Tanzania Country Climate Risk Profile Series

Mufindi District

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Climate Risk Profile
Mufindi District

Highlights

- The agricultural sector significantly contributes to food security, and income generation for nearly 80% of Mufindi's District population.
- Both food and cash crops are extensively grown in the region, with a few farmers involved in livestock production. Maize is the leading food crop while cattle are the main livestock kept.
- Variability in temperature and rainfall are climate change effects that have had a negative impact on the agricultural sector.
- The effects have impacted all actors, and stages of priority value chains i.e. input provision, on farm production, postharvest handling, and marketing.
- Women are more vulnerable to climate change due to the prominent role they play in agricultural production, and due to the various social norms limiting their inclusion and decision-making opportunities.
- Farmers employ both traditional methods (application of aloe vera and neem) and modern adaptation strategies (use of improved seeds and fertilizer) to address climate change. However, the impact on production remains negligible, and yields and income continue to decrease.
- The Tanzanian government, with support from the private sector and NGOs, has played a notable role in fostering agricultural resiliency to climate change through policy formulation, finance intervention, weather forecasting, inputs provision, and capacity support.
- Weak coordination among actors, inadequate finance, and information asymmetry are some of the impediments in the implementation of climate-smart agriculture initiatives.
- Formalization of communication platforms and strengthening linkages between value chain actors would help address these issues for effective implementation of climate change adaptation strategies

Acronyms and Abbreviations

ABEA	Animal Breeding East Africa
ACRP	Agriculture Climate Resilience Plan
AEZ	Agro Ecological Zone
AMCOS	Agricultural and Marketing and Cooperative Societies
ASDS	Agricultural Sector Development Strategy
BRITEN	Building Rural Incomes Through Enterprise
CARE	Cooperative for Assistance and Relief Everywhere
CCAFS	Climate Change Agriculture and Food Security
CIAT	International Centre for Tropical Agriculture
COWSO	Community Owned Water Supply Organizations
CSA	Climate Smart Agriculture
EMA	Environmental Management Act
FAO	Food and Agriculture Organization of the United Nations
HIMA	Hifadhi ya Misitu ya Asili ya Jamii
ICT	Information and Telecommunication Technology
ILRI	International Livestock Research Institute
LEAT	Lawyers' Environment Action Team
MIWA	Ministry of Irrigation and Water
MNRT	Ministry of Natural Resource and Tourism
MoA	Ministry of Agriculture
MoLF	Ministry of Livestock and Fisheries
NAP	National Agricultural Policy
NAPA	National Adaptation Programme of Action
NCCS	National Climate Change Strategy
NEMC	National Environment Management Council
NFP	National Forest Policy
NGO	Non-Governmental Organization
NWP	National Water Policy
PSP	Participatory climate Scenario Planning
RCP	Representative Concentration Pathway
RDO	Rural Development Organization
SACGOT	Southern Agricultural Growth Corridor of Tanzania
SUA	Sokoine Univeristy of Agriculture
TARI	Tanzania Agricultural Research Institute
TASAF	Tanzania Social Action Fund
TMA	Tanzanian Metrological Agency
TNBS	Tanzania National Bureau of Statistics
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
VICOBA	Village Community Banks
VSLA	Village Saving and Lending Associations
WUR	Wageningen University & Research

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

Foreword

The agricultural sector in Tanzania is facing high climatic risks. Frequent and severe temperature and precipitation, recurrent droughts and increased incidences of pests and diseases are some of the climate effects that have been observed. Catalyzed with rising input prices and price volatility, there has been a decline in food productivity and farmer incomes. The natural resources that support agricultural production—including rivers and forests—are also degrading due to extreme climate events. Projections indicate that these trends are likely to worsen in the coming decades, with temperatures increasing by nearly 2.7°C by and 4.5°C by 2060 and 2090 respectively (Irish Aid , 2018). At the same time, both day and night temperatures will become more extreme, and precipitation will begin to vary more dramatically by geographic area.

Smallholder farmers are particularly vulnerable to the effects of climate change because of their low access to the resources needed to adapt to changing conditions. Among smallholders, women are more vulnerable due to their outsized role in agriculture and the social limitations placed on their decision-making and inclusion. A lack of coordination and information symmetry between stakeholders have prevented the full implementation of policies aimed at mitigating climate change.

The government, with the support of development partners, has put in place a number of policies, strategies and guidelines to address climate change. The National Agriculture Policy (2013), National Climate Change Strategy (2012), National Adaptation Programme of Action (2007), and the Climate Smart Agriculture guideline (2007) provide a framework for creating agricultural resiliency in the face of climate change.

This Climate-Smart Agriculture (CSA) Profile documents the need for, and adoption of CSA practices at the local level in Mufindi District. This profile is an output of the CSA/SuPER project on Upscaling CSA with Small-Scale Food Producers Organized through Village Savings and Lending Associations (VSLA). The project is implemented by Cooperative Assistance and Relief Everywhere (CARE) International, the International Center for Tropical Agriculture (CIAT) (now part of the Alliance of Bioversity International and CIAT), Sokoine University of Agriculture (SUA), and Wageningen University and Research (WUR).

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

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

Agricultural context

District context

Mufindi District is in the southern part of Iringa Region, bordering Kilolo District to the northwest and Iringa District to the north. The district also borders Njombe Region to the south and Mbeya Region to the west. Mufindi District encompasses 6,710 km^2 of land, of which approximately 10% is covered by water–including the Ruaha River, Kihansi River, Mwenga River, Kihanga Reservoir, Ngwazi Reservoir, and Nzivi Reservoir. The latter three are artificially constructed dams, and are used for tourism, fishing, and electricity generation. Administratively, Mufindi has five divisions: Ifwagi, Kibengu, Sadani, Kasanga, and Malangali. Each of these are further divided into wards, villages, and hamlets[1]. Due to favourable rainfall distribution and fertile soils that support agricultural production, population is concentrated in the highlands.

People and livelihoods

As of 2012, Mufindi District has a population of approximately 265,830, indicating a 0.7% annual growth since 2002. The population constitutes more female (52.6%) compared to men (47.4%). Within the District, Kibengu Division experienced the highest population growth at 1.8% per year, followed by Kasanga Division at 1.2%. Mufundi's population is quite youthful[2], an estimated 44% is below the age of 15 years, nearly 33% is aged 15–35 years, and less than 5% is above 65 years. This implies a young and growing labor force. Nevertheless, there is a higher percentage of young people ages 15–35 in urban areas (41%) than rural areas (32%), likely due to male emigration to urban areas in search of work. Approximately 51% of the Mufindi District population is of working age (15–65). The working age population is also concentrated in urban areas, pushing the district's dependency[3] ratio higher.

Literacy[4] levels within the district sat at 79% in 2012, and had increased by 5% since 2002. Approximately 15% more men than women are literate as a result of limited family funds for schooling, and lower valuation of educated women (UNESCO, 2013).

As of 2012, 63% of the population used metal roofing and only 3% use mud and thatch. Earthen floors were present in 67% of the households. About 44% had baked brick walls, and 32% had sundried brick walls. Over 43% of the population had access to improved water sources. Malangali Division had the best water accessibility at over 73%. In the rural areas, more than 59% of the population had access to clean water.

Mufindi District has road network covering about 1,363km, 57% of these are earthen, 38% gravel, and only 5% tarmac. High quality road networks are important in increasing accessibility of remote area thus facilitating socio-economic activities within an area. This implies limited transportation capacity and, by extension, limited socioeconomic activities, particularly during the rainy season and in remote areas. By 2012, 35% of the district had mobile network coverage. This implies that communication infrastructure is not well developed, thus information dissemination might be challenging for the agricultural actors.

