District and region	AEZ	ACZ	Rainfall	Soil type	Limitations	Livelihood Enterprise	Recommended CSA packages of Technologies and Practices	Gender Recommendations
21	– Babati district, Manyara	– Semi-Arid – E2, (other similar AEZ, E3, E4, E8, N1, N2, N5, N7, N8, N9, N10, P1, P2, P9, P10, P12, S1, S2)	A	– Unimodal with Rainfall range from 800 – 1000 mm.	– Mainly deep, well drained, dark reddish brown, yellowish red or red sandy clay loams and sandy clays with low natural fertility; and deep, moderately well to imperfectly drained, brown, pale yellow, light grey sands and loamy sands with very low natural fertility	– Inadequate rainfall – Very low to moderate natural soil fertility – Low soil water holding capacity – Slope (in places) – Shallow soil depth in places	– Maize, Sunflower, Pigeon pea, sorghum and livestock	• Use of appropriate rain water harvesting and storage practices, pit cultivation e.g. Chololo pits) • Use of soil and water conservation practices on slopping land terracing, ridging, Fanya Juu – Fanya Chini ridges) supported with application of manure, cover cropping • Use of conservation agricultural practices with emphasis of minimum tillage, cover crops, manuring and crop rotation • Use of agroforestry and improved bee keeping practices • Use of adapted crop varieties (drought tolerant and early maturing) supported with good agronomic practices including IPM • Use of adapted livestock breeds and improved livestock management.	• Enhance women and youth capacity to adapt • Potential for women to benefit from increased productivity • As above for the orchards and other agroforestry practices, use of adapted crops and livestock. Gender analysis is crucial.

CHAPTER 5: ROLES AND APPROACHES FOR CSA IMPLEMENTATION AND UP-SCALING

Strong institutional support is required to: promote inclusivity in decision making; improve the dissemination of information; provide financial support and access to markets; provide insurance to cope with risks associated with climate shocks and the adoption of new practices; and support farmers' collective actions. Many institutions and stakeholders, including farmers (and farmer organizations), private sector entities, public sector organizations, research institutes, educational institutions, and Civil Society Organizations can play important roles in supporting the adoption and up-scaling of climate-smart agriculture. Successful CSA technologies and practices can be up-scaled with active participation of all stakeholders. Communities need to be involved and farmers are encouraged to be innovative. Multi-stakeholders' participation and active community involvement in projects/program design and development are critical for successful climate-smart agriculture implementation and up-scaling.

5.1 Roles

5.1.1 Government

- The Government should sensitize and create awareness on impacts of climate change, and appropriate technologies and practices for adaptation. This can be done using various means such as mass media (radio, TV, newspapers, social media and drama groups), farmers' exhibitions and resource centres (demonstrations). For example, in the case of mass media, the government should first identify and select interested media to engage in disseminating and promoting the CSA guideline. Government can also help in bringing together different media groups to formation of media networks or working groups on CSA promotion in Tanzania.
- Government should organize and conduct meeting for capacity building for media representatives to enable them understand and then engage in disseminating and promoting the CSA guideline appropriately.
- The government should promote documentation, wide sharing and dissemination of identified CSA technologies and practices. This will enable more farmers and other players to effectively adopt CSA;
- Build the capacity of extension, producers and other stakeholders in the use of existing/new/improved CSA technologies and practices;
- The government should establish partnership/collaboration with institutions and the private sector that will help and improve access of required implements/equipment including promoting local manufacturing of equipment and maintenance/service of equipment or facilitating purchase of those equipment such as rippers, biogas plants, and the *ngwamba* hoe for up scaling identified CSA technologies and practices;
- Links should be established to connect farmers with input and output markets and service providers (strengthen value chain and technical backstopping) for facilitating up scaling of identified CSA technologies and practices;
- Financial support or opportunities from both public and private sectors to farmers, pastoralists, fish and forest dependent communities should be provided to upscale identified CSA technologies and practices;
- Increase public expenditure into research and development and innovations through national budget;
- Intensify field demonstration/field days'/study tours to enhance adoption of existing/new/improved CSA technologies and practices;
- Sensitize and promote private sector to invest on up scaling best identified CSA technologies and practices; including provision of climate services. Also support development of private sector input and appropriate CSA technologies outreach and distribution networks;
- Develop and provide improved Early Warning information (weather and climate) to help farmers and other stakeholders in up scaling identified CSA technologies and practices;
- Establish and ensure public–private partnership in coordinating climate information services at all levels. The aim of climate information service is to develop and provide appropriate climate knowledge and information, which local farmers, experts (e.g. planners and extension workers) and also researchers use for agricultural related activities;
- Establish a feedback mechanism for evaluation process of messages delivered for up scaling of identified CSA technologies and practices; and
- Monitor crops, livestock and fish pests and diseases affecting up scaling of identified CSA technologies and practices.

5.1.2 NGOs, and Development and Research Partners

- NGOs are heavily engaged in areas of climate-smart agriculture and natural resources management and can provide technical assistance to MALF for implementation of the ACRP, including climate finance readiness, and project feasibility studies.
- Researchers/Institutions can help in bringing together different stakeholders using Learning and Practice Alliance (LPA) approach which engages key stakeholders including policy makers, practitioners and farmers to join and work together in addressing existing problems and identify potential solutions. The LPA approach has the capacity to influence change in attitude, strategies, planning and resource allocations for up scaling CSA best technologies and practices.
- NGOs, development partners and researchers and institutions (Universities) should facilitate capacity building to increase knowledge and skills on up scaling best CSA technologies and practices through training to farmers and extension staff.
- NGOs and development partners can also help in changing the mind-set of policy makers, practitioners and also farmers by emphasizing the importance of Indigenous Knowledge (IK) that is compatible with best CSA technologies and practices, and supported with scientific knowledge in scaling up through communicating research findings on IK and through training.
- Researchers and development partners to conduct participatory research work on improved technologies and practices that is informed by needs of users and agro-ecological zones along the value chain. In addition to conduct on-farm research into low-cost appropriate technologies and practices and deliver them as packages.

5.1.3 Private Sector

They mainly collaborate with research institutions to develop and test technologies that can yield good results in adapting to climate change. Climate change is a challenge that needs both public and private interventions, so the private sector can play an important role in identifying opportunities, maximizing profit, and managing risks. Working with the private sector allows public institutions to multiply the number of partners to work with, thus enabling scale. But the public sector must empower the private sector to invest in climate-relevant activities and products. They can do this by creating enabling environments and enacting conducive policies that encourage investments. CSA initiatives offer opportunities to refine approaches for private sector engagement with smallholder farmers in ways that improve outcomes for both parties through commercially viable partnerships. This challenge brings on board other partners such as governments, donors, and services providers who have an interest in supporting smallholder farmers.

5.1.4 Farmers

- Farmers should form groups but also identify champion farmers who are very effective in obtaining and disseminating knowledge of CSA technologies and practices. Establishing farmers' groups and champion farmers should of course consider social dimensions due to the fact that the preferences of dissemination pathways always differ among gender groups;
- Farmers should engage in farmer field schools (FFS), which will include demo plots to help learn and disseminate practical knowledge on CSA packages;
- Learning visits and/or farmer field days/shows should be organized and facilitated for farmers. In addition, extension staff, private sector and policy and decision makers should learn by seeing. This will help farmers share knowledge and experiences of CSA practices among themselves, but also with policy and decision makers, extension agents and private sector;
- Farmers should be supported financially and/or empowered to establish and operate registered savings and loan groups to catalyse up-scaling best identified CSA technologies and practices;
- Knowledge sharing products (KSPs) should be designed to suit each category of stakeholder. For those with low education level, field days could be more appropriate mode of dissemination; farmers with small farm size prefer fellow farmer/trainers field visits; while young and educated farmers, print materials, electronic knowledge sharing such as use of media and mobile phones could be appropriate;

5.1.5 Media

- Media should engage in soliciting information from researchers including undertaking field visits to various locations in Tanzania for information gathering and sharing
- Organize programmes especially radios, TV and social networks to disseminate CSA technologies and practices that can be adopted by farmers to improve their production;
- Media should disseminate the CSA guideline and hence influence policy makers to put greater attention on CSA technologies and practices in policy formulation and planning to enhance agricultural production in relation to climate changes;
- Prepare documentaries on CSA and distribute to various users and beneficiaries in Tanzania and beyond.

5.2 Approaches

The agricultural extension approach in Tanzania involves farmers' groups in the planning and implementation process. It is also integrating different extension providers, allowing room for pluralistic extension approaches and empowering farmers organizationally and financially to demand for appropriate services. The extension services use a combination of dissemination pathways such as demonstration plots/FFS, farmer field days, exchange visits/study tours, technology transfer model, technical publications, training manuals/guidelines, radio/TV programs, cinema shows, agricultural shows/exhibitions, ICT facilities including mobile phones, website, emails and use of WARCs (equipped with technical information and few have computers). Also they use focus farmer groups and innovation and/or stakeholder platforms.

The specific approaches and methods are selected based on the local situation and the characteristics of the target group; while assuring most cost-effective combination of approaches and methods to optimise the intended impact.

