WFP
World Food Programme

SAVING LIVES
CHANGING LIVES

# WFP Critical Corporate Initiative: Climate Response Analysis for Adaptation

## Tanzania

Alliance

Bioversity International
CIAT International Center for Tropical Agriculture Since 1967 Science to cultivate change
CGIAR RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security CCAFS

**December 2021**

# Acknowledgements


## PUBLICATION INFORMATION

This publication is a product of the collaborative effort by the Alliance of Bioversity International and the International Center for Tropical Agriculture (The Alliance), the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), and the World Food Programme (WFP).

**Main authors:** Dorcas Jalango (The Alliance), Stephanie Jaquet (The Alliance), Benjamin Schiek (The Alliance), Aniruddha Ghosh (The Alliance), Julian Ramirez-Villegas (The Alliance), Harold Achicanoy (The Alliance), Alejandra Esquivel (The Alliance), Cesar Saavedra (The Alliance), Adam Savelli (The Alliance) Godefroy Grosjean (The Alliance).

**Project leaders:** Godefroy Grosjean and Peter Läderach
**WFP team leaders:** Pablo Arnal and Vera Mayer
**WFP country office - Tanzania:** Juvenal Kisanga, Matthieu Tockert and Mdathiru Abubakar

**Proofreading:** Scriptoria Solutions
**Design and layout:** Katya Kuzi

## SPECIAL THANKS

The authors would like to thank Giancarlo Pini (WFP), Felicitas Röhrig (Consultant), and Megan Mayzelle (Scriptoria Solutions) for their contributions to this publication.

## RECOMMENDED CITATION

This document should be cited as:

Jalango, D., Jaquet, S., Schiek, B., Ghosh, A., Ramirez-Villegas, J., Achicanoy, H., Esquivel, A., Saavedra, C., Savelli, A., Grosjean, G. 2021. WFP Critical Corporate Initiative: Climate Response Analysis Tanzania. The Alliance of Bioversity and The International Center for Tropical Agriculture; World Food Programme. 64 p.

# Table of contents

# Executive summary

**Tanzania's agricultural production system is largely dependent on rainfall and is thus highly susceptible to variabilities in rainfall and temperature.** An analysis of historic climatic trends depicts a scenario of high temperatures and uncertainty during the rainy season, which have resulted in recurrent floods and droughts at the national level. Future climatic projections show that unless effective mechanisms are put into place, these scenarios are likely to persist. With a projected 1-20C increase in temperature by 2050, warmer and hotter days are expected in every livelihood zone, especially in the central zone. Similarly, a 5-8% increase in rainfall is anticipated by 2050, with a projected increase of up to 13% in drought- and flood-prone areas. Substantial changes in rainfall are expected in the central and lake zones.

**These changes expose the central, lake, and northern livelihood zones to climatic risks that affect the production and suitability of crops and livestock.** The climate analysis shows that heat stress mostly affects the production of cattle and common bean, but with varying intensity, in every zone. The central zone has a 40% probability of heat stress occurrence by 2050. A suitability analysis shows that all three zones will become less suitable for bean production, with some areas becoming completely unsuitable for production. All three zones will continue to be suitable for rice production. No changes in maize suitability are expected. In addition to negatively impacting agricultural production, climatic hazards pose a livelihood threat to communities. For instance, there has been increased incidence of animal and human diseases, disappearance of indigenous crop species, drying up of water resources, and accelerated deforestation.

**An economic analysis conducted using the IMPACT model projects that, despite climate-induced losses, improved production and yield will increase the availability and stability of Tanzania's food supply until 2050.** These increases are expected to decrease levels of hunger and undernourishment by increasing caloric availability and consumption. While these gains are in line with socioeconomic trends, they are due to rapid industrialization, technological innovation, and improving education levels rather than improving climatic conditions. On the contrary, gains will be suppressed by negative climatic trends that will prevent the agricultural sector from reaching maximum potential productivity. Maize and other cereal crops face the gravest threat, although the production quantities and yields of all commodities modelled will be adversely impacted by climate change. The aforementioned gains may be distributed unevenly, leading to a disparity in areas of impoverishment. A geo-spatial hotspot analysis of eight vulnerability dimensions finds a high number of overlapping vulnerabilities of health, inequality, and food insecurity across every zone. In the absence of effective interventions, the current vulnerabilities suggest a prevalence of vulnerabilities in the future. This points to the urgency of implementing national-level agricultural and socio-economic development strategies at the zonal level.

**Tanzania has strong institutional capacity and a solid policy base to help improve food and nutrition security and manage the impacts of climate change.** However, the implementation of these policies at the zonal level is limited by weak links and coordination between institutions, a lack of human resource capacity, and small budgets

for climate change initiatives. Although climate change is not the principal focus of WFP's work in Tanzania, WFP still has the capacity to support the national government in implementing the climate change activities outlined in existing policies. Presently, WFP's climate resilience programming in Tanzania is aligned with Strategic Outcome 3's Activities 1 and 2 and Strategic Outcome 4's Activity 1. These outcomes focus on value chain development, providing climate services like finance and extension services, and building national disaster and risk management capacities.

**WFP needs to extend its scope of work to other geographical areas in Tanzania. Currently, there are programmatic interventions on climate change that are strongly aligned with WPF's Strategic Outcomes.** These interventions need to be scaled up to the household, institutional, and policy levels for increased impact. This study's recommendations identify climate-smart agriculture as a comprehensive approach to climate change mitigation and adaptation. Generally, the activities recommended prioritize improving productivity, providing climate information services, livelihood diversification, capacity building, investing in innovation hubs, and disaster-risk management. For the effective implementation of these recommendations, WFP needs to form strong partnerships with government ministries involved with climate change, research institutions, international and local NGOs, the private sector, and academic institutions. There is also a need to mobilize climate change funds from alternative sources like the national government, global climate funds, international development partners, and the private sector.

# Acronyms and abbreviations

| | |
|---|---|
| **AEZ** | Agro Ecological Zones |
| **ASDSP** | Agriculture Sector Development Support Program |
| **CCI** | Critical Corporate Initiative |
| **CDCS** | Country Development Cooperation Strategy |
| **CIAT** | International Centre for Tropical Agriculture |
| **CSA** | Climate Smart Agriculture |
| **CSP** | Country Strategic Plan |
| **FAO** | Food and Agriculture Organization |
| **FEWSNET** | Famine Early Warning System Network |
| **FYD** | National Five-Year Development plan |
| **GDP** | Gross Domestic Product |
| **GHG** | Green House Gas emissions |
| **GHI** | Global Hunger Index |
| **GII** | Gender Inequality Index |
| **IMPACT** | International Model for Policy Analysis of Agricultural Commodities and Trade |
| **KII** | Key Informant Interviews |
| **LZ** | Livelihood Zones |
| **NCCS** | National Climate Change Strategy |
| **RCP** | Representative Concentration Pathway |
| **TNBS** | Tanzania National Bureau of Statistics |
| **TZS** | Tanzania Shillings |
| **UNEP** | United Nation Environmental Program |
| **URT** | United Republic of Tanzania |
| **USAID** | United States Agency for International Development |
| **WFP** | World Food Program |

# Introduction

**The recent Zero Hunger Strategic Review from the World Food Program (WFP) has identified climate change as one of several new and complex drivers of hunger.** This novel threat to global nutritional security requires new approaches in terms of both design and resourcing. The international funding mechanisms that provide resources for addressing climate change are often beyond the reach of existing expertise in the specific program design requirements of such funds. In response, the Critical Corporate Initiative seeks to broaden and enhance WFP program-design capacities through a collaboration between the Program and Policy Development Department and the Partnerships and Advocacy Department. This effort will support the successful identification and pursuit of diversified financing opportunities to complement WFP's current resources.

**As part of the Critical Corporate Initiative, WFP's Climate and Disaster Risk Reduction Programs Unit (PRO-C), in collaboration with the Research, Assessment and Monitoring Unit (RAM), has developed a gap analysis of climate risk-management actions with the Alliance of Bioversity and CIAT and the CGIAR to identify thematic funding opportunities and priority actions.** The initiative was conducted in Burundi, Guinea, Guinea-Bissau, Haiti, Myanmar, Nepal, Niger, Pakistan, Somalia, and **Tanzania.** In close coordination with the national WFP officers, the Alliance of Bioversity and CIAT identified livelihood zones, key crops, priority outcomes, and key climate and non-climate hazards for each country. Analysis was then conducted using a diverse methodology including desk review, climate change modelling, the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) assessment, stakeholder workshops, and key informant interviews.

**The results are organized as follows:** the report begins with Part 1, which gives an overview of the national context, including geography, socio-economic background, climate projections, policy environment, and impact results. Part 2 provides an overview of the selected livelihood zones and includes analysis of the current and future threats of climate change. Part 2 also overlays the analysis's results with a separate analysis of prevailing socio-economic vulnerability. Part 3 analyses current WFP activities and how they may be optimized to strengthen climate change adaptation. It also offers recommendations for partnerships that may enhance the opportunities for programmatic optimization. Finally, Part 4 provides a synthesis of the main findings.

PART 1.

# National context

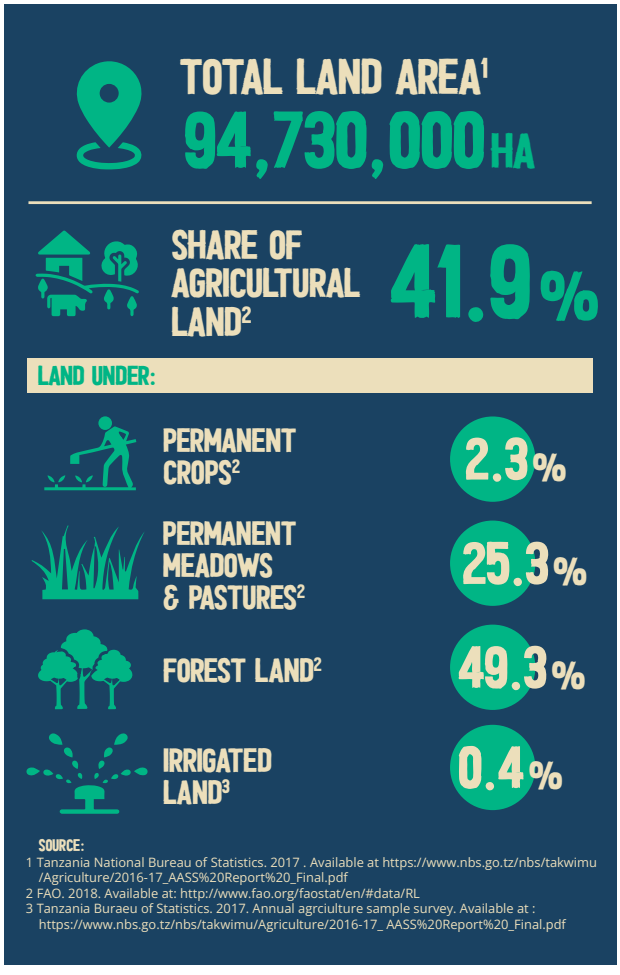
# 1.1 Geography and agro-ecological characteristics

**Tanzania[1], located in East Africa, is bordered by Kenya and Uganda to the north, Rwanda, Burundi, and Democratic Republic of Congo to the west, Mozambique to the south, and the Indian Ocean to the east.** The country covers a total surface area of 947,300 km$^2$. Around 93% of this area is terrestrial, consisting of the Tanzania mainland and Zanzibar. The remaining area is under inland water. Zanzibar is in the Indian Ocean, approximately 30 kilometers from the mainland. Administratively, Tanzania is divided into thirty-one regions, locally referred to as *mikoa.* Twenty-six of these regions are in the mainland, while five are in Zanzibar. These regions are further divided into 183 districts, or *wilaya* (Beal et al., 2015). The capital city is Dodoma, while Dar-es-Salaam is Tanzania's commercial hub.

**Tanzania is mountainous and rich in water resources.** There are about 25 mountains spread over the country. The highest of these mountains is Mount Kilimanjaro, elevated at an altitude of 5,895 meters above sea level. The major islands are 1,554 km$^2$ Unguja, 906 km$^2$ Pemba, and 518 km$^2$ Mafia, which are located off the east coast, and 647 km$^2$ Ukerewe, which is located in Lake Victoria. The main water bodies are lakes and smaller dams and rivers, which are found in the mainland. Lake Victoria, Africa's largest lake, constitutes nearly 57% of Tanzania's inland water. Lake Tanganyika, Africa's deepest lake, constitutes nearly 22% of Tanzania's inland water. Other lakes include the Nyasa, Rukwa, and Eyasi lakes. There are 5 dams, with the main ones situated along the Rufiji River basin. Their total capacity is approximately 4,196,000,000 million m$^3$ of water (USAID, 2015).

**Tanzania is home to a great number of national parks and game reserves.** The largest national park is Ruaha, which covers an estimated land area of 20,300 km$^2$ and traverses the Iringa, Mbeya, and Dodoma regions. The Selous is the largest game reserve. It occupies 18,971 km$^2$ of land and lies in the Pwani, Morogoro, Lindi, and Ruvuma regions.

**Both natural and planted forests exist in Tanzania. The natural forests include woodlands, montane forests, and**




1 The statistics provided in this section are from TNBS 2019 unless stated otherwise.

## AREA COVERED AS A SHARE OF AGRICULTURAL LAND[1]

**MAIZE[1]** 15.3%
ANNUAL YIELD[1] 5.3 T/HA

**BEANS[1]** 0.02%
ANNUAL YIELD[1] 0.7 T/HA

**RICE[1]** 3.7%
ANNUAL YIELD[1] 5.6 T/HA

## LIVESTOCK

| | POPULATION[1] | ANNUAL PRODUCTION |
|---|---|---|
| CATTLE | 30,672,001 | MEAT[2] (T): 479,071<br>MILK[2] (L): 2,278,461 |
| GOATS | 19,055,651 | MEAT[3] (T): 42,837<br>MILK[3] (L): 214,400 |
| POULTRY | 44,596,128 | MEAT[2] (T): 79,332<br>EGGS[2] (#): 3,575,621,000 |

SOURCE:
1 Tanzania Buraeu of Statistics. 2017. Annual agrciulture sample survey. Available at : https://www.nbs.go.tz/nbs/takwimu/Agriculture/2016-17_AASS%20Report%20_Final.pdf
2 Tanzania National Bureau of Statistics. 2019 . Available at https://www.nbs.go.tz/nbs/takwimu/references/Tanzania_in_Figures_2019.pdf
3 FAO.2019. Available at:http://www.fao.org/faostat/en/#data/QL

**mangrove forests.** The *Pinus patula* and *Cupressus lusitanica* are common varieties of planted forest (URT & Vice President's Office, Division of Environment, 2009). It is to be noted that the country is losing its forest cover at a rate of approximately 400,000ha annually (USAID et al., 2016). This is attributed to rapid population growth, which has resulted in the conversion of forest land into agriculture and human settlements (USAID, 2015). Most of the forests and other ecosystems such as rivers, wetlands, drylands, and savannah are harboured in the Rufiji basin. These ecosystems provide goods, services, and a means of livelihood for many communities. The basin has therefore been a resource in the development of climate change adaptation, using the integrated ecosystem approach (Taylor, 2011).

**Approximately 42% of Tanzania's land area is classified as agricultural land[2].** Due to its climate and geographical characteristics, Tanzania is categorized into eight ecological zones (AEZs): the central, eastern, lake, northern, southern, zanzibar, southern highlands, and western zones (Suleiman, 2018). This allows for diversification in agricultural production. Although Tanzania's agricultural production is mainly rain-fed, irrigated agriculture constitutes of 85% of the water consumed (USAID, 2015). Nonetheless, less than 1% of the country's planted land area is under irrigation (Figure 1). Although rivers are the main source of irrigation water, their irrigation potential has not been fully exploited. These water resources are under threat from climate change, pollution, and encroachment due to population related pressures (URT & Ministry of Agriculture, Livestock and Fisheries, 2017).

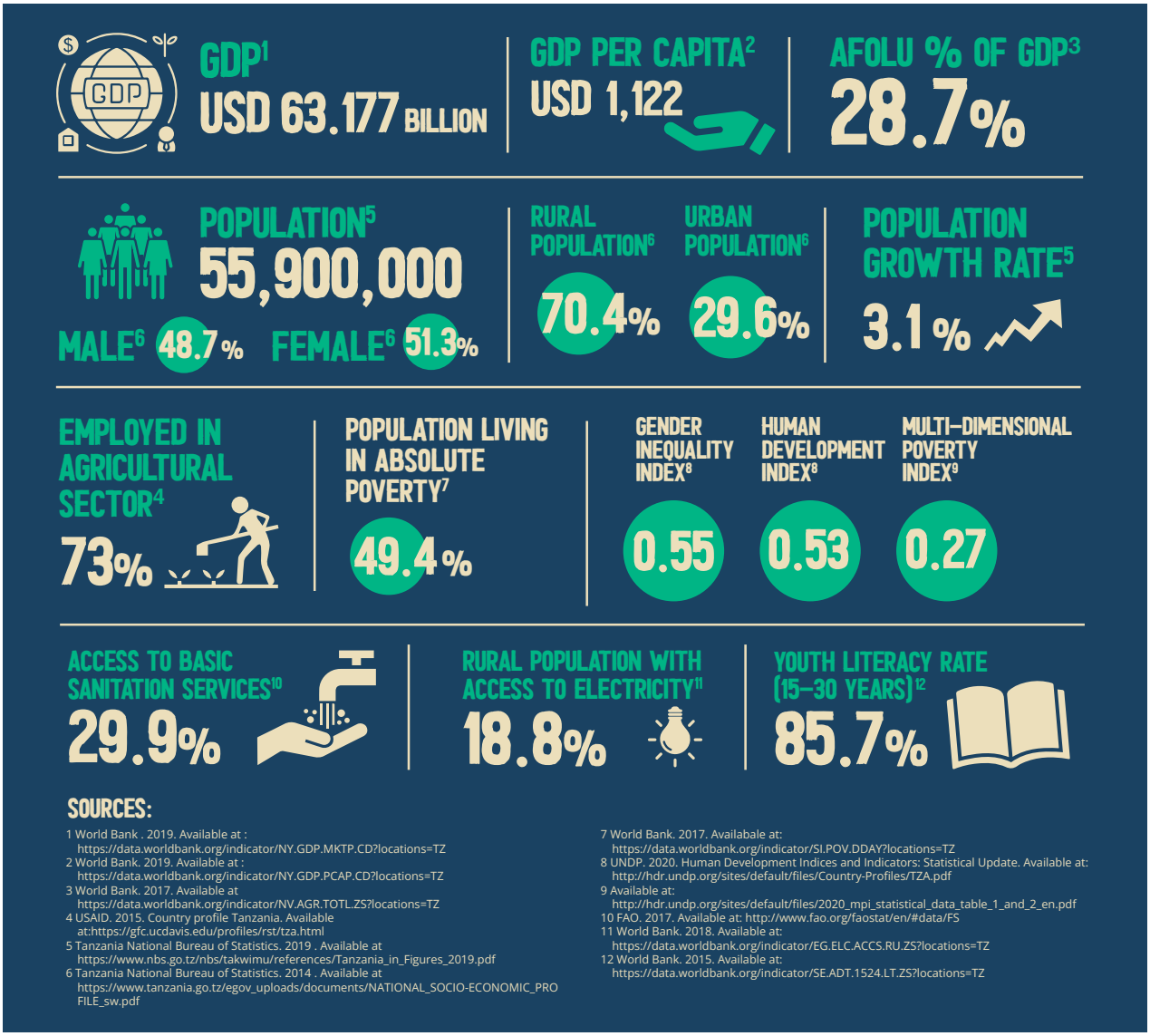
2 The FAO defines agricultural land as the share of land area that is arable, under permanent crops, and under permanent pastures. Arable land includes land defined by the FAO as land under temporary crops, temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Double-cropped areas are counted once.

