Tanzania Country Climate Risk Profile Series

Kilolo District

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Climate Risk Profile Kilolo District

Highlights

- Agriculture plays a huge role in the economy of Kilolo District, contributing to 81% of the Gross Domestic Product and providing employment to more than 80% of the population.
- Agricultural production is predominantly subsistence, with 82.5% of farmers engaging in cash and food crop production.
- Climate change, particularly variability in temperature and rainfall has adversely affected all levels of the value chain including; input provision, on-farm production, postharvest handling, and marketing.
- Women farmers are highly disadvantaged by traditional norms that inhibit them from owning productive resources such as land, thus are highly vulnerable to climate change and associated risks.
- The youth and women provide a bulk of the farm labor, including land preparation, planting, and harvesting. Production destabilization as a result of climate variability thus augments unemployment among the most vulnerable populations.
- Climate-smart agriculture strategies, such as conservation agriculture, crop management and drip irrigation, help reduce climate-associated risks. However, adoption rates of such practices are low due to a lack of finance options, weak extension services, and input and output markets.
- The government has played a key role in addressing agricultural climate resilience by; establishing policies and by-laws that govern the use of resources threatened by climate change, providing finance for implementing conservation initiatives, disseminating weather forecasts information, and building capacity of farmers.
- The private sector and NGOs support the government through provision of finance, conducting research, training farmers, and physical initiatives such as planting trees.
- However, lack of coordination between actors, inadequate financing, and information asymmetry have reduced the effectiveness of climate-smart agriculture initiatives.
- This presents an opportunity to strengthen linkages between actors and formalize communication sharing so as to facilitate effective implementation of climate change adaptation strategies.

Acronyms and Abbreviations

ACRP	Agriculture Climate Resilience Plan
AEZ	Agro Ecological Zone
AMCOS	Agricultural and Marketing and Cooperative Societies
ASDS	Agricultural Sector Development Strategy
CARE	Cooperative for Assistance and Relief Everywhere
CCAFS	Climate Change Agriculture and Food Security
CDI	Clinton Development Initiative
CIAT	International Centre for Tropical Agriculture
COWSO	Community Owned Water Supply Organizations
CSA	Climate Smart Agriculture
DoE	Division of Environment
EMA	Environmental Management Act
FAO	Food and Agriculture Organization of the United Nations
ICT	Information and Telecommunication Technology
IOP	Ilula Orphans program
JICA	Japan International Cooperation Agency
KCCMP	Kihansi Catchment Conservation and Management Project
MIWA	Ministry of Irrigation and Water
MNRT	Ministry of Natural Resource and Tourism
MoA	Ministry of Agriculture
MoF	Ministry of Finance
MoLF	Ministry of Livestock and Fisheries
NAP	National Agricultural Policy
NAPA	National Adaptation Programme of Action
NCCS	National Climate Change Strategy
NFP	National Forest Policy
NGO	Non-Governmental Organization
NWP	National Water Policy
PICS	Purdue Improved Crop Storage
PSP	Participatory climate Scenario Planning
RBWO	Rufiji Basin Water Office
RCP	Representative Concentration Pathway
RDO	Rural Development Organization
SIDO	Small Industries Development Organization
SUA	Sokoine Univeristy of Agriculture
TANAPA	Tanzania National Park Authority
TARI	Tanzania Agricultural Research Institute
TMA	Tanzanian Metrological Agency
UNESCO	United Nations Educational Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
USAID	United States Agency for International Development
VSLA	Village Saving and Lending Associations
WUR	Wageningen University & Research
WWF	Wild Wide Fund

Statistics given in this report are from the Kilolo District Council Socio-Economic Profile of 2016 (URT, 2015) unless otherwise indicated.

Foreword

The agricultural sector in Tanzania has been exposed to high climatic risks for the past several decades (Arce & Caballero, 2015). Experts and farmers assert that climatic risks including unpredictable rainfall, prolonged drought, and increased incidences of pests and diseases have resulted in declining agricultural productivity. Concomitantly, the rivers, streams, soils, and forests from which the rural poor build their livelihoods are on the verge of depletion. The situation has been further exacerbated by unstable commodity prices. Future climatic projections show that the climate trends are likely to worsen in the coming years. For instance, mean annual temperatures in Tanzania are predicted to increase by up to 2.7°C by 2060, and by close to 50% by 2090 (Irish Aid, 2018). Similarly, day and night temperatures are also expected to increase. Rainfall will become increasingly erratic both locally and regionally, with both floods and droughts growing in intensity and frequency.

Smallholder farmers have the poorest access to resources such as land tenure, water resources, crop and livestock insurance, financial capital, and markets, and thus are the least risk-resilient. Women farmers in particular suffer systematic discrimination in terms of access to these resources. Women are also culturally expected to execute the most laborious agricultural tasks in addition to their household responsibilities of caregiving, preparing meals, and collecting fuel and water. Meanwhile, men tend to be responsible for tasks involving financial exchange, such as land acquisition, sourcing capital for production, purchasing and applying chemicals, and identifying buyers. This cultural norm is reinforced by the tenure system, which assigns land ownership almost exclusively to men. These factors make women the most vulnerable sub-group of smallholder farmers (Irish Aid, 2018).

The national government, donor community, private sector, and development partners have invested in helping households prepare for such climate scenarios. A number of policies, strategies, programmes, and guidelines have been documented with the goal of boosting the adaptation capacity of vulnerable groups. Prominent among these are the National Agricultural Policy (NAP 2013), the National Climate Change Strategy (NCCS 2012), the National Adaptation Programme of Action (NAPA 2007), and the Climate-Smart Agriculture implementation guideline.

Despite these efforts, several issues remain unaddressed due to a lack of coordination among relevant actors. The development of a local Climate-Smart Agriculture Profile can support the clarification of roles and crucial points of coordination to assist in this effort. This Kilolo District profile thus underscores the climate-smart agriculture (CSA) investments undertaken by farming households in the region. This profile is an output of the CSA/SuPER project on Upscaling CSA with small scale food producers, organized via the Village Saving and Lending Association (VSLA) Project, and implemented by Cooperative Assistance and Relief Everywhere (CARE International), the International Center for Tropical Agriculture (CIAT) (now part of the Alliance of Bioversity International and CIAT), Sokoine University of Agriculture, and Wageningen University and Research.

Both qualitative and quantitative methods were used to gather the information herein, in accordance with the methodology employed by Mwongera et al. (2015). Secondary information was collected through an extensive literature review. Primary information was collected from interviews with agricultural experts, farmer focus group discussions, stakeholder workshops, and farmer interviews in Kilolo District.

This profile is organized into six major sections based on the analytical steps of the study. The first section describes the contextual importance of agriculture to Kilolo livelihoods and households. The second describes historic and future climatic trends. The third section highlights farmers' priority value chains. The fourth section addresses the challenges and cross-cutting issues in the sector. The fifth section details climate hazards experienced by farmers, as well as the current and proposed adaptation strategies. Finally, the sixth section outlines the policies related to CSA and the institutions that facilitate implementation of climate change initiatives.

Agricultural context

District context

Kilolo District lies in the northeastern part of Iringa Region, bordering Mufindi District to the south, Iringa District to the west, Dodoma Region to the north, and Morogoro Region to the east. The district covers an approximate land area of 7,875 km^2, and includes the Udzungwa mountain ranges. Approximately 14% of the district is covered by water, including numerous small streams forming rivers that eventually feed into the Great Ruaha River. Altitude ranges between 900 to 2,700 meters above sea level. The high altitude areas encounter temperatures of 8°–10°C, and 1,000–1,600 mm of precipitation annually, while low altitude areas have temperatures of 15°–27°C and 500–600 mm rainfall annually. Kilolo District is administratively divided into three divisions: Kilolo, Mazombe, and Mahenge, which are each further divided into wards and villages. Kilolo Division accounts for more than half of Kilolo District's water surface.

People and livelihoods

Based on the most recent population census of 2012, Kilolo District has a population of 218,130, 51.5% of which were women and 48.5% men. This represented a 7% increase in population growth since 2002, whereby the growth of women was three times that of men. This is likely due to male emigration to urban areas in search of work. Half of Kilolo District's population resides in Kilolo Division, but the gender distribution is similar throughout the three divisions. About 32.2% of the population is categorized in the youthful age group between 15–35 years[1] whereby there are more youths residing in the rural areas compared to the urban areas of the district. This could be due to the fact that a majority of the population (94%) in the district reside in rural areas. This makes youth the bulk of the labor market, and thus of crucial important in terms of national economics and policy. Kilolo District has a relatively high dependency ratio[2]. The average population density is 32 people/km^2; Kilolo Division is the most densely populated of the three divisions. In the period 2002–2012, Mahenge Division recorded an annual population growth rate double that of Kilolo District's overall growth rate (1.4% and 0.7%, respectively).

