Tanzania Country Climate Risk Profile Series

Iringa District

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Climate Risk Profile Iringa District

Highlights

- Agriculture plays an important role in the economy of Iringa District. The sector employs about 73% of economically active people and generates nearly 99% of the GDP of rural Iringa. More than 70% of the women work in agriculture.
- Crop production is the most important agriculture sub-sector, supporting nearly 70% of all agricultural households in the district.
- Climate change impacts are felt along the entire agricultural value chain; input acquisition, on-farm activities, post-harvest handling, and marketing. Of these, on-farm production is the most vulnerable to climate variability.
- Youth engagement in agriculture is low, primarily due to marginalization in development projects. Policies that encourage youth engagement are weakly enforced.
- Women provide 70-80% of agricultural labor in the district, and produce over 80% of staple foods. However, social norms and the policy environment prohibit economic gains accrued from these activities to women. Cultural practices also marginalize women in terms of decision-making, access and use of resources such as water and land.
- The government plays a major role in resilience building in terms of implementation of policies, marketing of agricultural produce, and design of projects that engage marginalized groups such as women and youth. The government is also the primary provider of agricultural extension in the district.
- Capacity to quantify the effects of climate change in the water sector is currently low. Similarly, the Tanzania Meteorological Agency lacks the financial and human resources to collect and disseminate climate information.
- Scarcity of resources impedes the President's Office, Regional Administration and Local Government (PO-RALG) in carrying out projects that can increase resilience. The local government primarily depends on funds from the national government.
- Little research on climate change and climate adaptation has been done in the district. As a result, there is a paucity of empirical evidence on existing vulnerabilities and associated adaptation options that could be scaled out.
- There is limited involvement of both governmental and non-governmental organizations along the entire value chain, particularly in regards to provision of inputs, training on use of agricultural inputs, access to credit, value addition, and marketing.
- Lack of resources, especially land, water and finances, inhibits both production expansion and intensification. Farmers use the same poor agricultural methods on the same pieces of land.
- Farmers in the district employ a number of adaptive approaches such as irrigation, "vinyungu", improved varieties among others. However, adoption rates remain low especially for women farmers, primarily due to lack of financial resources, lack of markets, and poor access to reliable information on the practices. In addition, women never make major decisions on use of productive resources.
- Provision of timely and accurate climate information, in combination with other adaptive approaches, such as use of early maturing, high yielding, and drought tolerant varieties, presents an important opportunity to enhance resilience among farmers.

Acronyms and Abbreviations

AEZ	Agro-ecological zone
ACRP	Agriculture Climate Resilience Plan
ASDP	Agricultural Sector Development Programme
CAN	Calcium Ammonium Nitrate
CCAFS	CGIAR Research Programme on Climate Change, Agriculture and Food Security
CCPP	Contagious Caprine Plural Pneumonia
CF	Clinton Foundation
CIAT	International Center for Tropical Agriculture
CGIAR	Consultative Group on International Agricultural Research
CHIRPS	Climate Hazards Infrared Precipitation with Stations
CSA	Climate Smart Agriculture
CSA-SuPER	CSA Sustainable, Productive, Profitable, Equitable, and Resilient
DICOTA	Diaspora Council of Tanzanians in America
EADDP	East Africa Dairy Development Project
ECF	East Coast Fever
FAO	United Nations Food and Agriculture Organization
FSP	Farm Subsidy Program
GHG	Greenhouse Gas
GDP	Gross Domestic Product
ICISO	Iringa Civil Society Organization
IITA	International Institute for Tropical Agriculture
JICA	Japan International Cooperation Agency
MALF	Ministry of Agriculture, Livestock, and Fisheries
ME	Ministry of Environment
MLHHSD	Ministry of Lands, Housing and Human Settlement Development
MMADEA	Mazombe Mahenga Development Association
MWI	Ministry of Water and Irrigation
MVIWATA	"Mtandao wa Vikundi vya Wakulima Tanzania"
NAFAKA	USAID-funded cereals project, Swahili for "cereals"
NAIVS	National Agriculture Input Voucher System
NAP	National Agricultural Policy
NAPA	National Adaption Programme
NCD	New Castle Disease
NCCS	National Climate Change Strategy
NEP	National Environmental Policy
NFP	National Forest Policy
NLP	National Land Policy
NGO	Non-Governmental Organization
PO-RALG	President's Office, Regional Administration and Local Government
QOL	Quality of Life
RCP	Representative Concentration Pathway
RUDI	Rural Urban Development Initiative
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SUA	Sokoine University of Agriculture
TADB	Tanzania Agricultural Development Bank
TARI	Tanzania Agricultural Research Institute
TMA	Tanzania Meteorological Agency
URT	United Republic of Tanzania
USAID	United States of America Agency for International Development
VUNA	UKAid funded project, Swahili for "harvest"
WUR	Wageningen University and Research
WWF	World Wide Fund for Nature

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

Foreword

Climate change is a major challenge facing the agriculture sector in Tanzania. The impacts of climate change on agriculture have been documented in several government reports, projects, and policies (URT, 2017, 2013, 2014, 2015; URT, 2007). Small-scale farmers are the most affected; their livelihoods are primarily agriculture-based, with relatively low adaptive capacity. Historical climate information shows that temperatures have significantly increased in recent years, while precipitation has remarkably decreased (URT, 2014). Associated effects of these changes include geographic shifts of agro-ecological zones (AEZs), rainfall variability, prolonged dry spells, and reduction of water volumes in rivers, lakes, and other water bodies. Climate projections indicate that the adverse effects of climate change are expected to increase in magnitude in the coming years. Temperatures are likely to increase by 1.4°C by 2030 and 2.1°C by 2070; the northwest and west are likely to experience faster warming (CIAT; World Bank, 2017). Of all economic sectors, agriculture is the most affected. Among employees of the agricultural sector, small-scale farmers are the most vulnerable. At the same time, the agriculture sector is also a major contributor to climate change.

There is increasing realization of the need of making agriculture more resilient to climate change, while at the same time achieving the valuable co-benefit of reducing emissions from the sector. In response, the government of Tanzania, in collaboration with various partners, seeks to put in place enablers in institutional, policy, and development frameworks to achieve this objective. Initiatives to date include the National Adaptation Programme of Action (NAPA 2007), the National Climate Change Strategy (NCCS 2012), the Agriculture Climate Resilience Plan (ACRP 2014), the Climate Smart Agriculture (CSA) Guidelines (CSA-G 2017), and the CSA Profile (CSA-CP 2017). Programmes such as VUNA and Southern Agricultural Growth Corridor of Tanzania (SAGCOT), among others, have also been designed to mitigate the effects of climate change. Evidence from all these efforts points to the pertinence of CSA in Tanzania. The CSA Guidelines and CSA Profile specifically highlight some of the practices from the national context that hold the most promise for increasing productivity, and resilience through adaptation, and mitigation of greenhouse gas (GHG) emissions. Given the context specificity of CSA, identification of scalable practices at the local level is a key priority for continued progress in this regard.

This profile seeks to identify scalable investments in CSA in Iringa district. It is one of the products of the CSA/SuPER - Upscaling CSA with small-scale food producers organised via VSLAs implemented by CARE International, the International Center for Tropical Agriculture (CIAT), Sokoine University of Agriculture (SUA), and Wageningen University and Research (Pamuk et al., 2018).

We use the methodology described by Mwongera et al. (2014). The methodology uses both quantitative and qualitative approaches. We collected secondary data from an extensive review of existing studies. We collected primary data through expert interviews, focused group discussions (FGDs), household survey, and a workshop in held in Iringa district. The workshop comprised of actors in the agricultural sector from government-, private-, faith-, and community based organizations, and farmers. All discussions in the document are based on the views of the stakeholders engaged in the study unless stated otherwise.

Iringa region is of strategic importance in terms of the Tanzanian economy. It is one of the four major food-producing regions in the Tanzanian mainland, and where two major national rivers (the Ruaha and the Rufiji) originate. These water bodies are of economic importance for ecosystem services, hydropower generation and agricultural irrigation among other uses (Pettengell & Fortnam, 2017).

This profile is organized into six main sections, each reflecting an essential analytical step in studying current and potential options for climate adaptation of important agricultural commodities in Iringa district. We first offer an overview of livelihoods, the role of agriculture in the district, a description of the key value chains[1] for food security and livelihoods, and major challenges to agricultural development. Information used in these sections is from both secondary and primary sources. The subsequent sections then discuss significant climatic threats based on historic and projected climate data, as well as perceptions on climate change from farmers and experts in the district. This serves as a foundation for the subsequent discussions on vulnerabilities and climate risks along the value chains, suggested adaptation strategies, and the associated challenges to adoption, all based on farmer and expert views. Next, we discuss CSA enablers within the Iringa context, including policies, institutions, governance, finances, and existing gaps and opportunities. Finally, pathways for bridging the gaps and strategies to strengthen institutional capacities and collaborations are highlighted.

1 A value chain is the process an agricultural product moves through, including various stakeholders, from production to sale.

Agricultural context

District context

Iringa district is one of the three districts (along with Mufindi and Kilolo) in the Iringa region, in the southern highlands of Tanzania. Iringa district borders Mufindi to the south and Kilolo to the east. To the north, it is bordered by Dodoma region, and to the west by Mbeya region. The district covers an area of 20,414 km^2. Ruaha National Park, a major tourist attraction, is within Iringa, and occupies about 52% (10,556 km^2) of its geographic area. Water bodies cover 3.4% of the land outside the national park. A large portion of the district ranges from 800 meters to 1,800 meters above sea level. It generally receives about 600–1000 millimeters (mm) of rainfall annually. The second season, from November to April, is rainy and cooler, and is of primary importance for agricultural production. The first season, from May to November, is drier and hotter. Iringa district is divided into six divisions: Idodi, Isimani, Kalenga, Kiponzelo, Mlolo and Pawaga. Idodi is the largest division, followed by Isimani; Pawaga is the smallest. Isimani division contains most of the total water surface in the district, and is also the driest of the divisions. Isimani is heavily affected by drought, while Pawaga is most prone to floods.