Electricity access in Mufindi is low. Statistics from 2012 show that only 39% of households use kerosene lights, and 95% rely on wood fuel for cooking. Most of the energy is channeled to the productive sectors of the economy. There was a 27% decrease in malnutrition between 2011 and 2015 thanks in part to governmental health programs for vulnerable populations, particularly children.

Agricultural activities

Mufindi District has a rainy season from November to June, with peak rainfall occurring in February and March. Overally, the District has a high altitude, and temperatures around 14°C. Two distinctive agro ecological zones (AEZ) exist in the region:

- The **Eastern Highlands** traverse the southwest and eastern Udzungwa Mountains. The altitude is 1,700–2,200 m above sea level, and average annual rainfall of 1400mm. Temperatures average just under 15°C, and soils are quite fertile.

1 A hamlet is a small settlement which is smaller than a village. They are referred to as "*Vitongoji*" in the local dialect.

2 The government of Tanzania categorizes children as ages 0–14 years, and youth as ages 15–35 years.

3 The dependency ratio is the number of people between 15–64 years economically supporting people aged below 14 years and above 65 years.

4 Literacy in this context is the number of people who can read or write in English, Swahili or any other language.

- The **Mufindi Plateau** covers the other half of the District, from Mafinga to Makambako. The altitude is 1700–2000 m above sea level. Average annual rainfall is approximately 950 mm, and average annual temperatures is around 14°C.

Agriculture employs nearly 80% of the population of Mufindi District, with a significant portion of agriculturalists located in the highlands. The numerous water bodies in Mufindi District enable farmers practice the vinyungu[5] system of production to supplement the food and income generated from rain-fed production (Amos, Majule, Raphael, & Mwalyosi, 2005). Common food crops in the District include maize, sorghum, beans, ground nuts, potatoes, wheat, and tropical fruits. Small scale livestock production is also widespread. Prevalent cash crops include tea, sunflower, pyrethrum, tobacco, and paprika. Ethnicity plays a conspicuous role in Mufindi's agricultural sector. The Wahehe constitute 85% of the population who are engaging in livestock and minority of livestock production. The Wabena and Wakinga, who comprise the remaining 15% of the population, dominating the tea and timber industries.

Land tenure is a primary determinant of farmers' ability to invest in CSA. In Mufindi, 65% of households own the land they inhabit (Finscope , 2017), thanks to affordable land and family inheritance regimes. Notably, a relatively high percentage of women in Iringa Region own land as a result of Mkakati Wa Kuondoa Umaskini Na Kukuza Uchumi Tanzania (MKUKUTA II)[6].

About 92% (568,874ha) of the total district land area is arable, but only 41% is under production. The distinction between food crops for home consumption and cash crops for sale is not always clear—many households sell food crops for complementary income. However, in general food crops are those that are processed and consumed at home or sold locally in informal markets, while cash crops are virtually never consumed at home, and are generally processed for sale in urban areas or internationally. The production area in Mufindi District dedicated to food crops rose steadily between 2011 and 2015, and averaged 205,797ha annually. This rise could indicate decreasing household economic or nutritional security, and a consequent refocusing of resources on meeting basic food needs. Of the food crop production area, maize occupied 78%, bean occupied 21%, and the remaining 1% was primarily occupied by wheat.

Cash crops occupied an average of 13,473 ha of land annually between 2011 and 2015. Sunflower was the major cash crop in the district, occupying 55% (7,342ha) of the total land under cash crop production, and producing an average of 7,342 tons annually. During the same period, tea occupied an average of 43% of cash crop production area and produced an average of 18,475 tons per year, 75% of which was for export (Baffes, 2004). The remaining 2% of cash crop area is primarily occupied by coffee.

The use of agricultural inputs has considerably boosted the yields of crops in Mufindi. The soils are naturally low in fertility, so chemical fertilizer use is common and on the rise. From 2011 to 2015, 16,704,850 kg was used annually. Diammonium phosphate (DAP) accounts for 48% of this total, followed by Nitrogen-phosphate Sulphur (NPS) and Urea at 22% each. Fungicides and insecticides are applied to control crop diseases. There have been efforts to introduce improved seeds, particularly for maize. Improved seed availability varies year-to-year; in 2015, 251,666kg of improved maize seed was supplied to Mufindi District, 57% of which was H-series.

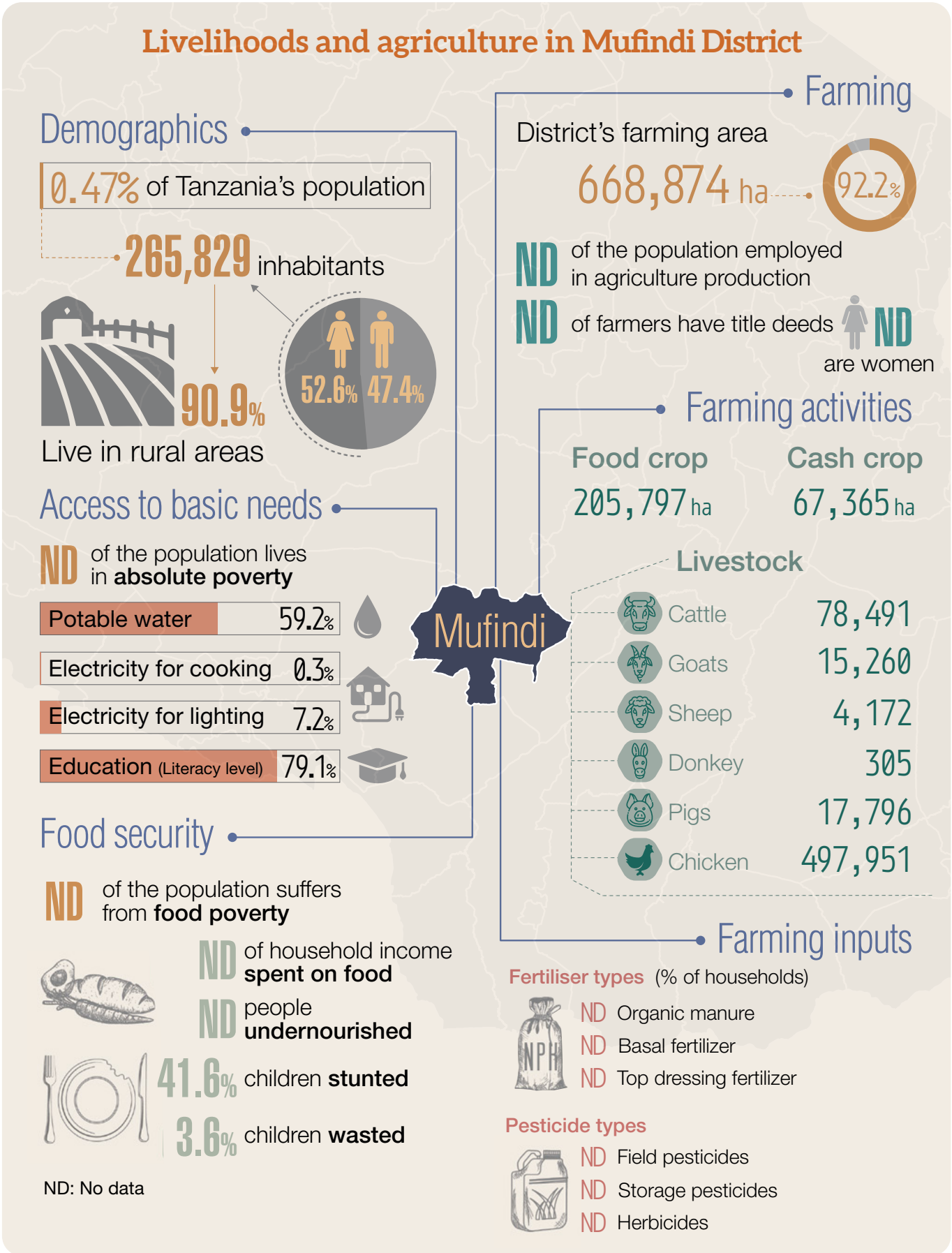
Mufindi has 4,420 ha of irrigable land, of which 1,365 ha (30%) was under irrigation as of 2015. Sadani Ward, which has just 100ha of irrigable land, has fully leveraged its irrigable potential. Manual implements such as ox ploughs and harrows are highly in demand, but supply has failed to keep pace, and deficits are common.