Poverty in Kilolo District, as measured by quality of housing and access to resources, is moderate compared to other districts in Iringa region. Approximately, 69% of the population has access to improved water sources, with Mazombe Division enjoying the highest levels (83%) of access. About 62% use metal roofing, and only 7% use mud and thatch roofs. An estimated 47% of the houses are built of baked or sundried bricks, while 20% are made of poles and mud, 72% of homes have earthen floors.

Adult literacy levels in Kilolo District have risen from over 74% in 2002 to nearly 79% in 2012. However, there are notable gender discrepancies in terms of literacy; 10% more men than women are literate. The difference is partly attributed to governance issues, including failed implementation of free education programs by the national government. Additionally, social and cultural values, such as early marriages, marked gender restrictions, narrowly defined household roles, and low valuation of female education, significantly disrupt the education potential of rural Tanzanian women (UNESCO, 2013).

Infrastructure plays an important role in the economic and social welfare of the inhabitants of a given region, by facilitating their access to resources and services. Kilolo District has an estimated 1,477 km of road network, 48% of this coverage is in Kilolo Division. The road[3] quality is generally poor; 74% of roads are earth, 19% are gravel, and only 7% of roads are tarmacked. The poor road network is a hindrance to transportation of goods, people, and services, particularly during the rainy season. The use and accessibility of information communication technology (ICT) is minimal; in the whole of Kilolo District, there is one Internet center, five mobile phone service points, and no television or radio stations.

The majority of households do not have electricity in Kilolo District. Therefore, wood fuel is dominantly used for domestic purposes such as cooking and heating. This explains the high consumption rates of wood in the district. Other sources of fuel such as kerosene and solar energy are also used for lighting, however, biogas has not been fully exploited.

1 According to the Tanzanian Youth Policy, people ages 15-35 are classified as youth.
2 Dependency ratio is the number of people between 15-64 years economically supporting people aged below 14 years and above 65 years.
3 Road networks make services and facilities more accessible to settlers by connecting those who are remotely located.

Between 2011 and 2015 the number of health facilities (that is hospitals, health centers and dispensaries) in Kilolo District have increased by 15%. The government of Tanzania has increased its efforts to improve healthcare access for vulnerable groups, particularly children. As of 2015, about 4% of children under five years were underweight in Kilolo District. Malnutrition under the age of one was recorded at 0.03% across the District, with Mahenge Division leading at 0.8%.

Agricultural activities

The climate in Kilolo District is conducive for a wide variety of production systems. The district has three distinct agro-ecological zones (AEZs) where arable land is present, enabling agricultural diversification;

- **Highland zone:** An extension of the Udzungwa Mountains, with altitudes of 1,600 to 2,700 m above sea level, annual precipitation of 1,000–1,600 mm, and temperatures below 15°C. The mild conditions and volcanic soils are optimal for maize, peas, bananas, wheat, potatoes and tea. Livestock production is minimal due to dearth of pasture.

- **Midland zone:** Traverses the Mazombe Plains at 1200–1600 m above sea level. Temperatures range from 15° to 20°C, average annual rainfall is greater than 500 mm but does not exceed 1000 mm, and soils are clay and sandy. Agricultural production is entirely rain-fed, and common crops include maize, sunflower, onions, sweet potatoes, tomatoes, cowpeas, and beans. Cattle, sheep, pigs, goats, and chickens are also common.

- **Lowland zone:** Covers the Mahenge Plains at 900–1200 m above sea level. Temperatures range from 15° to 29°C. Rainfall is unreliable and averages 500–600 mm annually, and soils are red and sandy. Irrigation is therefore widely employed in the zone. Livestock are also reared, including goats, sheep, indigenous cattle, donkeys, and chickens. Drought tolerant crop varieties such as sorghum, millet, and cassava, as well as irrigated paddy, vegetables, tomatoes, onions, and tropical fruits are common.

Agriculture is the cornerstone of Kilolo District in terms of both food production and income generation. Agriculture contributes to 83% of the district's Gross Domestic Product (GDP) and employs over 82% of the population. The agricultural landscape is dominated by extensive smallholder subsistence and cash crop systems. Vinyungu4 farm plots are increasingly common in Kilolo District; this traditional farming system leverages the soil moisture present near rivers to produce throughout the year (Kyando, 2007). In Kilolo, the practice is particularly common along the Mtitu River Basin in the Bomalango'mbe, Mtitu, and Ng'uruhe Wards.

Popular food crops include maize, beans, sorghum, and potatoes; common cash crops are tomatoes, onions, pyrethrum, and sunflower. Of the land currently under crop production, about 36% (59,400 ha) is dedicated to food crops such as maize, beans, paddy, sorghum, sweet potatoes, and potatoes. The rest is shared among cash crops and livestock. Maize alone accounts for 79% of the food crop production area, and beans an additional 18%. The district produces over 44,000 tons of cash crops annually, with tomatoes accounting for 51% of this total (about 22,670 tons) and onions an additional 30% (about 13,000 tons). The remaining 19% is composed of pyrethrum, sunflower, sesame, groundnuts, coffee, and other cash crops.

Livestock production also forms an important component of the area's nutritional security; 14% of Kilolo farmers produce both crops and livestock (Kyando, 2007). As at 2015, Kilolo District has a total livestock population of 639,500 animals. Chicken account for about 76% of this total, with 94% of them being indigenous breeds. Cattle compose 12% of the population, with 97% of cattle being indigenous species, and the overwhelming majority being dairy cows. The remaining 12% of the livestock population includes goats, donkeys, pigs, and sheep.

Land tenure is an incentive in the adoption of CSA. This is because farmers with land ownership are able to make long-term investments in e.g. soil health, trees, and infrastructure in certainty that they will still have access to the land when these investments reap returns. Kilolo District has high tenure security rates due to family inheritance and land affordability. Almost 56% of inhabitants are recorded to own land they live on (Fin scope, 2017). Some financial institutions allow the use of land as collateral; this encourages land ownership among women, allowing their involvement in diverse economic activities. Almost 95% of the district's land area is arable; however, only 25% (about

4 *Vinyungu* is a traditional farming system mostly carried out in the valley bottoms (mainly along rivers). The practice favours a wide range of agricultural activities throughout the year due to availability of water. Ideally, Iringa region has one main rainy season, thus *vinyungu* is practiced by smallholder farmers during the dry season to sustain production. Over the years, *vinyungu* plots have expanded as farmers suggest higher soil productivity compared to upland areas.

167,000 ha) is fully utilized. Similarly, less than 14% of the land fit for grazing is under use. The district thus has significant untapped agricultural potential in terms of land coverage.

Agricultural inputs have substantially improved productivity in Kilolo District. There has been a constant increase in the use of chemical fertilizers as soil infertility becomes increasingly inherent. Nearly 16,783,200 kg of chemical fertilizer is used annually. Urea accounts for over 44% of this total. Fungicides and insecticides are also commonly used. Improved seed is regularly used for maize and sunflower production. A total of 7,352 ha of land is irrigable, but only 49% of this is currently under irrigation. Irrigable land area is likely to shift with climate change impacts. Common farming equipment in the district include; ox ploughs, tractors, and power tillers.

Kilolo District has one of the highest rates of extension services received in the Iringa Region (URT, 2007). This has greatly enhanced agricultural productivity in the district. Additionally, a number of organizations have headed crop-focused projects in Kilolo. For instance, both CARE International and Agronomos Sin Fronteras have promoted sunflower production, and the latter has also promoted improved poultry productivity.

Table 1: Livelihoods and agriculture in Kilolo District

Livelihoods and agriculture in Kilolo District

Demographics

0.39% of Tanzania's population

218,130 inhabitants

51.5% | 48.5%

94.6% Live in rural areas

Access to basic needs

29% of the population lives in **absolute poverty**

Potable water	68.5%
Electricity for cooking	0.3%
Electricity for lighting	7.9%
Education (Literacy level)	78.8%

Food security

ND of the population suffers from **food poverty**

ND of household income **spent on food**

ND people **undernourished**

ND children **stunted**

ND children **wasted**

ND: No data

Kilolo

Farming

District's farming area

644,282ha — 95.3%

82.3% of the population employed in agriculture production

ND of farmers have title deeds — ND are women

Farming activities

Food crop	99,006 ha
Cash crop	21,563 ha
Soil/land conservation	1,224 ha
Farm forest	58,761 ha
Organic farming	4,123 ha

Livestock

Cattle	75,930
Goats	42,117
Sheep	10,810
Donkey	2,917
Pigs	23,685
Indigenous chicken	453,998
Exotic chicken	30,029

Farming inputs

Fertiliser types (% of households)

12%	Organic manure
38%	Basal fertilizer
53%	Top dressing fertilizer

Pesticide types

69%	Field pesticides
41%	Storage pesticides
0.2%	Herbicides

Climate and agriculture context

Historic and future trends

Kilolo District has suffered the extremes of climate change. The type of climate hazards experienced in the district vary substantially across AEZs. Both drought and floods have led to crop failure, livestock deaths, and environmental degradation. Extreme temperatures have also caused losses due to both heat stress and cold stress.