People and livelihoods

Iringa is sparsely populated (27 people/km^2), with a total population of 254,032 and with notable inter-divisional variation. Mlolo division is the most densely populated. There are slightly more women (51.5%) than men (48.5%) in Iringa as in the country. The population is youthful; 50% is less than 17 years old, and 48% is 15-35 years old. A majority (93%) of Iringans resides in rural areas[2]. The population growth rate from 2002 to 2012 is estimated at 0.3% annually. Pawaga division had the highest growth rate of 2.8%, while Isimani and Kalenga registered negative growth rates of -0.9% and -0.1% respectively. The negative population growth, especially in Isimani, is attributed to harsh climatic conditions that contribute to poor performance of agriculture, lack of alternative livelihoods, unavailability of food, and consequent poor quality of life and high mortality rates.

Quality of life indicators (QOL), including housing materials and amenities access, show low QOL in Iringa. For instance, 72% of households have earthen floors, 51% have mud walls, and 30% have grass/leaf thatched roofs. Access to improved water sources in the entire district is estimated at 63%; given that urban areas enjoy relatively high rates of improved water access, the rural population is likely to have significantly lower rates. Most households, and particularly in Isimani, have trouble accessing water, especially during the dry season. Challenges in water access affect women the most since they take the primary role in fetching water for household use (Sikira & Kashaigili, 2017).

Adult literacy is 76%. A disproportionate number of literate adults are male; this may be attributed to gender biases in education access. Gender biases go beyond education. The number of women with access to land, water and other resources does not match that of men despite an increase in the recent past. Men dominate decision making over household assets for instance sale and purchase of land, livestock, or house. Distribution of benefits from natural resource products are skewed towards men (Sikira & Kashaigili, 2017).

The district has a total of 1,597 km of road surface, of which 5% is tarmacked and 50% is earthen. Malnutrition levels are high in Iringa; approximately 7% of children below five years of age suffer from malnutrition, though this is just half of the national malnutrition level[3]. Kiponzelo division had the highest level of child malnutrition, at 10% in 2015. Nearly 97% of households use wood fuel as the primary source of energy for cooking, and 92% use kerosene as a light source.

The agriculture sector is important to the economy of the district as a source of both income and food. The sector contributes nearly 99% of the Iringa rural gross domestic product (GDP)[4], and engages 73% of economically active people, a majority constituted by women[5]. The majority of these (82%) are engaged in crop production. The remaining 18% are engaged in mixed crop and livestock production.

2 This is likely to shift in coming years as migrations to the town centers increases, particularly among young people searching for employment opportunities.
3 Number of underweight children was used to quantify malnutrition.
4 Iringa urban is important to the economy of the district; its contribution to agriculture GDP is low.
5 78% of women are engaged in agriculture at national level according to the Tanzania Demographic Household Survey 2014

Women are the major producers of food; the "vinyugu"[6] is most common among women for production of food crops (Pettengell & Fortnam, 2017). They also keep small livestock such as poultry, sheep and goat for home consumption. Brewing, cooking and selling bites are important alternative sources of income for women, while timber production, charcoal manufacturing, beekeeping, fishing, brick making and mining are important for men. Women tend to dominate in the less formal, less visible and more vulnerable livelihood alternatives (Lokina, Nyoni, & Kahyarara, 2017). Agricultural households in the urban centers of Iringa have relatively diverse livelihoods.

Agricultural activities

Iringa has a rich agro-biodiversity in terms of both crops and livestock (URT, 2016). The area enjoys a climate that favors production of a variety of crops (Ibid). Agricultural production in Iringa is primarily subsistence. Based on information from the district agricultural office, production takes place in all the 3 agro-ecological zones (AEZs), the AEZs have the following characteristics:

- **Lowland zone:** characterized by low mean annual rainfall of about 500–600mm, and temperatures of about 20–25°C. This zone covers Pawaga, Idodi and Isimani divisions. The soils in this zone are suitable for crop production, but productivity is limited due to low and unreliable rainfall. Crop failures are common in this zone. Farmers use irrigation to produce paddy, cotton, bananas, tomatoes, and onions, among other crops.

- **Midland zone:** characterized by relatively high annual rainfall of about 600–1000mm, and temperatures of about 15–20°C. It covers Mlolo, Kiponzelo, and Kalenga divisions. Agricultural experts in the district noted that this zone is suitable for production of maize, beans, Irish potato, sorghum, vegetables, and tropical fruits. The soils are relatively acidic due to high rainfall.

- **Transition zone:** This zone lies between the lowland and the midland zone. It includes parts of Kalenga and Isimani. It receives low rainfall, although it is less vulnerable to drought and other extreme weather conditions as compared with the lowlands. Crops produced in this zone include sunflower, sorghum, green maize, and cowpeas, among others.

Most Iringan land ownership is dictated by customary laws, under which 82% of households own land. Control over land (decisions on how to use, and sell) is dominated by men (Sikira & Kashaigili, 2017). Women normally access land through their husbands. A relatively large proportion (49%) of land outside the national park is arable; only 51% of this arable land is currently under production. This puts the district in a strong position in terms of production sustainability if good agricultural practices, such as CSA, are used, and if women are targeted with appropriate services and support, considering they do most of the production activities. Food crops occupy about 40% of the arable land (189,836 ha), while cash crops occupy about 10% (47,053 ha). The major food crops grown in the district include maize, sorghum, paddy, Irish potato, green peas, cowpeas and beans, among others. Maize occupied 65% of all the land under food crop production in 2015, followed by paddy (12%), Irish potato (10%), and beans (9%). Sunflower, tobacco, groundnuts, barley, tomato, cotton, and sesame are the most important cash crops. Sunflower occupied the largest area (82%) for cash crops in 2015, followed by tomato (5%) and groundnuts (4%).

About 16% of agricultural households use irrigation and 21% use improved seed. Soil erosion control, fungicides, and insecticides are used by 12%, 5%, and 23% of households respectively. Irrigation potential in the district is about 17,721 ha. Farmers use irrigation primarily for rice, and occasionally for tomato and watermelon production. Improved seed is used primarily for maize. This high utilization of improved seeds for maize is due to government-supported provision of improved maize seeds under the Fertilizer Input Subsidy Program (FISP). Although nearly 99% of agricultural households use inorganic fertilizer, they rarely achieve the recommended fertilizer quantities.

Livestock production plays an important role in the livelihoods of the Iringa people. There were approximately 980,000 livestock in the district in 2015. Chickens accounted for nearly 45% of this figure; cattle and goats accounted for 17% and 12%, respectively. Cattle, sheep, poultry, and goat breeds

6 Vinyugu is a traditional irrigation system. More details are in the adaptation section.

Livelihoods and Agriculture in Iringa District

Demographics

0.75% of Tanzania's population

300,571 inhabitants

93% Live in rural areas

51% 49%

Access to basic needs

93,177 of the population lives in **absolute poverty**

Potable water	68%
Electricity for cooking	0%
Electricity for lighting	3%
Education (Literacy level)	76%

Food security

4% of the population suffers from **food poverty**

ND of household income **spent on food**

ND people **undernourished**

ND children **stunted**

0.4% children **wasted**

ND: No data

Iringa

Farming

District's farming area

479,170ha — 49%

80% of the population employed in agriculture production

0% of farmers have title deeds

ND are women

Farming activities

Food crops	Cash crops
176,033ha	47,829ha

Livestock

1,093,663

Cattle	Goats	Sheep	Indigeneous chicken
169,064	118,307	64,672	441,513

Farming inputs

Fertiliser types (78% of households)

- 13% Organic manure
- 95% Basal fertilizer
- ND Top dressing fertilizer

Pesticide types (68% of households)

- ND Field pesticides
- 23% Storage pesticides
- <1% Herbicides

primarily consist of indigenous breeds kept under extensive production systems for home consumption of meat, milk, and/or eggs.

Various actors from government and private sectors have promoted select crops and livestock. For instance, United States Agency for International Development (USAID) promotes production of cereals, primarily maize, through the NAFAKA project, and fruits and vegetables, such as tomatoes, through the fruits and vegetables program. The government promotes production of maize through the input subsidy program, and organizations such as CARE International promote soybean and sunflower production.

Climate and agriculture context

Historic and future trends

Historical data shows remarkable changes in Iringa's climate from 1980 to 2005[7]. Average temperature has increased by more than 0.5°C in both the first and second seasons, with remarkable annual variations, particularly during the second season. The number of days with a maximum temperature above 35°C has significantly increased in the first season and slightly decreased in the second season. Both seasons show an increase in heat stress days, and drought risk[8]. Precipitation on the other hand has remained relatively unchanged in the first season, and slightly increased in the second[9]. However, annual averages vary remarkably. The second season has more years with daily precipitation of less than 15mm, and the first season has more years with daily precipitation of more than 23mm. Five day precipitation averages are also very erratic. For instance in 2016, the average in the first season and second season were over 45mm and 10mm respectively.

This combination of highly variable precipitation and increasing temperatures have resulted in a reduction of growing seasons, particularly in the second season of the year. This has an outsized effect on the yields of crops that require a long growing season.

Future projections by CIAT suggest that these trends will continue. Climate models typically output pessimistic (in which causes of climate change become more pronounced or worsen), status quo, and optimistic (in which causes of climate change reduce or improve) scenarios based on the RCP used. Here we cite results for 12 climate models, and 3 RCPs (2.6, 4.5 and 8.5)[10].

Projections by CIAT (based on (Ramirez-Villegas & Jarvis, 2010)) for Iringa for the years 2020–2065 show an increase in temperature in both seasons. The increase is more pronounced in the pessimistic scenario (RCP 8.5) and relatively mild in the optimistic scenario (RCP 2.6). All models indicate that the number of days with temperatures more than 35°C will increase, particularly in the second season; the number of days is greater in the pessimistic scenario compared with the optimistic scenario.

Projections for precipitation vary from model to model, with all models showing an increase in variability, particularly in the first season. Nevertheless, precipitation projections in the tropics is challenged by a number of factors, and as such there are systematic errors (Flato et al., 2013).
Evidence suggests some crops and production systems will be more affected than others. This will influence farm investment decisions, including which crops to grow and which adaptation options to use.
Given that existing trends are already handicapping farmers, and are likely to continue, it is crucial to put in place measures to increase farmer climate resilience.