5.2.1 Gender Responsive Approach

To succeed, the climate-smart agricultural practices depend on institutional and behavioral change, which is not possible without social analysis (including gender analysis) influencing policies, projects, and other interventions aimed at achieving sustainable CSA. Social inequality and social inclusion, particularly in reference to gender, have been recognized as a foundational issue in development, and a growing body of evidence demonstrates that more equal gender relations within households and communities lead to better agricultural and development outcomes, including increases in farm productivity and improvements in family nutrition (Farnworth *et al.* 2013; Farnworth and Colverson 2015).

A number of documents reflect the consensus that gender-based constraints must be addressed to increase agricultural productivity, improve food and nutrition security, reduce poverty, and build the resilience of rural populations. Recent work calls for development practitioners to understand and systematically engage with the complexities and variability of gendered roles and resources. By the same token, CSA strategies are unlikely to be effective, let alone equitable or transformative, without active attention to gender (Bernier et al. 2015). Gender-responsive policy and practice recognize and address the specific needs and realities of women and men based on the social construction of gender roles. Gender transformative interventions seek to transform gender roles and promote more gender-equitable relationships between men and women. They challenge the underlying causes of gender inequality that is rooted in broad political, economic, and socio-cultural structures. Because gender-transformative approaches seek to change rigid gender roles and relations, such approaches often go beyond the individual level to focus on interpersonal, social, structural, and institutional practices to address gender inequalities (FAO, 2015).

5.2.2 Community Based Approach

The approach is community-based extension whereby a practicing farmer or livestock keeper selected by their community and trained to a standard where they can offer credible advice and services in a specific area of production. A sizeable proportion of those trained 5-10 years ago have built a loyal client base by charging affordable fees for their services, and plan to continue in the role indefinitely. Even the poorest farmers and livestock keepers are benefiting from their services. Community Based Adaptation (CBA) requires comprehensive climate vulnerability assessment and then community adaptation planning. This participatory methodology builds 'adaptive capacity' which increases decision making skills in farming communities under increasing uncertainty. CBA is a model that explores options and enhances the capacity to adapt through community decision making on adoption. They will adopt when they themselves lead adaptation planning. This is why scenario planning is an integral part of good CBA – it drives adoption because farmers act on 'no-regrets' basis.

5.2.3 Farmer-Centred Research, Learning and Training Approach

i. ***Farmers Field School Approach***
It is used throughout the country and is incorporated within DADPs. It uses experiential learning and group approach and currently its successes have been seen especially in smallholder's irrigated rice farms where production has increased, key farmers train others. The impact of the approach is an increase in production seen in FFS members compared to non-FFS.Agricultural resource centres are permanently established in each District/ward used for demonstration of good agricultural technologies/practices.

ii. ***Farming System Approach (FSA)***
The approach builds greater farmer influence and participation in technology development and transfer through a Client Oriented Research and Development Management Approach (CORDEMA), Farmers priorities are incorporated into the research agenda & user-friendly technologies are developed. It is also used in some parts of the country.

iii. ***Farmer-to-Farmer Extension Approach***
This is the most common approach in some parts of the country whereby there are trained farmers who can train others; the approach is now used by other institutions.

iv. ***Champion Farmers***
This approach is also common in many parts of the country whereby extension services choose farmers to work with them in implementing their programs. Those farmers selected to lead "farmer-to-farmer" extension are often called model, master, or lead farmers and are chosen according to their agricultural expertise. In other initiatives, they are called farmer promoters or trainers, emphasizing their networking or training skills. An additional variant is the community knowledge worker, sometimes equipped with a smart phone to improve farmers' access to information and advisory services. Surprisingly, as pervasive as these programs are, little has been done to describe them, assess their effectiveness or distil lessons on successful implementation. In the context of document the farmers involved as "lead farmers" although we recognize that many other names are used to call them.

5.2.4 Landscapes and Ecosystems Services Approach

A landscape approach deals with large-scale processes in an integrated and multidisciplinary manner, combining natural resources management with environmental and livelihood considerations. The landscape approach also factors in human activities and their institutions, viewing them as an integral part of the system rather than as external agents. This approach recognizes that the root causes of problems may not be site-specific and that a development agenda requires multi stakeholder interventions to negotiate and implement actions.

The landscape approach helps to identify and develop positive externalities (including ecosystem services) and reduce negative impacts, especially from individual land users. Placing human well-being and needs at the centre of the land use decision-making process, the rights and cultural values (including religion) of involved communities and minority groups are respected alongside their land use objectives. This involvement helps ensure local commitment to solutions and the long-term success of sustainable development initiatives. Ecosystem approach differs from landscape approaches in that it may include multiple ecosystems.

5.2.5 Payment for Ecosystem Services (PES)

Payment for Ecosystem Services also known as payments for environmental services (or benefits), are incentives offered to farmers or landowners in exchange for managing their land to provide some sort of ecological service. They have been defined as "a transparent system for the additional provision of environmental services through conditional payments to voluntary providers. In Tanzania this approach is rather at its infant stage. It is possibly used in few cases in forestry development and agroforestry. In agricultural development, it has been applied to support sustainable land management in the Ruvu river catchment (pilot project)

5.2.6 Innovation Platforms

Innovation platforms/Focus farmer groups, these facilitate extension delivery and can share new innovations and market information within the group therefore use of farmer innovative ways (e.g. farmer facilitators, innovation platforms) have enhanced beneficiary interaction and internalization of issues revolving around agricultural services delivery and their livelihoods in general.

5.2.7 Information and Knowledge Generation and Sharing Approach

i. ***ICT facilities***
This approach is mainly used in the LGAs whereby availability of cellular phones in rural areas is enhancing access on marketing information and supply of inputs. Therefore, integration of extension service with other support services (input subsidy, ICT) accelerates pace of adoption of technologies. Also demand-driven concept and use of participatory approaches has led to farmer empowerment and promoted self-development, empowerment is seen in the formulation and implementation of Opportunity and Obstacles for Development (O& OD).

ii. ***Awareness Raising Campaigns***
The approach is mainly used in different areas of the country whereby sensitization and creation of awareness on impacts of climate change is done and appropriate technologies and practices for adaptation. This can be done using various means such as mass media (radio, TV, newspapers), farmer exhibitions and resource centres (demonstrations). The approach helps to promote documentation, wide sharing and dissemination of identified CSA technologies and practices, and enables more farmers and other players to effectively adopt CSA. It is also important on up of scaling best CSA technologies and practices identified, including provision of climate services.

5.2.8 Coordination Forum Approach

i. ***Learning Platform Alliance***
This approach is mainly used by Researchers/Institutions and can help in bringing together different stakeholders using Learning and practice alliance (LPA) approach which engages key stakeholders including policy makers, practitioners and farmers to join and work together in addressing existing problems and identify potential solutions. The LPA approach has the capacity to influence change in attitude, strategies, planning and resource allocations for up scaling of best CSA technologies and practices.

5.2.9 Sustainable Market Linkage Approach

i. ***Nucleus and Out Growers Approach***
Formal arrangement between agriculture companies and farmers (contract farming), the private sector facilitates farmers' access to credit, improved inputs, pooling of farmers' produce, processing and developing market links. This approach is common in the country and used by Kilombero Plantation Limited (KPL) in Morogoro Region.

5.3 Challenges for Implementation and Up-Scaling

There is abundant evidence indicating that the National Agricultural Research System has made available a wide range of improved agricultural technologies and practices that have high potential of alleviating poverty, enhancing food security and improving nutrition status of the majority (Matata *et al.,* 2011 and Mpanda *et al.,* 2014). Despite the efforts, knowledge of improved agricultural technologies is hindered by lack of financial resources, poor market access for farmers to adopt, and thus agricultural production is still undertaken using rudimentary technologies.

Agricultural technologies, their development, transfer and adoption are fundamental in increasing productivity, rural incomes and growth, adaptation to climate change and subsequently in contributing to poverty reduction as well as food security.

Low or non-adoption of recommended agricultural production practices is one of the major problems currently facing most regions of Tanzania. The modern agricultural production technologies (innovations) like improved varieties and fertilizer have not significantly been adopted by farmers, who continue to use traditional practices. Main reasons for low adoption include late or non-availability of inputs, high costs of inputs and low awareness on use of inputs. Government efforts to address these challenges include among others input subsidies, use of farmer field schools (FFS), demonstration farms and participatory action research, as well as involvement of private sector.

Poor and inefficient extension services is caused by shortage of extension staff and working facilities leading to inadequate capacity of up & out-scaling technologies at village and ward levels. This challenge can leave the agriculture sector underdeveloped and the rural farmers in chronic poverty. Poor extension services led to low CSA technology transfer to the farmers. Extension services consist of advice, know-how and technology transfer as well as input provision directly to farmers. Most farmers in Tanzania are smallholder and medium size farmers who employ rudimentary technologies leading to low productivity. The farmers have little capacity to hire field officers to solve problems requiring technical assistance.

Some government units and departments responsible for the promotion of CSA technologies and practices to farmers face financial resource constraints. A working paper by Mushi, 2013 on Climate Change Budget Screening for the Tanzania's Agriculture Sector identified that government spending on climate change related activities is at very low scale and pace. Hence there is a need for a better and sustainable financial supporting mechanism to support implementation of the CSA guideline at all levels.