Precipitation[5] and temperature are of the utmost importance to agricultural productivity. Data[6] trends from 1980–2015 (Figures 1 and 2) show increasing frequent and intense precipitation, and rising temperatures across time. The greatest difference in precipitation between the first and second season occurred in 2015. However, the years 2000 and 2010 were the least precipitation years for the first season, and 2005 experienced almost no precipitation. The maximum 5-day running precipitation, which depicts higher risks to flooding were in 2009 and 2015 during the first season. Average temperatures were lower in the first season compared to the second. The average temperatures increased by about 0.5°C across the data period, and periods of heat stress concomitantly increased. The lowest mean temperatures of slightly higher than 20.5°C were observed in 1993 and 1989 in the second and first season respectively. There was a mild increase in mean temperature of about 0.6°C and 0.4°C in the first and second season respectively, increasing exposure to heat stress, drought risks and reduced crop cycle.

CIAT[7] climatic projections reveal that the temperature and precipitation patterns in Kilolo District are likely to persist in the coming decades (2020–2065). Climate model projections[8] (Figure 3) indicate that these temperature and precipitation patterns are likely persist in the coming decades. Precipitation fluctuations may be particularly marked during the first season, and temperature extremes particularly marked in the second season. Given that climatic trends are already hindering the production of essential crops, these predicted trends pose a significant threat to economic and food security in Kilolo District.

Stakeholder perceptions on climate change

Farmers and experts[9] unanimously concur that there have been observable changes in climatic conditions over the past few years, particularly increasing variability and extremes in temperature and precipitation. These climatic changes have exacerbated the risk vulnerability of many smallholder farmers. For example, in Tanzania unusually early maturing and/or widespread loss of maize crops has been observed in major maize producing areas (Arce & Caballero, 2015). There has been increased presence of pests and diseases, forcing farmers to invest more of their time and money on fertilizers, pesticides, and insecticides to sustain their production. Lack of pasture and water has compromised livestock health, and forced herders to migrate in search of water and pasture. In some extreme cases, it has been observed that livestock alternatively feed on plastic bags due to lack of adequate livestock pasture

Consequently, water sources serving households in the area i.e. streams and flowing rivers are constantly drying up. This mostly affects people residing in the lowlands since they depend on water flowing from the uplands for irrigation and other activities. Similarly, D'haen & Nielsen (2017) observed that the livelihoods along the great Ruaha river catchment area are at risk since the rivers and streams are at the verge of drying up.

Farmers point out that the negative impacts of climate change on agricultural production and natural resources have also affected daily household life. Production decline reduces both household income and nutritional security. Persistent droughts are

5 The most frequent forms of precipitation are rainfall and snow but rainfall is typical in Kilolo DC. Data from 1980 to 2005 was retrieved from the Climate Hazards Infrared Precipitation with Stations (CHIRPS) http://chg.geog.ucsb.edu/data/chirps/

6 Data from 1980 to 2005 was retrieved from the Climate Hazards Infrared Precipitation with Stations (CHIRPS) http://chg.geog.ucsb.edu/data/chirps/

7 CIAT climatic projections are based on the Climate Change Agriculture and Food Security (CCAFS) project https://ccafs-climate.org

8 Climate models depict the potential impacts of worsening, constant, or reduced greenhouse gas emissions using Representative Concentration Pathways (RCP) (Flato et al. (2013). A Representative Concentration Pathway (RCP) is a theoretical concentration of greenhouse gas emissions for the purpose of climate modeling. Four RCPs have been widely accepted and used: 2.6, 4.5, 6, and 8.5, where increasing values represent an increase in greenhouse gas emissions. Results reported here are based on the averages of 12 climate models employing the four aforementioned RCPs.

9 Five experts (all male) from fisheries, livestock, and agricultural organizations were individually interviewed. Six farmer group discussions, each consisting of an average of 8 farmers from 6 value chains, were also conducted. See the appendix for additional details.

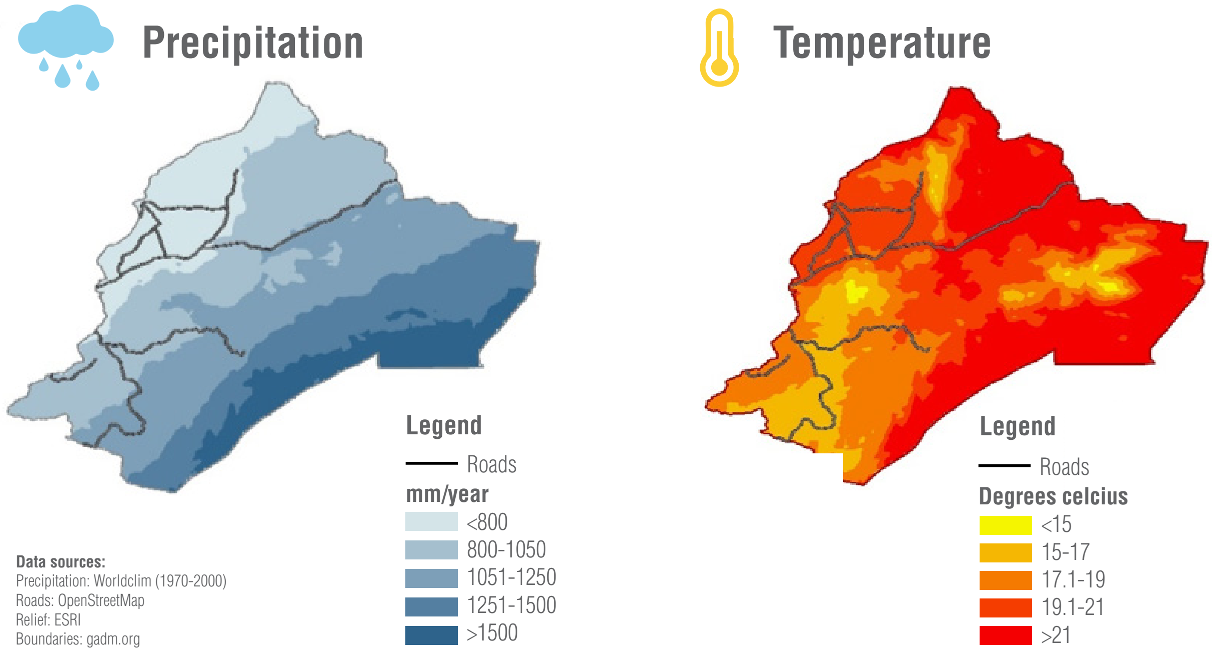

Figure 1: Average Precipitation and Temperature in Kilolo District, 1970-2000

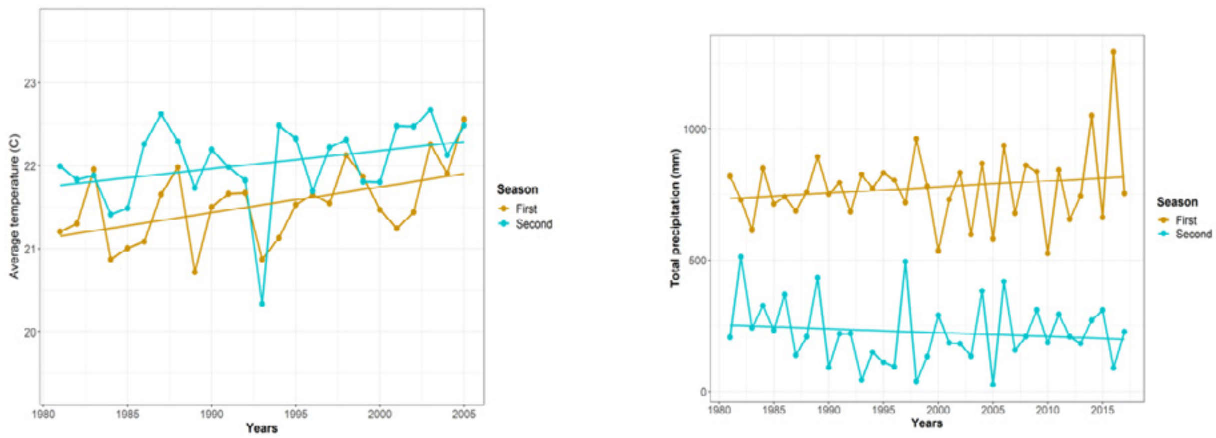

Figure 2: Annual average temperature and total precipitation for first and second seasons in Kilolo District