7 Temperature assessment completed as per (Chaney et al., 2014)agriculture, and infrastructure is necessary to adequately prepare and adapt to future change. This is a challenge in data-sparse regions such as sub-Saharan Africa, where a lack of high-density and temporally consistent long-term in situ measurements complicates the analysis. To address this, a temporally homogenous and high-temporal-and high-spatial-resolution meteorological dataset is developed over sub-Saharan Africa (58S-258N.

8 A climate risk is the potential for specific, climate-related consequences (climate impacts) for something of value (assets, people, ecosystem, culture etc.).

9 1980 to 2005 data from Climate Hazards Infrared Precipitation with Stations (CHIRPS) http://chg.geog.ucsb.edu/data/chirps/

10 Representative Concentration Pathway (RCP) is a measure of the level of atmospheric warming associated with amount of GHGs in the atmosphere. RCP 2.6 shows less warming while RCP 8.5 shows a lot warming.

Stakeholder perceptions on climate change

Experts and farmers report observing climate change and variation[11]. There were no differences in the changes observed by men and women. However, some accounts such as Pettengell & Fortnam (2017) report differences in perception between men and women. In this study, men reported a slight increase in heat in Nyakadete, while women made no mention of heat.

The stakeholders we interviewed remarked that temperatures have not only increased significantly but have also become highly variable. According to the stakeholders, associated effects include increased frequency of frost in some parts of the district, and incidences of malaria following a proliferation of mosquitos. The stakeholders also observed that rainfall has become erratic in both temporal and spatial terms. Historically the rainy season begins in mid-November and continues to April; in recent years, it begins as late as January and ceases before April. According to the stakeholders, dry periods have become more frequent and prolonged. For instance, Isimani, once a major maize producer nationally, is now semi-desert due to human activities such as deforestation. The stakeholder also noted that water volumes in the Kipiusi, Lyandembela (similar observation in Kassian et al., 2016), Rukari, Ruteni, Luhami, and Madibila, rivers, as well as Mtela Dam, have significantly reduced due to the reductions in rainfall and increased evaporation associated with higher temperatures. Similarly, floods have also become more common in the district. Flooding increases the risk of outbreaks of diseases such as cholera, and results in soil erosion and subsequent siltation into water bodies, in particular the Mtela Dam.

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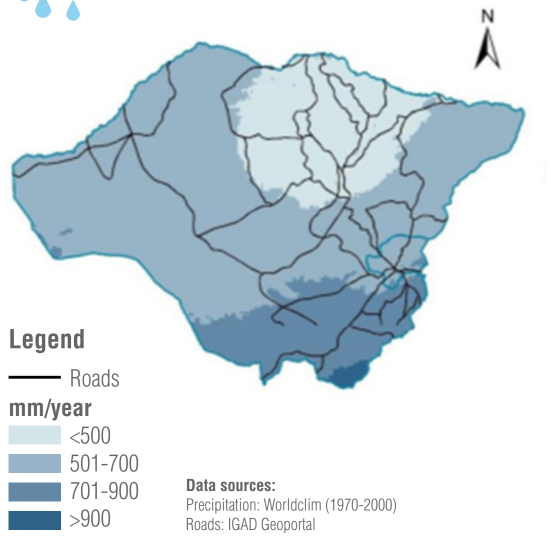
Farmers do not consider climate change as a global issue, but rather as just a variation in local weather patterns. They identify deforestation, burning of crop residue, population growth, and encroachment of wetlands and forest areas as the primary causes of the climate variability they see in the district.

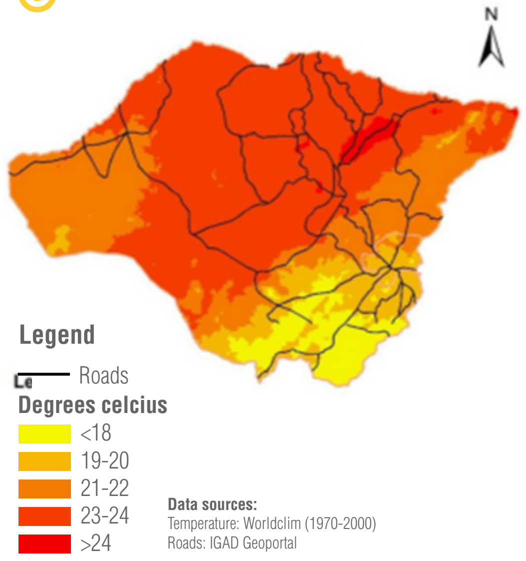
11 Farmers and experts were engaged through focused group discussions, individual interviews and a workshop.

Past and future impacts of climate hazards in Iringa District

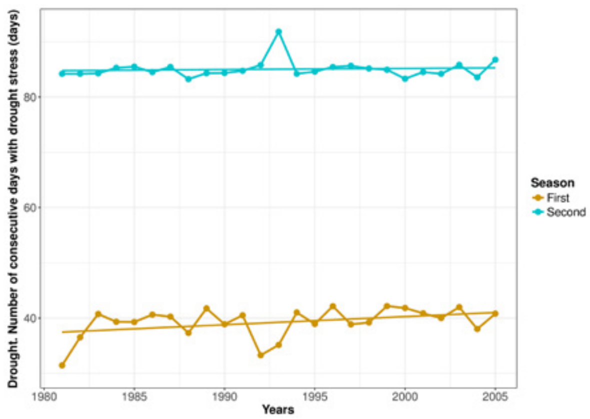
Precipitation



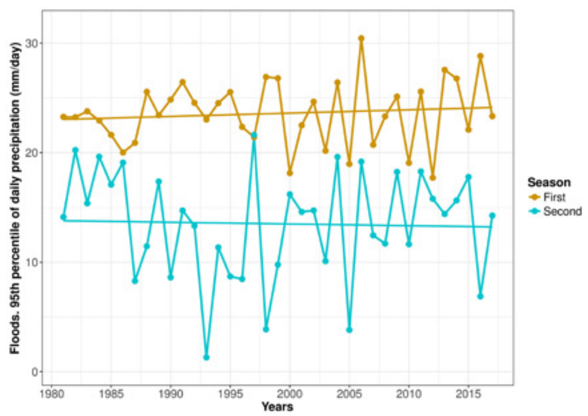
Temperature



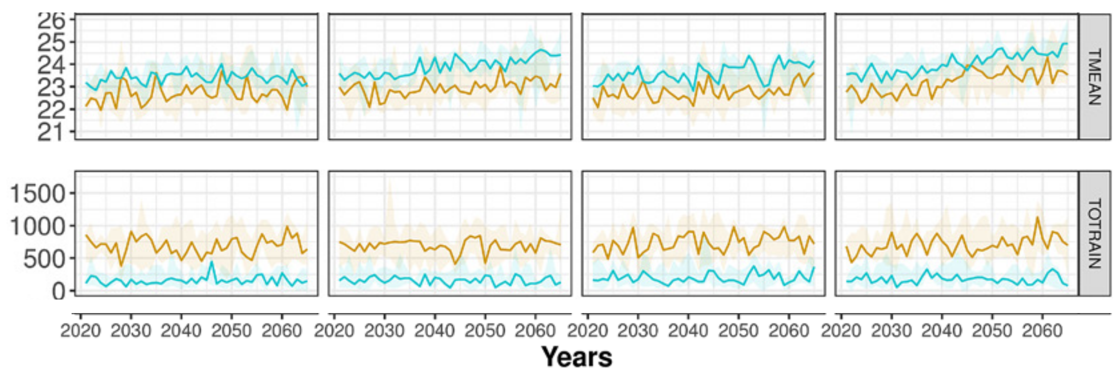
Historical droughts



Historical floods



Future precipitation and temperature projections



Agricultural value chains

For the purposes of this profile, four value chains were identified for in-depth analysis of the impacts of climate change. We first considered the value chains prioritized by different organizations. From there, we selected the four with the highest harvested area (ha), yield (kg), and economic value in terms of productivity and prevailing prices (Tanzanian shillings (Tsh). The selected value chains (maize, beans, soy bean, sunflower, Irish potato, sweet potato, rice, millet, tomatoes, cashew, beef and indigenous chicken) were then presented to district stakeholders experienced in the agricultural production systems of Iringa, including government experts from various ministries, private sector, and non-government organizations[12]. These stakeholders validated the selections using additional criteria, including perceived current and future climate suitability, percentage of the population engaged in the value chain, level of involvement of women and youth, and relevance of the value chain in poverty reduction[13]. Through this process, maize, rice, tomato, and sunflower were identified for further analysis here[14].

Maize

Maize is the dominant crop in Iringa district, engaging 61%-80% of the population. It is both a staple and a cash crop. Most of the producers are small-scale farmers who produce mostly for subsistence purposes and women provide the majority of field labor. The bulk of the surplus maize produced in Iringa is sold outside the district. Production is primarily rain fed. The crop is grown either as a pure stand or intercropped, often with sunflower or beans. Major producing areas include Mlolo, Kalenga, Kiponzelo and Isimani. Fertilizer use in maize is relatively high (220 kg/ha) (Benson et al., 2012) compared to other crops in the district. This relatively high use can be attributed to the fertilizer subsidies offered by government. The National Agricultural Input Voucher Scheme (NAIVS) targets to increase maize production through increased use of fertilizer and improved varieties in 65 districts. The program targets 2.5 million households. The program offers 100 kgs, which are not sufficient for 1 acre. Common maize varieties include H614, H628 (preferred for green maize, H625, and H691 (preferred for grain maize).

All other maize value chain actors, including input suppliers, processors, and wholesalers, operate at small scale. The district has not yet attracted large-scale input suppliers due to the low purchasing power of farmers among other reasons. The most common value addition process is maize flour production. Women dominate the maize flour trade, while men dominate maize grain trade. However, almost all maize producers process maize to flour mainly for household consumption. There are about 10 maize millers in the district, most of which are located in Iringa town. Average annual production from 2011 to 2015 was estimated at 222,075 tons. The total area under production of maize is about 44,200 ha, with an average of 0.83 ha per household.

Major challenges that face maize production in the district include highly volatile prices and a lack of finances to purchase fertilizers and other inputs. Since farmers use returns from maize to invest in production of other crops, low yields from maize translate to general low yields from other crops.