# 1.2 Socio-economic context

## 1.21 Agricultural production

**Agricultural production is an important pillar of Tanzania's economy.** It accounts for 65% of total employment and constitutes almost three quarters of rural income (Data, 2021b), (Suleiman, 2018). Agriculture also accounts for 30% of Tanzania's export earnings (Chongela, 2015) .

**27% of Tanzania's GDP was derived from agriculture, forestry, and fishing in 2020 (Data, 2021a). Although exact numbers are difficult to tally, the crops subsector accounted for approximately 73% of agricultural GDP between 1981 and 2010 (Chongela, 2015).** Both food and cash crops are extensively grown in Tanzania. Major food crops include maize, beans, rice, cassava, bananas, wheat, sorghum, millet, green grams, cowpeas, chickpeas, lentils, and pigeon peas. Coffee, tea tobacco, cashew nuts, and cloves are the main cash crops (URT,



2017). Tobacco, cashew nuts, and coffee are the leading export crops in Tanzania. As of 2019, cashew nut was the crop with the highest foreign exchange earnings. Cashew nut earned 808 billion TZS[3] in 2019, followed by coffee with 351 billion TZS and tobacco with 335 billion TZS (United Republic of Tanzania National Bureau of Statistics, 2019).

**Livestock production is the second largest agricultural subsector, contributing approximately 18% of Tanzania's agricultural GDP between 1981 and 2010 (Chongela, 2015).** It also supports crop production by providing manure and draft power for cultivation. About 42% of Tanzanian households rear at least one category of livestock, with production concentrated in rural areas (URT et al., 2014). Cattle, sheep and goats, pigs, and poultry are the main livestock varieties. Dairy production is intensive, contributing 30% of livestock production's BDP (Suleiman, 2018).

**Between 1981 and 2010, the fishing subsector in Tanzania contributed approximately 9% of the country's agricultural GDP (Chongela, 2015).** The country is supplied by both marine and inland fisheries resources, which are dominated by small-scale fish farmers (URT, 2016). Industrial fisheries have also been operational in the country since the 1980s, often specializing in prawn production for export. Despite Tanzania's significant fishery resources, poor fishing methods, water pollution, and coastal erosion have hindered the fishing sector **f**rom reaching its full potential (USAID, 2015). The sector has untapped opportunities to promote and grow domestic aquaculture production.

**Smallholder farmers play a critical role in agriculture, contributing 85% of the country's production.** Smallholder farmers utilize 80% of the country's arable land, with average land sizes of less than 1 ha (Suleiman, 2018). Smallholder production is mostly for subsistence, utilizes conventional farm inputs like hoes, and is heavily reliant on the erratic rainfall, rendering small producers particularly vulnerable to the impacts of climate change (URT, 2017). Because of challenges like inadequate access to credit, low input use, and ineffective policies, agricultural productivity has been on the decline. This has led to higher poverty rates and food insecurity among rural households.

## 1.22 Basic needs

**Based on a recent government survey, there has been general improvement in access to basic needs (URT, 2019b).** For instance, 29% of households have access to electricity. This a 16% and 11% increase from the 2007 and 2012, respectively. However, 68% of the country's urban population has access to electricity, as compared to only 18% of the rural population (World Bank Statistics, 2018).

**In Tanzania, 87% and 73% of households have access to improved water sources in the rainy and dry season, respectively.** The housing and population census reports that the main source of drinking water for 37% of households is tap water (URT, 2014). 59% of urban households drink tap water, as compared to 26% of rural households. 39% of rural households have access to unprotected water sources like dug wells and springs, as compared to around 9% of urban households.

**Almost 30% of the population has access to basic sanitation services. 93% have access to toilet facilities (URT, 2019b).** While 14% of the population use flush toilets, 78% use

3 The exchange rate as of 30/10/2021: 1 USD = 2299 TZS.

pit latrines and almost 8% have no sanitation facility at all. Waste disposal is a challenge, as only around 8% of the population uses refuse disposal companies. Around 36% of the population buries their waste in pits, nearly 32% dumps waste in bushes or open spaces, and nearly 23% burns their waste (URT, 2014).

**Generally, there is availability and access to modern sources of energy, both for cooking and lighting.** According to URT, electricity is the main source of lighting for around 47% of the urban population and nearly 6% of the rural population. Kerosene is more popular, with around 66% of the rural population and 42% of the urban population using kerosene. For cooking, firewood and charcoal are the most common. Almost 90% of the rural and 25% of the urban population use firewood. However, nearly 62% of urban dwellers use charcoal as compared to nearly 8% of rural dwellers.

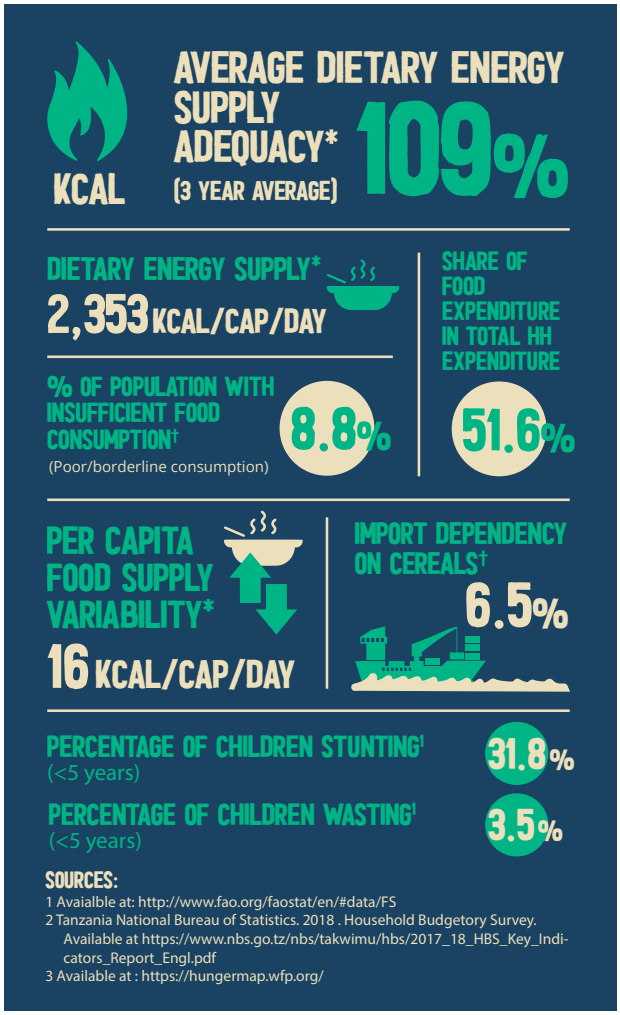
**Tanzania's number of health facilities has been increasing since 2015.** The number of hospitals, dispensaries, and other health centers increased from 7,519 to 9,104 in 2019 (URT, 2019). In 2018, 56% of people who were ill consulted health facilities (United Republic of Tanzania et al., 2019).

**Tanzania has a literacy rate of 72%, with a higher rate of 89% in urban areas. Rural areas have a literacy rate of 64%.** In both urban and rural areas, men were found to be more literate than women. In totality, men had a literacy rate of 74% and women had a literacy rate of 69%. A higher literacy rate ranging from 80-87% was recorded within the age bracket of 10-44 years (URT, 2014). The youth literacy levels are also relatively high at nearly 86% (World Bank Statistics, 2015). These high literacy rates can be attributed to free primary education campaigns.

# 1.23 Food and nutrition security

**According to the global hunger index, Tanzania is ranked 89th out of 107 countries, with a score of 25 (GHI Statistics, 2020).** This indicates serious levels of hunger. Though the country has a food self-sufficiency range of 88-112%, there is still the challenge of local food deficits. It also among the countries in Africa with the highest malnutrition levels (Lokuruka, 2021). Alleviating malnutrition is therefore one of Tanzania's development priorities (URT, 2018).

**Households in rural areas are more exposed to food insecurity than those in**



**urban areas, especially households that depend on food production as their main income source, live below the poverty line, and inhabit areas prone to drought (WFP & World Bank, 2013).** An Integrated Food Security Phase Classification (IPC) of 17 regions found that 118,603 people were in a food and nutrition security crisis, and that 1,067,425 were stressed (United Republic of Tanzania et al., 2019). Nationally, 8% of households, or 750,000 households, were food insecure, while nearly 2%, or 150,000 households, suffered from chronic food insecurity (WFP, 2013). This report used the FAO food security indicators of accessibility, availability, utilization, and stability to assess the food and nutrition status of Tanzania (Figure 3).

**In Tanzania, poor households spend a higher share of their expenditure on food than rich households (WFP, 2013).** Based on a recent household budgetary survey, the percentage of household consumption expenditure on food is estimated at around 52% (URT, 2019b). Food consumption is vital as it indicates levels of food insecurity (URT, 2019c). A recent survey found that cereals were the most commonly consumed food group within 975 households, while eggs and meats were the least commonly consumed (URT, 2019c). This implies over reliance on cereal foods, which poses a threat to food security.

**The average value of food production is important because it provides a measure of the country's food-production sector relative to the country's economy.** Production, purchase of food stocks, trade, and food aid are some of the ways that food is made available in Tanzania (URT, 2019c). Despite the fact that a country might currently be food secure, factors such as variability in weather conditions, political stability, and economic considerations may affect food security status (WFP, 2013).

## 1.24 Socio-economic challenges

**Climate change is the greatest challenge to Tanzania's socio-economic development.** The economy of Tanzania is characterized by climate sensitive activities, particularly within agricultural production (URT, 2011). The impacts of climatic hazards such as droughts, high temperatures, and rainfall variability negatively affect both land and water resources. Dwindling water resources and land degradation due to soil erosion have had a negative effect on agricultural production and the livelihoods of communities.

**Insecure land tenure and the fragmentation of land parcels have affected agricultural production, social security, and environmental sustainability (URT, 2016).** This discourages investments that could boost food security, drives land conflicts and grabbing, and leads to the underutilization of productive land.

**Tanzania's poverty levels are rising.** Almost half of Tanzania's population lives under the poverty line, with less than 1.90 USD daily (World Bank, 2017). As of 2018, the basic-needs poverty rate was around 26% while the food poverty rate was 8%. There is a disparity in rural and urban poverty: close to 81% of Tanzania's poor reside in rural areas (URT, 2019b).

**Notable efforts have been made in Tanzania to ensure equality among the population. However, gender equality and empowerment remain critical issues in Tanzania.** Tanzania's gender inequality index, which reflects social gender inequalities, is high compared to other countries. Out of 162 countries, Tanzania is ranked 146th, with a GII value of 0.55 (UNDP, 2020). The participation of women in the country's labor force and secondary education is still lacking when

compared to male participation. There is also a high adolescent birth rate in Tanzania, which interferes with the ability of young women to complete school and become economically empowered.

**Tanzania is still facing challenges in its health sector.** Diseases like malaria, HIV, and tuberculosis are sources of morbidity and mortality rates in the country. The 2019 URT records that the annual incidence of HIV infection is less than 1%, with a higher prevalence in women than men. Malaria is the leading cause of child mortality in Tanzania, and the country is among the 22 countries with the world's highest tuberculosis burden (WFP, 2017).

**Tanzania's economic growth has been hampered by corruption and poor governance.** This is attributed to little government accountability, low institutional capacity, and poor public participation. Further, the call for self-governance in Zanzibar and Zanzibar's separation from the Tanzanian mainland resulted in internal conflicts (WFP, 2017).

# 1.3 National climate profile

**The climate in Tanzania is varied, ranging from a tropical climate in the coastal region to a temperate climate mainly in the highlands.** Most of Tanzania experiences two rainy seasons, with the exception of the southern and central highlands, which experience one rainy season. The long rains, or *masika*, are between March and June, and the short rains, or *vuli*, fall between October and December. The singular rainy season in the highlands runs from November to April and record the highest rainfall in the country. Annual total rainfall ranges from 400 to 2400mm (USAID, 2015). Given Tanzania's mountains, annual average temperatures range from as high as 27°C to as low as -3°C, while the median annual average temperature is 23°C (USAID, 2015). Temperature and rainfall vary regionally, with the highest annual rainfall of 2058 mm recorded in the Bukoba region and the

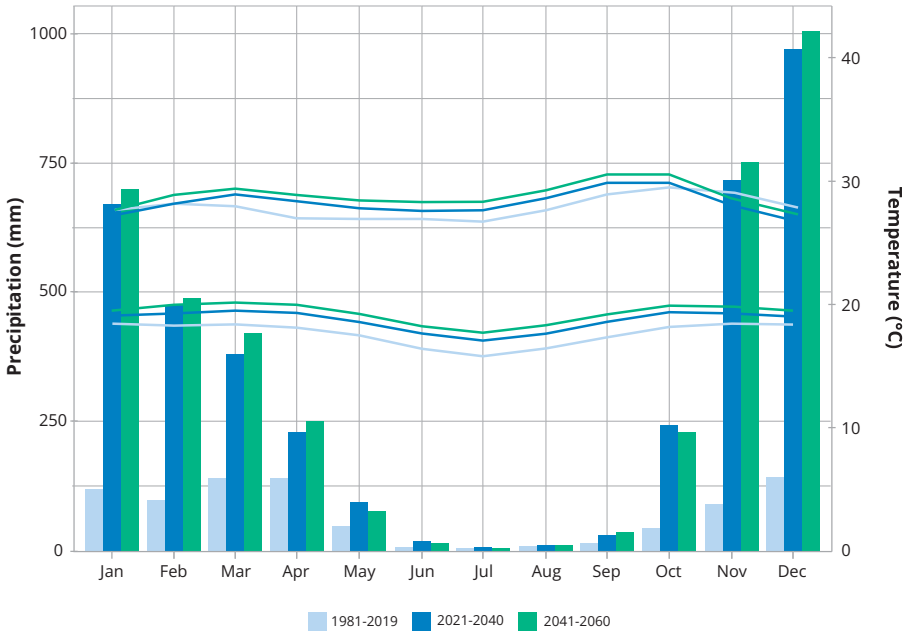



**Figure 4:** Historical (1980-2019) and future (2021-2060) temperature and precipitation trends in Tanzania. Temperature trends are represented by lines, and precipitation trends represented by bars.

lowest of 600mm recorded in Kilimanjaro. The country's highest temperature of around 30°C was recorded in Same, and the lowest of 12°C was recorded in Mbeya (TNBS, 2019).

**Historical (1981-2019 and future (2021-2060) temperature and precipitation trends show that *masika*, which lasts from March to June, is the main rainy season and receives continuous high rainfall (Figure 4).** The wettest months during this season are March and April, which both receive between 100 to 400 mm of rainfall. However, the season has a relatively dry period towards its end, with as little as 5mm of rainfall in June through August. Maximum temperatures are experienced in October, which is the onset of the vuli season. The vuli season lasts from October to December. The highest recorded temperature in this season is 28°C.

# 1.4 Economic analyses using IMPACT

**This report's economic analysis of climate change was done using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT).** This model evaluates linkages between agricultural policy, climate change, and technologies in agricultural systems. The socioeconomic basis for the results presented in this chapter is Shared Socioeconomic Pathway 5 (SSP5), a policy, population, and GDP trajectory characterized by rapid industrialization, high levels of technological innovation, and improving educational levels alongside fossil fuel-driven industrialization with little effort to mitigate the impacts of climate change[4] (Robinson et al., 2015). Assumptions regarding future temperature increases due to carbon concentration and radiative forcing are captured in different Representative Concentration Pathways (RCPs), which account for long-term changes in temperature and precipitation, but not for changes in climate variability or the incidence of extreme weather events (Robinson et al., 2015). For this study, RCP 8.5, the most pessimistic carbon concentration scenario available, is assumed. RCP 8.5 projects a mean global temperature rise of 1.4-2.6 degrees Celsius over 2005's temperatures by 2050. The combination of SSP5 with RCP 8.5 envisions a bleak outlook, exacerbated by increased fossil fuel use - although some of the worst impacts in terms of food availability are partly offset by an optimistic increase in technology and education levels. A "no climate change" scenario is also modelled as a benchmark against which to compare the impacts of climate change. This scenario is referred to as "No-CC" in accompanying figures and text.

**In IMPACT analyses, yield is modelled as a function of both biophysical and economic factors. This means that negative climate impacts can be offset by technological improvements like germplasm and farm management as well as economic incentives for farmers to invest in inputs.** Conversely, economic incentives can exacerbate biophysical yield loss if price signals lead investments elsewhere or if farmers switch to more profitable alternative crops. These relative impacts then translate into a rebalancing of the comparative advantages or disadvantages of commodities with respect to one another, and of the comparative advantages of nations trading in these commodities. This rebalancing, in turn, shapes the price signals that drive changes in economic yield and productive decisions at the farm level.

4 IMPACT does not account for perturbations resulting from the COVID-19 pandemic.

**It is important to note that IMPACT results are reported at the country level and not disaggregated to the sub national level.** The results' relevance therefore lies in the context they provide for making decisions at the livelihood zone level. Understanding climate vulnerability at the national level provides critical information to policy makers to formulate climate change and agricultural development strategies that can be implemented at the zonal level. See examples of these development strategies in Part 1.5. The IMPACT results' information could similarly guide investments and interventions in infrastructure and institutions required to leverage points of resilience and mitigate points of vulnerability.

**IMPACT outputs present one possible scenario of future conditions in order to provide general guidance on policy and development interventions.** Below, IMPACT climate change projections related to the supply, demand, and availability of key crops and livestock commodities in 2050 are compared against respective no-climate change benchmarks. This comparison is made to identify points of vulnerability and resilience in Tanzania's agricultural sector, particularly in relation to food production and availability[5]. The commodity focus is chosen by in-country experts based on relevance to the country's diet and farms, especially in relation to current and future food security.