Livestock play a significant role for farming households in Mufindi district. As at 2015, the livestock population in the district was about 614,000. Of this, approximately 498,000 were chicken, 78,500 were cattle, 17,800 were pigs, and 15,250 were goats. Over 90% of cattle and poultry are indigenous species. Swine flu has significantly decreased the pig population in recent years, and the dearth of veterinary personnel in the area has exacerbated the gravity of the situation. As of 2015 there were just 20 livestock officers in the entirety of the district (Table 1).

5 Vinyungu is a traditional farming system in Tanzania practised in valley bottoms or flood plains by smallholder farmers. The practice facilitates production of multiple annual crops since there is only one rainy season in the region thus the area is dry for a better part of the year. In Iringa region, the practice is common in river basins where streams and water catchment areas are found (Kyando, 2007).

6 MKUKUTA is a Swahili words that stands for "Mkakati Wa Kuondoa Umaskini Na Kukuza Uchumi Tanzania", a national strategy for growth for poverty reduction. It outlines priority areas that can be focused on in enhancing economic growth. One of them has been empowering women through access to productive resources such as land

Table 1: Livelihoods and agriculture in Mufindi District



Climate and agriculture context

Historic and future trends

Variation in temperature and precipitation[7] are the two most common climatic risks indicators in Mufindi district. Rainfall variations have led to flooding and erosion, consequently resulting to loss in crops and livestock, thus an inconvenience to agricultural activities. Heat stress emanating from extreme temperatures has had negative impact on the maturity of crops and death of livestock.

Historical data[8] from 1980 to 2015 (Figures 1 and 2) reveals increasingly frequent climate extremes in recent years. Highest (more than 900mm) and lowest (less than 500mm) precipitation rates were observed in 2015 and 2010 respectively during the first season. Rainfall was however constantly lower in most years during the second season. Rainy season erosion risks were highest in 2005, and the longest deluge, lasting 5 consecutive days occurred in 2009. The lowest temperatures were observed in the first season in 1989 and 1993. The year 1987 and 2015 experienced the record-high mean temperature of 23°C in the second season. Average temperatures increased by 0.7°C and 0.6°C in the first and second season respectively, increasing drought risks.

Climatic Projections by CIAT[9] (Figure 3) indicate that the temperature and precipitation patterns are likely persist in Mufindi District in the years 2020–2065. Projections from the climate models[10] show continued increases in average temperatures in Mufindi District, with particularly marked precipitation extremes during the rainy season and particularly marked temperature extremes during the dry season. Given that climatic trends are already hindering the production of essential crops, these predicted trends pose a significant threat to economic and food security in Mufindi District.

Stakeholder perceptions on climate change

Farmers and experts[11] unanimously concur that there have been observable changes in climatic conditions over the past few years, particularly increasing variability and extremes in temperature and precipitation. Delays in onset of the rainy season and droughts have hindered or prevented crop production, particularly food staples such as maize and beans. Floods have eroded soils and damaged crops infrastructure. Extreme temperature fluctuations have brought unprecedented snow, as well as crop and livestock death due to temperature stress. Heat-enabled new strains of pests and diseases affecting humans, animals, and crops. Maize and cattle have been heavily impacted, and there have been increased incidences of malaria among community members. Local water resources have become increasingly limited, particularly along the Ruaha River (D'haen & Nielsen, 2017). These climate changes have exacerbated the vulnerability of smallholder farmers who depend on agricultural productivity for both food and economic security.

Farmers have taken adaptive measures to combat these effects of climate change. Using weather forecasts to plan in advance is a common practice. Farmers with capability invest in inputs such as irrigation equipment, improved seed, fertilizer, and pesticides to improve their climate-adaptive capacity. Some farmers also join Agricultural Marketing and Cooperative Societies (AMCOS) to augment their bargaining power in buying inputs and selling products. Livestock keepers migrate to more favorable areas.

Locals strongly correlate the changing climatic conditions with environmental degradation, and consequently find policies supporting environmental conservation to be the most effective way to respond to climate change. Restrictions on water resource usage and burning vegetation have demonstrated positive impacts over the past several years, and tree planting initiatives have assisted in preserving local forests and river flow. Consistent implementation and enforcement of such policies are prerequisite to their effectiveness.

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7 Precipitation can be defined as water that falls from the sky either in form of snow or rain. The most frequent form of precipitation in Mufindi is rainfall. Precipitation has therefore synonymously been used with the term rainfall.

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

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

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

11 Six experts from veterinary, water/irrigation, and agricultural organizations were individually interviewed. Seven farmer group discussions, each consisting of an average of 8 farmers from 6 value chains, were also conducted. See the appendix for additional details.

Agricultural value chains

The government, NGOs, and the private sector stakeholders assisted in the identifying four value chains[12] discussed in this profile, to represent the spectrum of ecological, social, and economics challenges Mufundi District is experiencing as a result of climate change. In their selection, the stakeholders considered: the production area (ha) under which crops are cultivated, yield (kg), gross margins, women and youth engagement, future and present climate adaptability, percentage of population engaged in the value chains, and the contribution towards poverty alleviation.

The beans, soy, sunflower, potato, sweet potato, paddy, millet, tomatoes, cashew nuts, beef cattle, and poultry value chains were shortlisted for further consideration. Ultimately, bean, maize, avocado, and cattle were selected for further analysis herein (Table 2).

Maize

Maize is a staple food in Mufindi, and the district's climate is favorable for its production. As such, 81–10% of the population produce it for their own consumption, and 1–20% produce it for sale. Although maize occupies the vast majority of food crop production area (77%), it continues to be produced in small-scale systems due to the inaccessibility of smallholder credit and loan services to enable the investments necessary for scaling. Maize is generally intercropped with leguminous crops such as beans; Between the 2011 and 2015, annual production of maize averaged to 385,936 tones. Kiyowela and Ihanu Wards led in maize production at 13% of total district production each, followed by Mapanda Ward at 11% of total district growing area.

Input supply occurs at medium scale, and is restricted by capital availability. The most essential inputs are fertilizer and improved seed varieties. Maize is one of the crops under irrigation in the district. Processing in the district remains small scale due to low investment capital and low production supply. Traders generally operate at medium scale, and sell maize in other deficit regions of the country, as well as internationally (Makombe & Kropp, 2016). Women are key in the maize value chain, they are responsible for agricultural labor—including land preparation, planting, and harvesting—as well as storage, market pricing, and household food preparation. Male household members apply fertilizer, process maize, and create business linkages with buyers and input suppliers.

The major opportunity for developing the maize value chain in Mufindi District is increasing access to capital. This would enable scaling of production, which would in turn catalyze scaling of input supplies, postharvest handling, and marketing.

Bean

Bean is a major food crop in Mufindi District, and is grown for both consumption and sale. An estimated 61–80% of the population is involved in the bean value chain at medium scale. As of 2015 the annual district production was 62,166 tons, accounting for 13.5% of the total food crops produced. In most instances, bean is intercropped with maize to enhance soil fertility (Farrow, 2014). Ihanu, Kiyowela and Mapanda Wards lead in bean production.