Organizations promoting maize production include One Acre Fund, USAID, Brighten, and Tanzania Agricultural Development Bank (TADB). One-Acre Fund mostly offers inputs; USAID offers both inputs and training while TADB mostly offers credit.

Potential strategies that can enhance maize production include lifting of bans of selling maize to neighboring countries, lowering export duty, which is currently high, and ensuring efficient functioning of the subsidy program.

Rice

Rice production in Iringa is mostly small scale. The major producing divisions are Idodi, Pawaga and Isimani. Yields are relatively low; the average annual production in 2011–2015 was 67,237 tons on 6,938 ha. Although it is not a primary staple crop, women and youth are heavily engaged in rice production. Youth tend to conduct planting, and all other production activities are generally done by women. According to farmers interviewed and workshop participants, fertilizer use in rice production is relatively moderate within the district, and pesticide use is low. The crop is grown in pure stands under flood irrigation.

12 A list of stakeholder consulted is given in the acknowledgements.

13 A three-tiered scale (high, medium and low) was used to identify the value chains that scored highest in aggregate across all criteria.

14 This evaluation in no way suggests that other value chains are of lesser importance. Rather, we have attempted to prioritize the limited scope of this overview to provide information on the value chains that impact the most number of individuals in the district.

Input and market value chain actors range in size; there are small, medium and large-scale input suppliers, and medium to large-scale processors and wholesalers.

The major production challenge for rice is limited access to water, especially during the dry season. There are no boreholes or dams in the growing areas, and farmers generally do not have the capacity to harvest water. Climate variation increases production costs. This, coupled with low market prices, result in low incomes from rice production.

Institutions involved in the rice value chain in the district include Bayer, which supplies fertilizers and pesticides, Rural Urban Development Initiatives (RUDI), which provides inputs, and the Japan International Cooperation Agency (JICA), which supplies inputs and offers training to the farmers.

Sunflower

Sunflower is both a cash and food crop in Iringa district, but it is primarily grown for subsistence on a small scale. On estimate, 41%–60% of the population is engaged in sunflower production, most of which is concentrated in Isimani, Pawaga and Idodi. Average hectarage in 2011–2015 was 37,166 ha, while average annual production within the same period was about 1,345 tons.

Small-scale farmers produce sunflower under rain fed conditions with minimal use of fertilizer, improved varieties, pesticides, or other inputs. Nevertheless, use of improved seeds remarkably increased in 2015 due to support from both government and non-governmental organizations. The preferred seed variety is SWAT 145; other popular varieties include Kenya Fedha, High Sun 33, and Recodi.

Different gender groups play different roles in the sunflower value chain. Men acquire most of the production inputs (land, fertilizers and seeds) except in a few cases where projects target women. This may limit the extent to which women can adopt new technologies. Land preparation is perceived as a man's activity. Both men and women do weeding, while women dominate post-harvest handling activities such as drying, winnowing and grading. Men dominate processing, transporting and selling of sunflower.

There are no major processors in the district; only about 10 small sunflower processing mills exist, seven of which are located in Isimani. There is potential for enhancing value addition. Technologies used currently to press oil are not efficient. Major actors in the value chain include CARE International, CUAMM, Clinton Foundation, and Ritenga.

Tomato

Tomato is a cash crop in Iringa. It is mainly grown in Kalenga and Tanangozi. Given that tomato is highly perishable, it requires significant post-harvest handling; as such, the value chain engages many stakeholders comprising 81–100% of the population of Iringa.

Production is at small and medium scale, or about 0.25–0.5 acres. Very few farmers produce tomato on 1–2 acre farms. Tomato production is primarily rain fed, though some farmers use irrigation or methods such as "vinyungu[15]" and growing near catchment areas and rivers. Common varieties include Mkulima, Balton, Hasila, Tanya, and Rio Grande. The crop requires a lot of inputs, particularly fertilizer and pesticides, and is mostly grown in pure stands.

Men dominate the tomato value chain, in input acquisition, production and marketing. Women do the weeding most of the time, while male youth do grading, packaging and transporting. This may imply that men dominate cash crop value chains even if the crops are perceived to be "women" crops, and that women do the non-paid (rewarded) activities in the value chain.

Major challenges to expansion include lack of resources and unstable markets. Despite its small-scale production and challenges due to climate vagaries, Iringa supplies tomatoes for more than half of the year. However, given its seasonality and perishability, there is a glut of tomatoes on the market for half the year, and scarcity for the other half.

Input suppliers and processors are small to medium scale. The dominant processor is the private company Darsh, which processes tomatoes to shelf-stable paste, is the only medium-sized processor in the district. Poor technology and lack of capital are the major constraints to processing at scale. Actors in the value chain include development organizations such as Association of Tomato Growers, and USAID, among others.

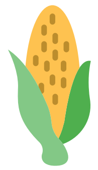
15 Vinyungu is a farming system (traditional irrigation) where farmers cultivate valley bottoms through harnessing water from rivers and springs to enable them produce crops throughout the year.

Provision of seeds and other inputs | On - Farm production | Harvesting storage and processing | Product marketing

% of people engaged in the value chain

Types of actors engaged in Value Chain

Maize



61-80%

Actors: S (S) | F (S) | P (S) | W (S)

Importance of women and youth in the value chain: High

Key Activities (S)	Key Activities (F)	Key Activities (P)	Key Activities (W)
Land acqusition	Land preparation	Threshing	Aggregation (farmers do this collectively)
Buying improved seeds	Weeding	Drying	Linking farmers to markets
Buying fertilizer	Harvesting	Storage	Selling

Rice

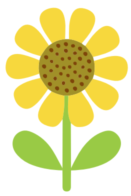
41-60%

Actors: S (S) | F (S) | P (S, M) | W (S, M)

Importance of women and youth in the value chain: High

Key Activities (S)	Key Activities (F)	Key Activities (P)	Key Activities (W)
Buying seeds	Nursery preparation	Drying of rice	Linking farmers to markets
Hiring farming implements	Land preparation	Processing: Shelling	Promotion and selling
Buying of agro-chemicals	Weeding and fertilizer application	Packaging and transportation	

Sunflower



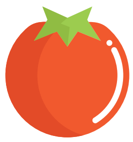
41-60%

Actors: S (S) | F (S) | P (S) | W (S)

Importance of women and youth in the value chain: Medium

Key Activities (S)	Key Activities (F)	Key Activities (P)	Key Activities (W)
Sourcing for land – hiring or apportioning from owned land	Land preparation	Threshing and winnowing	Promotion. (This is made possible through packaging the seeds well)
Sourcing for seeds	Planting	Transpotation	Pricing
Purchasing fertilizers	Weeding	Milling	Selling

Tomato



81-100%

Actors: S (M, L) | F (S, M) | P (S, M) | W

Importance of women and youth in the value chain: High

Key Activities (S)	Key Activities (F)	Key Activities (P)	Key Activities (W)
Hiring land, oportiing family land to tomato production	Land preparation	Processing	Pricing
Purchasing of seeds (some farmers do seed multiplication on their farms)	Planting	Storing	Selling
Purchase of pesticides	Spraying (includes pesticides, fertilizers and herbicides)	Transportation (normally using motorcycles, hand carts and lorries)	Linking farmers to markets

Conventions

Types of actors: S Service providers F Farmers P Processors W Wholesalers/retailers

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

Challenges in agriculture

Information collected from agricultural expert interviews and farmer FGDs show that the agricultural sector in Iringa faces important biophysical, climatic, institutional, political and cultural challenges.

Experts working in agriculture and farmers in Iringa district noted that climate is an important challenge to agricultural production in the district. Extreme weather in the last few decades has resulted in a reduction in yields of most crops. Farmers have trouble knowing what and when is best to plant. This increases both production cost and risks.

High temperatures, reduced and variable rainfall, frost, late-start of growing seasons, reduced growing seasons, flooding, and erosion have had significant negative impacts on production systems (FAO, 2016). Climate impacts are aggravated by insufficient access to climate information, and a lack of knowledge on how to use the climate information to enhance adaptive capacity. Due to climate variability, conventional methods of predicting weather, such as appearance of termites and mango plant flowering, have become much less accurate.

Poor access to financial services is a major impediment to improved agricultural productivity. Very few institutions currently provide or hope to provide credit to farmers. Institutions currently offer small, short-term loans that do not allow farmers to make long-term investments. The remoteness of some parts of the district further limits access by farmers to financial institutions, which are primarily concentrated in urban and peri-urban areas. Climate vagaries and bouts of poor weather further deter financial institutions, thus aggravating the issue.

Small-scale farmers are generally unable to expand and scale their production due to simple resource constraints such as the one outlined above. A lack of access to financial services leaves small-scale farmers without reasonable options for breaking the poverty cycle. For example, less than 4% of agricultural households have access to credit services. Women farmers have even lower rates of access; although women are the ones mostly involved in agricultural activities, only 27% of all farmers who received credit are female. It is unclear whether this discrepancy is due to female farmers failing to seek out credit services, or whether they are explicitly excluded from credit markets.

Women farmers are also disadvantaged in terms of access to other productive resources such as water and land. Experts in agriculture and farmers agreed that a culture and policy environment that suppresses women worsens their vulnerability. The tenure system in the district and the whole country explicitly disadvantages women. They have much more limited control of land use than men. Some change has begun in this regard due to deliberate efforts by government and other partners to reduce gender inequality. For instance, the National Agriculture Policy (NAP) and the National Land Policy (NLP) have several gender considerations (Acosta et al., 2016)[16].

Access to agri-markets is a major challenge. Some market access issues cut across all agricultural commodities, while others are unique to certain commodities. For instance, rice buyers tend to prefer varieties that are not commonly grown in the region; hence, rice farmers have limited markets. High perishability and limited storage structures challenge tomato marketing; Darsh is the only large-scale tomato buyer in the district, and farmers are strongly deterred by Darsh's purchasing arrangements. Price controls (e.g. on maize) and price setting by way of supply and demand (e.g. due to tomato seasonality) rarely favor the producer. Production and transaction costs can be quite high as well. For instance, farmers are sometimes required to pay a tax to move maize from one village to another. Low organization among farmers translates into very limited bargaining power for more favorable pricing.