# 1.41 Impact of climate change: supply side

**A comparison of climate change scenarios against a No-CC benchmark scenario offers insight into how vulnerable or resilient crops are to the effects of climate change.** IMPACT allows for farmers to adjust agricultural input levels and/or switch to new crops in response to price signals,


**Figure 5:** Differences between climate change and no climate change scenarios for production, area, and yield of key crops. For each year, the difference is calculated as the percentage difference between the CC value and the No-CC value.

5 "Raw" CC trajectories, without comparison to No-CC trajectories, are provided in Annex

thereby altering yield and area levels. Yields and area harvested may thus rise despite climate change related biophysical setbacks if the corresponding investment in inputs is profitable to the farmer. Conversely, the market forces modeled by IMPACT can also exacerbate biophysical yield loss.

**In Tanzania, the production of key crops, excluding rice, are projected to be lower than the No-CC benchmark by 2%-4% in 2030, and by 3%-6% in 2050 (Figure 5).** The low production is primarily due to lower yields relative to the No-CC trajectory. Maize area harvested is projected to be higher under climate change, but yields are projected to be so much lower that the overall CC impact on production is negative compared to the No-CC benchmark. Rice production, on the other hand, is projected to be higher under climate change than under the No-CC benchmark.

**Resilience to climate change may be due to a crop's intrinsic biophysical resilience, but it may also be because climate change damages to alternative crops are more severe.** The resulting relative scarcity of alternative crops places upward pressure on demand for - and thus the price of - the original crops, such that farmers are willing to invest in the inputs necessary to offset the biophysical yield loss that results from climate change.

## 1.42 Impact of climate change: diet trajectory

**Calorie availability is projected to be significantly lower under climate change than under the No-CC benchmark for many key crops (Figure 6).** Lower per capita calorie availability relative to the No-CC trajectory is especially pronounced for maize, rice, and other cereals. Climate change's impact on the per capita availability of pulse and livestock calories, on the other hand, is projected to be relatively less severe.

## 1.43 Impacts of climate change: prevalence of hunger and malnourishment

**While overall calorie consumption is projected to increase and malnutrition is projected to decrease by 2050 (see *Annex I: IMPACT Results*), the share of Tanzania's population at risk of hunger and numbers of undernourished children are projected to increase under the CC scenario (see Figure 7, left panel).** This is consistent with lower projected calorie intake under climate change, as discussed above. Import dependence for livestock is projected to be about the same under CC as under the No-CC benchmark. Rice import dependence, on the other hand, is projected to be substantially lower under CC, while maize import dependence is projected to be slightly lower (see Figure 7, right panel). Bean import dependence is projected to be slightly higher.

## 1.44 Conclusions and recommendations based on IMPACT

**Beans, the most important pulse crop, and maize, the most important cereal crop, demonstrate high vulnerability to climate change.** Rice, on the other hand, displays high resilience to climate change, as indicated by increased production under the CC scenario. This may be due to climatic conditions that are increasingly favorable for rice production, or the assumed adoption of

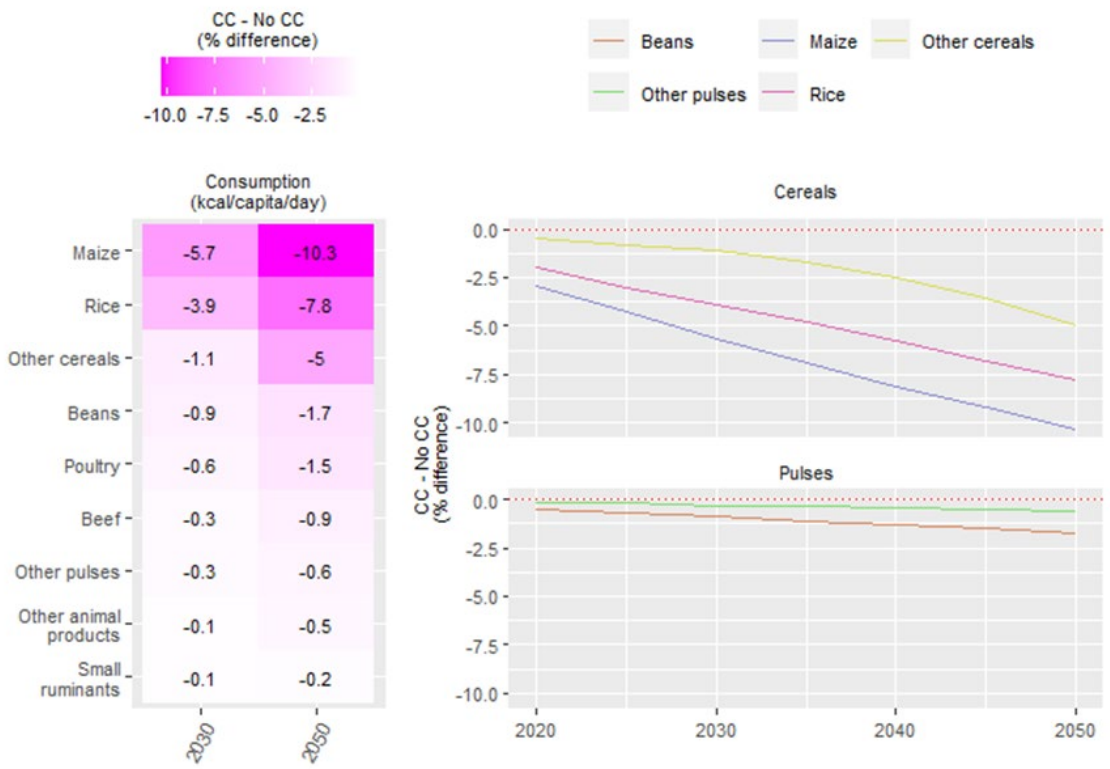



**Figure 6:** Percentage difference between the consumption (expressed in kcal/capita/day) of key commodities with and without climate change.

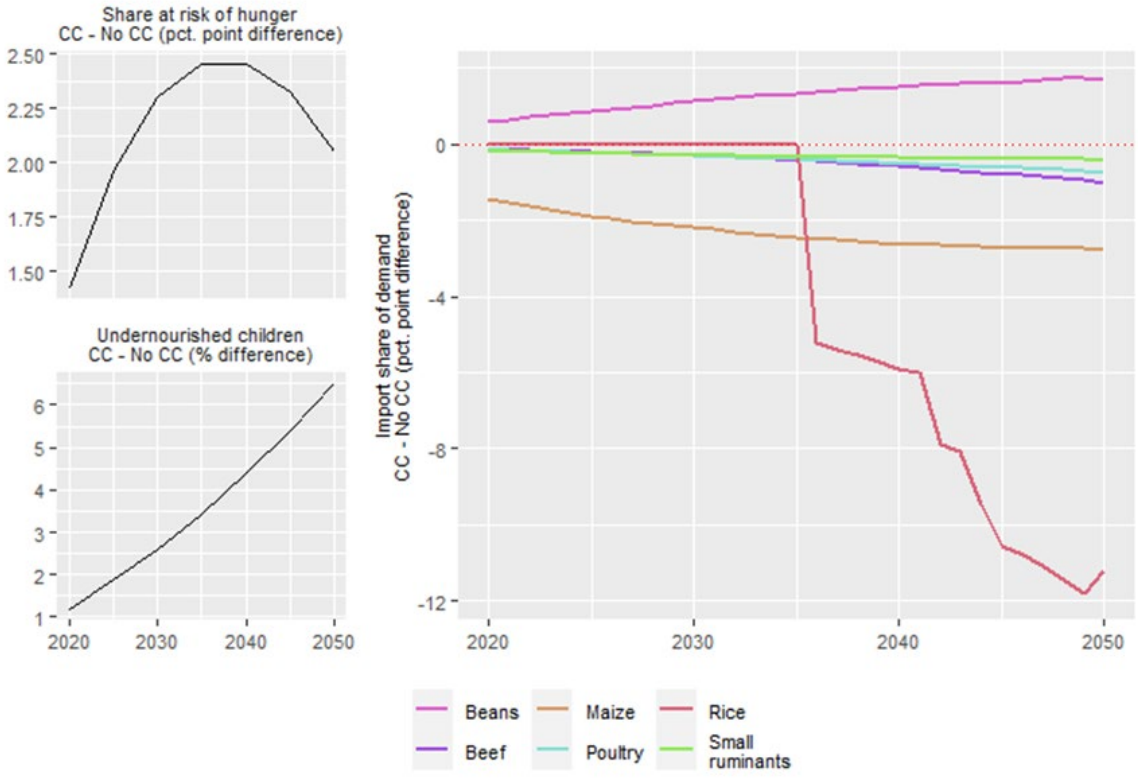



**Figure 7:** IMPACT projection of the share of Tanzania's population at risk of hunger, the import share of demand, and the number of undernourished children for the years 2020 to 2050.

improved rice varieties that can withstand harsh climatic conditions. Similarly, it could highlight increased investments in CSA technologies, such as irrigation equipment, that allow for production of rice regardless of climatic conditions. The vulnerability of maize and beans, however, creates a risk of food insecurity because both crops are a major food source for the majority of households. Already, Tanzania has undertaken research on improved maize and bean varieties that can be produced in diverse climatic conditions. To overcome low adoption rates among farmers, initiatives to upscale the adoption of these improved varieties might be useful. For example, strengthening input subsidy programs, especially for seeds, could help incentivize farmers. Alternatively, households could shift to substituting crops like beans with other pulses like cowpeas and green grams, and substituting maize with sorghum and millet. However, this process would call for a lot of sensitization among farmers because of existing negative perceptions of some crops.

**Cereals' high vulnerability to climate change correlates with low calorie availability and increased hunger.** The reverse is true for pulses and livestock, which exhibit a negligible change in calorie availability. This means that in the future, the dietary share of starchy staples will decline and is likely to be replaced by animal products. Care must therefore be taken to replace starchy staples with protein calories. The promotion of vegetable proteins as a substitute is therefore recommended. Interventions that could reduce high import dependency on legumes, especially beans, would play a significant role in this dietary transition. More attention should also be given to promoting legumes as an alternative source of calories.

# 1.5 National climate change policies[6] and development strategies

**This section provides a summary of the policy environment that drives Tanzania's climate response and development plans.** The section consists of a review of climate-related and -relevant policies and strategies. This information was gathered through literature review, discussions with WFP country offices, and key informant interviews (KIIs). Current investments in climate change from the government, multilateral donors, bilateral donors, International Financial Institutions (IFIs), and the private sector are also highlighted.

## 1.51 National climate strategies and finance mechanisms

**Tanzania has developed a number of strategies, policies, plans, and programs to enhance its adaptive capacity.** This has contributed to a better understanding of the impacts of climate change and opportunities for investment across various sectors of the economy. The National Climate Change Strategy (NCCS) was formulated in 2012 under the umbrella of the United Nations Framework Convention on Climate Change (UNFCCC). The NCCS actionizes the country's commitment to address climate change

6 The policies were extracted from https://extranet.who.int/nutrition/gina/en/policies/1564.

through administration of climate mitigation, adaptation, and cross-cutting interventions. The NCCS provides Tanzania with an opportunity to benefit from "fast start" climate funds, which, by 2020, had gradually risen to an annual threshold of up to 100 billion USD (URT, 2012). The National REDD+ Strategy and Action Plan of 2013 and the intended nationally determined contribution (INDC) of 2021 fortify the NCCS's objective of reducing greenhouse gas emissions (GHGs) in Tanzania. While REDD aims to achieve this by increasing forest cover, INDC has committed to reducing GHG by 10-20% across economic sectors by 2030 (REDD, 2012), (URT, 2015b). During its inception period, Tanzania's REDD initiatives were awarded a 17 million USD grant from the Norwegian government for a five-year period (REDD, 2012).

**Tanzania has made notable efforts in incorporating climate change adaptation and mitigation into agriculture and food security policies (Amwata et al., 2020).** Two examples are the Agriculture Climate Resilience Plan (ACRP) of 2014-2019, which outlines a participatory approach towards climate action in the agricultural sector, and the National Climate-Smart Agriculture Program of 2015-2025, which focuses on improving the agricultural sector for enhanced food security and climate resilience. Both of these examples have been financed by the national government and supplemented by donor funding (URT, 2016). Guidelines like the Climate-Smart Agriculture Guideline of 2017 grew from collaborative initiatives with the United Nations. This particular guideline was developed to help in the identification, implementation, and upscaling of climate-smart agriculture (CSA) practices in the country (URT & Ministry of Agriculture, Livestock and Fisheries, 2017).

**Environmental policies in Tanzania have created a foundation for climate change policies (Amwata et al., 2020).** Thus, several policies which guide the management of environmental resources that are vulnerable to climate risks indirectly address climate change. For example, the National Water Policy (NWP) of 2002, National Energy Policy (NEP) of 2003, National Water Sector Development Strategy of 2006-2015, and the National Forest Policy (NFP) of 1998 all address climate change. Tanzania has also made a deliberate effort to mainstream gender concerns in climate change action through the formulation of the National Strategy on Gender and Climate Change in 2013. The main objective of this strategy is to ensure that both women and men have access to and benefit from climate change interventions.

## 1.52 National development strategies and finance mechanisms

**Tanzania is a developing country with accelerated economic growth.** Nonetheless, as is highlighted in Part 1.2 of this report, poverty is widespread in Tanzania. The government has made notable efforts in the development of short-, medium-, and long-term strategies geared towards aiding the country's economic development. The Country Development Cooperation Strategy (CDCS) of 2014-2019 presents an opportunity for Tanzania to enforce policies and investments that would enhance socio-economic transformation and poverty reduction (USAID, 2014). This strategy is a product of a partnership with the United States, with funding from the President's Emergency Fund for AIDS Relief (PEPFAR), Feed the Future (FTF), the Global Health Initiative (GHI), and Partnership for Growth (PFG). Tanzania also stands to gain

huge economic growth by implementing the goal set out in its National Vision 2025 (TDV 2025). This long-term development goal was launched in 1999 with the aim of transforming Tanzania into a middle-income country by 2025. The TDV is implemented in a cycle of five-year development plans (FYD) that have been running from 2011-2012 to the present. The TVD aims to develop the country by improving livelihoods and food security and building a competitive economy. The realization that Tanzania could attain economic growth in the absence of donor funding led to the inception of the National Strategies for Growth and Poverty Reduction (NSGRP), locally known as MKUKUTA I[7] and MKUKUTA II (TIC, 2016). These strategies advocate for sustainable development, equitable employment, infrastructure, and affordable energy services. They are also among the strategies that push the country to adhere to TDV 2025.

**Tanzania has an agricultural base, and it is therefore relevant to align agriculture to its development strategies.** The Agricultural Sector Development Strategies, known as ASDS I - 2001 and ASDS II - 2015, contribute to NSGRP and TDV by providing a monitoring and evaluation framework to ensure that the stipulated outcomes and impacts are achieved. Their goal is to help Tanzania boost its agricultural growth rate to 5% per annum through the commercialization of agriculture. The activities outlined in these strategies primarily come from private-sector investments and increased public expenditure into the agricultural sector (URT, 2016a). Similarly, the National Agricultural Policy was developed to transform agriculture from a subsistence into a commercial activity (URT, 2013). This transformation would contribute to livelihoods, poverty alleviation, and economic growth. Another significant agricultural strategy is the *Kilimo Kwanza,* or Agriculture First, movement. It was launched in 2009 to enhance technological advancement in delivery of seeds and fertilizer so as to boost agricultural growth from 4 to 10% within the TDV's 2025 time frame. Its inception came as a response to the 2008 and 2009 food crisis in Tanzania (United Republic of Tanzania, 2016).

**Agricultural strategies aim at boosting food security, hence the augmentation of food and nutrition security policies.** The National Food and Nutrition Security Policy of 1992 is the main food and nutrition security initiative in Tanzania. Its implementation is enhanced by the National Nutrition Strategy, which guides nutrition-related work in the country (URT, 2015a). Despite significant efforts, food and nutrition security among vulnerable groups such as women and children is still not satisfactory. See Part 1.2.3 of this document for further explanation. Experts point out that food and nutrition security has not been fully integrated into the country's development plans from the local to national level. There is generally inadequate cooperation and coordination among the sectors of the economy that are responsible for food and nutrition activities in Tanzania.

## 1.53 International alliances and finance mechanisms

**Climate financing in Tanzania has provided a response platform to climate change-related issues.** Currently, the Ministry of Finance, through the national climate change fund, is responsible for climate financing. It is estimated that by 2030, the country needs to invest in approximately 60 billion USD in climate mitigation (Irish Aid, 2018). Tanzania

7 MKUKUTA is an acronym for *"Mkakati Wa Kuondoa Umaskini Na Kukuza Uchumi Tanzania".*

has observed increasing climate change expenditure over the years, mainly due to donor funding. However, there is still a significant gap in climate change adaptation financing. The country needs at least 500 million USD annually to implement climate change adaptation strategies, but only 150 million USD has been disbursed since the year 2000 (Norrington-Davies and Thornton, 2011), (IIED, 2019).

**The government is not adequately funding climate change activities and is thus over reliant on donor funds.** Tanzania's climate change adaptation and mitigation activities are funded from both national and international sources. The international sources include bi- and multilateral donors and civil society organizations (CSOs), while national sources involve the government and private sector (Irish Aid, 2018). Some of the major donors include the World Bank, the African Development Bank, Ireland, Canada, the United States, Japan, the United Kingdom, the European Union, and UN agencies. CSOs play a significant role in advocacy, monitoring, and evaluation, while the private sector focuses on disseminating and upscaling technologies (URT, 2016). Climate funds are dispersed through projects that are implemented at a localized level.

**As of 2013, Tanzania had been granted approximately 180 million USD by international climate funds for various adaptation and mitigation projects.** Climate mitigation has been funded since 2004 and represents about 64%, or 115 million USD, of Tanzania's international funding. REDD and other adaptation projects accounted for 24%, or 44 million USD, and 7%, or 13 million USD, of funding, respectively. The Iringa-Shinyanga Backbone Transmission Investment project is worth 52 million USD, was Tanzania's largest mitigation project, and was funded by Japan. It focused on the energy sector, with the goal of reducing energy lost through transmission (Trujillo et al., 2013). This channeling of mitigation funds towards energy projects has been consistent in enhancing the effectiveness of the national energy system. A typical case is the 45 million USD that was approved by the Least Developed Country Fund between 2015 and 2020 for mitigation projects in the energy sector (Climate funds, 2021)[8]. There is, however, a disconnect between the Tanzanian Ministry of Finance and the donor community, which an impediment to decision making that revolves around climate funds. This is mainly because most donors opted to offer the government administrative support on funding management. The existence of many donors, various funding mechanisms, and a lack of a formal donor coordination mechanism has resulted in parallel funding for similar activities. For example, a lot of attention has been focused on forestry (Norrington-Davies & Thornton, 2011).