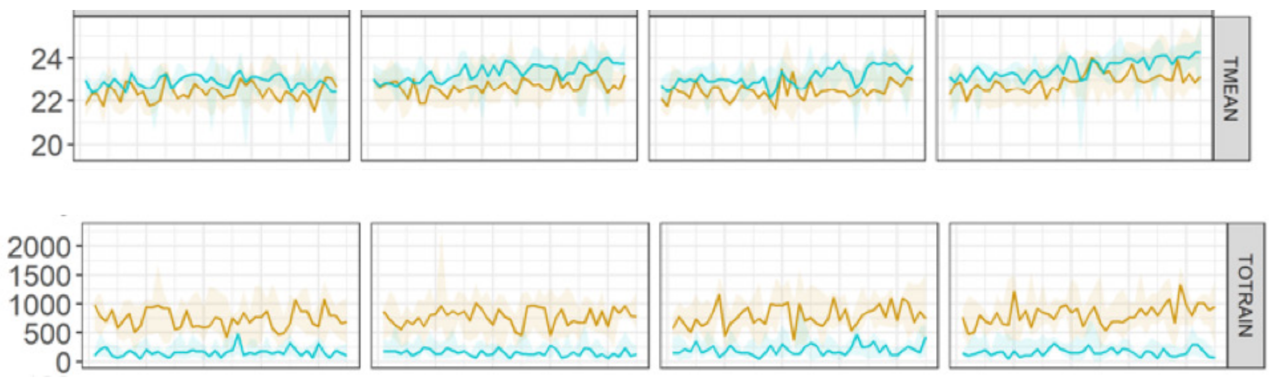

Figure 3: Future precipitation and temperature projections

drying up household water sources, and have forced families to travel long distances in search of water. The household composition and division of labor shifts drastically as well. In the wake of agricultural losses, family members, typically men, are forced to migrate to urban areas in search of work. Although women conduct most of the household and farm labor (even in the presence of men), the departure of household members nonetheless leaves women to grapple with the increasing challenges of rural smallholder life on their own. Meanwhile, decline in crop production leave the youth unemployed.

Some individuals from Kilolo District are hopeful that things will improve in the coming years. In general, however, experts and farmers remain concerned that this situation will worsen if appropriate measures are not put into place. Most farmers associate the observable climate change variations with extensive and uncontrolled deforestation, and they believe government reforestation and conservation initiatives would be the most effective solution. Already, local forest protection legislation has seen the reemergence of trees and increased water availability.

Agricultural value chains

For this profile, government, NGO, and the private sector stakeholders assisted in the identification of four value chains[10] to represent the spectrum of ecological, social, and economics challenges Kilolo District is experiencing as a result of climate change. These stakeholders considered; production area (ha), yield (kg), gross margins, women and youth engagement, future and present climate adaptability, percentage of population engaged, contribution toward poverty alleviation.

The maize, bean, soy, sunflower, potato, sweet potato, paddy, millet, tomatoes, cashew nuts, beef cattle, and poultry value chains were shortlisted for further consideration. Ultimately, bean, tomato, sunflower and poultry were selected for further analysis herein.

Bean

Beans are grown in Kilolo District as a source of food and income; 61-80% of the population is engaged in the bean value chain. Although its produced at all scales, most of the producers use it for home consumption and commercial purposes. Beans occupy 18% (10,780 ha) of the total land area under food crops in the district. Beans are leguminous in nature thus nitrogen-fixers (Manda, Alene, Gardebroek, Kassie, & Tembo, 2016), and as such are normally intercropped with maize to enhance soil fertility. In 2015, approximately 13,225 tons of beans was produced in Kilolo, making it second in terms of food crop production acreage in the area. Beans are among the major crops produced under irrigation in Ng'uruha, Image, and Udekwa Wards.

Local seed varieties and conventional production techniques are a characteristic of the Kilolo District bean production system. Seed suppliers operate at a small scale level. Value addition and processing operations are minimal, and the few that exist are small-scale enterprises. Thus, most of the beans are consumed in the unprocessed nature.

A majority of smallholders produce beans for their own consumption. Bean traders also operate on small scale, particularly given that most beans are purchased for household consumption. As such, the sale of beans in dependent on production surplus in excess of what the family needs. In most cases, this constitutes relatively small quantities. Women are primarily responsible for the manual labor involved in producing beans, including land preparation, planting, weeding, and harvesting. Men are responsible for land acquisition, purchase of inputs, and the transportation and sale of the product.

The current predominance of unimproved seed varieties represents the greatest opportunity for increasing bean productivity per hectare. Recycled local seed varieties tend to have low yields that only support subsistence production. Higher yields would enable farmers to more reliably have surplus for sale, and to have greater quantities of surplus, thus increasing income, augmenting supply, and enabling the growth of the bean value chain.

Tomato

Tomato is the leading cash crop in Kilolo District, and engages 41–60% of the population. From 2011 to 2015, an average of 22,672 tons/year were produced in the district, with a productivity of 20–25 tons per acre. Tomato is seen as a high-investment business venture with potential for economies of scale, and as such is generally produced in at least medium-scale systems. The Small Industries Development Organization (SIDO) has worked to better engage smallholders in tomato production.

10 An agricultural value chain includes all the of the activities and actors involved in bringing the agricultural product to the point of consumption, including inputs, production, trade, transport, marketing, and processing, among others (Kaplinsky & Morris, 2001).

In general, however, farmers with mid to high levels of income tend to dominate tomato production because of their greater ability to make up front input investments (Khasa & Msuya-Bengesi, 2016). As an extension of this, input markets tend to operate on large scale. Similarly, because producers generally harvest large quantities and tomatoes are highly perishable, processing also tends to be on a large scale. However, there are no tomato processing plants in Kilolo District, so perishability of produce is widespread. Given that tomato is a staple in local diets, its consumption is also relatively intense; however, most households do not produce sufficient quantities to meet daily consumption demands.

There is significant gender variation along the tomato value chain. Women provide labour for farm activities such as irrigation and harvesting while men have a major mantle in land acquisition, and farm activities such as application of pesticides. However, men and women are jointly engaged in pricing and selling tomatoes. These operations employ significant numbers of individuals at various levels, thus increasing household purchasing power and playing a key role in food and nutritional security through income.

The greatest opportunity to develop the tomato value chain in Kilolo District is to facilitate up-front capital investments. Finance mechanisms such are credit, collateral, warehouse receipts, and insurance designed for smallholders would lower the barrier for low-income farmers wishing to engage in tomato production. Currently, financial institutions uphold rigid requirements for loans that make them inaccessible to most smallholders. Similarly, institutional finance or governmental assistance could enable the establishment of local processing facilities that would, in turn, bring socioeconomic stability through local employment and the associated purchasing power. Alternatively, the establishment of farmer associations could enable the necessary training and economies of scale for local, low-tech tomato processing and sale.

Sunflower

Sunflower production is currently concentrated in the Midland Zone of Kilolo District, although there is also a high production potential in the Highland and Lowland Zones. Approximately 21–40% of the population is involved in sunflower production at small, medium and large scale. In the stakeholder context, small scale is defined as 0.2–2 ha plots, medium scale as 2–4 ha, and large scale as any plot size in excess of 4 ha. As at 2015, an average of 43,300 kg of improved sunflower seeds is supplied to farmers annually in Kilolo District.

An average of 1,948 tons of sunflower was produced in Kilolo District in the period 2011–2015. Inputs are sourced at a medium scale from Ilula town and the surrounding villages, and at larger scale from agro dealers in Iringa town.

Sunflower cooking oil is one of the most common value-added sunflower products. Sunflower oil processing is generally done on small scale in the Mazombe Division of Kilolo District, where 9 sunflower oil processing operations are stationed, each producing 1.5–2.8 tons of oil daily. The processors are the main target market for sunflower in the district, operating on small to medium -scale, and purchasing 50–500 tons. There are two prominent wholesalers in the district (Kepha Sanga and Aron Mgunda), who together purchase up to 2000 tons at a medium scale.

Sunflower plays a significant role in income generation, but its contribution to food security is minimal since it is primarily used for cooking. However, its role in nutrition security cannot be undermined since the oil has a high nutritional value. Women are heavily engaged in the sunflower value chain; they are primarily responsible for production, and consumption via food preparation. Men predominantly operate in packaging, processing, and linking with buyers. Jointly, men and women are involved in acquisition of inputs, land preparation, planting, and harvesting.

There is a great opportunity for developing the sunflower value chain through improving access to inputs e.g. village-based agro dealers. Agro dealers are often located at great distances from farmers, and road networks are generally poor. This is particularly challenging for smallholders. Production is capital intensive, creating a barrier for lower income households would encourage more engagement in production. There is also opportunity to improve the quality of sunflower oil products by optimizing the processing and drying technologies in use.

NGOs such as CARE International and the Clinton Development Initiative (CDI) have assisted farm households in accessing improved seeds and loans for sunflower productions. Additionally, CARE has been engaged in gender transformation initiatives in its pilots to ensure equality in terms of access to technology, inputs, and finances.