Cultural traditions also sometimes act as barriers to agricultural productivity. Some crops are produced for specific cultural purposes in spite of the fact that the local climate is suboptimal for their production. In other cases, farmers are simply accustomed to producing certain crops, such as maize, and hesitate to diversify to more resilient crops or drought-tolerant varieties.

Challenges to livestock production include unfavorable weather, as well as diseases such as foot rot, East coast fever (ECF), pneumonia, contagious caprine plural pneumonia (CCPP), fowl typhoid, New Castle Disease (NCD), and coccidiosis, among others.

Youth[17] engagement in Iringan agricultural is minimal. People older than 35 years tend to own most of the productive resources, especially land, and thus dominate the sector. Experts in agriculture working on

16 More details on efforts to enhance equality in Tanzania are in the policy section.
17 Youth in this context is defined as male and female persons ages 18-35 years.

various agricultural projects in the district noted that these older people are often reluctant to adopt new technologies, hence perpetuating low productivity. Low productivity and, consequently, low income potential in the sector, deter youth from agricultural employment. Additionally, most agricultural projects and development plans in the district exclude youth or do not foster youth inclusion. Youth rarely understand climate change partly because they have not witnessed the changes discussed above, and thus are the least prepared to adapt when climate risks arise.

While all farmers' qualities of life are negatively impacted by decreased productivity, women and children are the most affected. Women typically take on increases in workload in, for instance, land preparation and searching for water. This may be due to power imbalances between men and women that originate from social barriers that limit equality between the two groups. Children are the most vulnerable to malnourishment as a result of low production diversity and yield. Children's education is also affected; low farm incomes fail to meet basic household financial needs as well as pay school fees. On a community scale, there are frequent water use-based conflicts between crop farmers and livestock keepers, as well as between farmers upstream and those downstream. Farmers downstream are sometimes unable to plant as a result of upstream farmers diverting all river water to their farms (Pettengell & Fortnam, 2017). Water permits are issued in shifts due to high demand for water for agriculture and domestic use, which can detrimentally affect planting dates.

Climate vulnerabilities across agricultural commodity value chains

Climate change directly impacts entire agricultural value chains (Challinor et al., 2014). Both experts in agriculture and farmers in the district agree that resulting constraints in product supply instigate reduced nutritional security due to high prices and lower worker incomes. Importantly, low farm incomes also negatively impact the next year's input market and, consequently, productivity. In addition to farmers, these shifts in the market system affect a spectrum of actors, including input suppliers, processors, wholesalers, retailers, and buyers.

Drought, floods, precipitation variability, and frost were identified as the most problematic climate hazards to the four priority value chains in Iringa district[18] (see annex 2). Some impacts are common to all value chains, while others are unique to a specific chain. Each value chains is further affected in distinct ways. Some effects are specific to a certain stage, while others cascade from earlier stages. For instance, the effects of using poor quality seeds and fertilizer due to inaccessibility carry through from production all the way to markets. Isolated events may appear to affect only one industry within the value chain (e.g. a bout of poor weather reducing on-farm yield) but in fact may have an effect on all subsequent industries (e.g. post-harvest processors). Climate/weather risks expose farmers to other risks:

- **Input risk:** Access to inputs is impaired due to either poor condition of roads or increase in prices. Quality of input is also compromised.
- **Production risk:** These include low germination rates, low yields, crop failures, and pests and diseases. All these increase production costs.
- **Consumption risk:** Low yields, crop failure reduces access to food, reduces the number of meals that a household takes in a "normal" day.
- **Financial risk:** Arises when the farmer is unable to borrow or repay loans, due to disturbances (caused by weather and climate) in income flows. Unpredictable weather increases the opportunity cost of money; farmers find more pressing needs than investing in agriculture.
- **Price and market risks:** Volatility in both input and output prices due to weather. Climate hazards result in poor quality produce. This impairs access to markets. This risk is also associated with high costs of aggregating produce and looking for buyers (transaction cost).

The major climate-related constraints on each value chain are presented below as crucial opportunities to improve farmer resiliency and productivity while simultaneously mitigating the impacts of climate change. The tables below then present the major threats to each phase of each value chain, how farmers are currently adapting, and other options to improve farmer resiliency.

18 Hazard in this context refers to the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

Crosscutting issues

Low input use is rampant in Iringa, and a major cause of low productivity. Climactic variability, in combination with low input use, results in doubly low yields of lesser quality. The low yields and low prices for agricultural net low farm incomes, which in turn limit purchasing power for inputs in subsequent years; and so the cycle of poverty continues. Poor quality inputs and high prices also play a significant role in low input use among farmers. For instance, a bag of Calcium Ammonium Nitrate fertilizer (CAN) is currently trading at Tsh. 68,000; this is approximately equivalent to the price of 3 bags of maize. A hectare produces on average 16 bags of maize; the average small-scale farmer family has just 0.83 ha of maize. Given that this is just one of many input costs, it is apparent how deterring input prices can be. Fertilizer from the subsidy program does not always meet the needs of the farmers hence the farmers have to incur cost of purchasing more fertilizer.

The aforementioned climactic shifts have brought on a proliferation of soil-, water-, and seed-borne diseases in Iringa that exacerbate production cost and yield issues. For instance, maize must now be treated for fall armyworm, and tomato requires heavy spraying due to increased incidences of Bacterial Wilt. More chemicals are also needed for potato production due to frost as well as tomato leaf miner infestations.

Farmers frequently minimize input use in reaction to climactic uncertainty as a risk reduction mechanism. For example, farmers in regions with adequate rainfall tend to use more fertilizers than farmers in areas with less reliable rainfall. Farmers also use more inputs during the second season than in the first season.

Another common coping strategy is extending cultivation into the wetlands to offset low production. Even restricted areas, such as near water bodies and Mtela Dam, are affected. Secondary income activities such as charcoal burning are also popular. Men are increasingly migrating to urban centers to look for alternative livelihoods. All of these coping strategies in fact exacerbate the effects of climate change and reduce mitigation opportunities.

Primary climactic issues and opportunities across each stage of the four highlighted value chains

	Maize	Rice	Sunflower	Tomato
Primary Climactic Threats	• Drought • Precipitation variability	• Drought • Flood	• Flood • Frost	• Drought • Frost
Key Inputs	• Land • Seeds • Fertilizer • Water	• Seeds • Farm implements • Agro-chemicals • Water	• Land • Seeds • Fertilizer • Water	• Land • Pesticides • Seeds • Water
Key Input Constraints	• Sufficient land access to accommodate extensive maize demands • Early maturing and drought tolerant seed varieties • Good fertilizer access	• Selection of correct seed germination rate, yield, and drought tolerance • Appropriate farm implements • Agro-chemical access	• Ease of access to land that is of good quality and not prone to flooding • Good road infrastructure	• Land acquisition • Pesticides • Quality seed varieties
Key Constraining? Production Practices	• Timely land preparation • Weeding • Timely harvesting	• Seed/seedling production • Land preparation • Weeding • Scaled adoption of irrigation and well-developed irrigation infrastructure	• Land preparation • Good planting practices • Weeding • Reliable drainage systems	• Land preparation • Planting • Pesticide and fertilizer access
Key Constraining? Postharvest Practices	• Threshing to reduce storage and transport demands • Drying to reduce postharvest losses • Storage to support market stabilization	• Proper drying • Shelling and packaging • Reliable transport	• Threshing and winnowing • Reliable transport • Milling	• Processing • Storage • Reliable transport
Key Market Constraints	• Cooperative bulk sales • Farmer-market linkages • Reliable sales	• Access to markets at the right time	• Promotion • Packaging	• Farmer-market linkages • Price stability • Cooperative bulk sales
Key Structural and Social Constraints	• Access to improved seeds, land fertilizers, extension support, credit and water for women	• Access to improved seeds, land fertilizers, extension support, credit and water for women	• Access to improved seeds, land fertilizers, extension support, credit and water for women	• Access to improved seeds, land fertilizers, extension support, credit and water for women

Adaptation Strategies

On farm adaptation options

A number of CSA practices as highlighted in the national CSA guidelines (URT, 2017) can be applied in Iringa district:

- **Crop management,** including use of drought tolerant, early maturing, high yielding, salinity tolerant, and flood tolerant varieties
- **Soil management,** including agroforestry and conservation agriculture
- **Water management,** including water harvesting and irrigation inter alia
- **Livestock management,** including fodder conservation, manure management, and improved breeds
- **Energy management,** including use of improved stoves and biogas

Farmers already routinely employ several CSA practices with limited awareness that they can help cushion them from future climate variability. Annex 1 shows farmer awareness and use of some of the CSA practices. A few of these include:

- **Irrigation:** Farmers mostly use watering cans for crops such as tomato and maize, and flood irrigation for rice production. Irrigation technology used in the district is rudimentary, hence low efficiency and high water wastage.
- **"*Vinyungu*":** This traditional irrigation method involves shallow canals in valley bottoms. This practice has different names in different places; "majaruba" in Mara region, "ndiwa" in west Usambala, "ngoro/matengo" in Ruvuma region. This practice enables farmers to produce throughout the year.
- **Intercropping:** mostly cereals and legumes: Yields are sometimes reduced depending on the crops intercropped. Due to this, farmers are advised to use rotational, or relay cropping instead.
- **Erosion control:** soil erosion is not a serious challenge as it is in Kilolo. Erosion control structures include terraces, bunds, and gabions/ sandbags.
- Planting trees
- Using recommended spacing
- **Conservation agriculture:** mulching, cover crops, crop rotations, and minimum tillage.
- Contour farming

Nevertheless, from interviews with district workers in agriculture, farmers more often than not employ adaptive practices in response to prevailing needs (coping strategies), rarely considering long-term resilience. For instance, limited access to inputs due to floods, drought, and unpredictable rains prompts them to use alternatives such as local seeds, manure, and traditional methods of pest and disease control (such as ash application). Participants in the workshop indicated that farmers with limited resources end up not using inputs such as fertilizers and manure altogether. This represents an important opportunity to modify current responses to more climate-resilient approaches.

On farm and off farm services

Access to crucial services is key to enhancing the adoption of CSA practices.