## 1.54 Policy gaps and opportunities

**The biggest gap in climate change policy in Tanzania is that most policies are multi-sectoral, yet climate change is sectoral.** This means that currently, there is no single policy that specifically addresses a given area. The policies are packaged as programs and strategies, which are then implemented by the local government. Climate change governance in Tanzania is decentralized at the division level, whereby the Division of Environment (DoE) coordinates and oversees the implementation of policies (Dhaen & Nielsen, 2017). There are also institutional gaps in terms of poor coordination and a lack of human resource capacity, which hamper

8 Climate funds update available at: https://climatefundsupdate.org/data-dashboard/

the operationalization of existing policies (Irish Aid, 2018). In addition, climate change is tackled as an environmental issue, since it is under the DoE's jurisdiction. This creates opportunities to spearhead programs that could enhance sectoral linkages and partnerships between the government and the private sector to aid in the implementation of climate change initiatives.

**There are funding gaps in both national- and local-level responses to climate change.** According to Yanda et al., climate change finance appears to be more of a financial rather than a policy concern (Yanda et al., 2013). Overdependency on external donor funding and lack of proper financial planning hinders the execution of climate change action plans (Norrington-Davies and Thornton 2011). There are also conflicts in terms of accountability. This presents an opportunity for the private sector to develop business models and plans to support climate change.

**Generally, there is still a gender gap in climate change policy (Irish Aid, 2018). Women are more vulnerable to impacts of** climate change and have a lower capacity to manage the risks. Despite efforts to incorporate gender into climate change strategy, implementation is challenged. Organizations like WFP could design their programs to incorporate activities that would build adaptive capacity. Some of these activities, such as improving market access and using value addition technologies, are time saving and income generating and are discussed broadly in Part 3 of this report.

PART 2.

# Context within selected livelihood zones

# 2.1 Livelihood zones, with rationale for selections

**The Famine Early Warning and System Network (FEWSNET) describes a livelihood zone (LZ) as a map of areas within which people broadly share the same livelihood patterns.** LZs play an important role in understanding the impact of climatic hazards on people, targeting geographic assistance, and customizing LZ monitoring systems. While Tanzania is demarcated into 78 LZs, this profile prioritized several similar LZs and grouped them into three broader LZs for analysis. These three LZs are referred to as the central, lake, and northern zones (Figure 8). These LZs were selected in relation to the country's dual rainfall regime that divides the territory into unimodal and bimodal zones. The bimodal zone was prioritized, given the frequency of climatic shocks and food shortages among households. This zone traverses the north, east, northern coast, and northwest of Tanzania, and covers the central, northern, and lake LZs. Additionally, major crops like maize, rice, and beans and livestock like cattle, goat, and poultry were selected based on their economic relevance and production dynamics across the LZs. The characteristics of the LZs discussed in this section are based on Tanzania's 2008 FEWSNET report and information provided in the key expert interviews (Network & System Network (FEWSNET), 2008).

## CENTRAL ZONE

**The central zone traverses the Dodoma, Singida, and Tabora areas.** This zone is mainly a dry lowland and receives an annual average rainfall of between 500 and 800 mm. Both crop and livestock production rely on rainfall. The main food crops produced in this zone include sorghum, millet, and maize. Cattle and goats and sheep, or shoats, are also reared extensively. Livestock farmers depend on rainfall for water supplies and pasture production, while crop farmers mainly depend on rainfall for food production. Over the past two decades, this zone has experienced irregular trends of increasing or decreasing rainfall. These trends have led to poor rainfall distribution, which has affected general soil moisture content.

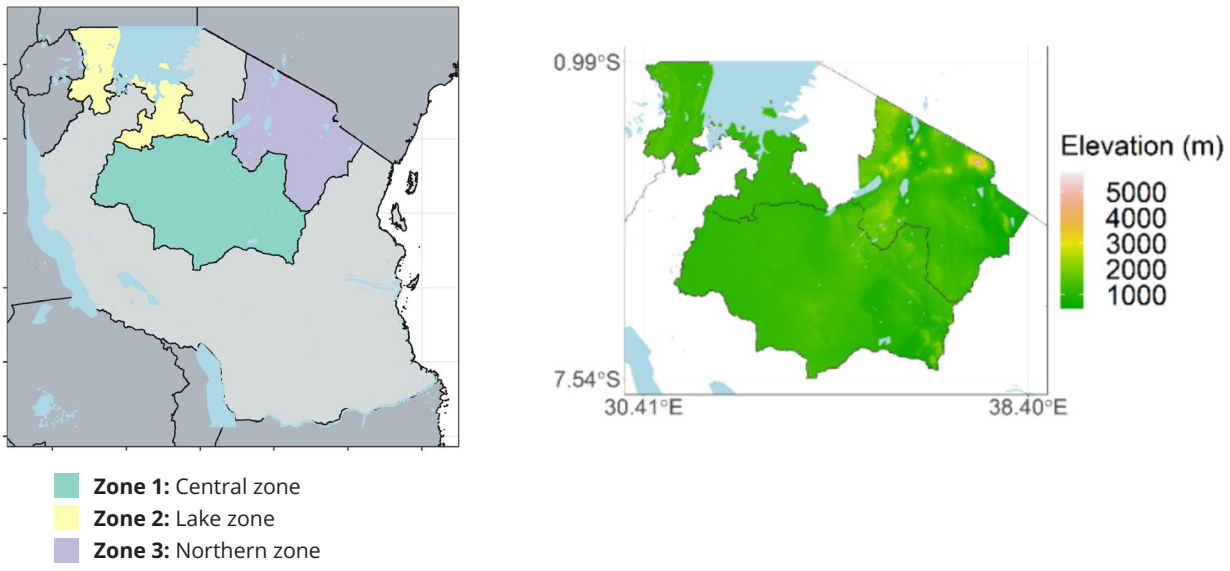



**Figure 8:** Map and elevation of selected LZs in Tanzania.

**Livestock production is the main source of income for a majority of households in this zone, and is derived mainly from the sale of cattle, poultry, and shoats.** A few households earn their income from the sale of cash crops like sesame, groundnuts, and sunflower. The main marketing channels for agricultural commodities are local traders. However, cash crops are transported to major towns like Dodoma or Dar-es-Salaam for sale. Cooperative societies are not widespread and have failed to organize farmers and thus to increase their bargaining power.

**Inadequate rainfall threatens food and livelihood security in the central zone.** This livelihood zone has a "borderline" food security status, indicating that when faced with climate hazards such as temperature increase, drought, and floods, poor households are likely to face hunger and require years to recover sold assets. This fact, coupled with the low availability of and high price of inputs, keeps farmers from producing significant quantities of high-quality food. Consequently, the food produced in this LZ cannot sustain the population's food needs, meaning households need to purchase food to meet the deficit. This depletes household savings, further limiting adaptive capacity. Households are often forced to seek out alternative sources of livelihoods like casual labor or selling charcoal and honey to supplement their income.

## LAKE ZONE

**The lake zone covers the areas of Kagera, Mwanza, and Shinyanga.** This is a lowland zone with a minimum average annual rainfall of 500mm and a maximum average annual rainfall of 1200mm. Similar to the central zone, farmers in the lake zone mainly practice rain-fed agriculture, especially livestock farmers who rely on rainfall for watering, forage production, and the production of food crops. Cattle, shoats, pigs, and poultry are extensively reared in this livelihood zone. Almost every household is engaged in the production of food crops, including maize, beans, rice, bananas, cassava, and sweet potato.

**Insufficient and erratic rainfall is a major threat to livelihoods in the lake zone.** Unpredictable precipitation has affected the generally reasonable food security level and has reduced income among households. When faced with hazards like droughts, floods, and recurrent periods of low production, poor households are likely to become food insecure. Most households are therefore unable to produce enough food for the whole year and must supplement production by purchasing additional food. In some instances, households that are below their survival requirements may require external assistance.

**Agricultural households must therefore look for alternative sources of income to meet their food requirements.** Revenues from cash crops like cotton, coffee, and rice are a major source of income for households. Some also engage in casual labor in mines or in agricultural labor. Livestock sales, particularly for wealthier households, can help make ends meet. These sales are facilitated through local markets, markets in bigger towns, and exports. The existence of good road networks, mainly to Uganda, allows for a steady flow of commodities in and out of the zone. On the other hand, poor local market access and fluctuations in the prices of food and cash crops discourage farmers from investing in production, which negatively impacts nutritional security.

## NORTHERN ZONE

**The northern zone, which is made up of the Arusha, Kilimanjaro, and Manyara areas, is a zone with ample rainfall.** However, some areas in this LZ receive low levels of annual rainfall, bringing the average to between 550 and 950 mm. With its relatively temperate

climate, the northern zone experiences both the *masika* and *vuli* rainy seasons. This allows most households to raise food and cash crops alongside livestock. Maize, beans, plantain, and sorghum are major food crops, while sunflower, coffee, onions, and pigeon are grown as cash crops. Cattle, sheep, goats, and pigs are also widely kept by households in this zone.

**Generally, the northern zone is considered to be a highly productive and food-secure livelihood zone.** Almost all households in this zone depend on market sales to meet a substantial proportion of their food needs. Livestock, especially cattle, is a significant source of income for households in this zone. Most livestock are sold to traders in local markets or in larger towns like Arusha. Crops such as coffee and plantain are also sold to international traders, especially in Kenya. However, price fluctuations disincentivize consistent crop production. For example, when the price of maize drops, farmers often replace it with sunflower in the next growing season.

**Production hazards negatively impact food security and livelihood generation in the northern zone.** Inadequate rainfall has been reported to affect food security every other year. Rainfall has become unpredictable and unevenly distributed, with either a early or a late onset. Frequent floods and droughts have also been experienced. Households must devise ways of adapting to these hazards. Some are investing in the construction of water harvesting dams and improved agronomic practices. Some areas, including Kilimanjaro and Arusha, have a suitable road infrastructure which allows for seamless trade throughout the year. On the other hand, households in areas such as Manyara are further from major markets, and poor road networks impede the sale of crops and livestock commodities.

**The northern zone is home to Mount Kilimanjaro, a major tourism hub.** This promotes the marketing of commodities in major towns and provides opportunities for casual labor. Quarries located within the northern zone also offer employment to laborers, which can significantly bolster the incomes of rural agricultural households.

# 2.2 Climate analyses across the livelihood zones

**This section contributes to an understanding of current and future climate trends and hazards across selected LZs.** Trends were assessed for the years 1980 to 2020, the years 2021 to 2040, and the years 2041 to 2060. For this analysis, RCP 8.5 and SSP5 were employed. These values refer to high-emissions and high adaptation-mitigation challenge trajectories. This RCP–SSP combination is close to the world's current emissions trajectory. This report focuses on 2030, given the short-term utility of the date for planning purposes, but extends the analysis to 2050 to assess post-2030 trends.

**The analysis is compounded on indices that correspond to the climatic risks affecting the central, lake, and northern LZs. These risks include heat stress, flooding, waterlogging and drought.** Heat stress, particularly on livestock, was assessed using the thermal humidity index (THI) that combines temperature relative to humidity. For the rainy season, heavy precipitation was represented with a 5-day average running precipitation (P5D) value that is indicative of

flood risks. Waterlogging was based on the number of days during the growing season with waterlogging (NWLD). Lastly, the number of dry days (NDD) during the growing season with precipitation less than 1mm a day-1 was used to measure drought.

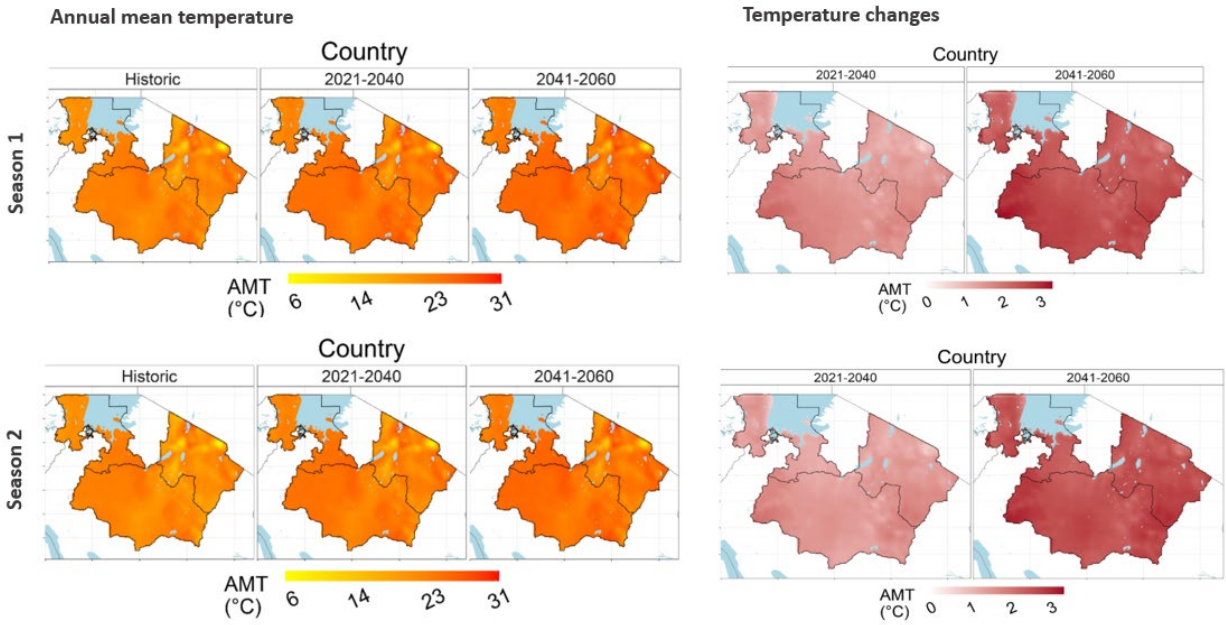



**Figure 9:** Historic (1980-2019) and future (2021-2060) annual mean temperature across the central, northern, and lake zones of Tanzania.

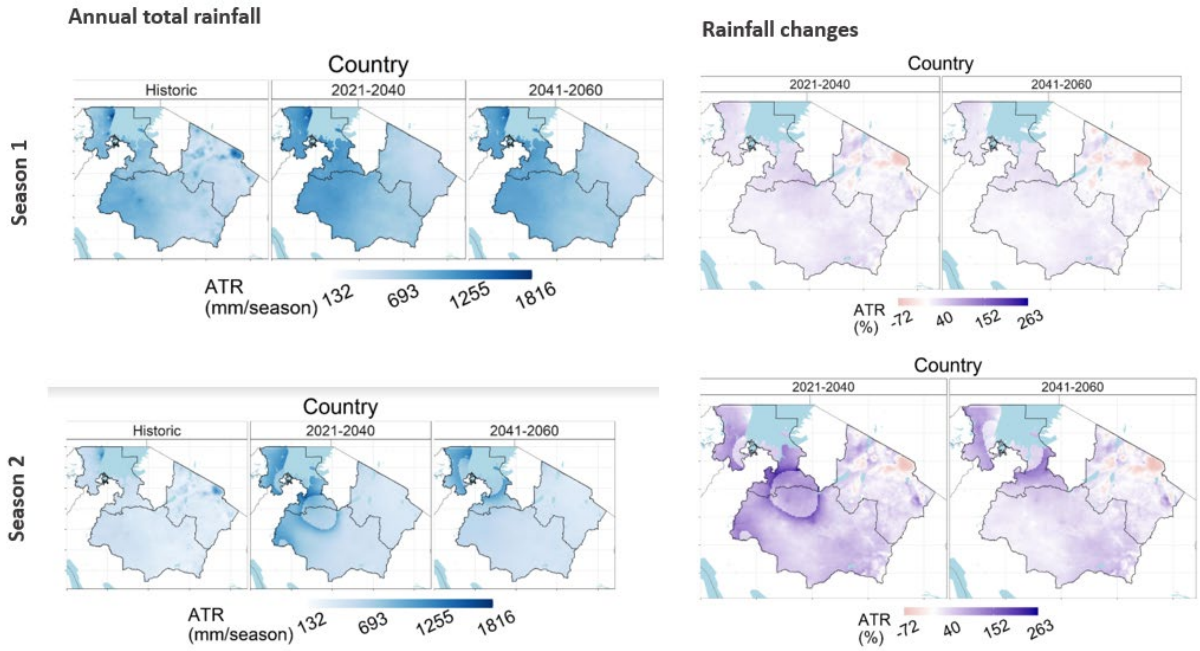



**Figure 10:** Historic (1980-2019) and future (2021-2060) annual total rainfall across the central, northern, and lake zones of Tanzania.

# 2.21 Mean climatic projections

**Historical temperature trends show a consistent increase in high annual mean temperatures (AMT) in every LZ in both the first and second season.** An AMT of above 18°C has been observed in the central, northern, and lake zones. Future projections show that all the three LZs will continue to be hotter, with an expected increase in temperature of 1-2°C between 2021 and 2040. Between 2041 and 2060, temperatures are expected to increase by a further 1°C (Figure 9). Great changes will be expected in the central zone, where temperatures could increase by up to 2°C.

**Precipitation is also expected to increase significantly across all LZs between 2041 and 2060.** The first season has been wetter compared to the second season. The annual total rainfall (ATR) trends show that all the three LZs received high rainfall of more than 1000mm per year between 1980 and 2019. Projections show that rainfall is likely to increase by between 5 and 8% between 2021 and 2040. More rainfall is anticipated between 2041 and 2060, with an increase of more than 13%. The central and lake zones will experience greater changes in rainfall (Figure 10).

# 2.22 Climate risk analysis

## HEAT STRESS

**Incidences of heat stress are projected to increase in the Central and Lake zones throughout the year, especially during the second season.** In the Northern zone, the first season has experienced more heat stress and the trend will continue in future. As the central zone is likely to experience the highest increase in temperature, it is more susceptible to heat stress (Figure 11). The impact of heat stress is more pronounced on cattle production than on goat production and is also more pronounced on sensitive crops such as the common bean.

## DROUGHT RISK

**Drought conditions, while persistent and damaging, are likely to decrease slightly across all LZs between 2041 and 2060.** Historically, drought is a common occurrence in both the first and second season. The second season is extremely dry, with more than 3 consecutive months with almost zero rainfall (Figure 12). Climatic projections show that although less drought will be experienced in future scenarios, it will still be persistent throughout the year. Drought is experienced in every LZ, but it's a major problem in the northern zone due to the intensive impacts that are discussed in Part 2.2.4 below.

## FLOODING AND WATERLOGGING RISK

**Given the projected increase in rainfall, flooding and waterlogging risks are anticipated in the first and second season (Figures 13 and 14).** Overall, flash flood risk is similar to regular flooding risk (based on maximum 5 day running average rainfall). As shown by the P5D and NWLD indicators, waterlogging and flooding are a challenge in the middle of the rainy season. Incidences of waterlogging and flooding are highest in the second season during the months of November and December. There is however a higher risk of flooding compared to waterlogging across all the LZs. While waterlogging is more pronounced in the central and lake zones, flooding is likely in every LZ and very likely in the lake zone.