Local chicken

Poultry is a very important value chain in Kilolo District; local chicken is produced by 81-100% of the population. Compared to other livestock, poultry are easy to keep,

Table 2: Value chain characterization

% of people engaged in the value chain	Provision of seeds and other inputs	On - Farm production	Harvesting storage and processing	Product marketing
	Types of actors engaged in Value Chain			
Bean 61-80%	S (S)	F (L)	P (S)	M (S)
Importance of women and youth in the value chain	High (4)			
Key Activities	Land acqusition; Purchase of inorganic fertilizer; Purchase of seeds	Land preparation; Planting seeds; Weeding	Packaging; Storage; Transportation	Market promotion; Linkage to buyers; Selling
Tomato 41-60%	S (L)	F (M)	P (L)	M (L)
Importance of women and youth in the value chain	Medium (3)			
Key Activities	Land acqusition; Preparation of farm equipment; Purchase of farm inputs (seeds, fertilizer and pesticides)	Land preparation; Weeding; Spraying	Collection and packaging; Transportation; Processing	Linking to buyers; Pricing; Selling
Sunflower 21-40%	S (M, L)	F (S, M, L)	P (S)	M (S, M)
Importance of women and youth in the value chain	High (4)			
Key Activities	Financial capital; Hiring land; Purchase of farm inputs (seeds, fertilizer and pesticides)	Land preparation; Planting; Harvesting	Drying; Packaging; Processing	Pricing; Linking to buyers; Product promotion
Local chicken 81-100%	S (S, M)	F (S, M)	P (S, M)	M (S, M)
Importance of women and youth in the value chain	High (4)			
Key Activities	Purchase of chicken; Purchase of feeds; Purchase of drugs and vaccines	Build poultry house; Routine vaccination; Daily management	Transportation; Selling; Slaughtering	Linking to buyers; Selling; Product promotion

Conventions

Types of actors: S Service providers F Farmers P Processors M Marketing

S Small-scale M Medium-scale L Large-scale ND = No data

Importance of women and youth in the value chain: 1 2 3 4 5

1 = very low
2 = low
3 = medium
4 = high
5 = very high
0 = non existant
N/D = no data

require little start-up capital, and are in demand; as such, production contributes heavily to food security and income generation. As with the human population, about 51% of the chicken population in Kilolo District is concentrated in Kilolo Division. The bulk of poultry production is done at small scale and medium scale, mostly by women. Productivity is however relatively low. Input suppliers also operate a small scale, with only a few at medium scale. Slaughtering, processing and sale of chicken is primarily done at small scale within the home, the few medium-scale processors sell to hotels and restaurants.

The local chicken value chain engages both men and women. The purchase of inputs, daily management, and sales are a joint effort of men and women. Enclosure construction and slaughtering are primarily the responsibility of men.

The fact that value addition for poultry in the district is almost non- existent is an indication that it could be an entry point to improve value chain. This creates an opportunity for generating more income from poultry by products for the farmers. Improved accessibility of veterinary services and inputs is also an opportunity that can be explored to improve productivity in the value chain through disease control and management. Despite the fact that chicken production requires little start-up cost, the maintenance inputs, including feed, vaccinations, and medications, can be a major constraint for many farmers. These costs tend to increase during disease outbreaks. Additionally, many producers are unaware of best poultry management practices, and continue to rely to traditional techniques. All of these factors result in low productivity.

Challenges in agriculture

Foremost, among the challenges confronting agricultural production in Kilolo is climate change. As previously discussed, climate change impacts have increased production costs and reduced output, creating a vicious cycle of reduced income, lowered ability to invest in production systems, decreasing outputs, and growing food scarcity among vulnerable households. The most vulnerable households, such as those with low literacy rates, are disproportionately affected because of their lower capacity to e.g. access climate-related information and financial services. Several development partners have offered CSA trainings on inputs and best practices. However, adoption of recommended CSA strategies (FAO, 2017) among Kilolo District farmers remains low. This is primarily due to financial hardship.

Training increases farmers' knowledge, but it does not provide them the capital needed to make a change in their practices. Most farmers still find it difficult to select the correct farming inputs, seeds and planting season that well adapts to the changing environmental conditions. Indeed, as climate change impacts become greater, the costs required to simply maintain the status quo increases. For example, pest and disease outbreaks increase the demand for pesticides, and the prices raise concomitantly. Vulnerable households are the first to be priced out of the input markets, thus perpetuating a cycle of poverty. In some cases, farmers have attempted to adapt with the limited resources available in ways that could have long-term negative consequences. For instance, while CSA generally recommends diversification as a mechanism for distributing risk, farmers may move away from diversification to focus all of their resources on a single product in an attempt to improve productivity and earnings. In the case of a drought, floods, pests, or diseases that cripples this production system, the household experiences extreme food and economic insecurity.

Kilolo District local experts underscore the importance of financial mechanisms to support CSA risk management initiatives in the district. To date, the government and development partners have been the chief financiers of such initiatives. However, financial instability in recent years has limited their scope of work. Long-term solutions such as finance services tailored to smallholders hold great promise, but to date have not been implemented. Kilolo District ranked fourth in Iringa region in terms of financial uptake (Finscope, 2017). Mobile money has gained significant traction in Kilolo District; 70% of the population uses a mobile money service. This has become the leading source of financing—although an informal one. Public-private partnerships could capitalize on the existing mobile technology platforms to enhance financial inclusion in Kilolo District.

Access to timely, relevant, practical information continues to be a challenge for Kilolo producers. While farmers do receive climate information, it is not consistently delivered via an accessible mechanism. Normally, information is delivered too late to allow an appropriate response, or is not accompanied by a recommended course of action. The Tanzanian Meteorological Agency (TMA) is currently the authoritative source on climate data, and has been supported by partners such as FAO to access field-level weather data. Farmers, however, find that the information provided is overly generic in terms of geographic area and sector. Local, agriculture-specific information with details on pests and other risks, as well as recommendations as to how to apply the information, is in high demand.

Middlemen currently dominate the marketing system in Kilolo District. This substantially reduces the profit margin for producers, thus inhibiting their ability to invest in the next production cycle, and in climate adaptation strategies. As product quality decreases, identifying interested buyers at profitable prices becomes increasingly difficult. Poor infrastructure further deters farmers from transporting their produce to potential markets. The Highlands are particularly affected by infrastructure issues as roads become impassable in the rainy season, thus restricting farmers to their local markets where produce fetches relatively low prices. Farmer organizations can help ameliorate these issues by increasing bargaining power and minimizing postharvest losses.

Climate change affects women farmers in notably different ways compared to their male counterparts. When crops are lost, men tend to migrate to urban areas in search of work. In contrast, social norms require women to stay on the farm with the children. This obliges women to grapple with the ongoing impacts of climate change alone. As a growing number of inputs are required to compensate for climate impacts, women's farm labor intensifies. In addition, they take on the work traditionally conducted by men, and often adopt side businesses to make ends meet. This cycle increases women farmer's vulnerability and decreases their adaptive capability in the face of risks (Alston , 2014). Importantly, it also means that women are at the forefront of making daily decisions in terms of natural resource and agricultural management in the face of climate change (Sikira & Kashaigili, 2016). Similarly, as climate change cripples productivity, youth unemployment rises.

Climate vulnerabilities across agricultural commodity value chains

From interviews with agricultural experts and farmers, climate change has associated risks that endanger the livelihoods of farming households .The impacts of climate change on producers has a ripple effect across the entire value chain, variedly affecting input dealers, processors, traders, and consumers (Dazé & Dekens (2016). Value chain actors have had to improvise methods of coping with the climatic risks.

Though each value chain identified the climatic risks[11] (Table 3) at different stages, there is observed uniformity across the four value chains. However, clear patterns of supplementary risks that are a result of climatic risks are highlighted across the value chains;

- **Inputs:** Increased demand for improved seed varieties and large quantities of chemical inputs increases prices; farmers begin to be priced out of the market and use lower quality, or insufficient inputs to optimize productivity. Supply exceeds demand and input suppliers experience inconsistent sales.
- **Production:** Time, financial, and energy costs of production increase, yields decrease. Resources are channeled from other productive activities in an attempt to maintain productivity. Yield quality and quantity are compromised.
- **Consumption:** Poor yields translate to inconsistent food supplies, thus threatening nutritional security. High demand and low supply drives up prices and makes produce inaccessible to most vulnerable households.
- **Finance:** Increase production prices and declining yields result in reduced farmer income and purchasing power. This decreases farmers' ability to access the finance services needed to invest in the next production cycle or CSA adaptation strategies. Economically strained households neglect longer terms investments such as education in order to meet basic daily needs.
- **Price and market:** Lower quality products—or even questions about product quality—lowers market rates and reduces profitability. With fewer willing buyers, farmers incur additional time, energy, and financial costs seeking out market options.