Input use in bean systems is minimal, so input supplies remain at a medium scale. Similarly, bean trade functions at medium scale since there is a higher preference for beans as food due to its affordability. There is no evidence of bean processing in the district at any scale. Women are crucial in bean value chains. They acquire seeds, apply fertilizer, prepare land, plant, pack, store, and assist with marketing and sales. Women also prepare household meals, thus controlling bean consumption. Men are solely responsible for applying pesticides. Market promotion and selling of beans is jointly undertaken by men and women. This is because these activities determine the profitability from bean production.

A number of challenges impede development of the bean value chain. Most importantly, the low use of key inputs such as fertilizer and improved seed stifle yields, which has a ripple effect throughout the value chain. Climate change has exacerbated low bean yields with unpredictable, unfavorable weather conditions and increasing prevalence of pest and disease. The Tanzanian Agriculture Research Institute (TARI) is playing a major role in helping improve access to improved bean seed varieties.

Avocado

Avocado is a newly adopted cash crop in Mufindi district. About 21–40% of the population is actively involved in production at a small scale. The crop is new enough, thus its contribution to food security and local economics is yet to be quantified. Also, farmers producing avocado are still very few, and lack surety of

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

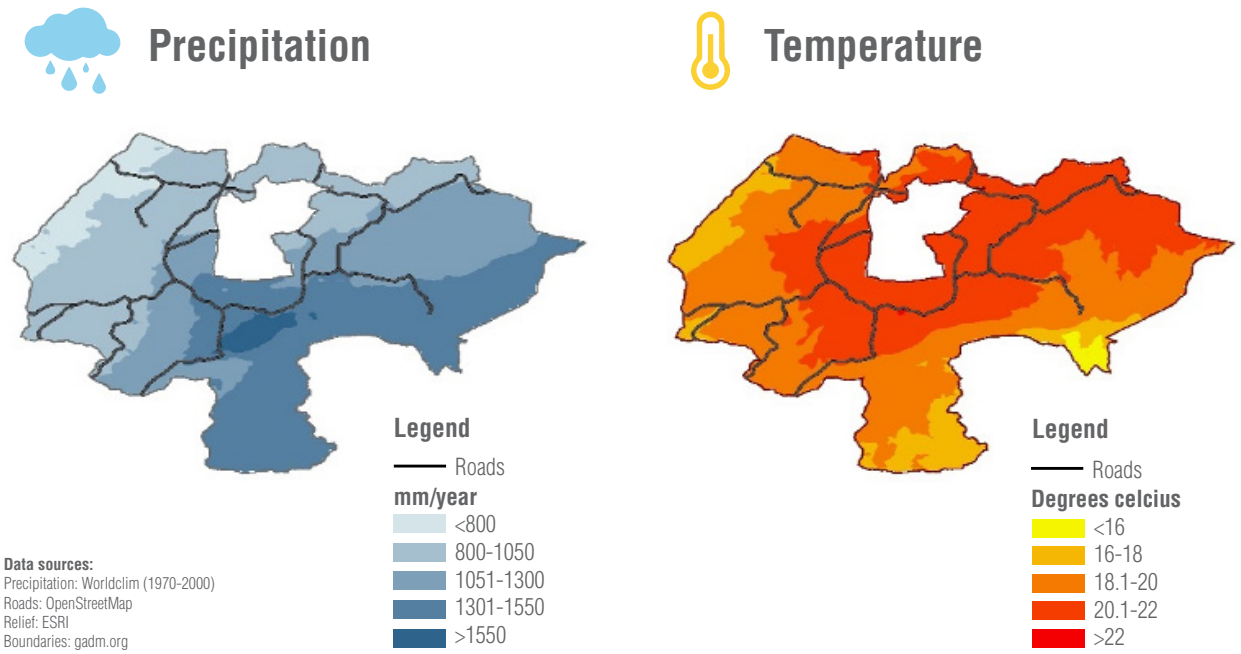

Figure 1: Average Precipitation and Temperature in Mufindi District, 1970-2000

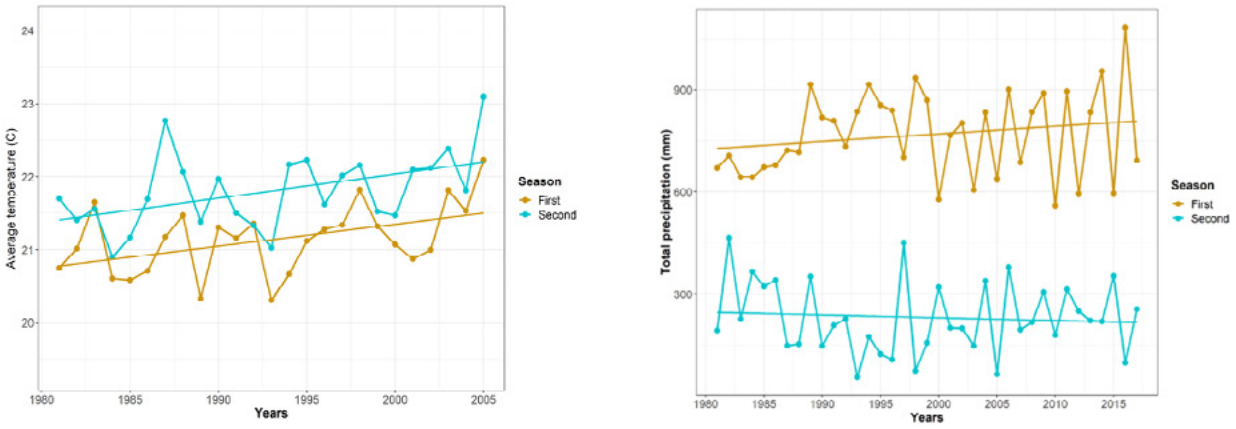

Figure 2: Annual average temperature and total precipitation for first (rainy) and second (dry) seasons in Mufindi District

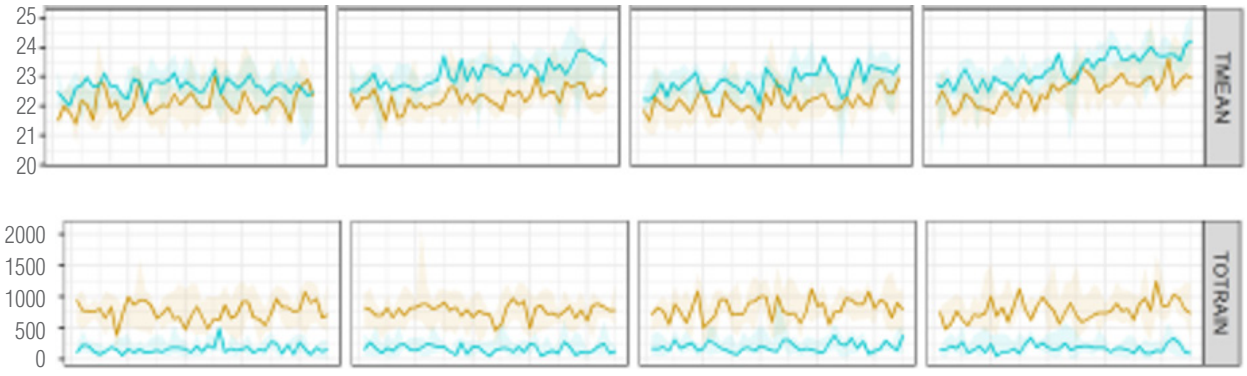

Figure 3: Future precipitation and temperature projections

profitable markets. The bulk of avocado production in Mufindi District occurs in Ifwagi Division.