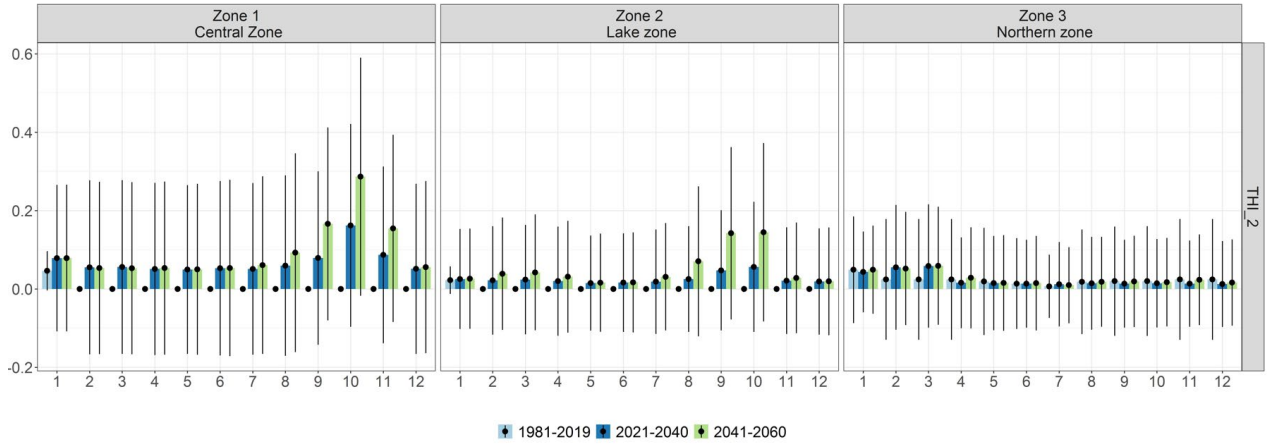



**Figure 11:** Monthly variation (expressed on the x axis) of the percentage of days per month likely to experience conditions of heat stress (expressed on the y axis) in historic (1981-2019) and future (2021-2040, 2041-2060) periods across the central, northern, and lake zones of Tanzania.

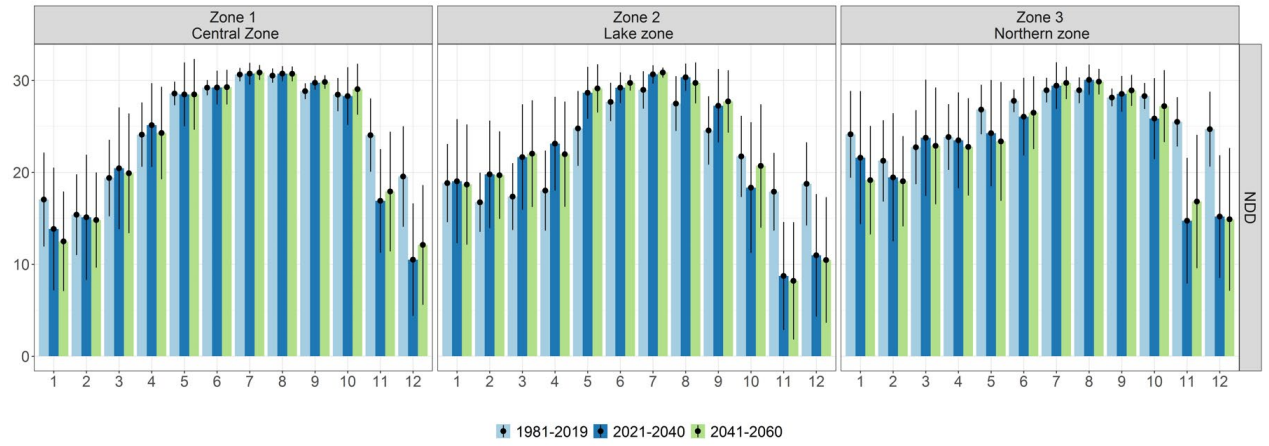



**Figure 12:** Historic (1981-2019) and future (2021-2060) projections of drought occurrence in the central, northern, and lake zones of Tanzania.

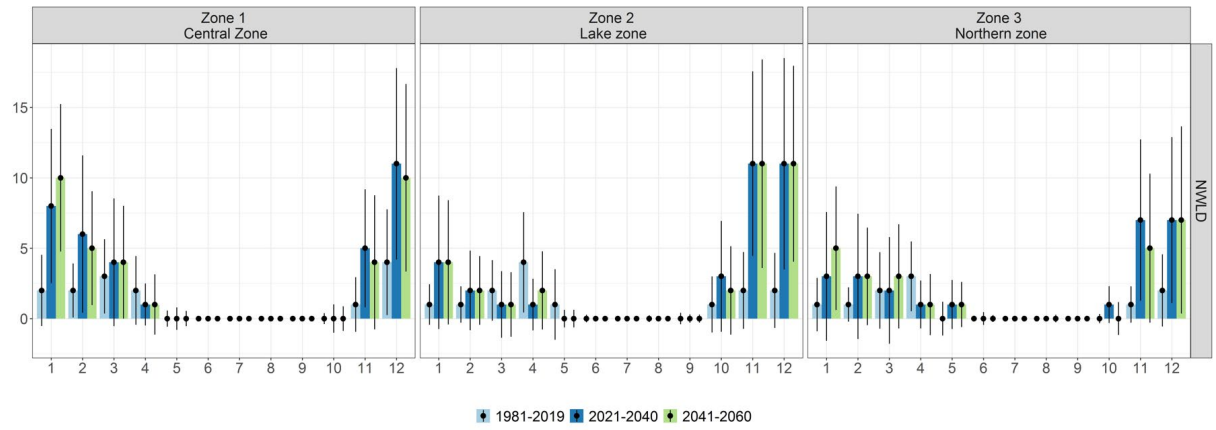



**Figure 13:** Historic (1981-2019) and future (2021-2060) projections of waterlogging occurrence in the central, northern, and lake zones of Tanzania.

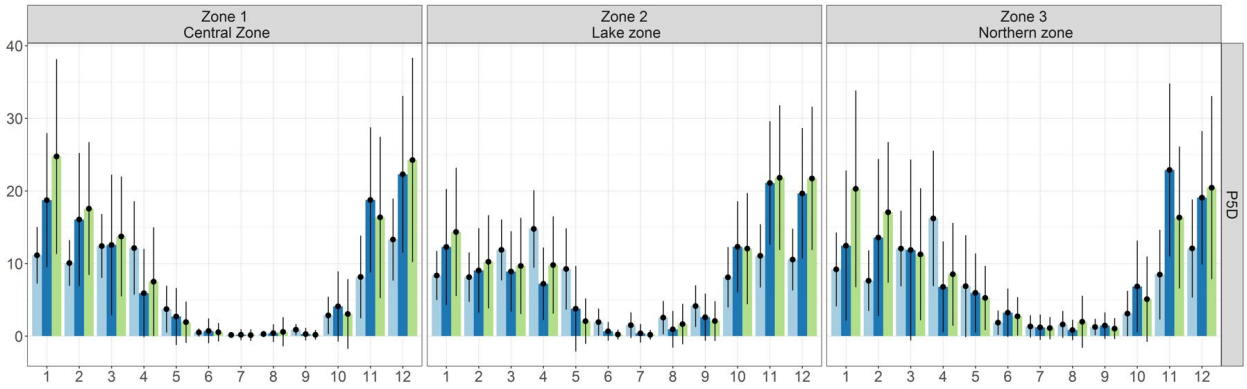



**Figure 14:** Historic (1981-2019) and future (2021-2060) projections of flood risks in the central, northern, and lake zones of Tanzania.

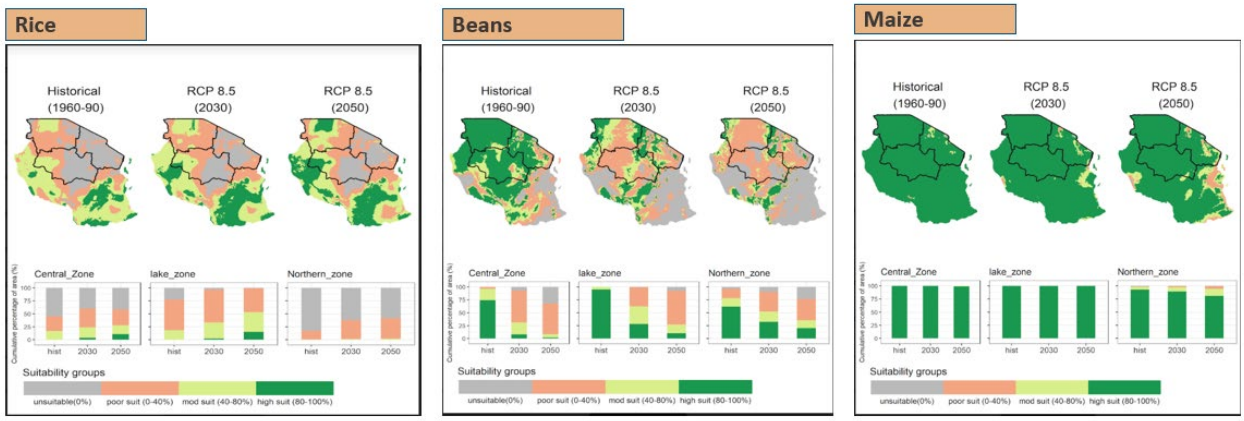



**Figure 15:** Historic (1960-1990) and future (2030-2050) suitability of rice, beans, and maize in the central, lake, and northern zones of Tanzania.

# 2.23 Risk: crop suitability analysis

**The EcoCrop model was used to find the areas suitable for crop production under current and future climate conditions in Tanzania (Ramirez-Villegas et al., 2013).** EcoCrop has been used in numerous research projects to conduct suitability assessments and understand the impacts of climate change on a large number of different crops. The model uses crop specific parameters such as minimum, maximum, and average temperature and cumulative precipitation during the growing season that was estimated across a spatial resolution of 5 x 5 km. For Tanzania, the suitability analysis was carried out for the staple crops of rice paddy, beans, and maize.

**From 1960 to 1990, climatic conditions have negatively impacted the suitability[9] of crops in most production areas (Figure 15).** For example, close to 80% of the northern zone is unsuitable for rice production, while parts of the central and lake zones feature moderate to poor suitability. Bean suitability in all the three zones is above 50%, with the lake zone featuring optimum suitability.

9 Crop suitability is measured as the cumulative percentage of area used for growing a certain crop.

All zones are highly suitable for maize production.

**Future projections that span 2030 to 2050 show a variation in the suitability of key staple crops.** As shown in Figure 15, suitable bean growing areas will diminish across all LZs in the future. The central and lake zones will be left with almost no suitable areas for production. However, some areas in the central and lake zones will become newly suitable for rice production, most likely due to increasing temperatures and different rainfall conditions. No significant changes in maize growing conditions are expected across the three LZs.

## 2.24 Threats to livelihoods

**Climatic hazards are a threat to livelihoods in the central, northern, and lake zones.** The threats discussed below come from Tanzania FEWSNET 2008 and KIIs, along with various experts from each LZ.

**In different intensities, all the three LZs have experienced unpredictable rainfall, recurrent droughts, and increasing temperatures.** Generally, unpredictable rainfall has disrupted crop calendars, resulting in low productivity. This has significantly contributed to high food and nutrition insecurity and loss of income among households. In the northern zone particularly, severe drought in 2014 and 2017 led to food shortages and the death of livestock. In the central zone, drought and inadequate rainfall have resulted in low production and an increase in food crop prices. Similarly, the central zone has faced increasing temperatures, leading to high evapotranspiration rates. This has a major effect on soil moisture, lowering crop performance. In the lake zone, drought has reduced grazing lands for livestock and depressed the production of fish, fruits, and herbs. The drying up of water sheds also causes water shortages at the community level. Horticultural crops are greatly affected during periods of drought and high temperature.

**Flooding and waterlogging have also had a negative impact on livelihoods across the central, lake, and northern zones.** For instance, in the central zone, heavy rainfall during harvesting in May and June affects the quality of produce through contamination by aflatoxins. In the lake zone, flooding along the shores of Lake Victoria hindered the production seasons of 2019 and 2020. Agricultural activities in areas along the shores of the lake, which is predominantly used for cultivating sweet potatoes, beans, and vegetables, were largely abandoned. In addition, waterlogging, particularly in the black cotton soils that are preferred for cotton and maize production, led to crop failure in the years 2019 and 2020 in the lake zone. 2019 floods in the northern zone interfered with the transportation of agricultural products by damaging roads and bridges. On the other hand, due to excessive floods, there was an increase in natural ponds, resulting in larger catfish populations. In highland areas, numerous landslides were experienced.

**Changing climatic conditions have also been associated with increased incidence of crop pests and human diseases.** In the lake zone, the changes in climatic conditions have led to the disappearance of indigenous food crop varieties and the drying up of watersheds. In 2013, the Mwanza Region in the lake zone experienced for the first time an outbreak of a serious horticultural pest known as the tomato leafminor moth, or *Tuta obsoluta.* An outbreak of fall army worms, or *Spodoptera frugiperda,* in maize crops and Cassava Brown Streak Disease appeared in 2017. These resulted in reduced crop yields

and hunger amongst households. Fall army worm has recently appeared in the central zone, mostly affecting sorghum and maize production. In the northern zone, human diseases such as malaria have become prevalent due to the increasing population of mosquitos.

**Non-climatic hazards like deforestation and wild animal invasions also pose a threat to livelihoods.** Deforestation is accelerating in the northern zone, where households have resorted to cutting trees as an alternative source of livelihood. Invasion by wild animals is common in every LZ. The proximity of the central zone to the Ruaha Game Reserve and that of the lake zone to the lake exposes households to invasion by wild animals such as elephants. Invasions of farms and residential areas have become rampant, destroying crops and killing domesticated livestock.

# 2.3 Vulnerability analysis: hotspots with co-occurrence of risks

**To assess the spatial distribution of vulnerabilities across the selected LZs, and to identify areas prone to co-occurring vulnerabilities, data was compiled on a set of indicators in Tanzania and then mapped.** A group of indicators such as food insecurity and nutrition, inequality, and poor health were selected to best represent three primary pillars of vulnerability as summarized

**Table 1:** Indicators considered to derive the vulnerability hotspot maps in Figures 17-18, including their categorisation. All included indicators are identified as such and the reason for any exclusion is noted.

| Variable specificity | Variable grouping | Variable | Inclusion status |
|---|---|---|---|
| Primary | Food insecurity & nutrition | Food insecurity | Included |
| | | Wasting prevalence | Included |
| | | Stunting prevalence | Excluded (insufficient variation) |
| | | Underweight prevalence | Included |
| | Gender and educational inequality | Male years of schooling | Included |
| | | Female years of schooling | Included |
| | | Gender education gap | Included |
| | Health | Plasmodium falciparum incidence rate | Included |
| | | Plasmodium vivax incidence rate | Excluded (insufficient variation) |
| | | Under-5 mortality per 1000 live births | Included |
| | | Diarrhoea prevalence | Included |
| Additional | NA | Soil organic carbon content | Included |
| | | Active fires | Included |
| | | Soil pH | Included |

in Table 1. Food security and nutrition was based on either direct estimations of food insecurity or on food consumption scores alongside estimates of child development and nutrition. Inequality was represented by proxy, using education and education-based gender indicators. Nutrition and health was represented by a combination of disease prevalence and mortality rates. Indicators were then tested to determine whether values covering the livelihood zones showed enough spatial variability to meaningfully contribute to the vulnerability hotspots map. For the variables which did meet these criteria, values were binarized according to a threshold used to separate values demonstrating "high" vulnerability from those which did not meet this criterion.

**The resulting binary layers were then summed up to show the prevalence of indicators that display high vulnerability (Figure 16a) and aggregated at the variable grouping level to illustrate the combinationsoffoodsecurityandnutrition, gender-based educational inequality, and poor health which contribute to societal vulnerability.** A similar process was used to produce maps of vulnerability hotspots using the additional indicators in our analysis, although no aggregation into variable groupings was performed due to the diverse nature of the variables used. In Figures 16-17, "no areas of high vulnerability" indicates that the indicator values in this area did not exceed a predetermined threshold for "high" vulnerability. All variables used in the spatial

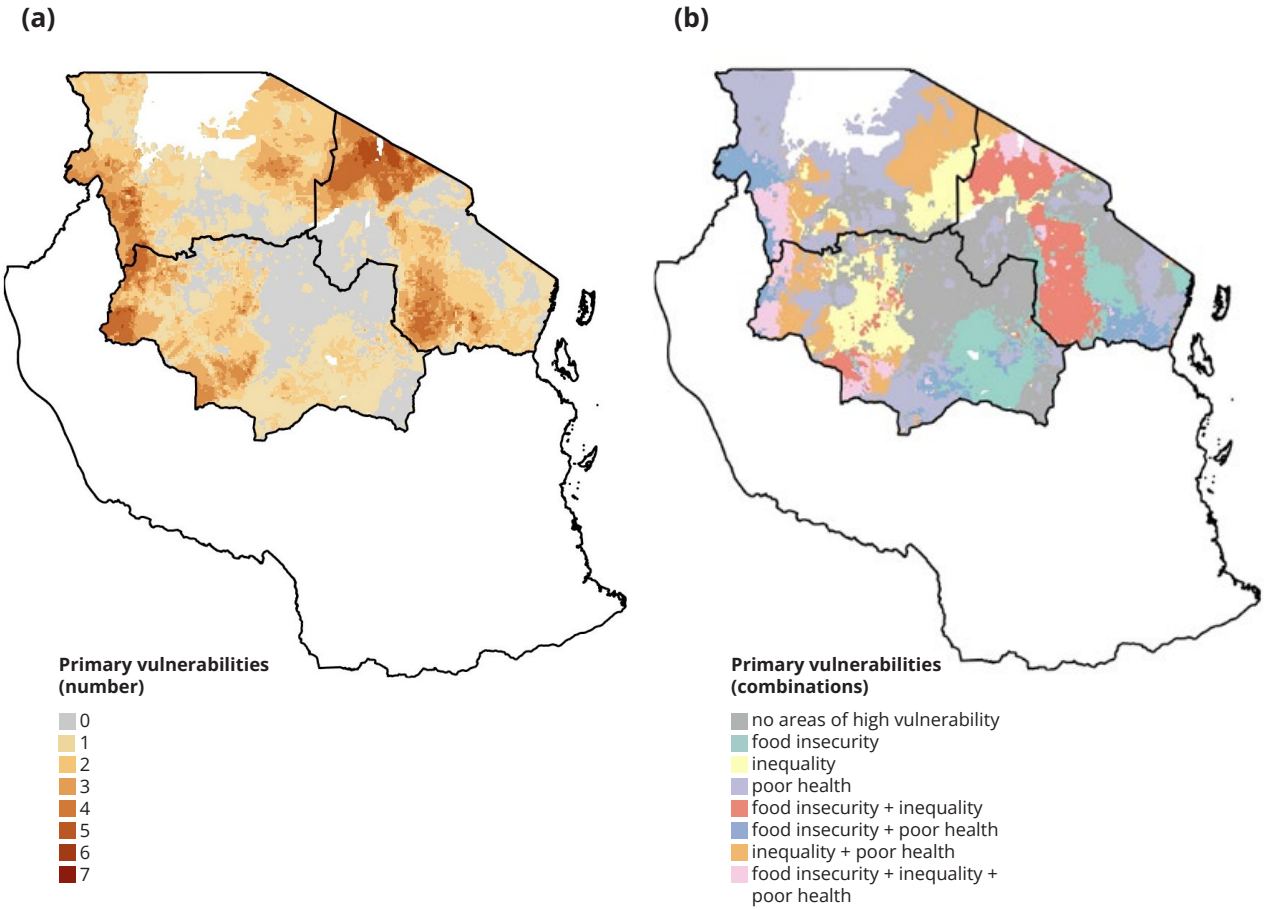



**Figure 16:** Total number of high vulnerability metrics, including food security and nutrition, health, and inequality; (b) Food security and nutrition, inequality, and health hotspots across the livelihood zones, shown as combinations of vulnerability metrics. These specific vulnerability metrics are labelled as 'included' in Table 1.

analysis are labelled as "included" in Table 1. Further methodological explanation is detailed in Annex 2.