The response of the Private sector and CBOs in Tanzania to provide extension delivery and create incentives for farmers to adopt new CSA methods is still low. This is due to many factors including low participation of private sector and CBOs in extension delivery and hence small numbers of farmers are receiving extension services at the village level.

There are poor structures and infrastructure such as roads, irrigation facilities, processing facilities, market facilities, weak information, communication and networking among agriculture stakeholders in the country. For example, poor infrastructure like roads especially feeder roads that are meant to facilitate services to the farmers are insufficient and hence this scenario contributes to low productivity and post-harvest losses.

CHAPTER 6: RECOMMENDATIONS

6.1 Capacity Building Needs

This guideline is targeted at agricultural stakeholders at all levels from decision/policy makers, district (local government) designing and planning level, development partners, private sector down to the farmers.

Enhancing the capacity of key stakeholders at different levels involved in planning, disseminating, implementing, monitoring and evaluating CSA is of paramount importance.

Women, who play a key role in the agriculture sector, need to be provided with knowledge and training opportunities and be actively involved in the planning and implementation of agricultural development projects and programmes.

- **National Level**
  Provide short and long term training to professional staff on CSA to strengthen their capacities to design policies, and to plan, monitor, and evaluate CSA and natural resource management programmes.

- **Local-Level (District, Ward, Village)**
  Training by field level extension agents, development agencies (including NGOs) will be provided to field-level extension trainers on CSA to build capacity of farmer-extension agents, organize and conduct farmer learning opportunities (e.g. study tours, farmer cross-visits) etc. Extension agents will be equipped with skills to initiate and promote links between communities or farmers and public or private sector institutions.

- **Farm Level**
  On-farm training, village workshops, seminars and farm visits will be effectively used to provide knowledge, create awareness and strengthen capacity of field workers and farmers to promote adoption of CSA in the country.

6.1.1 Awareness

Awareness raising is an important stage for effective dissemination of knowledge and technologies and to be successful, it needs to use all appropriate communication channels such as radio, television, print media, leaflets, brochures, oral communication, and traditional communication. Awareness raising targets different socio groups such as government authorities, central and local administrative authorities, religious, traditional leaders, opinion leaders, NGOs, civil society, donors and media. Planning of awareness raising strategy should therefore take account the target group, the message for each target group (preferably specific to the group), and the appropriate channels for communicating those messages.

Likewise, training should also take into account the specific role of each target group (stakeholders). Relevant training manuals should be prepared for the target group, which will also serve as a reference during the implementation stage.

6.1.2 Training

Training of key stakeholders in climate change and climate-smart agriculture is important in order to increase knowledge and understanding, which eventually contribute to change or shape their mind-sets in their undertakings. Training should therefore be done based on the roles of the stakeholders at different levels.

6.1.3 Integrate Climate Change Topics in the Syllabus

Educational institutions actually prepare and shape future working force of different professionals including the rural agrarian community. Most of the agrarian community use knowledge and skills acquired at different stages of their education. Introduction of climate change topics in the syllabus would therefore be building capacity of not only future farmers but also future stakeholders of climate change (Policy maker, Researcher, Planner, Economist, Engineer, and Doctor etc.). LIMAS project in Lindi and Mtwara involved Primary schools within the project area. They introduced a topic of Conservation Agriculture in the syllabus under social skills (*stadi za kazi*), science and geography subjects; supported by practical skills in the schools' demonstration plots and recorded a high success which is expected to be carried forward. The government should take up the agenda and oversee possibilities of mainstreaming it in the curriculum or syllabus.

6.1.4 Improve Capacity and Knowledge on M&E of CSA

Many projects and programmes are often faced with insufficient evidence-based good practice despite the resources and efforts committed in the implementation, partly due to weak monitoring and evaluation processes. While many stakeholders (NGOs, CBOs, Development partners) are actively involved in extension and technology dissemination as direct support to smallholder in development projects and programs, the evaluations of projects have often not included much thoroughly assessment of approaches and methods. Participatory monitoring and evaluation methods (PM&E) are needed to facilitate lesson-learning, local ownership and a more reflective and responsive outcome. Hence capacity building in participatory monitoring and evaluation at all stages is important for effective capturing of the lessons on the efficacy and other attributes of the upscaling processes.

6.1.5 Enabling Access to Resource Provision, Improved Access (Information Packages) and Dissemination of Climate Information Services

In Sub-Saharan Africa, inadequate capacity to collect, analyse and disseminate climate-related information, combined with poor farmer knowledge and skills in using such information, are significant constraints to productive farming. This hence exacerbate the vulnerability of smallholder farmers who are vulnerable to climate fluctuations and weather extremes, and are expected to suffer more from climate change. Using participatory methods, scientists are now working with farmers to understand climate impacts on farming systems and rural livelihoods and to identify locally appropriate climate-smart solutions. With institutional support and policies, advisories and climate information services offer great potential to enable farmers to make informed decisions, better manage risk, take advantage of favourable climate conditions and adapt to change.

Farmers can adapt their practices to climate change, but they need good information about the conditions in store. Improving the link between climate information and agricultural practices, especially those of smallholder farmers in developing countries is key for adaptation. Climate information services include immediate and short-term weather forecasts and advisories and longer-term information about new seeds and technologies and market developments. This service is especially useful in helping farmers to manage risks, and in offsetting much of the uncertainty that often constrains decision making and innovation. Since this is a relatively new area in extension service delivery, the government and developing agents should provide support in setting up appropriate systems including learning from other countries which have such services in operation.

Gathering rainfall and other climatic data is vital if the accuracy of forecasting is to be improved. Gathering local data, such as on market prices, is important in developing valuable, relevant and timely information services that improve farmers' decision-making in the context of an uncertain climate. Improved delivery of information is another key area for example the use of interactive community radio, loud speakers in markets, as well as mobile text messaging and email. Feedback from farmers on the quality and accessibility of information delivered, and on their willingness to pay for it, are important elements in enhancing the value and sustainability of climate information services.

6.1.6 Risk Management and Insurance Scheme in Agriculture

Weather-related risks are the largest threats to agricultural productivity and food security in Tanzania. Extreme events such as droughts and floods are among the highest risks to agricultural productivity and shocks can have significant impacts at all levels from the national economy to individual households. Interventions for the types of risks typically faced by the agriculture are needed and are mainly of three types:

- Risk Mitigation, or actions to prevent events from occurring, limit their occurrence, or reduce the severity of the resulting losses. Examples include pest and disease management strategies, crop diversification, and extension advice,
- Risk coping or actions to help the victims of a risky event (a shock such as a drought, flood, or pest epidemic)

cope with the losses it causes. Examples include government assistance to farmers, debt restructuring, and remittances through mechanisms such as social safety net programs,

- Risk transfer, or actions that transfer risk to a willing third party, at a cost. Financial transfer mechanisms trigger compensation or reduce losses generated by a given risk, and they can include insurance, reinsurance, and financial hedging tools.

Insurance may be an important mechanism for farmers to break the cycle of low input, low output faming. A variety of insurance schemes in Africa promise effective financial support when weather calamities happen. By protecting farmers in the event of extreme weather, crop insurance also reduces the risks of debts incurred by farmers taking credit at the start of the season. A weather based insurance scheme (experimented in Ethiopia, Kenya, Malawi and Mozambique) has taken a broader approach to risk and strengthening farmers' food and income security.

6.2 Key Requirements for Implementation and Up-Scaling CSA

In dealing with CSA adoption, as well as with agricultural technology adoption, there has been increasing recognition of the importance of focusing on the gender-heterogeneity behind the adoption choice itself. The integration of gender into CSA also means understanding how gender, and thus its adoption of CSA practices, will evolve together with climate change in the future. 'Gender responsive' actions are essential element for the successful uptake of CSA as the adoption of CSA practices is highly sensitive to gender.

6.2.1 Improved Productivity, Building Resilience and Associated Mitigation Co-Benefits

CSA will help reduce vulnerability of the agriculture sector by increasing productivity, enhancing adaptation and resilience of the farming systems and communities; and reducing emissions intensity in the context of achieving food and nutrition security, sustainable development and poverty reduction. Many agricultural practices and technologies contribute to both adaptation and mitigation goals simultaneously. Practices that promote sustainable management of forests for their role in climate stabilization can simultaneously provide multiple benefits for local communities. Farmers are more likely to adopt an agricultural practice if they can see immediate benefits of doing so.

6.2.2 Value Chain Integration

This approach is holistic in that it considers input supply, production, agricultural services, climate services, traceability, marketing and business support services as necessary building blocks. Under the approach, both public and private sectors are seen as critical actors in the value chain. Knowledge and capacity building are critical strategic priorities to leverage innovations and increase efficiencies. The approach also provides enabling framework for integrating gender and the needs of the youth.

Agricultural interventions that aim to improve farmers' access to markets may not have climate adaptation as their primary aim. Nonetheless, getting farmers integrated into robust and fair markets can help them become more resilient to climate change.