Similarly, the supply of inputs is at a small scale level due to as yet nascent demands. The sale of avocado is within the district thus is mostly on a small scale. Currently, there are no avocado processing industries in Mufindi District. Since avocado is a new venture, there are many fewer restrictive social norms surrounding it than other value chains. As such, women and men jointly contribute to activities along the value chain such as acquisition of land and capital, land preparation, planting, harvesting, storage, transportation, market promotion, and pricing. Women are the primary sellers of avocado.

The primary opportunity for developing the avocado value chain is clarification of best practices. The crop is new, and hence the value chain remains to be established in many regards. Extension services are particularly crucial for new production systems, as are links to profitable markets. To date, there has been significant support for avocado production. The Village Community Banks (VICOBA) have offered financial services, while the Rural Development Organization (RDO) and Kibidula Farm have built capacity on agronomic best practices.

Cattle

Cattle accounts for 12.8% of the animal population in Mufindi District. Approximately 61–80% of the population of Mufindi engages in production. Cattle are used for draught, milk, meat, and manure, and thus contribute to both food and income security. Over 90% of the cattle in Mufindi District are indigenous; about 8% are dairy cattle, and 1% are beef cattle. Production remains small scale level due to lack of investment capital for scaling, and lack of knowledge of best animal husbandry practices. Low productivity has also been experienced due to scarcity of pasture. Malangali, Sadani and Kasanga Divisions lead in cattle production.

Agrovets are the major input suppliers for the cattle value chain. They provide feed concentrates, medications, and vaccines at small scale. Vaccinations are only administered by veterinary officers. The leather industry is the primary processor in the cattle value chain. Mufindi District produced close to 4,000 hides between 2013 and 2015. Processing of both hides and meat remains at small scale. Cattle traders also operate at medium scale. Women are the primary actors in the cattle value chain; they source for extension and veterinary services, as well as rearing, feeding, and processing cattle. Men on the other hand are responsible for slaughtering, pricing, and creating economics links with suppliers and buyers.

The primary barrier to development of the cattle industry is the difficulty in obtaining inputs, particularly in the face of climate change. Cattle require quite a bit of feed, medication, and vaccines. These needs increase during extreme events such as drought and disease outbreaks. Feed in particular becomes very expensive and difficult to obtain—in part due to poor transportation networks—as extreme heat and drought decreases pasture availability. Similarly, costly cooler boxes become necessary for meat and milk products during heat waves.

The International Livestock Research Institute (ILRI), Heifer International, and the Mufindi District departments have significantly supported development of the cattle value chain through genetic improvement, livestock feed optimization, and vaccination services.

Challenges in agriculture

As previously discussed, climate change impacts have increased production costs and reduced output, creating a vicious cycle of reduced income, lowered ability to invest in production systems, and growing food scarcity among vulnerable households. The most vulnerable households, such as those with low literacy rates and income, are disproportionately affected.

Mufindi District farmers are challenged by lack of decision support services. Precipitation forecasts are currently the primary source of information available. However, there is a lack of recommendations regarding how to respond to the fluctuating conditions. Without any better option, farmers stick to their traditional cropping calendars, which are equally unreliable. There is also a significant shortage of extension agents and veterinary personnel. In the absence of sufficient government extension services, private extension services have proliferated. However, the current policy environment is not favorable for the expansion of private services (Kwileja , 2014). Several development partners have offered CSA trainings, and the trained farmers feel more prepared to confront climate and environmental issues.

Training increases farmers' knowledge, but it does not provide them the capital needed to make a change in their practices (Dekens & Bingi, 2014). Approximately 62% of Mufindi District inhabitants have access to mobile finance lending (Finscope, 2017) and VICOBA.

However, the portion of farmers, who are often resource-restricted, are still without solution. Those who do have access to credit are often obliged to use it simply to maintain, rather than innovate, their current practices. In some cases, farmers have attempted to adapt with the limited resources available in ways that could have long-term negative consequences. For instance, while CSA generally recommends diversification as a mechanism for distributing risk, farmers may move away from diversification to focus all of their resources on a single product in an attempt to improve productivity and earnings. In the case of a drought, flood, pest, or disease that cripples this production system, the household experiences extreme food and economic insecurity. The national government and development partners are the main financiers of climate change initiatives, but there is still need to facilitate more financing options.

Infrastructure development is also greatly needed in Mufindi District. The district has majorly one rainy season, which has been significantly impacted by climate change. Irrigation acts to largely unlink day-to-day crop survival from the increasing vagaries of rainfall. Currently, only 30% of irrigable land is under irrigation. There is significant untapped potential for irrigation canals infrastructure in Mufindi District. Canals would also help divert heavy rains away from roads and decrease soil erosion. Currently, the road network is of poor quality and becomes impassable during heavy rain. This makes timely movement of produce to market almost impossible and extremely costly. As transaction costs increase, farmer profit decreases. Draught animals and motorcycles are popular alternatives for moving produce, but inherently limit economies of scale. In the case of cattle products, the issue is compounded by the need of costly coolers for milk and meat, and water and food for live animals. Cattle frequently die during transportation. Unreliable markets and compromised product quality may mean that farmers encounter low prices or a lack of buyers upon arrival. Farmer groups and associations have addressed these issues to some extent with bargaining power, but infrastructure continues to act as a bottleneck.

Climate vulnerabilities across agricultural commodity value chains

Subsistence rural farmers, particularly poor households, are the most directly affected by climate change. They therefore tend to exploit their surroundings to sustain their livelihoods. The impacts on producers has a ripple effect across the entire value chain, negatively affecting input dealers, processors, traders, and consumers, each in different ways (Rhiney & Ajayi ,2018).

Four main climatic risks[13] (Table 3) showed clear patterns of impact across all four of the highlighted value chains. These climatic risks consequently cause other risks as highlighted;

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

13 A risk is the likelihood of the unfavourable effects of climate impacting farmers when exposed to climatic variabilities such as floods, drought and frost (Barlow et al., 2015).

Table 2: Value chain characterization

% of people engaged in the value chain	Types of actors engaged in Value Chain			
Maize	S M	F S	P S	M M
81-100 %	Importance of women and youth in the value chain: High			
	Key Activities	Key Activities	Key Activities	Key Activities
	Purchase of seed	Land preparation	Processing	Market promotion
	Purchase of inorganic fertilizer	Planting seeds	Storage	Linkage to buyers
	Purchase of pesticide	Harvesting	Transportation	Pricing
Bean	S M	F M	P ND	M M
61-80 %	Importance of women and youth in the value chain: Very High			
	Key Activities	Key Activities	Key Activities	Key Activities
	Purchase of seed	Land preparation	Packaging	Pricing
	Purchase of inorganic fertilizer	Planting seeds	Transportation	Promotion
	Purchase of pesticide	Spraying pesticides	Storage	Selling
Avocado	S S	F S	P ND	M S
21-40 %	Importance of women and youth in the value chain: Medium			
	Key Activities	Key Activities	Key Activities	Key Activities
	Land acquistion	Land preparation	Collection	Product promotion
	Extension advice	Planting	Storage	Pricing
	Financial capital	Harvesting	Transportation	Selling
Cattle	S S	F S	P S	M S
61-80 %	Importance of women and youth in the value chain: High			
	Key Activities	Key Activities	Key Activities	Key Activities
	Extension advice	Feeding	Slaughtering	Selling
	Purchase of feeds	Deworming	Milk processing	Linking to buyers
	Veterinary services	Vaccination	Transportation	Pricing

Conventions

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

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

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

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

Crosscutting issues


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Agricultural production in Kilolo District is highly Reliable input markets—both in terms of supply and price—are currently lacking in Mufindi. As climate change impacts become greater, the cost of upholding the status quo increases. Inputs, tools, and labor run in short supply, and are subject to significant price increases. Farmers are left to use limiting, relatively ineffective traditional techniques, such as hand tools and herbal remedies. Vulnerable households are the first to be priced out of the inputs markets, thus perpetuating a cycle of poverty. As of 2015, there was an estimated 38% shortage in the supply of mechanized farm equipment, which dramatically reduces labor expense and drudgery, and expedites land preparation during narrow times windows. The demand for fertilizer increased nearly by 7% between 2018 and 2019; only 66 and 73% of Diammonium phosphate (DAP) and Urea demand was met respectively. This is a clear indication of fertilizer shortage in the district. Improved seed varieties, fertilizers, veterinary services, and drugs and vaccines for cattle have proven equally difficult to acquire. In the case of pesticides, farmers use traditional herbs (such as neem, pyrethrum and aloe vera) as a coping strategy for pests and diseases.