**Only a small geographical area across the three LZs shows no indicators of "high" vulnerability (Figure 16a).** The highest concentration of vulnerability indicators lies in the northeastern corner of the northern zone and in eastern parts of the central and lake zones. In regards to specific vulnerability indicators (Figure 16b), food security seems to be more of an issue in the central and northern zones. Inequality prevails in every LZ, but with a lower concentration in the northern zone. Poor health is prevalent across much of the country and is particularly prominent in the lake zone. This prevalence, as explained in Part 2.1 of this report, could be due the periodic floods experienced in the zone that lead to the spread of malaria and other waterborne diseases such as diarrhoea. The western parts of the central and lake zones and a small area in the northern zone are subject to food insecurity, high inequality, and poor health.

**Additional vulnerability indicators include active fires and soil degradation (Figure 17).** Active fires cover a large proportion of the country, assuming a 5km impact zone per fire. Low organic carbon content in soil is highly prevalent across the central zone and very southern part of the lake zone, but does not impact the remaining areas. Soil pH is high across the western side of the northern zone and eastern side of the lake zone, but is mostly absent from the central zone. Very few areas are subject to a combination of high soil pH, low organic carbon content, and active fires. Low organic carbon content and active fires commonly coexist in the central zone. There is some overlap between high soil pH and active fires in the eastern part of the lake zone (Figure 17b).

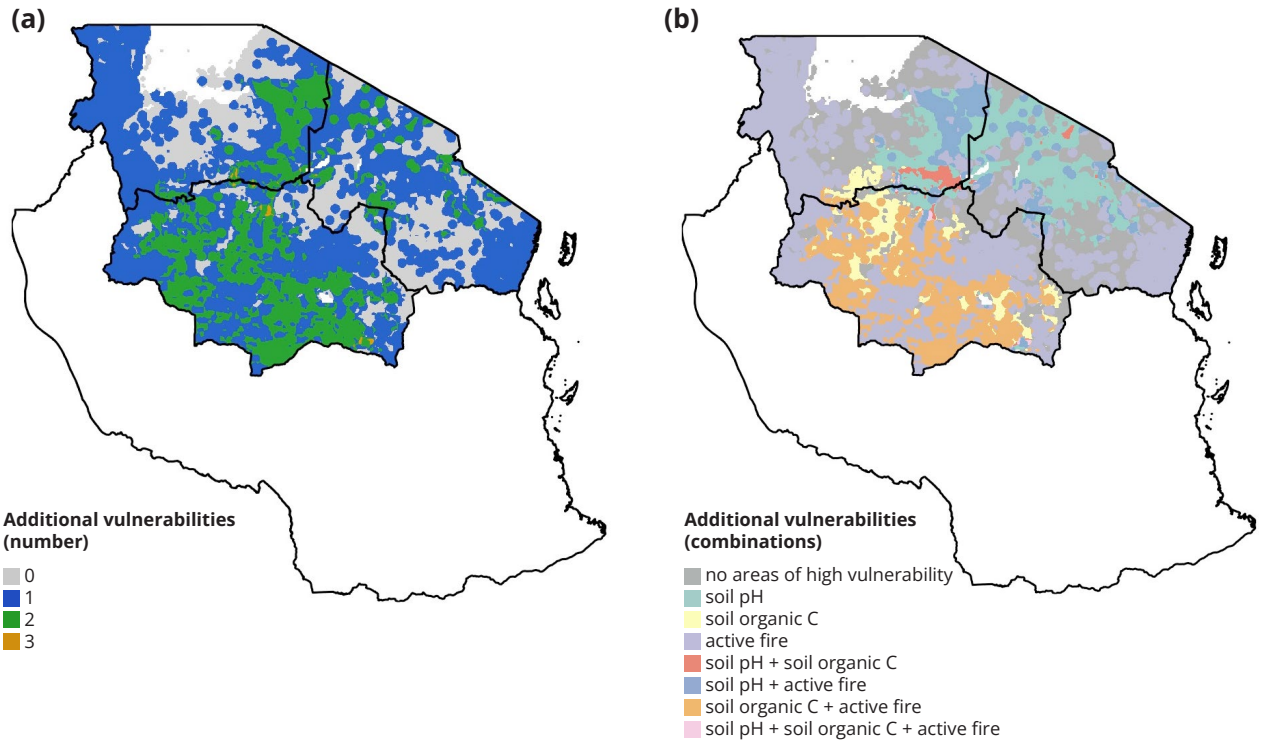



**Figure 17:** (a) Total number of additional vulnerability metrics classified as 'high' (negative outcome) in a given area; (b) Combinations of additional vulnerability hotspots across selected livelihood zones. The specific vulnerability metrics used are shown as 'included' in table 1.

PART 3.

# Review of World Food Programme activities and recommendations for optimization

# 3.1 Review of WFP's climate resilience activities and recommendations for programmatic response

**In Tanzania, WFP activities are implemented according to the Country Strategic Plan (CSP) 2017-2021.** The CSP design involves a wide range of stakeholders who identify and analyze the country's needs and priorities. It is closely aligned with Tanzania's FYDP II 2020-2021. Since WFP supports the government, its programs employ government data to understand underlying issues. The WFP country office works closely with government ministries, the local governments, and district authorities, all of whom play a role in ensuring the sustainability of WFP's programming.

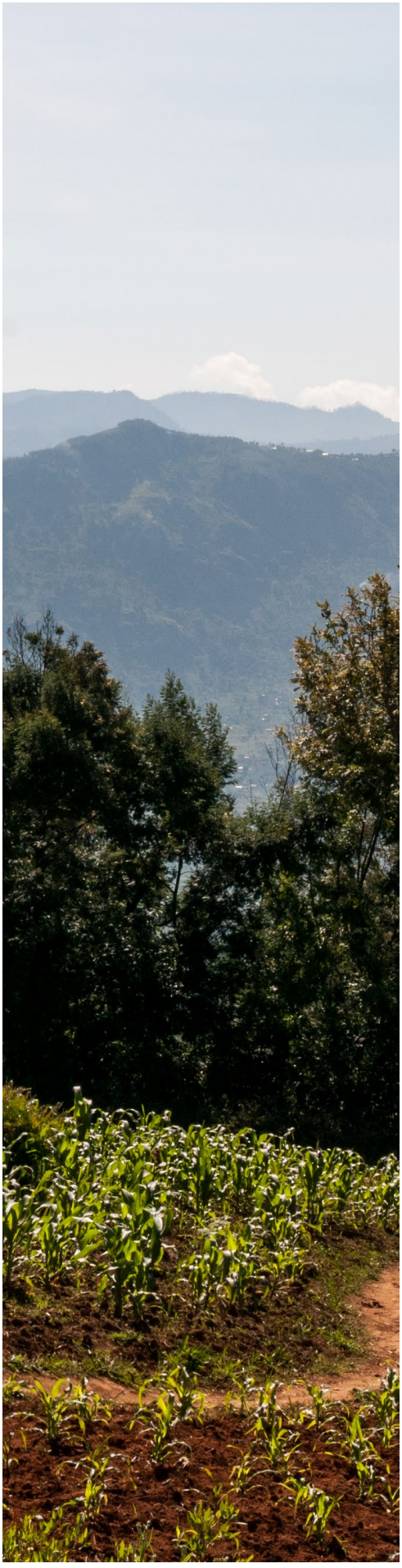
**The Tanzania CSP 2017-21 has five strategic outcomes (SOs)[10] that define its scope of activities in different regions of the country.** The first strategic outcome (SO1) aims at offering assistance to refugees by meeting their food and nutrition requirements. Following the WFP nutrition policy, the second outcome (SO2) focuses on ending malnutrition through capacity building and nutritional assistance. Strategic outcome three (SO3) aims to bolster smallholder production by increasing productivity and market access. Strategic outcome four (SO4) seeks to support national social protection and disaster management systems. Lastly, under strategic outcome five (SO5), WFP intends to design and establish hubs to foster and upscale innovations in Tanzania.

**Climate change is not the primary focus of WFP in Tanzania. However, climate change adaptation and resilience are addressed in activities that are aligned with SO3.** Activity 1 under SO3 focuses on ensuring the inclusion of smallholder farmers, especially female farmers, in formal value chains. WFP is working closely with the Ministry of Agriculture to provide value-chain support by rehabilitating warehouses for improved storage and enhanced market access. This helps to minimize post-harvest losses during adverse weather conditions, thus increasing income among farmers. Activity 2 under SO3 also has a strong focus on climate change. It emphasizes the promotion of CSA practices like using drought-tolerant crops and diversifying small-scale livestock among households. Working closely with ministries involved in climate change issues, SO3's Activity 2 seeks to upscale the use of climate services, including finance, insurance, and extension services. This action has been made viable through the integration of these climate services into interventions like the rural resilience initiative.

**SO4 addresses climate change as well. It does so by supporting the government and providing services to enhance national disaster and risk-management capacity.** Through Activity 1 of SO4, WFP is helping develop early-warning systems that can help the government cope with emergency shocks. WFP uses digital media and radio stations to disseminate climate and meteorological information. This information has greatly helped farmers. Most SO4 activities have

10 WFP Tanzania intervenes in five areas. These areas are refugees, nutrition, small holder farmers, resilience, and innovation. More info is available at: https://www.wfp.org/countries/tanzania.

been implemented in the northern and central zones. In the northern zone, farmers have benefited from training that helps them make informed decisions based on the seasonal weather forecast. The Participatory Integrated Climate Services for Agriculture (PICSA) project was recently implemented in the central zone. This project introduced a food security and climate change package that helped farmers manage climate-related risks. The package involved funding trainings for farmers and field officers in order to raise awareness on how weather information can be used to inform decision making and budgeting purposes.



# 3.2 Programmatic recommendations for WFP climate adaptation responses

**The programmatic recommendations highlighted in this section were derived from key informant interviews and a validation workshop.** Participants included experts working in government ministries and institutions, and local and international NGOs in Tanzania. The recommendations offer insight into potential WFP programming activities geared towards building the climate resilience of communities across all three livelihood zones.

## 3.21 Cross-cutting recommendations for WFP climate programming

**Tanzania is a large and geographically diverse country, so WFP has not been able to implement climate activities in every region.** The activities to

be implemented depend on the availability of resources and government priorities. Covid-19 has also affected WFP activities, as most of the activities are field based, especially those dealing with capacity building. WFP has internal, customizable tools to implement government programs and policies on climate change. However, policies need to be simplified and clearly defined in order to judge implementation needs at the local level and ensure relevant policies on a local scale.

**In Tanzania, climate change is considered an environmental issue.** It is important to note that because environmental issues have not been boldly adopted by the current strategic plan, WFP has an opportunity to expand on this plan. The next WFP's CSP concerns the oceans' environmental issues.

**WFP is well-positioned to support the Tanzanian Government in implementing climate change-related activities, as stipulated in its national policies.** Since WFP technically and financially facilitates the government, it can upscale and incorporate climate activities. The Office of the Prime Minister coordinates environmental and climate change issues and is an ideal for partner for WFP. Additionally, Tanzania's Climate Change Strategy of 2012 should be leveraged to address strategic climate change issues. WFP's CSP is developed in line with national policies; this means that there is an opportunity to incorporate climate resilience to an even greater extent in the upcoming 2022-2026 CSP. In this regard, the national framework for climate services emphasizes the need to improve the availability and use of weather and climate services – a key activity that WFP can support the government in realizing over the next five years.

**Presently, activities under SO1, SO2, and SO4 offer an entry point for upscaling WFP's climate-resilience activities in Tanzania.** SO4 is particularly significant, as building national capacity for improved emergency response preparedness is a core activity. This activity is intended to boost Tanzania's disaster risk management and reduction capacities. SO2 also seeks to build institutions' capacity to better deal with climate-related food and nutrition insecurity. Under SO1, WFP is currently supporting the government in formulating evidence-based policies. These activities can be further improved by ensuring that participatory processes are used.

**Generally, climate-smart agriculture (CSA) has a key role to play in forming a comprehensive strategy for sustainable production, climate adaptation, and emissions mitigation in the context of a changing climate.** Activities that seek to improve agricultural productivity, strengthen the delivery of climate information services, build the capacity of farmers and technical experts, foster livelihood diversification amongst smallholders, and promote innovations are highly recommended. Though most of these activities are strongly aligned with SO3, some may be carried out in accordance with SO1, SO2, SO4, and SO5. Specific recommendations for all LZs are discussed in the subsequent section.

## 3.22 Specific recommendations for upscaling WFP's climate programming

**The impact of drought, high temperatures, and floods on the livelihoods of communities in the central, northern, and lake LZs varies.** This means that programmatic interventions must be tailored to the magnitude and local impact of each hazard. As mentioned in the previous

section, a broad base of climate-smart activities are recommended. Some are already being implemented at the household level but require scaling at the institutional and policy level for greater impact. Table 2 below provides a detailed summary of programmatic interventions that need to be upscaled at the zonal level and their alignment to WFP Tanzania's current CSP.

**The implementation of climate-smart agricultural practices at the household level is inhibited by low access to and high prices of agricultural inputs.** The lack of access and high prices have a negative effect on food and nutritional security, as they result in insufficient quantities of low-quality food. Households also lack access to readily available and low interest loans, and farmer cooperatives have failed to increase their bargaining power. These challenges can be addressed by SO3's Activity 1, which aims to facilitate access to services and products among farmers in order to boost production. Farmers also need to be trained to produce valuable and highly nutritious food crops in order to meet health requirements. This recommendation is strongly aligned with SO2's Activity 2, which seeks to improve the nutritional status of vulnerable households through knowledge management and behavioral change. Additionally, women are bound by social roles and responsibilities that create different vulnerabilities and affect their ability to adapt to climate change impacts. Further, women have inadequate access to entitlements and assets, which limits their decision-making power, thereby making it difficult for them to offset and recover from hazards. Female farmers are specifically targeted in SO3, making SO3 in an ideal vehicle for gender-sensitive climate resilience initiatives.

**Following its involvement in building the capacity of government institutions through SO4's Activity 1, WFP should upscale programmatic interventions at the institutional level.** Presently, a number of institutions are helping the government promote CSA in Tanzania. The main focus has been to improve productivity and enhance adaptation and resilience among smallholder farmers. Inadequate financial and human resource capacity remain the biggest challenges for institutions that work on upscaling CSA.

**Finally, WFP's role in national policy advocacy and dialogue through SO1's Activity 2 could be leveraged to influence the local implementation of national climate change policies.** While Tanzania is committed to international and regional climate change policies, there are no existing climate change policies at the zonal level. Supporting the national government in implementing these policies is therefore key to building the resilience of climate-vulnerable communities. Because the implementation of policy interventions on the ground has taken a project-based approach, as opposed to a programmatic approach, WFP has a higher chance of upscaling interventions at the policy level (CIAT & World Bank, 2017).

**Table 2:** Programmatic recommendations for upscaling climate resilience in the central, lake, and northern zones of Tanzania.

| Livelihood zone | Hazard | Recommended interventions | Scale of intervention | Link to WFP programming |
|---|---|---|---|---|
| **Central zone** | **Heat stress** | • Intercropping<br>• Agroforestry to provide natural cooling systems | Household level | SO 3-Activity 2 |
| | | • Train farmers and extension officers on choosing crops that are heat-tolerant, such as sorghum and millet | Institutional level | SO 3-Activity 1<br>SO 2-Activity 2 |
| | | • Promote other crops like sunflower, regulate imports and exports | Policy level | SO 1-Activity 2 |
| | **Drought** | • Promote greenhouses<br>• Promote rainfall harvesting and boreholes<br>• Promote livelihood diversification, promote livestock production, promote alternative crop varieties such as grapes | Household level | SO 3-Activity 2 |
| | | • Train smallholder farmers so as to build their capacity | Institutional level | SO 3-Activity 1 |
| | | • Educate DCs and parliament on the effects of drought | Policy level | SO 1-Activity 2 |
| | **Flooding/ water logging** | • Encourage fish farming<br>• Plant crop varieties that are tolerant to waterlogging<br>• Improve drainage systems | Household level | SO 3-Activity 2 |
| | | • Promote the use of manure and fertilizer | Institutional level | SO 3 -Activity 2 |
| **Northern zone** | **Drought** | • Create awareness of drought-resistant crops | Household level | SO 3 -Activity 2 |
| | | • Strengthen food security assessment and analysis teams at the district level | Institutional level | SO 4-Activity 1 |
| | | • Promote crop-monitoring capacity at the national and local levels | Policy level | SO 5-Activity 1 |
| | **Flooding/ water logging** | • Improve the accessibility of climate information<br>• Build the capacity of farmers and extension officers to interpret meteorological information | Household level | SO 3-Activities 1 and 2 |
| | | • Improve infrastructure<br>• Map flood-prone areas | Institutional level | SO 4-Activity 1 |
| | | • Strengthen water level<br>• Strengthen information dissemination systems on flood forecasting<br>• Support the monitoring of climate indicators | Policy level | SO 4-Activity 1<br>SO 5-Activity 1 |

| Livelihood zone | Hazard | Recommended interventions | Scale of intervention | Link to WFP programming |
|---|---|---|---|---|
| **Lake zone** | **Floods/water logging** | • Promote rainwater harvesting<br>• Promote tree planting<br>• Train communities in aquaculture activities<br>• Build capacity in sustainable water-use strategies | Household level | SO 3-Activity 2 |
| | | • Diversify activities, incorporate fish cage farming and paddy rice cultivation<br>• Raise awareness among communities<br>• Establish drainage systems<br>• Promote the dissemination of weather forecast information<br>• Establish gene banks of indigenous seeds | Institutional level | SO 4-Activity 1<br>SO 3-Activities 1 and 2 |
| | | • Reinforce Water Sanitation and Hygiene (WASH) for disease management. WASH services are a government responsibility hence a policy area | Policy level | SO 1-Activity 2 |

# 3.3 Scoping WFP programmatic partnership opportunities

**Government ministries and parastatals have great partnership potential due to their wide coverage of activities throughout the country and adequate technical personnel and extension officers.** The Ministry of Environment coordinates climate change activities with other ministries, including the Ministry of Agriculture, the Ministry of Finance, the Ministry of Water, and the Ministry of Livestock and Fisheries. Thus, the importance of ministries in building climate resilience cannot be overstated. Government institutions and local government authorities can also be key partners due to their specialization in diverse climate change areas. For example, the Tanzania Meteorological Authority (TMA) provides climate information services, the Tanzania Bureau of Statistics provides data, and the Tanzania Social Action Fund (TASAF) specializes in issues of social protection.