Most important is access to financial services. Barely 4% of agricultural households borrowed money for agriculture during the 2007/2008 agriculture season. A majority (73%) of those who borrowed were men. About 40% of households borrowed from friends and relatives, and another 40% from savings associations. In 2017, about 15% of the borrowers borrowed from savings groups, 11% borrowed from informal moneylenders, and 3% from shop credit (Finscope, 2017). Savings associations are akin to accessing credit for farmers despite the presence of financing institutions such as Vision Fund, FINCA, and the Tanzania Agricultural Development Bank (TADB). Major causes of poor credit access include lack of information on the services available and how to receive them, poor access to institutions financing agricultural investments, and farmers' fear of going into debt. Salient constrains such as limited access to land, particularly for youth and women, exacerbate already limited credit options. Financial products such as warehouse receipting (this involves issuance of a document that shows that certain commodities have been deposited, or belong to a particular farmer), and insurance mechanisms are equally important to ensuring farmers are able to build their productivity and climate resilience. Agricultural insurance is gaining momentum, given its potential to overcome challenges that plague conventional agricultural financing (Mukherjee et al., 2017)

Agricultural extension services are key to ensuring farmers have access to the most updated information on CSA practices and technologies. Extension in Iringa is primarily provided by the government. Data from the 2007/2008 season show that about 77% of agricultural households received extension on crop production, including improved seeds, use of inorganic fertilizer, mechanization, irrigation, and storage. Almost 70% of livestock keepers received extension on feeds, proper feeding, proper milking, livestock fattening, disease control, herd size, and pasture establishment. Despite this high access to extension, the service is not consistent throughout the year, primarily mostly due to limited resources. Farmers report variability utility of extension services, and for the large majority, the cost of the services is out of reach. In addition, there are very few extension agents compared to farmers. Incorporating extension with other interventions offers an opportunity to improve accessibility.

Access to climate information is also limited. The Tanzanian Meteorological Agency (TMA) is the sole provider of climate information, which farmers receive through radio transmissions. Some agricultural and environmental programs train farmers on climate. However, the training stops once the projects phase out. The biggest hindrance to the use of climate information is "lack of credibility" of the information. Traditional weather prediction practices sometimes substitute for weather forecasts from TMA, but these practices are largely falling out of use. Provision of timely and accurate information, including forecast-based crop calendars, can enable farmers to plan before the hazards occur. Combining climate information services with other interventions, such as credit and extension, is one option for enhancing the use of climate information in making farm decisions. Tailoring these services and products for women farmers will be critical in achieving maximum outcomes.

The following tables present a mapping of hazards, associated consequences and adaptation options by farmers based on stakeholder opinions. The stakeholders were engaged in a 3-day workshop. In the workshop, stakeholders were asked to select 3 key activities for each of the four value chain stages namely (i) input acquisition, (ii) on farm production, (iii) harvesting, processing and storing, and (iv) marketing. The stakeholders then selected the most profound climatic hazards to these activities, discussed on-going practices (off farm/on farm) and finally proposed potential adaptation options that could scale up farmers' adaptive capacity.

Adapting agriculture to changes and variabilities in climate: strategies across major value chains

Maize	Acquisition of seeds and other inputs	On-farm production	Harvesting, storage and processing	Product marketing
Drought	• Reduced access to improved seed. • Inorganic fertilizer becomes unaffordable, particularly if the previous season was also dry.	• Hardened soil makes tilling difficult. • Delayed weeding increases competition between crops and weeds for water and nutrients.	• Increased occurrence of poor quality grains that break during threshing and are more susceptible to storage pests	• Increased cost of aggregation due to low yield volumes. • Low prices. • Selling is impaired
Magnitude	Moderate	Minor to Moderate	Moderate	Minor to Moderate
Farmer's current strategies to cope with the risks	• Reduce land under maize production. • Limit production to areas with water. • Use of drought tolerant and early maturing varieties. • Use own seed. • Reduce the use of inorganic fertilizers and manure.	• Minimum tillage, delayed land preparation. • Farmers delay weeding to reduce moisture loss. • Intercropping with cover crops such as cowpeas to diversify incomes.	• Use of local structures and sacks for storage.	• Store grain until prices improve. • Sell individually to reduce costs.
Other potential options to increase farmers' adaptive capacity	• Introduction of water harvesting, pit holes, and drip irrigation. • Provision of drought tolerant and early maturing varieties, accompanied with training on use of other inputs. • Fertilizer and pesticide subsidies. • Combination of synthetic fertilizers and manure	• Minimum tillage promotion. • Training on alternative methods of weed control, such as use of herbicides (This should be associated with water harvesting.) • Diversification to other enterprises such as livestock keeping and value addition.	• Use of drying machines. • Use of hermetic bags and/or plastic and metal silos.	• Enhancing entrepreneurial skills. • Establishment of bulk sales mechanisms.
Variable precipitation	• Uncertainty in land, seeds, and fertilizer acquisition, and in how much area to allocate to maize production.	• Delayed land preparation and weeding. • Early maturing varieties rot when unexpected rains fall.	• Delayed threshing and drying. • Rotting of the maize, resulting in fungal infection and contamination with aflatoxins.	• Aggregation is reduced due to low volumes. • Poor quality grains and low volumes deter buyers. • Low volumes and poor quality grains fetch low prices.
Magnitude	Minor to Moderate	Minor to Moderate	Minor	Moderate
Farmer's current strategies to cope with the risks	• Reduction of land under maize production. • Use of local seeds. • Use of early maturing varieties. • Avoid applying fertilizer; it can be washed away by excess rain, or can burn the crop due to lack of moisture	• Plant without proper land preparation. • Delayed weeding • Pulling weeds by hand. • Mixing varieties on the same piece of land (e.g. early maturing and local varieties).	• Leaving the maize in the field until rains subside. • Storing the maize in the kitchen for drying. • Cut and heap the maize on-farm.	• Sell individually at lower prices.
Other potential options to increase farmers' adaptive capacity	• Encourage use of organic manure.	• Promotion of minimum tillage. • Water harvesting and irrigation. • Enhance capacity of farmers to use herbicides, mulching, cover crops, and climate information. • Promote irrigation to enable optimized planting and harvesting times.	• Train farmers to bend the maize to reduce rotting. • Investment in maize drying machines. • Construction of warehouses throughout the district. • Supporting farmers to construct better storage at home.	• Strengthen farmer organizations. • Identify more lucrative uses for low quality maize.

Rice	Acquisition of seeds and other inputs	On-farm production	Harvesting, storage and processing	Product marketing
Drought	• Previous years' drought can also limit purchasing power as a result of poor yields. • Farmers are always risk averse when the weather is not predictable. • Water availability depends on rain. • Storage of the inputs is also a challenge.	• Overgrowth of seedlings in nurseries due to delayed transplanting. • Delay in land preparation. • Hard soils which most farm implements are not able to till. • Delayed weeding, and fertilizer application for lack of water.	• Rice grown during a drought has lower grain quality, and consequently requires more effort to shell. • Low production also increases the cost of packaging and transporting.	• Lack of buyers due to low quality and quantity. • Farmers get low prices for poor quality.
Magnitude	Moderate	Moderate to Severe	Minor to Moderate	Severe
Farmer's current strategies to cope with the risks	• Buying early maturing seed variety. • Collective buying of agro-chemicals. • Hiring farm implements from unaffected areas.	• Reducing the height of seedlings by cutting them a from the tip. • Using machinery for land preparation. • Collective action in completing farm operations. • Application of herbicides rather than manual weeding.	• Drying directly in the sun. • Machine grading the yield. • Sourcing rice from other areas for processing and resale.	• Diversifying rice uses. • Selling at low prices.
Other potential options to increase resiliency	• Enhance access to climate information and early-maturing seed varieties. • Augmenting farmer organization capacity to take collective action. • More fully leverage locally available manure.	• Accurate and timely climate information to inform farmer decisions on planting times. • Promote early maturing varieties. • Strengthening farmer organizations for collective purchase of inputs	• Use of solar energy for drying. • Investing in improved processing plants. • Technology for grading of the available produce	• Formation of more and stronger farmer organizations, cooperatives, and processing plants. • Finding lucrative alternative uses for lower quality rice.
Flooding	• Delayed purchase of seeds due to impassable roads and uncertainties on when floods may subside. • Delay in hiring farm implements and high hiring costs. • Delayed purchasing of agro-chemicals.	• Delayed nursery preparation. • Damage or destruction of nurseries. • Delayed and tedious land preparation, weeding, and fertilizing	• Flooding hinders drying; shelling becomes more tedious. • Floods hinder transporting product. • Low production due to floods also impair packaging by increasing packaging costs.	• Flooded roads limit access to remote areas. • Poor quality rice impedes selling and fetches low prices.
Magnitude	Moderate	Severe	Moderate to Severe	Severe
Farmer's current strategies to cope with the risks	• Use of early maturing varieties and tall varieties that are less easily submerged in water. • Collective action in tilling land "mgowe". • Hiring implements from unaffected areas. • Purchasing in bulk. • Use of local varieties.	• Making nurseries in flood free zone and transplanting to the flooded areas. • Use of minimum tillage. • Foliar fertilizer.	• Outsourcing rice from unaffected areas (traders). • Aggregation from various areas of the district.	• Storing produce during good seasons to meet demand from buyers during floods. • Selling in open-air markets without packaging.
Other potential options to increase farmers' adaptive capacity	• Increased use of improved varieties. • Improving policy, targeting and infrastructure to enhance access to improved seeds for women and men. • Expanding access to affordable credit through savings led financial inclusion (VSLAs) for women.	• Provision of timely and accurate climate information to women and to men. • Improve drainage and irrigation infrastructure. • Enhancing the use of foliar fertilizers, and providing knowledge on the use of the fertilizers to women and to men.	• Promoting the use of solar drying, and conducting further research on optimized rice drying. • Establishment of storage facilities. • Identifying profitable alternative uses and value-addition options for damaged rice. • Technology for grading the rice.	• Enhance formation of cooperatives and farmer organizations. • Building capacity in value addition, e.g. packaging. • Engage in promotion platforms such as advertising.