Crosscutting issues

Agricultural production in Kilolo District is highly dependent on rainfall. This puts the district at a production risk due to the climatic variations like to prolonged drought, which cause water scarcity. Nonetheless, there is still potential for land that can be expanded for irrigation since currently, only 49%

11 Following (Barlow et al., 2015), Risk is the likelihood of the unfavourable effects impacting farmers when exposed climatic variabilities such as floods, drought and frost.

of the land is actively under irrigation. Fluctuating temperatures have increased crop and livestock susceptibility to pests and diseases. As a result, the demand for pesticides, insecticides and fungicides continue to rise leading to escalated prices, which translate to high production cost.

Kilolo district having been characterized by small holder farmers is disadvantaged by the agricultural production methods in use. Most of the farmers still employ traditional farming methods, and inferior production tools such as ploughs and hand hoes. These practices are labour intensive, and in most instances do not guarantee maximum output. The annual supply (17,303) of farm implements that is meant to increase farm efficiency has failed to keep pace with the growing demand (19,202). Despite the fact that the use of chemical fertilizer has steadily increased by 48% between 2011 and 2015, accessibility and affordability of fertilizer among other inputs is still a concern. The use of improved seed varieties is limited to selected crops such as maize, sunflower, paddy and sorghum. For most crops, farmers use local seed varieties which are intolerant to adverse climatic conditions like frost, moisture stress and high temperatures.

When climate risks are at their peak, farmers apply varied coping strategies based on their economic capability. For instance, farmers in areas prone to frost and dry spell tend to use more of organic manure[12], eliminating the use of fertilizer. Specifically, farmers in areas that experience dry spell tend to shift cultivation to wetlands mostly river basins in order to maximize production. These strategies have failed to cushion farmers against the risks, and instead exposed them more to other effects of climate change. However, some improvised strategies have been of great importance to farmers, for example use of local methods like pyrethrum to prevents pests, and mulching and crop residue retention to maintain soil moisture.

12 From the stakeholder workshop, climatic risks such as drought and frost translate to an increase in the use of fertilizer to boost soil fertility. In most cases, the demand increases so do the prices. It is therefore very expensive for farmers to afford prompting the use of locally available and affordable inputs such as manure.

Table 3: Primary climatic issues and constraints across each stage of the four highlighted value chains

	Bean	Tomato	Sunflower	Local chicken
Primary Climactic Threats	• Frost • Drought	• Moisture stress • Extreme temperatures	• High temperatures • Moisture stress	• Low temperatures • Heat Stress
Key Inputs	• Land • Fertilizer • Seeds	• Land • Farm equipment • Seeds • Fertilizer • Pesticides	• Land • Fertilizer • Seeds • Pesticides • Credit	• Feed • Medication • Vaccines
Key Input Constraints	• Land acquisition challenges • High input costs	• High cost of inputs • Lack of decision support for input selection	• Land acquisition challenges • High input costs	• High input costs
Key Production Constraints	• Increasing costs of land preparation due to degradation • Increasing weed frequency	• Increasing operation costs • More frequent pests • Decreasing product quality • Increasing weeds • High upfront costs	• Increasing labor and land preparation costs to counteract climate impacts • Poor seed quality • Decreasing quality and yield of harvest	• Increasing scarcity of housing material • Increasing incidence of disease • Increasing cost of medical care
Key Post-harvest Constraints	• Postharvest loss • Lack of proper storage mechanisms • Difficulty in transportation	• Postharvest loss • Excessive processing time • Low processing output	• High processing costs • Lack of packaging material	• Lack of processing facilities
Key Market Constraints	• Poor infrastructure • Artificially low prices	• Artificially low prices • Decreasing number of buyers	• Artificially low prices • Difficulty in product promotion • Poor linkages to buyers • Heavy reliance on middle men	• Difficulty in product promotion • Price fluctuation • Unreliable supply
Key Structural and Social Constraints	• Lack of finance services • Low access to inputs • Poor infrastructure • Lack of knowledge services	• Lack of finance services • Poor infrastructure • Restrictive cultural norms • Land acquisition difficulty	• Lack of finance services • Low access to inputs • Lack of knowledge services • Poor infrastructure • Poor technology	• Lack of financial services • Low access to inputs • Poor infrastructure • Restrictive cultural norms

Adaptation Strategies

Potential CSA strategies

A number of strategies have been identified in the CSA guideline[13] (FAO, 2017) that could be applied at the farm level to increase the climate resiliency of agriculture in Kilolo District. These include:

- **Rain water harvesting**
- **Irrigation:** Use of irrigation systems e.g. drip/trickle irrigation
- **Soil and water conservation:** Use of methods such as terraces and ridges to prevent soil erosion
- **Agroforestry:** Strategically planting trees to support crop and livestock production, and as supplemental food and income sources
- **Conservation Agriculture:** Including the use of cover crops, crop residue management, intercropping, and minimum tillage
- **Good Agronomic Practices:** Including proper spacing, timely management, and pest and disease control
- **Integrated soil fertility management:** Targeted use of synthetic fertilizers along with manure
- **Improved crop varieties**
- **Crop insurance**
- **Improved livestock breeds**
- **Climate Information services**

Most farmers in Kilolo District are already employing some of the aforementioned technologies and practices. Some of the most popular include:

- **Integrated soil fertility management:** The use of chemical fertilizer has steadily increased in the district. Farmers use organic manure on crops such as beans and sunflower to enhance soil fertility, particularly when fertilizer prices become unaffordable. However, farmers have reported negligible impacts of using manure alone.
- **Irrigation:** The most common forms of irrigation are drip and bucket irrigation. Farmers in drought-prone areas also tend to shift cultivation to wetlands and river basins during the dry seasons. There is significant untapped irrigation potential in Kilolo District.
- **Conservation agriculture:** Mulching, particularly with crop residues to retain moisture, and crop rotation and intercropping to support soil fertility.
- **Good Agronomic Practices:** Including proper spacing and timely management. Farmers have found pyrethrum effective for pest control but report negligible impacts from neem and ash as pest control mechanisms.
- **Improved crop varieties:** Drought-tolerant sunflower is widely available, as well as improved maize, paddy, and sorghum. Only local seed varieties without tolerance for adverse conditions are available for tomato, bean, and most other crops.
- **Improved livestock breeds:** Local chicken varieties are well adapted to the climate
- **Climate information services:** Forecasts from TMA guide farmers on production seasons. CARE International also facilitates seasonal climate forecast through Participatory Climate Scenario Planning (PSP)[14], which includes local context analysis, stakeholder analysis, and local initiatives introduction.

Despite employing these strategies, farmers still encounter low yields and losses. This may be due in part to other suboptimal practices that are still in use. For example, farmers tend to increase fertilizer use in the wake of extreme climate events such as frost or drought. This not only drives up fertilizer prices and drains supply, but also fails to address the heart of the issue. Additionally, most of the farmers still rely on manual labor with ploughs and hoes. These practices are labor intensive and constrain potential output. Efforts have been made to make more efficient farm implements available, but the supply has failed to, meet the demand

13 The CSA Guideline engaged agricultural, environmental, and climate experts from private, public, and civil society sectors, and is designed extension officers and district development planners.

14 The PSP process is implemented in three stages. First the local context analysis is conducted to understand the local climate and vulnerable groups and resources. To support multi stakeholder integration, a stakeholder analysis is then conducted. Finally, the PSP is introduced to the local area to convince the locals on the initiatives that can be undertaken.

Table 4: Adaptive strategies for coping with climate variabilities across the highlighted value chains in Kilolo District

Bean	Input acquisition	On-farm production	Harvesting, storage and processing	Product marketing
Frost	• Value of land is low due to low productivity • Increase in use of fertilizer for stunted plants • High cost of purchasing improved seed varieties	• Increase in cost of preparing land • Delay of seed germination • Regeneration of weeds thus high cost of weeding • Difficulty in drying plants	• Rotting of produce due to high moisture • Difficult to store undried produce • Transportation is difficult due to weight from wetness	• Reduced selling price due to high moisture content • Market promotion difficult due to poor infrastructure • Linking farmers to buyers is difficult
Magnitude	Minor	Minor to Moderate	Minor	Minor to Moderate
Current coping strategies	• Delay for frost period to pass • Use of organic manure to minimize investment costs • Use of local seeds to minimize investment costs	• Increased weeding • Shallow depth seed planting	• Frequent sun drying before storage and transportation	• Promote marketing within locality.
Other potential strategies to increase resilience	• Delay technique for frost period to pass • Use of organic manure • Use of improved seed varieties • Consult weather forecasting	• Mechanical weeding • Shallow depth seed planting	• Solar dryers	• Establishment of agricultural and marketing cooperative society (AMCOS) for easier selling
Drought	• Delay in input acquisition • High cost of improved seed varieties	• Difficult to till land • Delay in seed germination • Difficulty in weeding • Reduced yield	• Poor quality of produce • High incidences of pests due to hot weather • High storage costs	• Low selling price due to low quality of produce • Difficult to get buyers due to poor quality produce
Magnitude	Moderate	Minor to Moderate	Moderate	Moderate to Severe
Current coping strategies	• Delay in input acquisition • Cultivation in wetlands • Use of organic manure to minimize investment costs • Use of local seeds to minimize investment costs	• Use of plough • Use of bucket irrigation • Use of hand hoes • Delayed planting	• Early harvesting • Local methods for pesticide control e.g. pyrethrum	• Use local markets • Hold products until prices increase
Other potential strategies to increase resilience	• Use of irrigation systems e.g. drip irrigation • Use of organic manure and crop residue retention • Use of drought tolerant bean seed varieties	• Use of drip and gravity irrigation • Mechanized weeding	• Early harvesting • Use of picks in tanks to control pesticides	• Establishment of AMCOs for easier selling