**Climate change research aims to provide options in minimizing climate risks. This aim amplifies the need for partnerships with research institutes.** The International Crop Research Institute for Semi-Arid Tropics (ICRISAT) is a pertinent research institute due to its extensive work in promoting CSA. ICRISAT is currently researching participatory variety selection (PVS) and participatory hybrid selection (PHS) in sorghum, pearl, and finger millet production. Government research institutions like the Tanzanian Agricultural Research Institute (TARI) have also researched and released crop varieties in order to combat or revamp resilience to climate change. For instance, TARI has

released eight varieties of cassava to combat Cassava Brown Streak and Cassava Mosaic Disease. The Crop Bioscience Institute has also produced resilient varieties of round potatoes. Partnerships with the above institutions would allow locally relevant CSA interventions to support WFP Tanzania's SO1, SO2, SO4, and SO5.

**Partnerships with international and local NGOs that are already working on climate change would support WFP's future resilience programming.** International NGOs, including UN agencies like FAO and UNEP, are already contributing to the formulation of CSA guidelines and working on local environmental issues. Similarly, the Tanzanian Red Cross Society facilitates emergency responses and is a promising partner for WFP's disaster risk reduction initiatives. Other organizations that could help expand the scope of climate change initiatives include Heifer International, which supports climate smart livestock production; Farm Africa, which promotes the production of improved varieties of sunflower, and World Vision, which works to build resilience among vulnerable groups.

**Civil society organizations (CSOs) and community-based organizations (CBOs) can assist in the local implementation of climate-related programming and should be seen as key impact partners.** These groups play an important role in policy advocacy, creating awareness, and training farmers. For example, Open Map Development Tanzania, the Tanzanian Civil Society Forum on Climate Change, the Tanzania Natural Resource Forum (TNRF), and the Mazingira Network and Sustainable Agriculture Tanzania (SAT) can all enhance WFP's impact at the ground level.

## 3.4 Funding opportunities for climate-resilient programming

**Climate change activities in Tanzania are mainly funded by the international donor community - see Part 1.5.3 for more information.** Certain UN agencies such as the United Nation Environmental Program (UNEP) and the UNDP Climate Adaptation Fund have intermediated climate finance in Tanzania. However, it is necessary to assess the best mechanisms to operationalize and govern funds in the Tanzanian context (Trujillo et al., 2013). Funding from multilateral sources like the African Development Bank (AfDB) is yet to be accessed. Similarly, Tanzania is eligible for the Adaptation for Smallholder

Agriculture Program (ASAP) and funding from the Africa Climate Change Fund (ACCF), but is yet to make a decision regarding these funds. Apart from donors such as the World Bank and Norway, funding from international development partners can be further pursued. USAID, the UK Foreign Commonwealth and Development Office (FCDO), and NGOs like the Netherlands Development Organization (SNV) are all potential financiers. Still, Tanzania has restricted access to climate funds due to the complexity of application procedures and limited awareness among national institutions of available funding opportunities.

**Global climate funds providers, including The Green Climate Fund (GCF) and the Global Environment Facility (GEF), present another opportunity to increase WFP Tanzania's climate change budget.** On account of its significance in the climate finance context, the GCF has become a principal source of international climate financing. Recent records show that the GCF board approved a grant of 109 million USD to Tanzania for climate action, particularly for sustainable water management and agriculture action (CIAT & World Bank, 2017). While lucrative, international climate finance can be challenging to access and is highly competitive. Long application processes render these sources medium- or long-term options, rather than short-term options.

**The government should increase its budgetary allocation for climate change activities in Tanzania.** Presently, Tanzania has not established a national climate funding mechanism, and the Ministry of Finance has not been directly involved in financing CSA initiatives in the country. Increased allocation of the country's domestic budget towards CSA would be an important stimulant for agroclimatic-related financing. The mechanisms used by other developing countries in Africa, like Kenya, for setting up national climate change funds could serve as an example to Tanzania. These mechanisms have the potential to consolidate and coordinate funds from various sources and to channel them towards climate action (CIAT & World Bank, 2017).

**The private sector in Tanzania is actively engaged in climate-related activities and therefore could also contribute to climate financing.** The private sector has supported and invested in a number of activities from policy formulation to project implementation. Some private sector actors have provided renewable energy and forestry services, and supported post-harvest activities like value addition, processing, and marketing (Trujillo et al., 2013). The strengthening of public-private partnerships (PPPs) therefore displays significant potential to improve agricultural productivity and could contribute to a more exhaustive agricultural sector growth strategy. A promising PPP exists between WFP and the Southern Agriculture Growth Corridor of Tanzania (SAGCOT), which is a regional partnership that promotes CSA development among smallholder farmers.

**With the development of Tanzanian CSA guidelines and programs comes opportunity to attract medium-to-large scale financing for localized CSA projects.** Already, there exists domestic funding from the Tanzania Agricultural Development Bank (TADB), which broadly finances agricultural investments in the country. Tanzania has a pool of micro-finance institutions that promote farmer groups and cooperatives by offering a variety of financial services. These institutions have helped improve farmers' access to credit. WFP could help vulnerable households access these sources of finance by assisting with the development of seasonal livelihood plans and community-based planning initiatives related to smallholder CSA.

PART 4.

# Synthesis

**Climate change is a major obstacle to Tanzania's socio-economic development. This analysis has focused on three livelihood zones:** the central, northern, and lake zones. These zones will experience different impacts of climate change in the future. Drought, floods, waterlogging, unpredictable rainfall, and high temperatures are the main climate hazards projected to impact these livelihood zones. The central zone shows a high probability of heat stress in future scenarios. Floods and waterlogging will be most severe in the lake zone. The northern zone is more likely to be affected by drought, especially during the wet season. Coupled with high poverty rates, limited access to health facilities, and inequality in resource allocation, these climatic hazards pose a significant threat to livelihoods. It is therefore necessary to evaluate the impacts of these climate hazards and to design adequate interventions that are specific to each zone.

**Climate change is projected to have mixed impacts on food availability, access, and utilization.** While the results of the IMPACT analysis show that the suitability of climate-resilient crops like rice may increase in decades to come, the production of staple crops that are critical to food security, like maize, are likely to be negatively impacted by climate change. Calorie availability will decline, which is likely to affect food availability. This phenomenon is projected to influence the consumption patterns of households; most households will substitute starchy staples with animal calories and fats. The percentage of the population that is at risk of hunger and undernourishment is therefore expected to increase in the future, given the prevailing climate change scenario. Awareness should be created among households on recommended dietary composition as well as the consumption of nutritious foods.

**The Government of Tanzania has shown a commitment to addressing climate change by integrating certain elements into development policies.** Several policies have been formulated to assess the extent of climate change's impacts, and effective intervention mechanisms have been put into place. However, implementation is hindered by inadequate financing and poor coordination among public institutions. Partnerships between government institutions and the private sector, and capacity building among government staff will strengthen sectoral links and help stakeholders to efficiently work together. Strategies on mobilizing funds from multiple sources are also important.

**Partnerships between the government and its development partners have also played a significant role in building climate resilience.** For example, WFP has been working with government ministries to implement climate activities designed for smallholder farmers and disaster and risk management. Still, these climate activities need to be upscaled at the household, institutional, and policy levels. Programmatic recommendations aim to strengthen CSA practices by targeting productivity, climate information services, capacity building, livelihood diversification, innovation hubs, and policy interventions. Building partnerships with international and local NGOs, the private sector, academic institutions, and other government agencies is commendable. Table 3 below shows a synthesis of the key findings from this report's analytical framework.

**Table 3:** Summary of findings from the review and the climate analysis

| | Livelihood zone | | Central zone | Northern zone | Lake zone |
|---|---|---|---|---|---|
| Analytical Insights | Current climate hazards | Drought | X | X | |
| | | Heat stress | X | | |
| | | Floods | | X | X |
| | | Waterlogging | X | | X |
| | Projected climate changes through 2050 | Temperature | High and increasing. Increase of 1-2°C is expected. **Most** changes will occur in this zone. | High and increasing, expected increase of 1-2°C is expected | High and increasing, expected increase of 1-2°C is expected |
| | | Precipitation | Rainfall will increase by more than 13% in the future. | Rainfall will increase by more than 13% in the future. Annual total rainfall will increase between 4 and 16%. | Rainfall will increase by more than 13% in the future. Annual total rainfall will increase between 4 and 16%. |
| | | Flooding/ waterlogging | Increased incidences in the middle of the rainy season will exacerbate in the future. | Increased incidences in the middle of the rainy season will exacerbate in the future. | Increased incidences in the middle of the rainy season will exacerbate in the future. |
| | | Heat stress | Higher risk of heat stress. 40% chance of heat stress occurrence by 2050. | Moderate risk of heat stress. | Moderate risk of heat stress. |
| | | Drought | Both wet and dry season drought. Months of nearly zero rainfall experienced. Less drought in the future. | Both wet and dry season drought. Months of nearly zero rainfall experienced. Less drought in the future. | Both wet and dry season drought. Months of nearly zero rainfall experienced. Less drought in the future. |
| | Hotspot analysis of current non-climate vulnerabilities | Primary vulnerabilities | - Food insecurity<br>- Poor health<br>- Gender-based inequality | - Food insecurity<br>- Poor health<br>- Gender-based inequality | - Food insecurity<br>- Poor health<br>- Gender-based inequality |
| | | Additional vulnerabilities | - Low soil organic C<br>- Soil PH<br>- Active fire | - Low soil organic C<br>- Soil PH<br>- Active fire | - Low soil organic C<br>- Soil PH<br>- Active fire |
| | IMPACT analysis of climate change on food access and stability through 2050 | Food availability concerns | **(+)** Production for rice is projected to exhibit resilience in the face of climate change, expanding production.<br>**(-)** Yields for cereals and pulses are generally lower under CC than under a No-CC scenario, especially for maize and beans.<br>**(-)** Calorie availability is generally lower under CC relative to the No-CC benchmark for staple crops like maize, rice, and other cereals. Pulse and livestock availability will increase. | | |
| | | Food utilization and stability concerns | **(-)** Import dependence under CC is lower for rice and maize, but higher for beans.<br>**(-)** Negative climate trends like heat stress, drought, and flooding can disrupt food supply and increase commodity prices.<br>**(-)** The percent of the population that is at risk of hunger and numbers of undernourished children are projected to be higher under CC than under the No-CC benchmark. | | |

| | Livelihood zone | | Central zone | Northern zone | Lake zone |
|---|---|---|---|---|---|
| Cross-cutting recommendations | **Partnership opportunities** | | **Research institutes:** International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Tanzanian Agricultural Research Institute (TARI), Sokoine University<br>**Government ministries and parastatals:** the Ministry of the Environment, the Ministry of Agriculture, the Ministry of Finance, the Ministry of Water, the Ministry of Livestock and Fisheries, Tanzania Meteorological Authority (TMA), Tanzania Bureau of Statistics (TNBS), and Tanzania Social Action Fund (TASAF)<br>**International and local NGOs:** UN (FAO and UNEP), Tanzanian Red Cross, Heifer International , Farm Africa, and World Vision<br>**Civil Society Organizations (CSOs) and Community Based Organizations (CBOs):** Open Map Development Tanzania, Tanzanian Civil Society Forum on Climate Change, Tanzania Natural Resource Forum (TNRF), the Mazingira Network, and Sustainable Agriculture Tanzania (SAT) | | |
| | **National-level policy support** | | National Adaptation Plan (NAP)<br>National Climate Change Policy + implementation framework | | |
| | **Province-level policy support** | | Rural municipality-level food security strategy, Local Adaptation Plan of Action (LAPA), provincial-level disaster risk reduction strategies | | |
| | **Institutional capacity strengthening** | | Capacity building on climate change adaptation and mitigation, formalizing communication sharing for effective implementation, investment in monitoring and accountability systems, training in resource mobilization and financial planning | | |
| | **Climate resource mobilization** | **Bilateral development partners** | Foreign Commonwealth and Development (FCDO), Netherlands Development Organization (NDO), USAID (United States Aid) | | |
| | | **Multilateral development Banks** | World Bank, African Development Bank (AFDB) | | |
| | | **International/ multilateral funds** | Green Climate Fund (GCF), Global Environment Facility (GEF) | | |
| | | **Government** | Ministry of Finance, Ministry of Planning | | |
| Specific Programmatic recommendations | **Household level (adaptation)** | **Flooding/ waterlogging** | Recommendations linked to SO3 – Act 2 (Table 2) | Recommendations linked to SO3 – Act 2 (Table 2) | Recommendations linked to SO3 – Act 2 (Table 2) |
| | | **Drought/heat stress** | Recommendations linked to SO3 – Act 2 (Table 2) | Recommendations linked to SO3 – Acts 1 and 2 (Table 2) | |
| | **Institutional level** | | Recommendations linked to:<br>SO1 – Act 1, SO2 – Act 2, SO3 – Acts 1 and 2, SO4 – Act 1<br>(Table 2) | | |
| | **Policy level** | | Recommendations linked to:<br>SO1 – Act 2, SO4 – Act 1, SO5 – Act 1<br>(Table 2) | | |

PART 5.

# References

# References


Amwata, D., Tumbo, M., Mungai, C., & Radeny, M. (2020). *Review of Policies and Frameworks on Climate Change, Agriculture, Food, and Nutrition Security in Tanzania.* CGIAR, CCAFS.

Beal, T., Belden, C., Hijmans, R., Mandel, A., Norton, M., & Riggio, J. (2015). *Country Profile Tanzania.* Sustainable Intensification Innovation Lab. https://gfc.ucdavis.edu/profiles/rst/tza.html

Chongela, J. (2015). Contribution of Agriculture Sector to the Tanzanian Economy. *American Journal of Research Communication*, 3, 14.

CIAT & World Bank. (2017). *Climart Smart Agriculture Profile, Tanzania.* International Center for Tropical Agriculture (CIAT); World Bank. https://ccafs.cgiar.org/resources/publications/climate-smart-agriculture-tanzania

Data. (2021a). *Agriculture, Forestry, and Fishing, Value Added (% of GDP)—Tanzania.* World Bank. https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=TZ

Data. (2021b). *Employment in Agriculture (% of Total Employment) (Modeled ILO Estimate)—Tanzania.* World Bank. https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=TZ

Famine Early Warning System Network. (2008). *Preliminary Rural Livelihood Zoning: Tanzania.* USAID, Chemonics International Inc. https://fews.net/sites/default/files/documents/reports/tz_zonedescriptions_en.pdf

IIED. (2019). *Decentralized Climate Finance in Tanzania.* https://pubs.iied.org/g04398

Irish Aid. (2018). *Tanzania Country Climate Change Risk Assessment Report.*

N. I. Lokuruka, M. (2021). Food and Nutrition Security in East Africa (Kenya, Uganda and Tanzania): Status, Challenges and Prospects. In B. Mahmoud (Ed.), *Food Security in Africa.* IntechOpen. https://doi.org/10.5772/intechopen.95036

Norrington-Davies, G., & Thornton, N. (2011). *Climate Change Financing and Aid Effectiveness Tanzania Case Study.*

REDD. (2012). *REDD Tanzania Fact Sheet.* https://www.forestcarbonpartnership.org/system/files/documents/Kenya%20FCPF%20REDD%20Readiness%20Progress%20Sheet_March%202012.pdf

Suleiman, R. (2018). *Local and Regional Variations in Conditions for Agriculture and Food Security in Tanzania: A Review.* Unpublished. http://rgdoi.net/10.13140/RG.2.2.13136.76801

Taylor, A. (2011). *Ecosystems, Development, and Climate Adaptation: Improving the Knowledge Base for Policies, Planning, and Management* (p. 30). World Wildlife Fund and Stockholm Environment Institute. https://www.sei.org/publications/final-report-tanzania-study-ecosystems-development-and-climate-adaptation-improving-the-knowledge-base-for-planning-policy-and-management/

TIC. (2016). *Tanzania Developemnt Plan—Booklet.* https://www.mcci.org/media/154357/tanzania-developemnt-plan-booklet.pdf

Trujillo, N. C., Bird, N., Watson, C., Nakhooda, S., Yanda, P., Calland, R., & van Rooij, J. (2013). *Understanding Climate Finance Readiness in Tanzania.* BMZ. https://www.ctc-n.org/sites/www.ctc-n.org/files/resources/giz2013-en-climate-finance-readiness-tanzania.pdf

United Republic of Tanzania National Bureau of Statistics. (2019a). *Tanzania in Figures.* https://www.nbs.go.tz/nbs/takwimu/references/Tanzania_in_Figures_2019.pdf

URT. (2012). *National Climate Change Strategy.*

URT. (2013). *National Agriculture Policy—Draft.*

URT. (2015a). *Tanzania National Nutrition Strategy.* https://scalingupnutrition.org/wp-content/uploads/2013/04/Tanzania_National-Nutrition-Strategy.pdf

URT. (2015b). *The United Republic of Tanzania First NDC.* https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20Republic%20of%20Tanzania%20First%20NDC/The%20United%20Republic%20of%20Tanzania%20First%20NDC.pdf

URT. (2016a). *Agricultural Sector Development Programme Phase Two (ASDP II).* https://www.kilimo.go.tz/index.php/en/programmes/view/agricultural-sector-development-programme-phase-ii-asdp-ii

URT. (2016b). *Perspectives on Climate-Smart Agriculture from across the Globe Tanzania Country Case Study Report.* Available at: http://www.fao.org/3/bu218e/bu218e.pdf

URT & Ministry of Agriculture, Livestock and Fisheries. (2017). *National Climate Smart Agriculture Guideline.* https://www.kilimo.go.tz/uploads/regulations/National_CSA_Guideline.pdf

URT, Ministry of Health, Community Development, Gender, Elderly and Children, National Bureau of Statistics, Office of the Chief Government Statistician, UNICEF, Office of the Chief Government Statistician, & UNICEF. (2019b). *Tanzania National Nutrition Survey Using SMART Methodology.* MoHCDGEC, MoH, TFNC, NBS, OCGS, and UNICEF.