Sunflower	Acquisition of seeds and other inputs	On-farm production	Harvesting, storage and processing	Product marketing
Floods	• Makes land acquisition difficult, and sometimes expensive. • Damaged roads hinder access to seeds and fertilizer. • If the crop is destroyed, then farmers do not even have seeds from their own farms. • Most of the growing areas do not enjoy good road infrastructure.	• Water-logged land delays land preparation and planting. • Poor germination. • Weeding becomes challenging. • Farmers are unable to use herbicides to control weeds.	• Flooding hinders proper drying of the seeds, thus impairing threshing and winnowing. • Transportation of the seeds becomes difficult due to damaged roads. • Wet seeds hinder milling, and, due to low production, there are insufficient quantities to be milled. • Mills may be damaged by floods.	• Poor quality hinders effective promotion. • Farmers cannot ask for higher prices due to poor quality. • Sometimes buyers need large quantities, which farmers cannot produce.
Magnitude	Moderate	Moderate to Severe	Moderate	Severe
Farmer's current strategies to cope with the risks	• Shifting to growing areas that are not flood-prone. • Recycling seeds when improved ones are not in the market. • Use of manure, or using neither fertilizer nor manure.	• Shifting to flood free zones. • Late planting. Construction of simple drainage structures; • Uprooting weeds.	• Building raised structures for drying and threshing. • Using oxen and donkey carts for transport. • Construction of factories in flood free zones.	• Farmers do not promote or package the product. • Construction of shelves for promotion and storing. • Farmers never sell, and instead construct of slated house (kichanja) to store the produce.
Other potential options to increase farmers' adaptive capacity	• Construction of flood bunds and drainage systems. • Have input outlets easily accessible in all villages. • Supplying additional stock in anticipation of floods.	• Drainage systems construction. • Use of early maturing seeds. • Application of herbicides.	• Construction of raised structures for drying and threshing at scale. • Construction of flood bunds. • Construction of all-weather roads and drainage structures. • Increasing the number of millers constructed in flood free zones.	• Construction of improved drainage structures, markets, and warehouses.
Frost	• Farmers may be unaware of which areas are prone to frost. • Seed scarcity for the farmers who use their own seed. • Fertilizer caking.	• Delays land preparation. • May reduce germination rate of seeds and favor growth of fungus. • Weeds regenerate faster due to high moisture supply.	• Delayed drying slows threshing. • Frost reduces visibility, thus increasing the possibility of accidents and loss of produce. • Poor drying affects processing, which may in turn result in low quality oil.	• Promotion and packaging may become expensive given low production. • Poor quality oil seeds fetch low prices and deter buyers.
Magnitude	Minor	Minor to Moderate	Moderate	Moderate
Farmer's current strategies to cope with the risks	• Hiring land in places less affected by frost. • Shifting to frost-free areas. • Use of locally available seeds. • Replacing synthetic fertilizer with manure. • De-caking fertilizer with stones, which may lower the quality of the fertilizer.	• Wearing heavy clothing. • Working later in the day. • Weeding more frequently.	• Prolonged drying. • Delayed transportation. • Use of small pressers to extract oil.	• Packaging in frost-free areas. • Opting not to promote. • No selling.
Other potential options to increase farmers' adaptive capacity	• Using greenhouses. • Provision of timely and accurate climate information for better planning. • Storing of fertilizers in climate-regulated warehouses. • Promotion of liquid fertilizers.	• Using tractors for land preparation. • Use of frost-resistance seeds. • Use of herbicides.	• Investment in dryers and threshers, especially for poor quality seeds. • Value addition and storage until conditions are good for transportation. • Investment in technologies that can completely extract oil from poor quality seeds.	• Use of modern warehouses to store the produce. • Formation of producer groups to leverage bargaining power.

Tomato	Acquisition of seeds and other inputs	On-farm production	Harvesting, storage and processing	Product marketing
Drought	• High cost of hiring land in wet areas or areas near water sources. • Low seed multiplication. • Low seed purchasing, since farmers are not certain about the weather and the returns. • Reduced pesticide purchase rates given farmer uncertainty as to whether they will plant.	• Soils require more effort to till. • Poor germination and potential need to reseed. • Agro-chemicals, including pesticides, herbicides and fertilizers, are less effective in dry conditions, hence farmers must use more, increasing cost.	• Reduced quantities for processing and transportation implies higher cost per unit. • High temperatures increase perishability. Shelf life is reduced.	• Poor quality product deters buyers and lowers prices. Volumes sold are reduced. • Farmers face the risk of not having buyers. • Farmers and brokers compete for buyers.
Magnitude	Severe	Moderate to Severe	Moderate to Severe	Moderate
Farmer's current strategies to cope with the risks	• Hiring land in more favorable area. • Water harvesting and irrigation. • Reduced purchasing of seed, fertilizer, and pesticides. • Use of traditional pesticides. • Rotational farming.	• Use of manure and mulching to reduce moisture loss. • Timely planting. • Planting drought tolerant varieties. • Use of traditional pesticides such as ash, pepper, and some intercrops.	• Preservation with salt and drying. • Storage in structures with no refrigeration. • Formation of farmer associations for increased bargaining power.	• Using brokers. • Use of media for market information. • Formation of farmer associations.
Other potential options to increase farmers' adaptive capacity	• Introduction of greenhouses and drip irrigation. • Increased use of drought tolerant seeds, particularly among resource-constrained farmers.	• Sub-soiling, water harvesting, and countering to prevent run-off. • Use of improved seeds to enhance germination, particularly for resource-constrained farmers. • Combined use of the traditional methods and chemicals. • Subsidized chemical inputs for most resource-constrained farmers.	• Value addition to other products, such as tomato sauce and tomato wine. • Use of storage facilities with refrigeration. • Packaging in tins and foils that can withstand high temperatures. • Value addition products such as tomato sauce.	• Encourage formation of farmer associations to have collective bargaining power. • Contract farming. • Encouraging farmers to get into production and marketing contracts.
Frost	• Farmers may lack cash flow to purchase inputs in future years as a result of crop failure due to frost. They will also lack seeds to recycle. • Increased purchase of pesticides given that frost offers favorable some pests. Farmers also need more chemicals to prevent the crop from frost	• Reduces labor productivity, resulting in more work needed to complete land preparation. • Low survival rate of seedlings. • Increased use of chemicals against pests, diseases, and the frost itself.	• Low production increases per unit cost of transportation, processing, etc.	• Low prices, low buyer interest, and high competition due to poor quality product.
Magnitude	Moderate	Moderate	Moderate	Moderate
Farmer's current strategies to cope with the risks	• Hire land in frost-free areas. • Minimize inputs. • Use of own seeds. • Use of traditional methods to control pests and diseases. • Farmers with resources use more commercial chemicals.	• Delayed land preparation. • Limited use of crop calendars. • Reseeding. • Increased use of chemicals to prevent diseases. • Resource poor farmers use traditional methods to prevent diseases.	• Use poor quality tomato as feed and/or sell locally (without transporting to markets). They are never stored.	• Sell individually at low prices at farm-gate to reduce costs. Sell to brokers. • Sell collectively.
Other potential options to increase farmers' adaptive capacity	• Research to develop frost tolerant varieties.	• Promotion of minimum tillage. • Use of greenhouses, particularly for resource-poor farmers. • Approaches that combine traditional and modern pest and disease control.	• Provision of improved equipment to farmers to reduce waste. • Use of the spoiled tomato as manure. • Identifying lucrative uses of low quality tomatoes at farm level.	• Encourage farmers to form farmer groups and cooperatives.

Policies for climate change adaptation

Several national documents (policies, strategies, action plans, and guidelines, among others) seek to address climate change in terms of agriculture and the environment. These include the CSA Guidelines (2017), National Agriculture Policy (NAP; revised 2016), CSA Programme (2015), Agricultural Sector Development Programme Phase 2 (ASDP 2; 2016), Agriculture Climate Resilience Plan (ACRP; 2014), and the National Climate Change Strategy (NCCS; 2012)[19].

The CSA Guidelines highlight the status and opportunities for CSA, and priority practices for certain regions in the country. Iringa district is not among the featured regions. The Guidelines also highlight the pertinence of mainstreaming gender equality into CSA. Some of the gender considerations include prioritization of strategies that ease access to credit for women, land ownership, and promotion of CSA practices that can reduce the labor burden on women.

ASDP 2 seeks to sustainably increase productivity, and enhance commercialization of small-scale agriculture. The program also seeks to improve food security and nutrition, enhance gender equality, and mainstream youth into development plans. In addition, the ASDP elaborately highlights the need for improving resilience to climate change and variation through climate smart approaches and CSA. Some of the target areas for CSA highlighted in the ASDP 2 include irrigation, conservation agriculture and integrated soil management. The strategy also addresses pertinent issues regarding CSA such as gender, policy for CSA, collaboration among institutions, and community-based participatory approaches to planning and resource management (URT, 2016b).

Given the role that women play in agriculture, additional policies seek to address challenges in agriculture that are unique to women. Some of the policies include the National Plan of Action (NAPA-2007), National Guidelines for Mainstreaming Gender Related Policies, Plans and Strategies (NGMGRPPS-2012), National Water Policy (NWP-2002) and Environmental Management Act (EMA-2004).Though this is a big step, most of the policies lack clear strategies of addressing the root causes of inequality (Acosta et al., 2016).

Objectives of the NAP include increasing productivity and adaptability of agriculture to climate change through promotion of irrigation, more involvement of the private sector, mainstreaming gender into the development agenda, and redress of road infrastructure challenges.

The NCCS seeks to enhance mitigation through awareness creation on climate change, and streamline climate change interventions with national development plans.

Other relevant policies include the National Environmental Policy (NEP; 2007), the National Forest Policy (NFP; 1998), and the National Land Policy (NLP; 1998, revised 2016).

The NEP does not have a direct link to climate change, though it seeks to address environmental degradation, challenges to access to good quality water, and deforestation. The original land policy of 1998 sought to address encroachment of grazing lands caused by the growing population and expanding crop production area. Gaps in the policy necessitated revisions in 2016. Some of the issues forwarded for revision include access to land and ownership by women, and resettlement of landless people (DiCoTA, 2016).

Despite the presence of these policies, there are no clear strategies of enforcement and implementation at regional and district levels. In theory, all of the above-mentioned policies are enforced at local levels by the relevant ministries with support from President's Office, Regional Administration, and Local Government (PO-RALG). However, awareness about these policies is low among experts and farmers alike; this complicates enforcement.