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

Importantly, it also means that women are at the forefront of making daily decisions in terms of natural resource and agricultural management in the face of climate change (Sikira & Kashaigili, 2016). Closing the gender gap would dramatically shift Mufindi District's economy (Patil & Suresh Babu,2018).

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

	Maize 	Bean 	Avocado 	Cattle 
Primary Climactic Threats	• Drought • Delay in onset of rainy season	• Frost • High temperature	• Frost • Drought	• Drought • High temperature
Key Inputs	• Seeds • Fertilizer • Pesticides • Land	• Fertilizer • Seeds • Pesticides • Land	• Land • Fertilizer • Seeds • Pesticides	• Feed • Vaccines • Medication
Key Input Constraints	• Lack of decision support in input selection • Increasing input costs • Inadequate time for input preparation when rainy season becomes unpredictable	• Increasing input cost • Lack of decision support in input selection • Reduction in viable land	• Reduction in viable land • Increasing input costs	• Increasing scarcity and costs of inputs • Cattle management is difficult
Key Production Constraints	• Increased labor cost for land preparation, controlling pests, harvesting • Delay in planting and land preparation • Increased pest incidences reduce yield and quality	• Increased labor cost for land prep, controlling pests, harvesting • Diseases such as seed rot	• Increased labor cost for planting and controlling pests • Decreased fruit quality	• Increased labor cost for disease control • Increased need for vaccines and medications • Low meat and milk production
Key Post-harvest Constraints	• Increased cost of processing, storage and transportation • Infestation by storage pests	• Delayed bulking • Increased cost of harvesting • Difficulty in storage and transportation	• Rotting of fruits • Increased storage costs • Difficulty in transportation	• High water requirements • Death of cattle • Unfavorable conditions for milk and meat processing • Difficulty in transportation
Key Market Constraints	• Difficulty in identifying buyers • Higher promotion costs • Lower market prices	• Lower market prices • Higher promotion costs	• Artificially low prices • Difficulty in product promotion • Poor linkages to buyers • Heavy reliance on middle men	• Difficulty in product promotion • Price fluctuation • Unreliable supply
Key Structural and Social Constraints	• Poor access to affordable inputs • Poor infrastructure	• Poor access to credit • Poor infrastructure • Poor access to affordable inputs • Low institutional support	• Poor access to credit • Poor infrastructure • Poor access to affordable inputs • Low institutional support • Poor land use planning	• Low institutional support • Conflicts over shared resources

Adaptation Strategies

Potential CSA strategies

A number of strategies have been identified in the CSA Guideline[14] (FAO, 2017) that could be applied at the farm level to increase the climate resiliency of agriculture in Mufindi District. These include:

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

Many farmers in Mufindi District are already employing some of the aforementioned technologies and practices, although in many cases not to the extent necessary to foster true climate resiliency (Table 4). Some of the most common practices include:

- **Integrated soil fertility management:** Farmers enhance soil fertility by using fertilizer, and animal, and farmyard manure. Cattle production is a major source of animal manure
- **Soil and water conservation:** Construction of drainage canals, water troughs, and rain water harvesting during the rainy season
- **Irrigation:** Particularly drip irrigation
- **Conservation Agriculture:** Particularly crop residue mulching, intercropping and crop rotation.
- **Good Agronomic Practices:** Including proper spacing, timely management, improved seed varieties, and shed construction for cattle.
- **Improved livestock breeds:** Few farmers in Mufindi have access to genetically improved cattle, or the relevant training in best management practices.
- **Climate information services:** Precipitation forecasting is readily available from the TMA, but farmers also get information from trainings, and newspapers, radio, and programming such as CARE International's participatory climate scenario planning (PSP)[15].

Farmers agree that CSA strategies, including optimized inputs, improved seed, robust extension services, and strong market networks would create agricultural climate resiliency. Stakeholders concur that government intervention is needed to establish such larger-scale enabling environments. In the meantime, farmers' ability to implement these strategies is minimal and dependent on their available resources during any given season. Despite best efforts to employ these strategies, farmers are still encountering low yields and losses, which reduces their ability to continue such adaptive practices in the future. Consequently, other suboptimal practices are still in use.

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

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

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

Maize	Input acquisition	On-farm production	Harvesting, storage and processing	Product marketing
Drought	• Increased input costs due to high demand of fertilizer, seeds and pesticides	• Increased labor needs • Reduced plot size due to increased inputs and labor • Difficulty in planting • Low maize production	• High processing cost • High cost of storage due additional material requirements • High cost of transportation	• Decreased demand due to decreased purchasing power • Low prices for maize
Magnitude	Moderate to Severe	Moderate to Severe	Moderate	Severe
Current coping strategies	• Formation of groups to buy in bulk • Use of manure fertilizer • Joining Savings, credit and cooperative groups • Use of traditional pesticides	• Reducing plot size • Farmers jointly cultivate land rotationally • Using crops to pay labor instead of cash	• Farmers reduce amount of maize processed • Use animals for transportation	• Collecting maize in one center • Use of barter system • Value addition to increase price
Other potential strategies to increase resilience	• Use of improved seed varieties • Conservation agriculture • Integrated soil management • Improved pesticide accessibility	• Proper land preparation, spacing, and harvesting methods and timing • Practice joint land rotationally	• Low-tech processing machinery • Innovative storage techniques and structures • Improvement of the feeder roads	• Marketing cooperatives • Government provide a pricing mechanism
Delay in onset of the rainy season	• Lack of decision support for input selection • Narrow window for management activities • Increased cost of pesticides	• Increased labor costs • Delay in planting • Delay in harvesting • Increased exposure to pests and diseases	• Increased cost of processing • Increased storage costs • Increased transportation costs	• Low supply precludes bulk sales • Poor quality of maize • Decreased demand and purchasing power
Magnitude	Moderate	Moderate	Moderate	Moderate to Severe
Current coping strategies	• Drought resistant varieties • Use of farmyard manure alone • Use of traditional pesticides	• Farmers jointly cultivate farms rotationally • Timely harvesting to avoid pests	• Reduce quantity of crops processed • Improvised pesticides for storage • Use animals for transportation	• Collective marketing • Adding value to crop to increase price
Other potential strategies to increase resilience	• Use of early maturity seed varieties • Improve accessibility of inputs e.g. through subsidies	• Mechanized farming • Early planting	• Low-tech processing machinery • Improved storage and road infrastructure • Timely harvesting	• Government provide a pricing mechanism