Tomato	Input acquisition	On-farm production	Harvesting, storage and processing	Product marketing
Moisture stress	• Increased costs of inputs • Lack of decision support for input selection • Need for expensive equipment	• Ploughing becomes more difficult thus high operation costs • Susceptibility to insects, pests and diseases • Wilting due to evapotranspiration	• High loss due to rotting • Low yield • Reduction in viable processing time • Inadequate supply for large scale processing	• Low price due to poor quality produce • Decrease in number of buyers • Inadequate supply to meet demand
Magnitude	Moderate to Severe	Severe	Moderate	Severe
Current coping strategies	• Reduce production area • Mulching • Use of improved crates • Village saving and lending membership	• Mulching and crop rotation • Joint transportation	• Contacting extension workers • Contact Village Based Agro-dealers • Integrated Pest Management • Use small scale machinery	• Join AMCOs
Other potential strategies to increase resilience	• Improve land tenure system • Use of improved seed varieties • Build farmers capacity in grading	• Link farmers to farm equipment companies • Drip irrigation • Facilitate collection centers • Develop local IPM recommendations	• Build capacity in quality control and grading • Cooperative contracts with processors	• Facilitate the use of market collection centers • Join AMCOs
Extreme high and low Temperatures	• High cost of migrating in search of viable production area • Lack of decision support for inputs and equipment • Increased costs of inputs	• Increased operation costs due to additional land management • Increase in incidences of insects, pests and diseases	• High wastage due to rotting • Low quality of output • Decrease in yield	• Low prices due to poor quality of produce • Insufficient supply to allow for bulk sale and processing • Decrease in number of buyers
Magnitude	Moderate	Moderate to Severe	Severe	Severe
Current coping strategies	• Reduce production area • Mulching • Use improved crates • Join VSLAs	• Decrease in spraying intervals to allow for evapotranspiration • Mulching and crop rotation • Contact extension agents • Irrigation	• Integrated Pest Management • Collection centers • Form groups for joint transportation • Use of small scale machinery • Contact Village Based Agro-dealers	• Join AMCOs • Grade produce
Other potential strategies to increase resilience	• Improve land tenure system • Develop Integrated Pest Management recommendations	• Establish equipment hiring centers • Use of drip irrigation • Use resistant variety with big canopy • Link farmers with financial institutions for loans • Use of green houses	• Contracts with processors • Introduce cold rooms • Build capacity in quality control	• Form farmer associations • Use common market centers

Sunflower	Input acquisition	On-farm production	Harvesting, storage and processing	Product marketing
High temperatures	• High capital required to purchase agricultural inputs • High cost of renting land with nearby water source	• Low rate of seed germination • Risks of declining quality and quantity of yield	• Poor quality of produce due to over drying or fungi • Special packaging materials are costly • Technical malfunctioning of machines which affect quality	• Low prices due to poor quality • Difficult to link farmers to buyers
Magnitude	Moderate to Severe	Moderate	Moderate	Moderate
Current coping strategies	• Formation of AMCOs to access inputs • On farm seed production by hub farmers to reduce input cost • Use of farmyard manure to reduce input cost • Acquiring seed loans • Proper seed selection and use of drought tolerant varieties	• Preparation of land when its wet • Proper agronomic practices e.g. spacing • Timely planting and harvesting • Crop rotation, crop residue mulching, intercropping	• Adequate sun drying • Use sacks or traditional stores to avoid fungi • Use of local processing methods	• Store produce until prices are high • Use brokers to promote products • Selling directly to processors
Other potential strategies to increase resilience	• Link farmer groups with financial institutions	• Conservation agriculture • Use of soil moisture sensor • Application of weather information • Crop intensification	• Solar dryers • Use of Purdue Improved Crop Storage (PICS) bags • Improved storage structures • Providing farmer groups with processing and refining machinery	• Use of Warehouse Receipt Systems • Use mass media and stickers/ labels for promotion • Contract farming • Strengthen existing farmer associations
Moisture stress	• Increased cost of agricultural inputs • High financial capital required for labor and irrigation	• High cost of land preparation • Low germination rate	• Reduced quality of yield • Costlier packaging materials required • High processing costs • Machinery malfunctions which further reduce quality	• Low prices due to poor quality • Difficulty in getting buyers
Magnitude	Moderate to Severe	Moderate	Moderate	Moderate
Current coping strategies	• Formation of groups to access financial capital/seed loans • CA – Crop rotation and residue retention • On farm seed production • Use of farmyard manure	• Land preparation when soil is wet • Timely planting and harvesting • Use of drought tolerant varieties • On farm seed selection	• Proper sun drying • Use of sacks and traditional storage to prevent fungi • Use local processing methods	• Store produce until prices hike • Use brokers as promoters • Selling directly to processors
Other potential strategies to increase resilience	• Link farmer groups to financial institutions • Sensitize farmers to form associations • Adopt CA – Crop rotation and residue retention • Strengthening bulk procurement from farmer associations	• Adopt CA - Crop rotation and residue retention • Introduction of planting machinery • Proper agronomic practices • Use hybrid seeds that are drought tolerant • Use of weather information • Use of moisture meter	• Introduction of drying machines and sheets • Facilitate farmers' access to improved storage • Sensitize farmers on the use of PICS bags • Provide farmer groups with processing and refinery machinery	• Use of warehouse receipt systems • Promotion through mass media, labelling/stickers • Formation of farmer processor associations • Strengthen existing farmer associations • Contract farming • Linking farmers to processors

Local Chicken	Input acquisition	On-farm production	Harvesting, storage and processing	Product marketing
Extreme low temperatures	• Loss of chicks • Increased expense for feed, supplements, and medications • As crop expenses also increase, crops may be prioritized over poultry for limited resources	• Increased vaccine cost due to high incidences of diseases • Intensive management of chicken is required • Susceptibility to respiratory diseases • Structure to protect from cold expensive to build	• Low body weight • Decreased egg production	• Difficult to link farmers to buyers
Magnitude	Moderate to Severe	Moderate to Severe	Minor to Moderate	Severe
Current coping strategies	• Reduce number of chicks purchased • Use local feeds to reduce costs • Use of traditional medicine e.g. aloe vera to reduce costs	• Keep chicken in the house for warmth	• Collect chicken in areas where there is high supply	• Farmers shift to selling crops • Sell only chicken products e.g. eggs and manure • Sell in local markets
Other potential strategies to increase resilience	• Establish local brooding pens • Mobilize farmers in groups to buy feeds and share knowledge on management skills • Train farmers to produce nutritious feed on-farm	• Mobilize farmers in groups to share construction costs • Supplementary feeds and vaccines	• Educate farmers on multiple sources of income • Encourage farmers to sell chicken even during harvesting period especially through auctions	• Linking farmers to markets to ensure consistent supply of chicken • Sensitize farmers to sell chicken during harvesting period • NGOs and local government to support promotion of chicken
Heat stress	• Chick mortality • Increased costs of drugs for disease prevention	• High cost of constructing chicken houses that allow for ventilation • Increased water demand • Decreased appetite	• Susceptibility to death during transportation	• High supply in effort to make sale before poultry succumb to heat stress • Oversupply of chicken causes prices to fall
Magnitude	Moderate to Severe	Moderate to Severe	Moderate to Severe	Severe
Current coping strategies	• Farmers maintain small stock • Use of traditional herbs e.g. neem to decrease costs	• Free range system • Early slaughtering of chicken when detect symptoms of diseases	• Transporting chicken from nearby places in small quantities • Provision of water frequently during transportation • Home slaughter for local sale	• Sell chicken directly to urban dwellers within seasonal market
Other potential strategies to increase resilience	• Train farmers on importance of vaccines • Form groups to share costs of purchasing feeds and drugs	• Train farmers in semi-intensive system of production • Farmers to form groups to share costs of construction	• Use special vans for ventilation	• Link farmers to buyers at a reasonable prices to increase profitability

Policies for climate change

The threat of climate change on people's livelihoods is likely to increase if appropriate adaptation and mitigation measures are not put into place. In response to this, the United Republic of Tanzania (URT), in coordination with development partners, has established policies, programs, strategies, action plans, and guidelines to address the challenges of climate change with a focus on youth and gender inclusion, environment, and agriculture.