6.2.3 Research for Development and Innovations

The role of research should be re-oriented to support innovations that facilitate the transition to climate-smart agriculture by smallholder farmers. New and emerging agricultural research partnerships should identify technological advances that respond to the impacts of climate change and climate variability. A major thrust will be on the use of climate-smart agricultural practices and technologies, promoting improved land management and sustainable crop-livestock and fisheries intensification, in order to bolster farmers' adaptive capacity through participatory action research and support the national vision of achieving food security.

6.2.4 Improving and Sustaining Agricultural Advisory Services

Agro-advisory services that include climate applications for agriculture will help farmers to better make informed decisions in the face of risks and uncertainties. Climate applications include seasonal weather forecasts and; monitoring and early warning products for drought, floods and pests and diseases surveillance. These products and services would increase the preparedness of the farmers, well in advance, to cope with risks associated with climate variability and change. Furthermore, robust agro-advisory services would catalyse private sector investment in priority areas such as weather-based index insurance and associated infrastructure.

6.2.5 Climate and Weather Forecasting

The variability of the weather parameters including rainfall is attributed to variability nature of the climate system. Rainfall is the most variable weather parameter which causes uncertainties and risks in agricultural undertakings particularly rain-fed agriculture thus making smallholder farmers vulnerable to climate variability. The impacts of climate change have exacerbated the natural climate variability resulting to poor intra-seasonal temporal rainfall distribution, uncertainty in onset of seasonal rains and increase in frequency of extreme weather events (such as drought and floods), among others.

In order to help the farming community, adapt to climate change impacts capacity building in weather projections, forecasting and early warning systems is necessary. In addition, provision of location specific, tailor-made, easily understood climate services to farmers is of paramount importance to facilitate decision making and planning of agricultural ventures.

When implemented along with CSA, climate and weather forecast information will reduce the risk and uncertainties attributed to climate variability and change. Seasonal climate forecast information will inform farmers in advance on the onset of the season and the seasonal outlook. Information on onset of the seasonal rains provides an insight on when to start preparing land for planting whereas the seasonal outlook will provide information for planning the type of crop to plant and farm management practices in case of excessive or deficit soil moisture.

In addition to seasonal climate forecast, intermediate weather updates during the season such as monthly and decadal weather forecasts information will provide monitoring information on the seasonal progress and can aid on-farm planning in case of weather changes within the season. However, it is important that forecasts be downscaled to local areas as CSA is carried out at specific agro-ecological zones. In addition, the information should be tailor-made, easily understood by farmers, timely delivered and be disseminated through affordable communication channels to smallholder farmers.

Timely delivery of relevant and site-specific weather and climate information advisory services can improve farmers' decision-making and build their adaptive capacity.

6.2.6 Effective Institutional Coordination

This is crucial for achievement of horizontal and vertical integration required for effective discharge of the CSA Program. The horizontal integration achievement requires a framework that provides for high-level guidance while vertical integration is instrumental in determining the roles of various sector institutions and devolved governments, state actors and non-state actors in performing CSA mandates. The proposed coordination framework will improve Inter-Ministerial and Local Government coordination; enhance partnerships with the Private Sector and Civil Society Organizations; and strengthen coordination with Development Partners.

6.2.7 Integration among Practices

There are many CSA practices which can be combined or implemented together to enable and ensure high and improved land and water productivity. Combining or integrating two or more CSA practices of course depends on the nature of the land, crop to be grown and production objectives of the farmer or community.

6.2.8 Financing CSA

Most financing of CSA initiatives is based on donor funding. Implementation of the CSA technologies and practices require sustainable financial mechanism. National budgetary support is important as CSA is a priority and important in national and local economies. The Government needs to secure funds for climate change in the agriculture sector, specifically to address climate resilience. In addition, LGAs will need to increase the amount of budget resources and improve overall planning for CSA implementation. On the other hand, where possible, Payment for Environmental Services (PES) should contribute to CSA interventions.

Mainstreaming of CSA into national and local level strategic investment is important so as to get funds for implementing CSA. Through ASDP2 the CSA technologies and practices can be implemented to adapt and mitigate climate change impacts. On the other hand, Development Partners need to give technical and financial support to the agricultural sector to prepare bankable project/program proposal so as to access the global climate funds such as Green Climate Fund.

6.3 Monitoring and Evaluation Plan

The aim of the Monitoring and Evaluation (M&E) Plan (Table 3) is to provide a general picture of how the government will assess the CSA guidelines implementation and up-scaling together with changes as the results of CSA packages adoption. The M&E plan will therefore track progress across levels and scales of the CSA guidelines implementation but focusing mainly on:

- Impact level: Changes in people's livelihood and the environment (long term change)
- Effect level: Behavior change, institutional change and changes in district planning systems
- Output level: Results of CSA interventions
- Activity level: Completion of CSA interventions

The monitoring and evaluation event (table 4) shows who will be responsible for delivering each objective. One important element of M&E that is often times forgotten is the budget to implement the M&E activities. Therefore, it is important that a budget must be set aside. The milestones in terms of when to expect completion of the M&E activity should also be included.

The M&E of the CSA guidelines implementation should consider a participatory monitoring approach. Participatory monitoring recognizes and capitalizes on community, households and all stakeholders engaged in the adoption of the CSA packages. In other situations, external evaluators or assessors could be used. This is important in helping governments, donors and other stakeholders to use the information for validating the adopted CSA practices, referencing but also identifying areas of further support. External monitoring and evaluation can also increase transparency and accountability of implementing the CSA practices.

Budget for monitoring and evaluation (M&E) is important. Experience shows that when budgets are allocated for M&E, the intended objectives of increasing number of people engaging in initiatives increases. Thus, there are must be budget for monitoring implementation of the CSA practices at district level. The M&E budget should also consider documentation and dissemination of success stories to reach more audience within and outside the country.

Table 3: Monitoring and Evaluation Plan

Objective	Performance Indicators (Aggregate Indicators)	Data Source	Collection Methods (Tools and Processes)	Frequency	Responsibility
Improved capacity of agricultural and environmental agencies of Districts promoting CSA packages to facilitate participatory and sustainable agricultural development	1. Systems for promotion as well as coordination of CSA packages in Agricultural plans and policies at district level agreed and in place 2. percent of district resources allocated to promote CSA adoption by local farmers	• Annual national plan and budget documents • District agricultural development plans (DADPs) and its respective budget • Ward as well as Village reports • DCC meeting minutes	• Semi-structured interviews with government authorities • Document reviews • Review of minutes of meetings	Annually	• HEMU • Partner Organizations • Researchers
Increased adoption of climate-smart agriculture packages by farmers and farmers' groups	1. percent of all district in Tanzania promote implementation of climate-smart agricultural packages to their local farmers 2. percent of farmers in district practicing CSA packages to increase land and water productivity under current climate variability	• District agriculture department, • Agricultural Extension Agent (AEAs) Farmers • Pilot community members • Community co-ordinating body	• Semi-structured interviews with AEAs, farmers and partner organizations • Field observation • Review of district reports	Semi-annually	• HEMU • Partner Organizations • Researchers
Improved capacity of CSOs, public and private institutions to provide relevant and high-quality services and inputs to farmers to enable implementation of recommended CSA packages.	1. Farmers in six pilot communities and others reporting having improved access to services they need 2. Number of service providers reporting use of new skills and knowledge, based on community needs	• Farmers in pilot communities • Pilot community members • CBOs • Service Providers	• Focus group discussions with farmers • Semi-structured interviews with service providers	Semi-annually	• HEMU • Partner Organizations • Researchers

Table 4: Monitoring and Evaluation Events

What	Purpose	Measure What	Responsibility	Input From	When
CSA guideline implementation evaluation	Determine extent to which CSA guidelines' purpose has been achieved, evaluate guideline implementation process & strategy	• Capacity built and organizational development of Service Providers, District, Partners • CSA guidelines' implementation processes and strategies	• HEMU Team • Advisory Team • External Resource Person • Researchers • Local Resource Person • District authorities	Financial resources	November 2017
Districts reviews	Review progress towards achieving their set goals and objectives to promote CSA packages' adoption	• To be determined in with CBOs, would include CBO adoption of processes facilitated by project	• HEMU Team • Researchers • Local Resource Person • District authorities	Financial resources	July-August 2017

CHAPTER 7: CONCLUSION

Agricultural practices and technologies, their development, transfer and adoption are fundamental in increasing productivity, rural incomes and growth and subsequently contributing to poverty reduction as well as adapting to climate change. One of the major factors constraining development of agriculture in Tanzania is the failure of the farming community to adopt existing improved agricultural practices and technologies.

There is abundant evidence showing that the National Agricultural Research System (NARS) has made available a wide range of improved agricultural technologies and practices that have a high potential of alleviating poverty, enhancing food security and improving nutrition status of the majority (Matata et al., 2011 and Mpanda et al., 2014). Despite availability of those improved agricultural technologies developed or made available to farmers by (NARS), production is still being undertaken using rudimentary technologies.

Low or non-adoption of improved agricultural production practices and technologies is one of the major problems currently facing the farming community in most parts of Tanzania. Major reasons for low adoption include cost of production, poor access to markets, low involvement of private sector to enhance investment, and limited awareness.

Government efforts to address these challenges include among others, input subsidies, use of farmer field schools (FFS), demonstration farms and participatory action research, as well as involvement of private sector. Moreover, these efforts are crippled by the impacts of climate change facing agricultural sector.