Bean

	Input acquisition	On-farm production	Harvesting, storage and processing	Product marketing
Frost	• Lack of decision support for input selection • Increased fertilizer costs	• Increased labor costs for land preparation • Seed rot • Difficulty in spraying	• Delayed bulking • Risky transportation • Difficulty in storage	• Low quality produce • Decreased demand and purchasing power
Magnitude	Moderate to Severe	Moderate to Severe	Moderate	Moderate
Current coping strategies	• Use of improved seed varieties • Use of mulching and organic fertilizer	• Use of crop calendar • Delaying land preparation • Use of sticky material to control pests	• Increase labor force • Use weather forecast • Have storage facilities within farm • Use of pit bags and grain cribs	• Value addition through grinding and grading
Other potential strategies to increase resilience	• Seed preservation • Increase input accessibility e.g. through subsidies • Plastic mulching	• Use of tractors in land preparation • Use of weather forecast • Lab seed treatment	• Introduce machines for bulk processing • Use of storage silos	• Establishment of AMCOs • Promotional materials • Selling through auctions
High temperature 	• Reduced seed viability • Increased incidences of pests	• Difficulty in land preparation • Delay in planting • Delay in spraying	• Early bursting of pods • Transportation risks • Difficulty in storage	• Poor quality of produce • Lower demand and purchasing power
Magnitude	Moderate	Moderate	Minor to Moderate	Minor to Moderate
Current coping strategies	• Use of local seeds • Use of organic manure • Mulching	• Use of weather forecast • Use of crop calendar	• Use of available storage facilities • Use sisal bags for storage	• Grading of beans • Showcasing samples
Other potential strategies to increase resilience	• Input subsidies • Use of hybrid seeds	• Use of green houses • Fumigation	• Climate-controlled warehouse infrastructure • Use of machines for bulk processing	• Establishment of agricultural AMCOs • Promotional materials • Use of market information systems

Avocado

	Input acquisition	On-farm production	Harvesting, storage and processing	Product marketing
Frost	• Lack of decision support for input selection • Increased fertilizer costs • Increased pest and disease incidence	• Increased labor costs for land preparation • Seed rot • Difficulty in spraying	• Delayed bulking • Transportation is risky • Difficulty in storage	• Low prices due to poor quality • Decreased demand • Promotion is restricted
Magnitude	Moderate to Severe	Moderate to Severe	Moderate	Moderate
Current coping strategies	• Renting land • Attending seminars and workshops • Information from newspapers and radio • Loans from village community bank • Selling property for capital • Use pyrethrum as herbicide	• Spot digging and robust weeding • Planting legumes for fertility • Use of family labor • Plot size reduction • Mixed cropping systems	• Packaging in plastic satchels (virobas) • Boiling avocados before storage • Forming village groups for collection • Use of animals for transport	• Lobbying and communication • Giving samples as promotion • Selling at low prices
Other potential strategies to increase resilience	• Demonstration plots • Use of improved seeds • Improved finance services for inputs and machinery	• Timely planting • Skilled labor to support decision making	• Provision of quality harvesting and collection equipment • Provision of skilled labour • Climate-controlled trucks	• Collection centers • Quality standardization • Labelling of fruits • Promotional materials • Streamline government processes
Drought	• Decrease in land value • High extension costs • High capital requirement • Increased fertilizer use	• High cost of land preparation • Reduced yields	• High cost of harvesting • Low yield/high postharvest loss • High costs of storage and transportation	• Low product quality • Low demand • Low marketing price
Magnitude	Moderate to Severe	Severe	Severe	Severe
Current coping strategies	• Construction of drainage canals • Use of drip irrigation • Information from newspapers and magazines • Attending technical seminars • Loans from VICOBAs • Selling property for capital	• Agroforestry • Spot digging and weeding • Use of pyrethrum as herbicide • Planting legumes to enhance fertility	• Family harvesting • Farmer group collection • Packing avocados in plastic satchels (virobas) • Boiling avocados to extract juice • Use of animals for transportation	• Giving samples to consumers • Lobbying • Reduce price of fruits
Other potential strategies to increase resilience	• Allocate land for avocado production • Improved accessibility of extension services • Subsidize improved seed • Use of manure • Permanent water sources for irrigation	• Improved accessibility of machinery e.g. tractor • Use of green houses • Use of weather forecasts • Timely planting • Investment in avocado by NGOs	• Proper harvesting tools • Farmer groups • Construction of storage facilities • Skilled labor for packaging • Improve road infrastructure • Fruit transportation vans	• Formation of collection centers • Labelling • Advertisement on radio and Internet • Streamline government processes • Government regulation of imports and price fluctuations • Promote export

Cattle

	Input acquisition	On-farm production	Harvesting, storage and processing	Product marketing
Drought	• Increased water and pasture requirements • Increased costs of vaccines and drugs • Increased costs of veterinary services	• Lack of nutritious feed • Disease outbreak • Starvation of cattle	• Low production of meat and milk • Poor quality of milk and meat • Death of cattle during transportation	• Low price of products • Low buyer demand • Oversupply of products
Magnitude	**Moderate**	**Minor to Moderate**	**Moderate**	**Moderate**
Current coping strategies	• Rain water harvesting • Crop residue preservation • Use of local herbs (neem, aloe vera) to treat diseases • Improved breeds • Use of leguminous forage crops and concentrates	• Use of herbs e.g. aloe vera • Use of concentrates • Rotational grazing • Destocking	• Use of feedlots • Water trough construction	• Cattle fattening for a specified period with concentrates, minerals, silage, and hay
Other potential strategies to increase resilience	• Dam construction • Improve vaccine accessibility e.g. through subsidies • Conservation of water catchment areas	• Improved diet such as hay and silage • Drought monitoring • Cattle health management reforms • Soil fertility management for improved pasture quality	• Improved disease vector surveillance • Establishment of small milk processing plant • Protection of economic infrastructure	• Exemption of tax payment • Leather making
High temperature	• Increased cost of extension services • Increased feed requirements • Increased costs of vaccines and medications	• Low productivity • Increase disease incidences • Starvation and death of animals	• Bacterial infestation of fresh meat • High cost of storage • Low milk processing • Difficulty in transportation	• Low product quality • Decrease in sale price • Low demand
Magnitude	**Moderate**	**Moderate**	**Moderate**	**Moderate**
Current coping strategies	• Shed construction through agroforestry • Use of vaccines • Use of hay, silage and crop residues • Use of herbs • Use of supplements	• Rotational grazing • Zero grazing • Use of extension advice • Water trough construction	• Use of freezers and cool boxes • Use of preservation bags • Use of motorcycles	• Use of mobile phones
Other potential strategies to increase resilience	• Drought resistant fodder varieties • Strengthen research and development • Improve medication accessibility • Strengthen animal health infrastructure	• Climate change adaptation training • Diversification of feed • Disease surveillance • Monitoring weather conditions • Environmental management	• Use of freezers • Provision of motor cycles • Construction of slaughter slabs	• Development of economic infrastructure e.g. open small markets

Policies for climate change

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

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

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

The CSA Guideline (FAO, 2017) was designed to transform Tanzanian agriculture into a climate smart sector by the year 2030. The guideline seeks to inform policy makers, guide stakeholders, create awareness, underscore the risks associated with climate change, and offer a framework for monitoring the implementation of CSA practices. Since its inception, the CSA Guideline has offered a platform for the implementation of CSA initiatives by various stakeholders with an emphasis on cost effective, integrated approaches to on-farm solutions.

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

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

Tanzania has a stable policy framework to address climate change, and the country has made significant resource investments in the same. Nevertheless, there has been negligible impact since the implementation of the earliest policies. Inadequate implementation and enforcement is a recurring policy challenge. Even following decentralization of implementation activities, stakeholder coordination continues to hinder progress at various administrative levels. Even small village committees are challenged by bureaucracy in activities such as establishing natural resource management guidelines. Proper coordination mechanisms and effective planning between all stakeholders would help ensure policy effectiveness at all levels.