In addition, a number of by-laws leverage national policies at district level to regulate deforestation, burning of crop residue, cultivating sloppy areas, cultivating wetlands and water sources, and water use rights. The by-laws are equally plagued with weak enforcement. In the interviews, respondents claim that weak enforcement is due to corruption. Furthermore, some of the by-laws conflict. For instance, one government institution gives provision of cultivating 30 meters from a water body bank, while another gives 60 meters. This often results in conflicts among farmers as well as between the respective government institutions.

19 For more details see CIAT; World Bank (2017).

Governance, institution resources and capacity

Several governmental and non-governmental institutions work in agriculture in Iringa. The national institutions include the Ministry of Agriculture, Livestock and Fisheries (MALF); Ministry of Environment (ME); Tanzania Meteorological Agency (TMA); Ministry of Water and Irrigation (MWI); Ministry of Lands, Housing, and Human Settlement Development (MLHHSD); and research institutions such as Tanzania Agricultural Research Institute (TARI).

The MALF, together with research institutions, develop new agricultural technologies, frameworks, and policies. The ministry also promotes CSA approaches, such as improved crop varieties, irrigation, and livestock vaccination. The livestock unit has also supported implementation of a number of programs that focus on capacity building and engagement of marginalized farmer groups. For example, the East Africa Dairy Development Project (EADDP) with Heifer International supports youth entrepreneurship in livestock, enhancing household income through livestock production, management of GHG emissions from livestock, reseeding pastures, and planting trees. MALF collaborates with other ministries, including MWI, in matters relating to land and water management. TMA plays an important role in collation, analysis and dissemination of climate data. However, as most of the government departments in the country, the agency suffers from a deficiency of human resources (numbers and capacity) and modern equipment. For instance, TMA does not have adequate capacity to monitor wind or articulate the occurrence of hazards such as frost.

The local government (PO-RALG), is comprised of district and village councils, and plays an important role in governance. The PO-RALG aids in implementation and dissemination of agricultural technologies and policies. It also acts as a bridge between farmers and the relevant ministries and institutions, in addition to monitoring, evaluating, and providing technical backstopping of CSA activities at the local level. The district council supervises and implements development plans. The village council ensures public participation in the design of government development projects from the grassroots level. For instance, the village councils are responsible for local land use plans[20] and prioritizing development projects for funding, in alignment with national government objectives. Given that all district and village council activities are funded federally, national interests can limit their operations.

Non-government organizations (NGOs) operating in the district include Heifer International, USAID, Vision Fund, Clinton Foundation (CF), Tanzania Rural Urban Development Initiative (RUDI), One Acre Fund, and World Wide Fund (WWF). Community-based organizations include Iringa Civil Society Organization (ICISO) and Mazombe Mahenge Development Association (MMADEA) among others (Foundation for Civil Society, 2017). Institutions from the Consultative Group on International Agricultural Research (CGIAR) centers working in Iringa include CIAT and the International Institute of Tropical Agriculture (IITA). Institutions of higher learning are also involved in climate change issues in the district, including Ardhi University and Sokoine University of Agriculture.

USAID supports a number of projects focusing on resilience in Iringa. The projects' focus areas include cereals, youth, women, and fruits and vegetables. The cereals project NAFAKA[21], implemented by partners such as RUDI, IITA, CIAT and *"Mtandao wa Vikundi vya Wakulima Tanzania"* [22] (MVIWATA), seeks to improve livelihoods through promoting value addition by processors, facilitating linkages between farmers and markets, enhancing nutrition through bio-fortification, and trainings and demonstrations on demonstration plots. The project also seeks to promote use of improved varieties.

The fruits and vegetables project aims to link farmers to markets, and increase productivity through use of CSA practices such as drip irrigation. World Wide Fund for Nature (WWF) is also implementing a number of projects, including the Ruaha River project, the Ruvuma landscape program, and SAGCOT. The organization is transitioning to landscape projects with the aim of holistically solving resource management and agricultural issues. The approach is anticipated to attract more expertise, avoid duplication of effort, and increase impact.

20 The village councils play an important role in the Land Tenure Assistance project funded by USAID.
21 This is Swahili for cereals.
22 Mtandao wa Vikindi vya Wakulima Tanzania is Swahili for National Network of Farmer groups in Tanzania

Despite the strong presence of institutions addressing challenges posed by climate change on agriculture in the district, a number of factors weaken their capacity for successful implementation of CSA strategies. Coordination and collaboration is a major challenge. This is mostly due to fear of competition among organizations, lack of resources for convening various stakeholders, and weak structures for information sharing. An underlying factor that aggravates this challenge is that each organization has a specific mandate, and approaches to achieving objectives. It can become quite challenging to reconcile these distinct approaches and objectives to achieve a common goal. Another challenge is lack of technical capacity; very few people have received training on climate change and climate risk management. The channels through which funds reach implementing institutions may also hinder operations. Government funding in particular is prone to delay.

Synthesis and Outlook

Iringa district has a huge untapped agricultural potential, yet the effects of climate change currently challenge production. Drought, frost, precipitation variability, and floods affect the entire supply chain. The effects are both direct and indirect; some are specific to input, production, post-harvest handling and marketing stages, while others cascade from the input stage all the way to marketing. Climate models indicate that these issues will continue to worsen in the future.

Low use of inputs such as fertilizer and improved seeds; poor access to finance, extension, and climate information services; low rates of farmer cooperative organization; and use of conventional methods of production exacerbate the problems of low productivity. Addressing these issues through CSA approach can dramatically enhance productivity and resilience, particularly for marginalized and resource-constrained small-scale farmers.

A number of national policies seek to address agricultural and environmental challenges in the district. However, most of these policies are at a national level and do not fully account for regional and district-level contexts. Local by-laws, which seek to leverage these policies, also suffer from weak enforcement. As a result, encroachment of wetlands, deforestation, environmental degradation, conflicts among water users, and other sustainability challenges continue.

Adoption of adaptive strategies is not new to farmers; they employ irrigation, mulching, improved seeds, and intercropping, among others. However, they rely on outdated technologies in implementing these practices, and adoption rates remain low. Most importantly, farmers are rarely, if ever, prepared to implement these adaptive strategies when and where they are needed. Feedback from various stakeholders in the district highlights the potential for integrating new and additional CSA practices into farmers' current adaptive strategies.

Special attention should be given to women, given the role of agriculture in their livelihoods. The policy environment should address salient challenges that women face such as limited access to resources especially land and water, and fair distribution of incomes from agriculture. Though significant progress has been made in mainstreaming gender equality into development plans at both national and district level, a lot is yet to be done. Men dominate in all the value chains, in resource use decision making and marketing, and eventually income control. This predisposes women to higher risk, and deprives them of an adaptive capacity. CSA practices that reduce labor burden, targeted credit, and extension can increase women labor productivity and improve their wellbeing.

Significant opportunity exists for greater collaboration among institutions and formation of synergies across projects. This has potential to reduce duplicative efforts and increase impact. Very few organizations are taking a holistic approach in addressing climate change and agriculture. Current bottlenecks to collaboration include competition among organizations and limited data and information sharing. Addressing these issues could help foster harmonization in climate resilience goals and efforts. There is also need to enhance capacity in the various organizations on climate change and climate risk management and augment human and financial resource access for government institutions.

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Farmer groups

Maize farmer group (Magulilwa), Tomato farmer group (Ibumila), Sunflower farmer group (Kisinga), Potato farmer group (Kiponzelo), Rice farmer group (Idodi).

Annex 1

The table shows percentage of farmers aware of, have used, and used the CSA practices in the last season. The data was collected from 960 farm households in Iringa District in 2018.

Knowledge about, and use of CSA practices (% of farmers)			
CSA practice	Know practice	Ever used practice	Used practice in the last season
Mulching	32	15	7
Terraces	79	58	31
Water Harvesting	16	3	1
Irrigation	95	51	40
Conservation Farming	9	4	3
Organic Manure	97	78	56
Cover Crops	24	17	12
Crop Rotation	36	17	13
Intercropping	95	82	62
Rhizobium Inoculation	2	0	0
Chemical Fertilizer	98	97	76
Raw Planting	98	96	79
Plant spacing	79	75	61
Organic Pesticide	42	27	18
Inorganic Pesticide	95	87	66
Drying	73	62	57
Threshing	85	62	53
Improved Storage Facility	65	45	36
Pest Control	63	59	49
Grading	44	39	34

Annex 2

Working definitions

Drought
A period of abnormally dry weather long enough to cause a serious hydrological imbalance (IPCC, 2014). The dry conditions may be because of a shortage of precipitation during the growing season (agricultural drought), or reduced runoff and percolation (hydrological drought). In this profile, drought refers to all aspects, i.e. dry spells (including late abnormal late start of rain season) that negatively affect normal farm activities such as land preparation, planting, and fertilizer application.

Flood
This refers to accumulation of water over areas not normally submerged, as a result of river or other water body overflows, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods (IPCC, 2014). Iringa District is most vulnerable to river floods, and flash floods in both urban and rural areas.

Frost
Refers to formation of ice crystals on surfaces. However, frost is also commonly used to refer to associated injury (without ice formation on leaf surface) when plant tissue temperature falls below a critical value resulting in an irreversible physiological condition conducive for death or malfunction of plant cells (Snyder and Melo-Abreu, 2005). Iringa district is vulnerable to radiation frost, i.e. frost characterized by a clear sky, little wind, temperature inversion (temperature increases as height increases), and air temperatures falling below 0°C while day temperatures remain above 0°C. This is unlike advection frost, which occurs when night and day temperatures fall below 0°C, resulting in the formation of ice. Advection frost is associated with cloudy conditions, moderate to strong winds, no temperature inversion, and low humidity.

High/low temperature
Refers to temperatures significantly above/below the long-term mean temperatures. In this profile, we also take high/low temperature as a subjective measure based on experience of various stakeholders (farmers, livestock keepers, and reseachers).

Improved variety
Refers to varieties (of any crop) that have been bred to be more drought-, flood-, and frost tolerant, high yielding, resistant to diseases, early maturing, and water efficient.

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