There have been various initiatives to address these impacts including compliance to CAADP and Malabo Declaration as well as the 2011 Johannesburg Communiqué, which urges African countries to invest in facilitating adoption of CSA practices and approaches. The ACRP also admit that CSA practices and technologies can increase yield in the changing climate. In recognition of the CSA potential to contribute to a triple win for food security and climate change adaptation and mitigation, Tanzania is ready for implementing CSA practices and approaches.

Existence of this CSA guideline is an important step toward achieving the global and national goals of sustainable agriculture production in a changing climate. This CSA guideline will compliment Government efforts and help in bridging the gap between researchers, policymakers, farmers, private sectors, CSOs, and development partners by providing guidance during planning, decision making, budgeting and implementation by presenting a wide range of technologies and practices that are climate-smart with intention to provide an opportunity for scaling up the most promising ones in the country.

ANNEXES

Annex 1. Task Team Members

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Annex 2. Agro-Ecological Zones of Tanzania

The FAO/Kilimo agro-ecological zones map of Tanzania (De Pauw, 1984) shows natural and physical regions which are sufficiently uniform in climate, physiography and soil patterns to facilitate generalised descriptions and evaluation of the agricultural potential. The database and map constitute a condensed inventory of the agricultural environment with statements on the physical potential or constraints for agricultural development.

Each AEZ has a unique combination of altitude, precipitation, landforms and soils. Most of the AEZs have one dominant temperature and precipitation regime respectively. In general, most AEZs have two or more dissimilar soil types. Dominant soils have been used to sub-divide the zones into smaller units (e.g. zone C into C1, C2, and C3) with homogenous temperature, precipitation and soil characteristics. This sub-division generated 64 AEZs of which 63 are arable while one is rock land (Figure 6). The physiography, climate and soils are briefly described below

i. **Physiography**

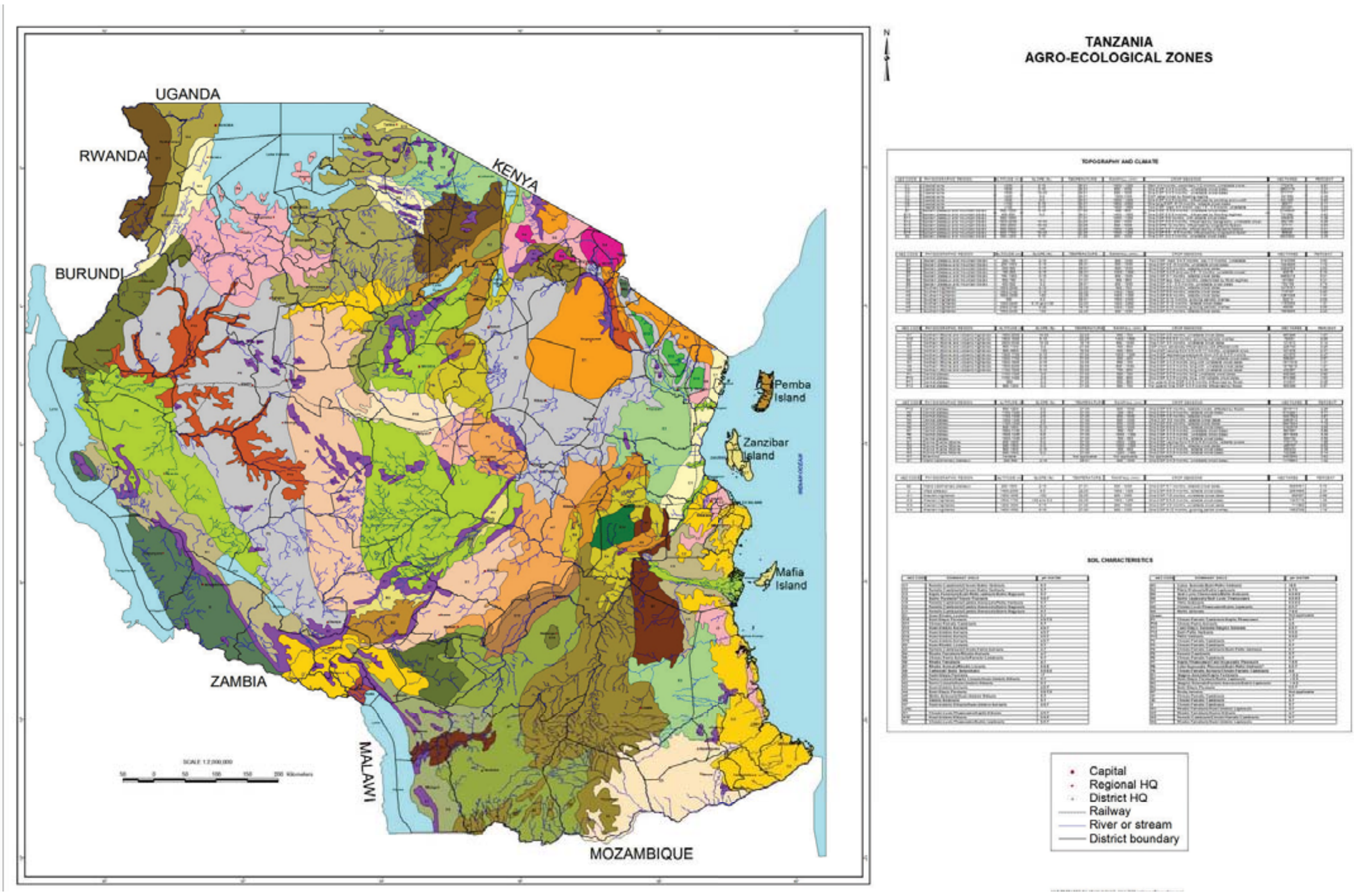
Physiography or landform is described in terms of general drainage conditions (uplands or lowlands, water shedding or water receiving), relief, altitude and occurrence of significant land degradation or soil erosion. This information is used for a broad interpretation of suitability for crops with specific drainage or temperature requirements.

ii. **Climate**

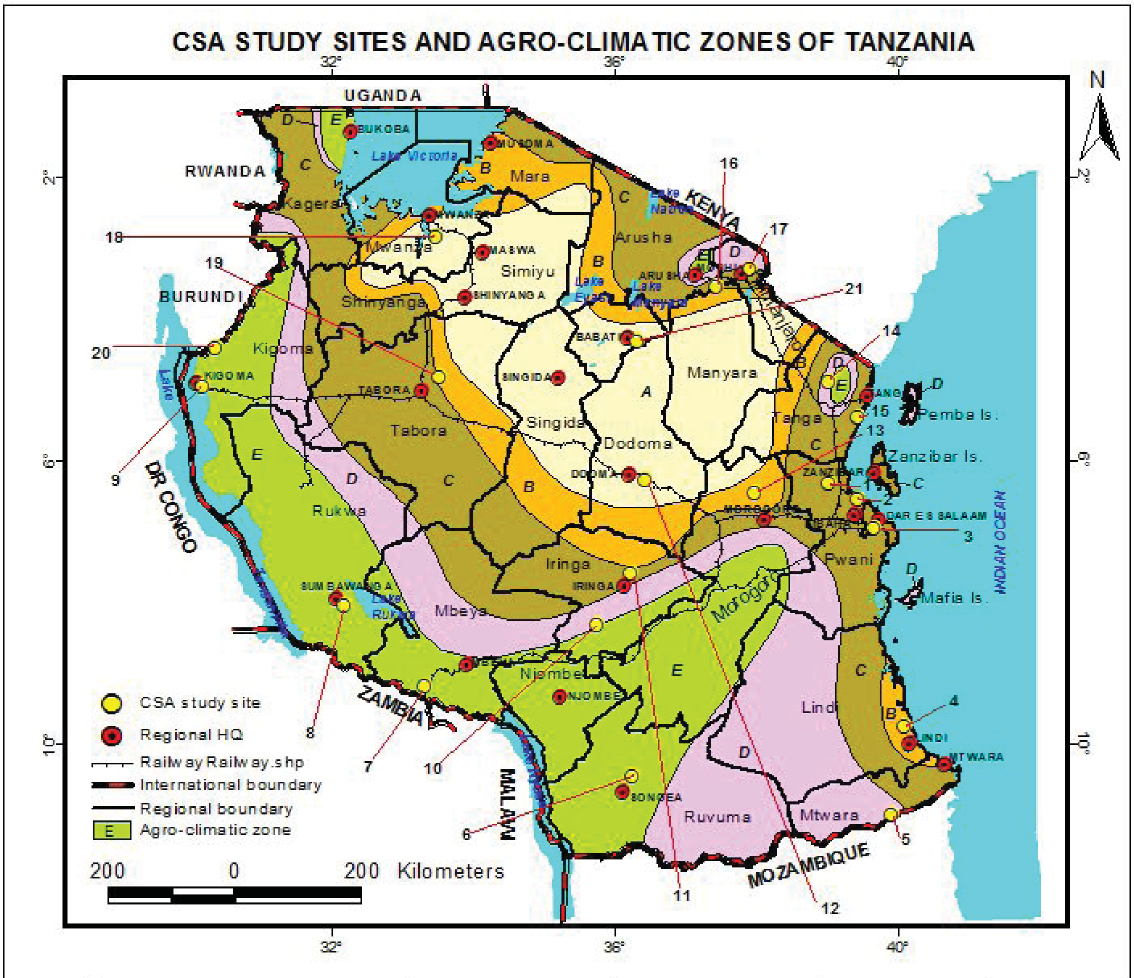
The AEZ map specifies temperature regime and the growing period (GP). Temperature is described on the basis of mean annual maximum temperature (T_{max}), mean annual minimum temperature (T_{min}) and the mean annual range of temperature (T_{range}). These determine the temperature regime that is used as a concept to describe moisture availability. Temperature zones are defined on the basis of altitude and used to establish temperature limitations for particular crops. The GP is the period during an average year when temperature and moisture conditions are favourable for crop growth. It is estimated by means of a simple water balance model comparing rainfall, moisture storage of soils and potential evapo-transpiration. Key characteristics for the GP such as the beginning, end and duration are established and mapped in moisture zones.