Governance, institution resources and capacity

Mufindi's agricultural sector is supported by a number of public and private sector organizations. The government is primarily represented by the Ministry of Agriculture (MoA) and the Ministry of Livestock and Fisheries (MoALF). In coordination with Tanzania Agricultural Research Institute (TARI), the government ministries conduct research on improved crop and livestock varieties and disseminate knowledge on best agricultural practices. The Ministry of Natural Resource and Tourism (MNRT) offers support on management and protection of environmental resources that facilitate agricultural production. Similarly, the Ministry of Water and Irrigation (MWI) ensures the sustainable management and supply of water resources. The Tanzanian Meteorological Agency (TMA) plays a major role in providing weather information.

There has been marked governmental decentralization in terms of climate change adaptation in Mufindi (Mniwasa & Shauri ,2001). The Division of Environment (DoE) under the Vice President's Office was mandated to coordinate environmental issues, including climate change adaptation and mitigation. This effectively gave the district government the jurisdiction to implement national policies at a local, practical level. Since 2007, the district government operates as three departments [16]: the Natural Resources, the Community Development, and the Planning Departments.

This decentralization has given Mufindi District the capacity to manage climate change issues through government-supported programs in partnership with development partners and NGOs. For instance, the Tanzanian National Bureau of Statistics (TNBS) provides data to elucidate which areas within the district are in greatest need of support and CARE International both provide seasonal climate forecast through participatory scenario planning, wherein households explore potential climate changes and consider optimal responses. The Tanzania Social Action Fund (TASAF) provides tree seedlings.

Campaigns on environmental conservation and management are also widespread and well-supported. Multiple organizations work with the Natural Resources Department to provide training on integrated water management, reforestation, and conservation agriculture. These include Lawyers' Environment Action Team (LEAT), Hifadhi ya Misitu ya Asili ya Jamii, Mufindi Water Department, and Building Rural Incomes Through Enterprise (BRITEN). Organizations such as Halali, Unilever, Del Tree, and Misitu Sao Hills provide training on environmental management. Panda miti kibiashara promotes agroforestry for income generation and environmental benefits.

The four value chains highlighted in this review have also received support in terms of CSA strategies. Heifer International and the International Livestock Research Institute (ILRI) are longstanding partners of the cattle sector, offering support in terms of feed optimization, vaccinations, and genetic resources. Kisolanza Farm, Kibidula Farm, and Rural Development Organization (RDO) offer capacity building for most crop value chains through practical farm demonstrations. Organizations such as the International Center for Tropical Agriculture (CIAT) (now part of the Alliance of Bioversity International and CIAT), Food and Agriculture Organization (FAO) and Animal Breeding East Africa (ABEA) provide CSA information sharing platforms such workshops, reports, and seminars.

The International Centre for Tropical Agriculture, CARE international, Sokoine University of Agriculture, and Wageningen University & Research have implemented joint research and development programs in Mufindi District, including the CSA/SuPER Project, under which this document has been produced.

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

Financial access is also a major determinant in CSA strategy implementation. Smallholder farmers have dedicated a huge percentage of their limited assets to addressing the impacts of climate change. The Ministry of Finance (MoF) is responsible for financing development initiatives, but budgeting for such efforts has been unreliable for the past several years. Partners such as the Japan International Cooperation Agency (JICA), the Southern Agricultural Growth Corridor of Tanzania (SACGOT), TASAF, and the National Environmental Management Council (NEMC) have also provided crucial financial support. Village Community Banks provide small agricultural loans. Still, limited financing remains an impediment, and additional budget allocations are needed to implement the recommended strategies. Sustained public financing alongside the current private sector initiatives will be necessary to effectively implement CSA on the long term.

Synthesis and outlook

Climate trends indicate increasing frequent and extreme temperatures, precipitation, and drought events will impact Mufindi District. Farmers are faced with myriad challenges and high risk exposure, and productivity is in decline, trapping smallholders in a cycle of poverty. Here we showcase the extent to which these changes will impact four priority value chains in the district: maize, bean, avocado, and cattle.

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

Effective strategies must be put in place to foster agricultural resiliency in the face of climate change. There is significant untapped potential for jointly increasing productivity as well as the resiliency of Mufindi farmers to climate change. At present, farmers are limited to coping strategies within reach of their very limited time and financial resources as they struggle to maintain their livelihoods. Finance services tailored to smallholders, agricultural weather services, robust extension services, improved seed, accessible inputs, irrigation and postharvest infrastructure, and healthy market linkages are just a few examples of the opportunities at hand.

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

The national government, in collaboration with development partners, has set forth policies to address climate change. Some of these policies acknowledge the key gender issues that have hampered CSA best practices. Nevertheless, as a whole, the implementation of these policies has been inconsistent, with poor coordination and information sharing between actors. Consequently, many issues persist, and overall impact remains in question. Governmental decentralization has given Mufindi District has remarkable institutional capacity to implement CSA. However, close coordination is needed in order to fully leverage this important opportunity to implement the recommended CSA initiatives at the household level in Mufindi District.

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Acknowledgments

This profile is an initiative of CARE International Tanzania, Wageningen University Research (WUR), the International Center for Tropical Agriculture (CIAT) (now part of the Alliance of Bioversity International and CIAT), Sokoine University of Agriculture (SUA), and the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS). It is part of the project CSA/SuPER: Upscaling CSA with Small-Scale Food Producers Organized via Village Savings and Lending Associations (VSLAs). This project is co-funded by NWO-WOTRO Science for Global Development under the Global Challenges Program, the European Commission through IFAD under the 'Building livelihoods and resilience to climate change in East & West Africa', and CCAFS." The authors accept sole responsibility for the contents of this report. The report does not necessarily reflect the views of the European Commission or IFAD.

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The document has been developed under the coordination of Evan Girvetz (CIAT), Haki Pamuk (WUR) and Blandina Karoma (CARE International Tanzania) with technical leadership of Tumainiely Kweka (CARE International Tanzania).

Special thanks to the following for providing information

Institutions

Mufindi District Council – Departments of Agriculture, Water and Irrigation, Livestock and Fisheries, Natural Resources and Environment, Planning, and Community Development; Tanzania Social Action Fund, and Private Forest Program

Farmer groups

Cabbage farmer group (Ikongosi), Peas farmer group (Mtwango), Tea farmer group (Luhunga), Maize farmer group (Sadani), Bean farmer group (Mtambula), Agro-pastoralist farmer group

Annex 1

Table 5: Knowledge and Use of CSA Practices

Percentage[17] of farmers from Igombavanu, Mtwango and Sadani Wards of Mufindi District who aware of, have used, and used the CSA practices in the last season.

Knowledge about, and use of CSA practices (% of farmers)			
CSA practice	Aware of practice	Have used practice before	Used practice in the last season
Mulching	23	7	20
Terraces	27	9	19
Water Harvesting	25	11	17
Irrigation	39	22	31
Conservation Farming	15	9	12
Organic Manure	69	47	60
Cover Crops	30	7	12
Crop Rotation	41	23	35
Intercropping	50	42	52
Rhizobium Inoculation	5	14	6
Chemical Fertilizer	72	42	69
Raw Spacing	67	33	58
Organic Pesticide	38	34	29
Inorganic Pesticide	72	43	78
Drying	33	25	31
Threshing	65	50	58
Improved Storage Facility	48	26	44
Pest Control	77	61	70
Grading	72	41	63

17 The values in the table were calculated as an average of the percentage of farmers from each of the three wards. Data collected from 50 farmers (18 female and 32 male) in May 2019