The Environment Management Act (EMA 2004) and National Adaptation Programme of Action (NAPA 2007) have attempted to manage aspects of climate change in the country at large. Particularly, the National Climate Change Strategy (NCCS 2012) was formulated to tackle climate change via greenhouse gas emission reduction through investments in the energy sector. The strategy operates under the United Nations Framework Convention on Climate Change (UNFCCC), an umbrella for all countries with a high vulnerability.

The agricultural sector is broadly covered by the National Agricultural Policy (NAP 2013) and the Agricultural Sector Development Strategy (ASDS 2016). NAP focuses on the role of agriculture in the Tanzanian economy, while the ASDS establishes a structure for achieving targets within the sector. Together, these two policies aim to improve agricultural productivity and growth through sectoral transformation.

The CSA guideline (FAO, 2017) was designed to transform Tanzanian agriculture into a climate smart sector by the year 2030. The guideline seeks to inform policy makers, guide stakeholders, create awareness, underscore the risks associated with climate change, and offer a framework for monitoring the implementation of CSA practices. The document offers specific CSA practices and technologies in the context of gender sensitivity, community involvement, multi-stakeholder participation approaches, and institutional linkages and support.

There are also policies that indirectly address climate change by tackling issues related to land and other natural resources that are at a high risk of climate impacts. The 1997 Land Policy and the Tanzanian Agriculture Climate Resilience Plan (ACRP 2015-2019) focus on agricultural land, while the National Water Policy (NWP 2002) and the National Forest Policy (NFP 1998) address water and forests as natural resources.

Gender-sensitive policies acknowledging the unique impacts of climate change on women are crucial for addressing gender discrimination in access to services (Sikira & Kashaigili, 2016). Gender integration in Tanzanian national policies stands at 59%; in terms of implementation, however, much remains to be accomplished (Ampaire et al., 2019). National policies such as EMA 2014, NAP 2013, NAPA 2007, and NCCS 2012 explicitly address gender differences in terms of climate change, but stop short of addressing the underlying causes of these discriminatory practices. This is to some extent acknowledged by the Gender Policy (2000), which aims to ensure that 90% of able-bodied women take part in agriculture and related activities.

Inadequate implementation and enforcement is a recurring policy challenge. Stakeholder coordination hinders progress at various administrative levels. Even small village committees are challenged by bureaucracy. Proper coordination mechanisms and effective planning would help ensure policy effectiveness at all levels.

Governance, institution resources and capacity

Kilolo's agricultural sector is supported by a number of public and private sector organizations. Farmers and field experts generally rate NGO programs and initiatives more highly than those of the government. The government is primarily represented by the Ministry of Agriculture (MoA) and the Ministry of Livestock and Fisheries (MoLF), whichoversee issues related to crop and livestock production. In coordination with Tanzania Agricultural Research Institute (TARI), the government ministries conduct research on improved crop and livestock varieties and disseminate knowledge on good agricultural practices. The Ministry of Natural Resource and Tourism (MNRT) offers support on management and protection of environmental resources that facilitate agricultural production. Similarly, the Ministry of Water and Irrigation (MWI) ensures the sustainable management and supply of water resources. The TMA plays a major role in providing weather information.

There has been marked governmental decentralization in terms of climate change adaptation in Kilolo. The Division of Environment (DoE) under the Vice President's Office was mandated to coordinate environmental issues, including climate change adaptation and mitigation. This effectively gave the district government the jurisdiction to implement national policies at a local, practical level. Since 2007, the district government operates as three departments[15]: The Natural Resources Department deals with climate change and land issues, the Community Development Department facilitates community engagement in development initiatives, and the Planning Department ensures its operations.

This decentralization has given Kilolo District the capacity to manage climate change issues through government-supported programs in partnership with development partners and NGOs. For instance, the Kihansi Catchment Conservation and Management Project (KCCMP) and Ilula Orphans program (IOP) have played significant roles in public awareness through stakeholder training and demonstration plots. For example, the Food and Agriculture Organization of the United Nations, the United States Agency for International Development (USAID) - WARIDI project, and the University of Greenwich Commonwealth Sponsorship have all offered trainings on climate risk management. The WARIDI project has also worked closely with the TMA to relay weather forecasting to farmers through participatory scenario planning. CARE International also provides seasonal climate forecast through participatory scenario planning, wherein households explore potential climate changes and consider optimal responses.

Campaigns on environmental conservation and management are also widespread and well-supported. Training on environmental conservation has been implemented by the Union of Livestock Keepers in Ruaha, as well as the Tanzania National Park Authority (TANAPA). The Wild Wide Fund (WWF) for Nature address both environmental and wildlife conservation. The Rufiji Basin Water Office (RBWO) independently manages water use. The office trains community members on water management and issues permits to control water use. Community Owned Water Supply Organizations (COWSO), Emmanuel International, and the Rural Development Organization (RDO) also play important roles in capacity building as well as building and repairing infrastructure such as dams.

The four value chains highlighted in this review have also received support in terms of CSA strategies. SIDO has supported tomato farmers in acquiring small scale machinery for value addition. CARE international and the CDI have supplied improved sunflower seed, and hub farmer seed production and seed loan programs have supported dissemination of these improved seeds. CARE international, CIAT (now part of the Alliance of Bioversity International and CIAT), Sokoine University of Agriculture, and Wageningen University & Research have implemented joint research and development programs in Kilolo District, including the CSA/SuPER Project, under which this document has been produced.

Despite the presence of these diverse organizations supporting climatic risk reduction initiatives, poor coordination between them has slowed progress toward their shared goals. Formalized communication, information transparency, and political will could significantly improve coordinative efforts (Dazé & Dekens, 2016).

Financial access is also a major determinant in CSA strategy implementation. Smallholder farmers have dedicated a huge percentage of their limited assets to addressing the impacts of climate change. The Ministry of Finance (MoF) is responsible for financing development initiatives, but budgeting for such efforts has been unreliable for the past several years. Partners such as the Japan International Cooperation Agency (JICA) have supported the government in financing CSA. Still, limited financing remains an impediment, and additional budget allocations are needed to implement the recommended strategies.

Synthesis and outlook

Climate trends indicate increasing frequent and extreme temperatures, precipitation, and drought events will impact Kilolo District. Farmers are faced with myriad challenges and high risk exposure, and productivity is in decline, trapping smallholders in a cycle of poverty. Here we have showcased how these changes will impact four priority value chains in the district: bean, tomato, sunflower and poultry.

Effective strategies must be put in place to foster agricultural resiliency in the face of climate change. There is significant untapped potential for jointly increasing productivity as well as the resiliency of Kilolo farmers to climate change. Financial services tailored to smallholders, agricultural weather services, robust extension services, improved seed, accessible

15 The district government operates under the local government and reform programme commonly referred to as PMO-RALG. It consists of three departments; The district planning department overally ensures the district government is fully operational, the natural resource department deals with climate change and land issues, while the community development department facilitates community participation in developmental initiatives.

inputs, irrigation and postharvest infrastructure, and healthy market linkages are just a few examples of the opportunities at hand.

Women in particular play a crucial role in Kilolo agricultural production, and their importance in CSA initiatives cannot be overstated. Nevertheless, culture and social norms preclude women from the majority of agricultural decision-making. Consequently, gender inclusion must be approached with great sensitivity. Gaining equal access to rights and services, such as land tenure, finance services, and extension services, would be a crucial first step toward gender inclusivity.

The national government, in collaboration with development partners, has set forth policies to address climate change. Some of these policies acknowledge the key gender issues that have hampered implementation of the best CSA practices. Nevertheless, implementation is inconsistent, and there is poor coordination and information sharing between actors, and so many issues persist. Governmental decentralization has given Kilolo District has remarkable institutional capacity to implement CSA. However, additional funding is needed in order to fully implement the recommended CSA initiatives at the household level in Kilolo District.

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Annex 1

Table 5: Knowledge and Use of CSA Practices

Percentage of farmers from Ilula, Bomalango'mbe, Ngu'ruhe and Ruahambuyuni Wards of Kilolo District who aware of, have used, and used the CSA practices.

Knowledge about, and use of CSA practices (% of farmers)			
CSA practice	Aware of practice	Have used practice before	Used practice in the last season
Mulching	18	10	6
Terraces	17	16	15
Water Harvesting	19	13	9
Irrigation	47	43	41
Conservation Farming	26	18	12
Organic Manure	42	29	19
Cover Crops	8	6	6
Crop Rotation	70	58	55
Intercropping	46	30	25
Rhizobium Inoculation	0	0	0
Chemical Fertilizer	92	82	80
Raw Spacing	61	46	43
Organic Pesticide	14	7	6
Inorganic Pesticide	71	68	63
Drying	49	43	39
Threshing	42	52	42
Improved Storage Facility	34	21	19
Pest Control	97	87	88
Grading	29	16	20