iii. **Soils**

The AEZ map provides a brief description of the soils that occur in each zone in terms of the soil units established for the map Soils and Physiography. Some assessment of the natural fertility status and the moisture storing properties of the soils is given as well. This information is used to identify crops that can grow optimally with reference to temperature regimes and length of the dependable growing periods. Further refinement of the set of suitable crops within an AEZ can be undertaken considering local topography, erosion hazards, drainage conditions, soil depth and texture, and fertility status.



Annex 3. Agro-Climatic Zones of Tanzania



No	NAME OF SITE	WARD	DISTRICT	REGION	ACZ
1	Kiwangwa	Kiwangwa	Bagamoyo	Pwani	C
2	Zinga	Zinga	Bagamoyo	Pwani	C
3	Chamazi	Chamazi	Temeke	DSM	C
4	Mchinga	Mchinga	Lindi	Lindi	B
5	Chikwedu	Mcholi I	Newala	Mtwara	D
6	Msindo	Msindo	Namtumbo	Ruvuma	E
7	Ihanda	Ihanda	Mbozi	Mbeya	E
8	Ulinji	Mollo	Sumbawanga	Rukwa	E
9	Kagera	Kagera	Kigoma Ujiji	Kigoma	E
10	Lyasa	Mafinga	Mufindi	Iringa	D
11	Igingilanyi	Kising'a	Iringa Urban	Iringa	C
12	Chololo	Kikombo	Dodoma	Dodoma	A
13	Wami Dakawa, Kwamhuzi	Dakawa	Mvomero	Morogoro	B
14	Magoma	Magoma	Korogwe	Tanga	D
15	Madanga, Jaila	Madanga	Pangani	Tanga	C
16	Makiba	Makiba	Arumeru	Arusha	C
17	Iwa	Kirua Vunjo West	Moshi Rural	Kilimanjaro	C
18	Nange	Igokelo	Misungwi	Mwanza	A
19	Usagari	Magengati	Nzega	Tabora	B
20	Mwayaya	Mwayaya	Buhigwe	Kigoma	E
21	Gedamar	Gallapo	Babati	Manyara	A

An "Agro-climatic zone" is a land unit in terms of major climates, suitable for a certain range of crops and cultivars (FAO, 1983). The agro-climatic classification is nothing but an extension of the climate classification keeping in view the suitability to agriculture. Agro-climatic zones are widely defined on the basis of either rainfall, temperature or altitude depending on which is considered as governing parameter. Whereas temperature conditions are generally favourable for most forms of agriculture, it is mainly rainfall which controls the limits in the field of human activities and it is the decisive factor in economic development. Therefore, this climatic zonation of Tanzania is based on rainfall which is the most variable climatic parameter.

Agro-Climatic zones of Tanzania are based on the comparison between rainfall and the water requirements of the vegetation or crops using the amount of rainfall that can be expected to be reached with a probability of 80percent. The purpose of zoning is to delineate areas with similar sets of potentials and constraints for agriculture development.

Annex 4. Location and Characteristics of the Baseline Study Sites

AGRO-CLIMATIC ZONE C

Study Site 1: Bagamoyo District (Kiwangwa), Pwani Region

This study site is situated in Bagamoyo District in Pwani Region and it falls under Agro ecological zone C1 (AEZ C1) that lies below 200m above mean sea level and having two dependable growing seasons: March-April and October-December. The mean annual temperature T_{max} is 29 – 31^{0}C and the mean annual temperature T_{min} is 19 – 23^0 C. The main farming system of this area is production of maize, cassava, paddy, pineapple, cashew nuts and coconut. Agricultural activity is largely subsistence and low value crops. Common cash crops in the study area are coconut, fruits, cashew and sesame while important food crops include maize, sorghum, paddy, cassava, and legumes. Pineapple is being cultivated by majority of farmers because it is the main income generating activities in the area. Livestock is another enterprise in Kiwangwa that includes cattle, goats, sheep, pigs and poultry but few numbers of farmers are engaged to it.

Study Site 2: Bagamoyo District (Zinga), Pwani Region

This study site is found in Bagamoyo District in Pwani Region and a large part of Zinga is found along the coast. The site falls under Agro ecological zone C2/C3 (AEZ C2/C3) that lies below 500m above sea level. Mean annual rainfall is 800-1000mm/year with one dependable growing period (DGP) per year with duration of 3 - 4½ months, and unreliable onset dates. The mean annual temperature T_{max} is 29 – 31^{0}C and the mean annual temperature $T_{min}$is 19 – 23^0 C. The population in Zinga depends on agriculture and most of the household near the coast depends on fishing. Common food crops in the study area are maize, paddy, sunflower and cassava, while cashew, coconut, sesame, fruits, sorghum and cowpeas are common cash crops for the study site and few farmers keep poultry. Seaweed farming is another enterprise in the study area carried out along the coast of Indian Ocean in Zinga.

Study Site 3: Temeke District (Chamazi), Dar es Salaam Region

This area falls under Agro-ecological Zone C2 (AEZ C2) that lies at an altitude of less than 500m above mean sea level and having one dependable growing season with a duration of 3 - 4.5 months. The rainfall pattern is unreliable and the annual rainfall is 800 - 1000mm. The area is urban, in which 4percent of its population are involved in agriculture activities. The main food crops cultivated in the study site include paddy, cassava, sweet potatoes, vegetables and fruits. The major cash crop is cashew nuts, water melon, okra and other vegetables. Livestock is another enterprise that contributes 30-50percent of cattle milk in the municipality, and there is a high number of poultry, goats and pigs. Poultry keeping is emerging and growing very fast in relation to other activities.

Study Site 11: Iringa District (Kising'a and Igingilanyi), Iringa Region

This area falls under the agro-ecological zone AEZ H1 (AEZ H1). It is mainly flat and undulating to rolling plains and plateau at high altitude, 1,500-2,000 m above mean sea level. Major soils are deep, well drained, yellowish or reddish sandy clays to clays with moderate natural fertility. There is one DGP per year with duration of 5-6 months and reliable onset dates. Mean annual rainfall is 600-1,600 mm, mean annual maximum temperature (T_{max}) is 22-25^0 C and mean annual minimum temperature (T_{min}) is 10-15^0 C. Food crops grown in Kising'a village includes maize and beans (which are rain-fed) onions, tomatoes, varieties of vegetables and potatoes which are grown in valley bottoms (*vinyungu*) throughout the year. Crops grown in Igingilanyi village include maize, sorghum, sunflower, tobacco, rice, groundnuts, cassava and vegetables. Few farmers do keep livestock although there are also large scale commercial farms in the area that practice farm out-grower system in livestock enterprises.

Study Site 15: Pangani District (Madanga and Jaila), Tanga Region

This site is found in Agro-ecological zone C4/C1 (AEZ C4/C1) along the Indian Ocean coastal belt with altitude of less than 200 m above mean sea level. Rainfall is 1000 - 1200mm/year. The length of the growing period in this zone is 2 Dependable Growing Periods (DPG) per year. The main DPG is March-April while the secondary DGP is October-

November. The population in Pangani relies on agricultural production for both food and cash. The main livelihood sources are production of cashew, coconut, maize, cassava, pulses, fruits and vegetables. Maize, cassava and rice depend on *masika* (long rain) and *vuli* (short rain) wet seasons. Perennial crops such as coconuts and cashew nuts are used as cash crops. Cattle and small stock are owned by households but account for only a small portion of their annual income. Households living closer to the coastline engage in fishing and a minority of the population collect seaweed and process fish.

Study Site 16: Arumeru District (Makiba), Arusha Region

This site is found in a low-rainfall zone found in Agro-ecological Zone N5 (AEZ N5). The altitude in this zone is 1300 - 1700 m above mean sea level. Rainfall is 600 - 1200 mm/year. The length of the growing period in this zone is one DPG with duration decreasing from 4-6 months to 2½ months with unreliable onset rainfall dates. Livestock production and crop cultivation are important for local households. The main crops are maize, cassava, beans, coffee, banana, Irish potatoes, sunflower, fruits, vegetable and livestock. All households rely on the market to meet the bulk of their food needs, and much of the cash for this comes from livestock sales, especially cattle. Production hazards exist but are not acute, and the mix of agro-pastoral production largely guarantees food and livelihood security.

Study Site 17: Moshi Rural District (Kirua Vunjo West), Kilimanjaro Region

The study site is found in Agro-ecological zone AEZ N4 (AEZ N4) in Kirua Vunjo West. The altitude in this zone is 900 - 3500 m above mean sea level. Rainfall is 500 - 1400 mm/year. The length of the growing period in this zone is one DPG with duration ranging from 3 - 5 months in the lowlands and 6 - 11 months in the highlands. The zone has unreliable rainfall onset dates. The zone has high population density but is highly productive and is food secure. Copious rainfall in the two seasons of *Masika* and *Vuli* and a relatively temperate climate enable substantial coffee production as well as a mix of crops, with maize and bananas uppermost for food. Other crops include coffee, beans, fruits, and vegetables while livestock enterprises also prevail. Dairy products from cattle and goats provide households with additional income and food.

AGRO-CLIMATIC ZONE B

Study Site 4: Lindi District (Mchinga), Lindi Region

This area falls under Agro-ecological zone C2 (AEZ C2) that lies at an altitude of less than 500m above mean sea level and having one dependable growing season with a duration of 3 - 4.5 months. The main farming system of this area is production of paddy, maize, cassava, cashewnuts, sesame, vegetables, sorghum and fishing. Cashewnuts and sesame are considered as their main cash crops while maize, paddy, sorghum, cassava and vegetables are food crops.

Study site 13: Mvomero District (Dakawa), Morogoro Region

This is a low land zone (400 - 500m) found in Agro-ecological zone E9 (AEZ E9). The mean annual rainfall is between 800 - 1000 mm and has one dependable growing period with duration of 4.5 - 6.5 months with unreliable onset. Agriculture is the dominant activity and majority of households in this zone rely heavily on crop production to meet most of their annual food and cash needs. The main crops grown are cassava, rice, maize, and bananas. Other crops include beans, millet, peas, potatoes, coffee, groundnuts, citrus fruits, mangoes, jackfruits, sugarcane, coconut, tomatoes and eggplant. With the exception of few paddy and sugarcane fields, cultivation is carried out mainly by use of the hand hoe, using primarily family labour and hired labour when the situation demands. Tractors are available only to a few individuals. Livestock keeping is also practiced by few farmers.

Study Site 19: Nzega District (Magengati), Tabora Region

This area is found in Western part of the country in Tabora Region at Nzega District under Agro-ecological Zone P3 (AEZ P3). The district receives rainfall of between 650 mm and 1,200 mm annually, falling between the months of October or November and December and a dry period from January to February/March and a second lower peak occurring soon after the dry spell in February or March and the rains then tail off in April/May. Livelihood sources are crop production including tobacco, cotton, maize, rice, cassava, and sorghum. Livestock such as cattle, sheep and goats, and chicken are kept for milk, meat and egg production respectively. Much income is generated from harvesting forest products (wood and non-wood) including honey, timber, building poles, charcoal and wildlife.

AGRO-CLIMATIC ZONE D

Study Site 5: Newala District (Mcholi 1), Mtwara Region
This is low land zone (200-500m) found under Agro-ecological zone E5 (AEZ E5). The mean annual rainfall is between 800-1000 mm and having one dependable growing period with duration of 5 - 6 months with unreliable onset. Major crops grown in the zone that contribute to community livelihoods include cashew, sesame, cassava, maize, pulses (pigeon peas, cowpeas) and rice. Cashew nuts are the main cash crop though pigeon peas and sesame are also cultivated.

Study Site 10: Mufindi District (Mafinga), Iringa Region
This area is found in Lyasa Iringa Region and falls under the Agro ecological Zone H1 (AEZ H1). It is mainly flat and undulating to rolling plains and plateau. The altitude is high ranging from 1,500-2,000 m above mean sea level. Major soils are deep, well drained, yellowish or reddish sandy clays to clays with moderate natural fertility. There is one DGP per year with duration of 5-6 months and reliable onset dates. Mean annual rainfall is 600-1,600 mm, mean annual maximum temperature T_{max} is 22-250C and mean annual minimum temperature T_{min} is 10-15^0 C. Main livelihood enterprises include maize, sorghum, sunflower, tea, beans, fruits and vegetables, and livestock. Food crops such as maize and beans are rain-fed while onions, tomatoes, varieties of vegetables and potatoes are widely grown under irrigation in the valley bottoms (*vinyungu*) throughout the year. Other livelihood sources include sale of timber from plantations. All households in the zone rely on agricultural production as their main source of food and income. Poorer households supplement their crop incomes by working on better-off household's farms. Better-off households earn additional cash by selling livestock, especially cattle. Poorer households can only afford to sell a few animals and often according to immediate need.

Study Site 14: Korogwe District (Magoma), Tanga Region
This site is found in Magoma Ward, Korogwe District and is located in Agro-ecological zone E2 (AEZ E2). The altitude in this zone is 500-1200 m above mean sea level. Rainfall in some areas is less than 500 mm/year, while in others it is 800 - 1,000 mm/year. The length of the growing season in this zone is one dependable growing period (DPG) with duration of 2 - 2½ months and unreliable onset date. The main food crops are maize, cassava, paddy, fruits and vegetables. Livestock keeping of poultry, sheep, goats and cattle are common. Heavy reliance on crop production for food and cash make households especially vulnerable to food stress if rains fail.

AGRO-CLIMATIC ZONE A

Study Site 12: Dodoma District (Kikombo), Dodoma Region
The study site is found in Kikombo Ward (Dodoma Region) in agro-ecological zone P9 (AEZ P9) with altitude of 1100-1300 above sea level. It is a dry zone which receives 600-1000 mm of rainfall per year, which is often enough to grow food and cash crops. The length of the growing period in this zone is one DPG with duration of 4-5 months and has reliable onset dates. Households depend on livestock as the main source of income. Better-off households earn most of their income from selling their cattle, shoats and poultry. Households may also earn portions of their annual income from selling cash crops, like sesame, groundnuts, and sunflower. Other crops grown are sorghum, bulrush millet and maize food and livelihood security depend on successful rains. Livestock owners rely on the rains to recharge pastures and water supplies, and all depend on the rain for successful crop yields. Beekeeping is also practiced in this area.

Study Site 18: Misungwi District (Igokelo), Mwanza Region
This study site is found around Lake Victoria area under the Agro-ecological Zone P8 (AEZ P8). Livelihoods in this area are based on cotton, paddy, maize, fishing and livestock keeping. Maize crop is grown for sale and for food. Other sources of income include fishing and mining activities, in particular gold, which is plentiful in the zone. Employment on farms and in gold mines provides another source of income to many communities within and outside the zone. Most communities are made up of local farmers comprising 90 percent of the population.

Study Site 21: Babati District (Gallapo), Manyara Region
The study site is found in Gallapo Ward and is located in Agro-ecological zone AEZ E2 (AEZ E2). The altitude in this zone is 500 - 1200 m above mean sea level. Rainfall in some areas is less than 500mm/year, while in others it is 800 -

1,000 mm/year. The length of the growing period in this zone is one Dependable Growing Period (DPG) with duration of 2 - 2½ months and unreliable onset date. Mixed crop-livestock, mostly maize-based systems are widely found in Babati District that are intercropped with varying species, such as common maize, beans, pigeon peas, sorghum and sunflower, according to altitude and rainfall availability. In the lowlands, paddy rice is cultivated where irrigation is available. The area has bimodal rainfall ranging from 1,100-1,200 mm annually which allows cultivation of a wide range of food and cash crops in the zone. Sunflower, maize, pigeon pea, and coffee (as well as livestock) are sold as cash crops, but with wide differences in amounts and numbers.

AGRO-CLIMATIC ZONE E

Study site 6: Namtumbo District (Msindo), Ruvuma Region.

This area falls under agro-ecological zone AEZ E7 (AEZ E7) and is characterized by flat to rolling plains, locally hilly at medium altitude (750-1300 m), including strongly dissected uplands and low hills transitional to the medium altitude plateau. Major soils are moderately deep to deep, well drained, dark red to red clays with moderate to strong structure and evidence of clay illuviation. Natural soil fertility is low to moderate. There is one medium to long DGP with reliable onset dates per year with duration of 5-7 months in most of the zone. Mean annual rainfall is 800-1,000 mm, mean annual maximum temperature T_{max} is 27-30^0 C and mean annual minimum temperature T_{min} is 15-18^0 C. This area receives adequate annual rainfall and has one long growing season, which begins in November and ends in May. The length of growing period is between 150 and 200 days per year. The major crops grown are maize, cassava, yam, sweet potatoes, tobacco, paddy, coffee and cashew nuts.

Study site 7: Mbozi District (Ihanda), Mbeya Region

This area falls under agro-ecological zone AEZ U (AEZ U) and is characterized by complex flat to gently undulating plains, has an altitude of 800-1800m above mean sea level. Major soils are moderately deep to deep, well drained, reddish and yellowish sandy clay loams and sandy clays with low natural fertility. The area has one DGP per year with duration of 5-6½ months, in some parts 6-8½ months, and reliable onset dates. Mean annual rainfall is 800-1,200mm, mean annual T_{max} is 22-25^0 C and mean annual T_{min} is 10-15^0 C. Households in the area depends on crop production to meet the majority of their food and income needs. The main livelihood enterprises are maize, beans, paddy, cocoa, banana, coffee, sunflower livestock and fish farming. To meet immediate needs, poorer households often sell after harvest at low prices only to buy back food at higher prices when stocks run out. Aside from crop sales, the poor also sell poultry and/or engage in paid work inside or outside the zone. Wealthier households own more livestock and can afford to sell some cattle and goats throughout the year or according to needs. Flooding is the only impediment to crop production and security in the zone and may occur once in every five years. There is good road network connecting the region with moderate feeder roads that determine accessibility to different places.

Study site 8: Sumbawanga District (Mollo), Rukwa region

This site is found in Mollo under Agro-ecological Zone H5 (AEZ H5) and is mainly characterized by volcanic landforms ranging from undulating to rolling, medium to high altitude plains and plateau; to strongly dissected hills, mountains, plateaux and plains at medium altitude (1,200 - 2,400 m above mean sea level). Major soils are deep, well drained, dark grey brown loamy sands, sandy loams and loams rich in allophanic clays with high natural fertility. There is one DGP per year, increasing in duration from 6-9 months to 9-12 months, with overlapping growing periods. Mean annual rainfall is 1,000-2,000 mm, mean annual T_{max} is 22-25^0 C and mean annual T_{min} is 10-15^0 C. The area is also characterized by annual crop farming as an activity that provides most of their cash income followed by tree/forest resources, off-farm income, livestock keeping/herding, permanent crops, remittances, and fishing/hunting and gathering. Main livelihood enterprises include maize, beans, cassava, wheat, sunflower, livestock and fish farming enterprises. Roads are relatively good; although some feeder roads are impassable during the rainy season. Water availability for plantations is relatively good because of the characteristics of the catchment in the upper parts of the zone. Small scale and traditional irrigation is common in the area.

Study Site 9: Kigoma-Ujiji District (Kagera), Kigoma Region

This area falls under the agro-ecological zone AEZ W2 (AEZ W2) and is found at Kagera and Kibirizi villages. The study site lies within altitude of 800 – 1000 metres above sea level with annual rainfall of 600 – 1000 mm. Major soil types in this area are fine sandy, dark, reddish, brown and loams. The main livelihood enterprises in Kagera village are based on maize, oil palm, vegetables, paddy, sweet potatoes, beans and livestock keeping, while the main livelihood activities in Kibirizi village are based on fishing in Lake Tanganyika. Types of fishes include *Dagaa*, *Lumbo*, *Migebuka*, *Sangara* (Nile Perch), *Nonzi* and *Gomba*.

Study Site 20: Buhigwe District (Mwayaya), Kigoma Region

This area is found in Mwayaya village and falls under the AEZ W2. It lies within altitude range from 1500 - 1750 metres above the sea level. Major soils in this part are black, brown and alluvial. Annual rainfall is variable ranging from 1000 mm- 1600 mm. The main livelihoods are based on maize, coffee, banana, tea, palm oil, beans and sweet potatoes and livestock (cattle and goats).

Annex 5. Summary Results of Baseline Survey

AEZ	ACZ	Livelihood zone	Main crops	Main technologies	Main practices	Main livestock	Main technologies	Main practices	Main fishing	Main technologies/ practices	others	Adaptation strategies (percent CC impact)
C1 C4	B, C	Tree crops fishing coastal	cassava	Hand tools and improved seeds	Weeding, mulching, intercropping, slash and burn	They have chicken; want +cattle	Shade, concentrates and improved breeding	Free grazing / extensive. In 1 site zero-gr. because of a biogas plant	-	net fishing &hook fishing	In 1 site beekeeping & tree planting	Early planting, dry planting and early land preparation (85-100percent)
P8 P3	A, B	Cotton-paddy rice cattle	Maize paddy	Hand tools and improved seeds	Ridging, monoculture, crop rotation, intercropping	Chicken and cattle	natural mating reproduction & local breeds & boma	extensive	wild fishing in lake	fish nets & light	Local beekeeping	drought tolerant crop varieties & mulch (Majority)
E7 W2	A, E	Maize Tobacco Lake fishing	Maize (beans)	Draft animals' ox-plough, improved seeds	Ridging, monoculture, crop rotation, intercropping	Chicken, cattle and goats	Shade, concentrates &local breeds	Extensive, semi-intensive & manure management for biogas	wild fishing in lake	fish net & boats	-	Early land preparation (100percent)
W2H1 H5U	C, D, E	Coffee-banana Trees Rice-Maize bimodal	Maize (beans, sunflower, wheat)	improved seeds (draft animals' ox-plough)	Intercropping, mulching, weeding, crop rotation	Chicken, cattle and goats	Hand sprayer to control pests; boma & reproduction. Natural mating	semi intensive especially in dairy cattle production; intensive & extensive	tilapia	ponds	Beekeeping and tree planting	Drought tolerant crop varieties & irrigation & early planting (86-100percent)
P9 E2 E5	A, C, D	sorghum livestock Pastoral Maize cassava cashew sesame	Sorghum, maize, cashew, groundnut, sesame, sunflower	draft animals' ox-plough, hand tools and tractor	intercropping of maize & p. peas, mixed cropping, (weeding, ridging)	Chicken goat and cattle	improved breeds	Extensive and intensive	Tilapia and catfish	possibility of integrated systems with rice	Tree planting and beekeeping and 1 biogas plant	Drought tolerant crop varieties & irrigation & early planting (90-97percent)

E9 E2	B, D	Sisal Sugarcane cattle	Sugarcane, paddy, maize	draft animals' ox-plough, hand tools and tractor	row and space planting, monoculture	Chicken and cattle (goats)	Boma, vaccines and improved breeds	intensive (Also for chicken to collect manure)	tilapia	Ponds (in progress)	-	Dry planting, indigenous knowledge & early land prep (97-100percent)
N5 N4	A, C, E	Pastoral Coffee-banana	Maize banana	Tractor, improved seeds	Intercropping, ridging, monoculture, agroforestry	Goats, cattle and chicken	improved breeds dip tanks &paddock	Intensive (&extensive)	-	-	beekeeping	Irrigation and tree planting_ ***(60***-93percent)

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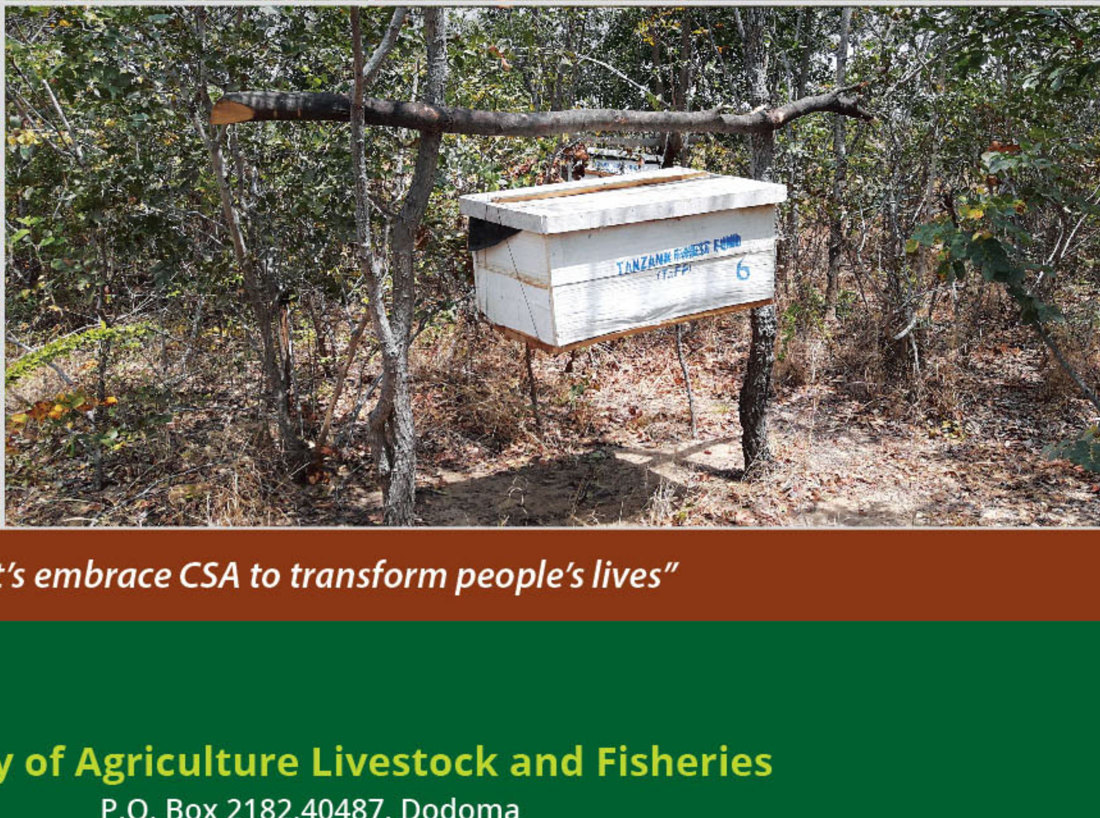

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