URT, National Bureau of Statistics, & Ministry of Finance and Planning. (2019c). *Household Budget Survey: Key Indicators Report.* https://www.nbs.go.tz/index.php/en/census-surveys/poverty-indicators-statistics/household-budget-survey-hbs/413-the-2017-18-household-budget-survey-key-indicators-report#:~:text=The%202017%2D18%20Household%20Budget%20Survey%3-A%20Key%20Indicators%20Report,-The%202017%2D18&text=The%202017%2D18%20HBS%20revealed,Rural%20Areas%20(TZS%20361%2C956)

URT, National Bureau of Statistics, Ministry of Finance, Office of Chief Government Statistician, & Ministry of State, President's Office, State House, and Good Governance. (2014). *Tanzania Population and Housing Census—Basic Demographic and Socio-Economic Profile.* https://www.tanzania.go.tz/egov_uploads/documents/TANZANIA_MAINLAND_SOCIO_ECONOMIC_PROFILE_sw.pdf

URT & Vice President's Office, Division of Environment. (2009). *Fourth National Report on Implementation of Convention on Biological Diversity (CBD).* https://www.cbd.int/doc/world/tz/tz-nr-04-en.pdf

USAID. (2014). *Country Development Cooperation Strategy.*

USAID, NASA, Regional Centre for Mapping of Resources for Development, & SERVIR Eastern and Southern Africa. (2016). *Needs Assessment Report for Tanzania.* https://rcmrd.org/media-item/publications/training-booklet/category/16-resources-publications?download=114:needs-assessment-report-for-tanzania-21-july-2016

WFP. (2017). *Country Strategic Plans—United Republic of Tanzania* (p. 23) [Executive Board Annual Session].

WFP & World Bank. (2013). *Comprehensive Food Security and Vulnerability Analysis: Tanzania.* Available at: https://documents.wfp.org/stellent/groups/public/documents/ena/wfp259829.pdf%3F_ga%3D2.172052707.1555259642.1527599101-1634562328.1527599101

Yanda, P., Mushi, D., Henku, A. I., Maganga, F., Minde, H., Malik, N., Kateka, A., Bird, N., & Tilley, H. (2013). *Tanzania National Climate Change Finance Analysis* (p. 127).

PART 6.

# Annexes

# Annex 1: IMPACT results

## YIELD, HARVESTED AREA, ANIMAL NUMBERS, AND PRODUCTION

**In Tanzania, the production of key commodities, with the exception of maize, is projected to increase considerably in the coming decades (Figure 19).** This is due to a projected increase in both yield, harvested area, and animal numbers. Maize is the one exception to this trend, with projected decreases in both harvested area and yield.

**Future projections in terms of percentage changes can present a misleading picture of the relative prevalence of commodities if not interpreted against their baseline and future magnitude values.** This is especially true if the baseline values are small. For this reason, a companion table of projections expressed as magnitudes is provided in Figure 20, and a more detailed view of shares of harvested area is presented in the next section.

## CROP TRAJECTORIES

**Generally, Tanzania's total amount of cropland is projected to increase (Figure 21).** The shares of cropland that are allocated to key commodities are projected to change very little, with maize and other cereals besides rice projected to occupy the largest share of harvested area between now and 2050. Beans and rice are projected to occupy the second largest share of cropland, followed by other pulses.

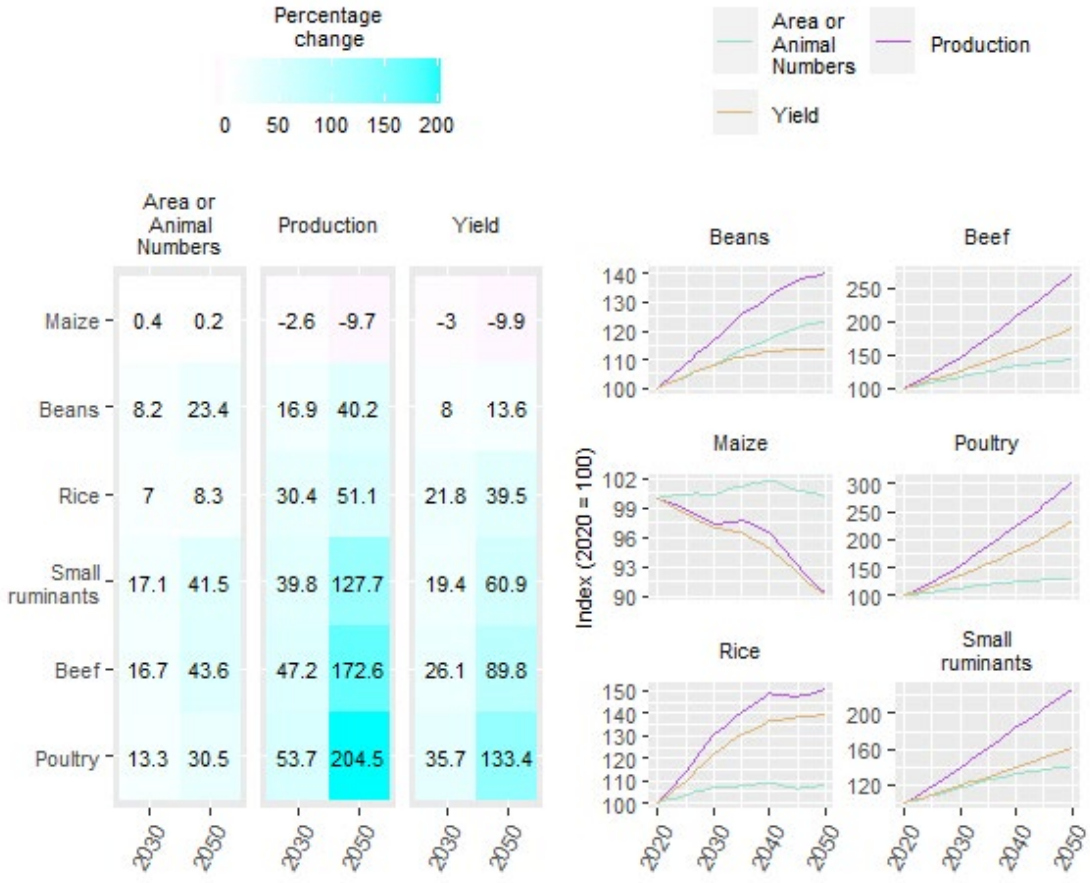



**Figure 19:** The IMPACT 2020-2050 projection of changes in yield, production, and harvested area or animal numbers for key crop and livestock commodities.

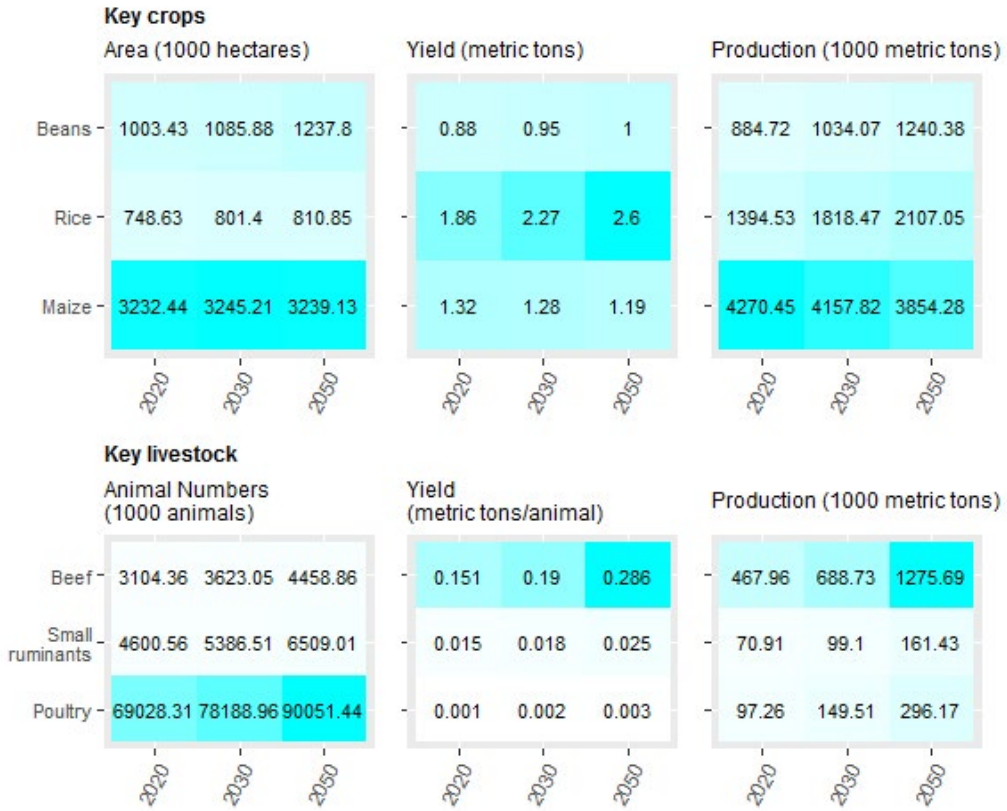



**Figure 20:** The IMPACT analysis's projection of the yield, production, and area or number of animals for major plant and animal commodities in 2020, 2030, and 2050.

## TOTAL AND DISAGGREGATED DEMAND

**Demand for key crop and livestock commodities is projected to grow considerably between now and 2050 (Figure 22).** This demand is projected to come mostly from rural households, although urban household demand is also projected to increase. For maize, beans, and rice, seed and industrial demand, labelled as "other demand" in Figure 22, may become increasingly important. To a lesser degree, export demand for rice is also projected to increase.[11]

## DIET TRAJECTORY

**Per capita diet composition out to 2050 is presented in Figure 23.** This accounts for food available from both domestic production and international trade.[12] The residual categories "other cereals", "other pulses", and "other animal products" are included for context. Per capita consumption of most key food commodities is projected to increase considerably in the coming decades.

**In more aggregate terms, consumption of starchy staples like cereals, roots, and tubers is projected to rise from about 979**

11 The "other demand" category "summarizes all other demands for agricultural products from sectors outside of the focus of IMPACT (for example, seeds, industrial use)" (Robinson et al., 2015).

12 Calorie availability is widely accepted as a reasonable proxy for calorie consumption, although the former may be higher than the latter by 10%-14%. The difference is lost as waste at the retail and household levels (Popkin, 1993).

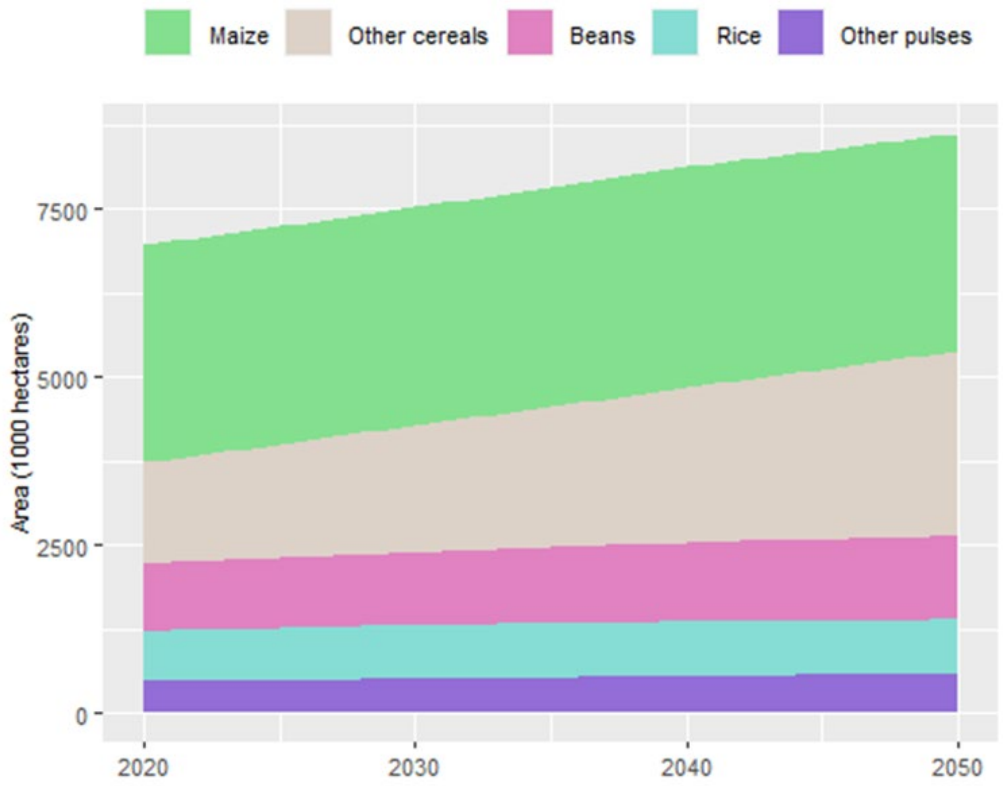



**Figure 21:** The IMPACT 2020-2050 projection of harvested area for key crops and residual categories.

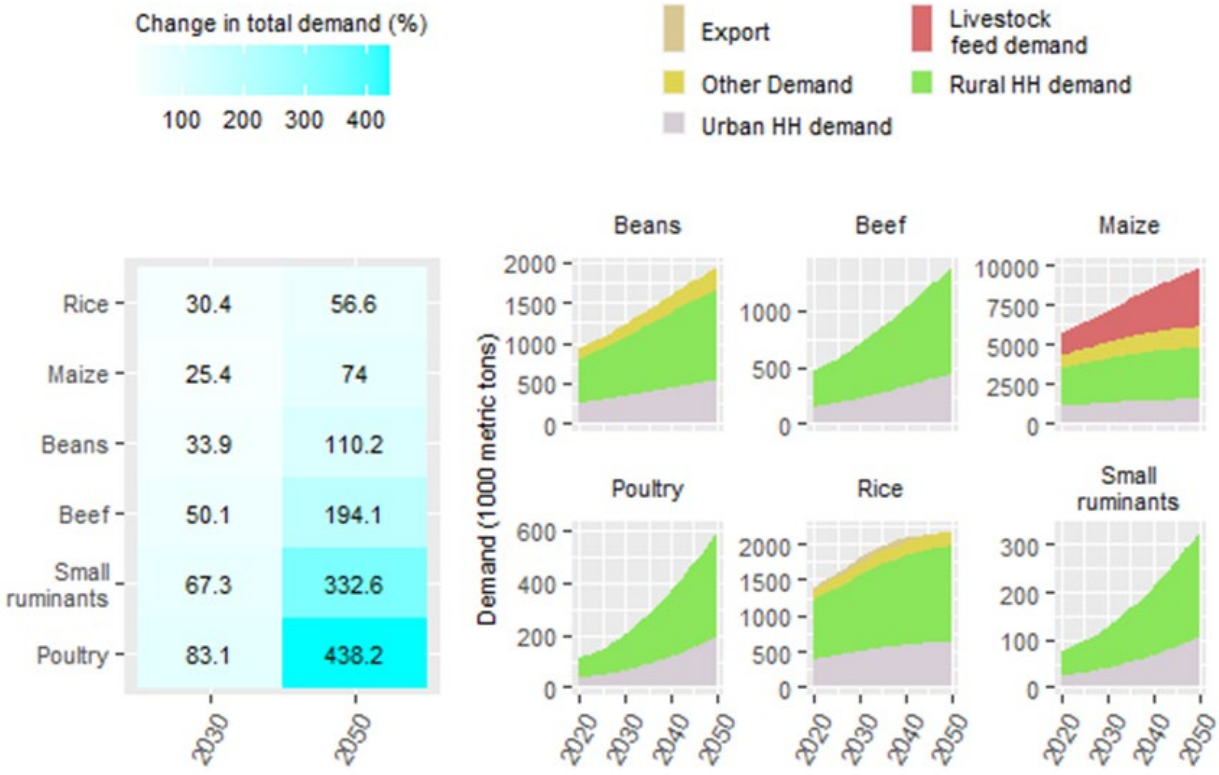



**Figure 22:** Projection of demand for key crops according to the IMPACT 2020-2050 analysis.

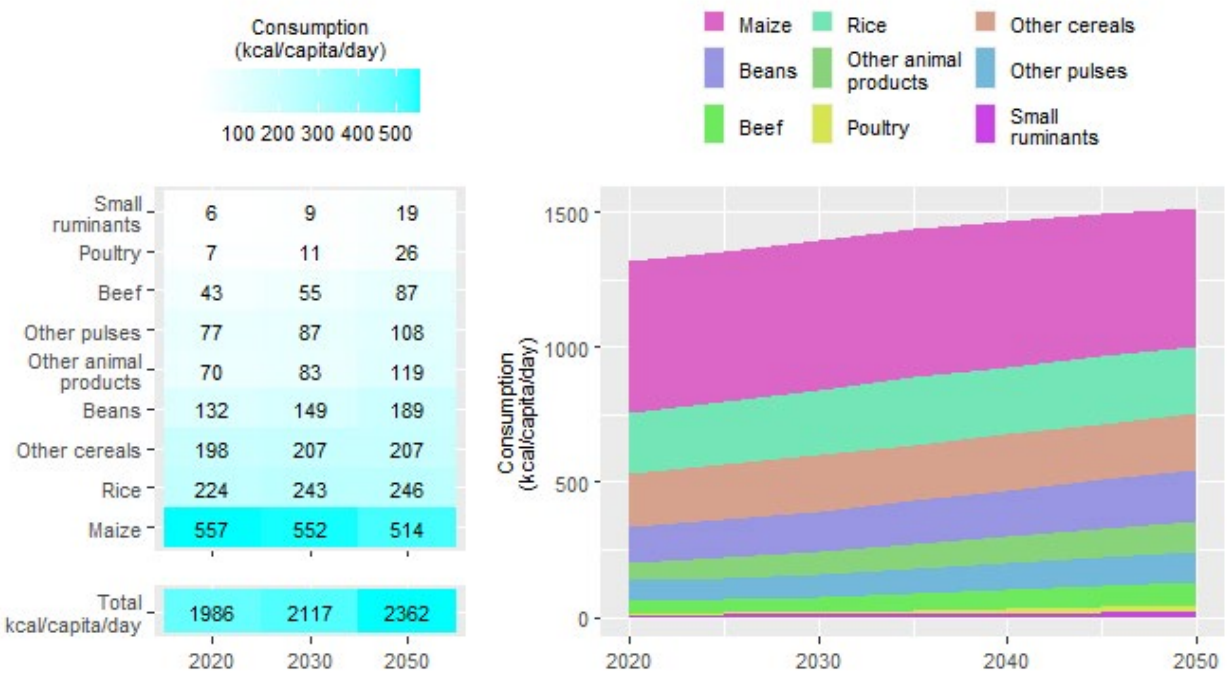



**Figure 23:** The IMPACT 2020-2050 projection of the energy value of key products, measured in kcal/capita/day.

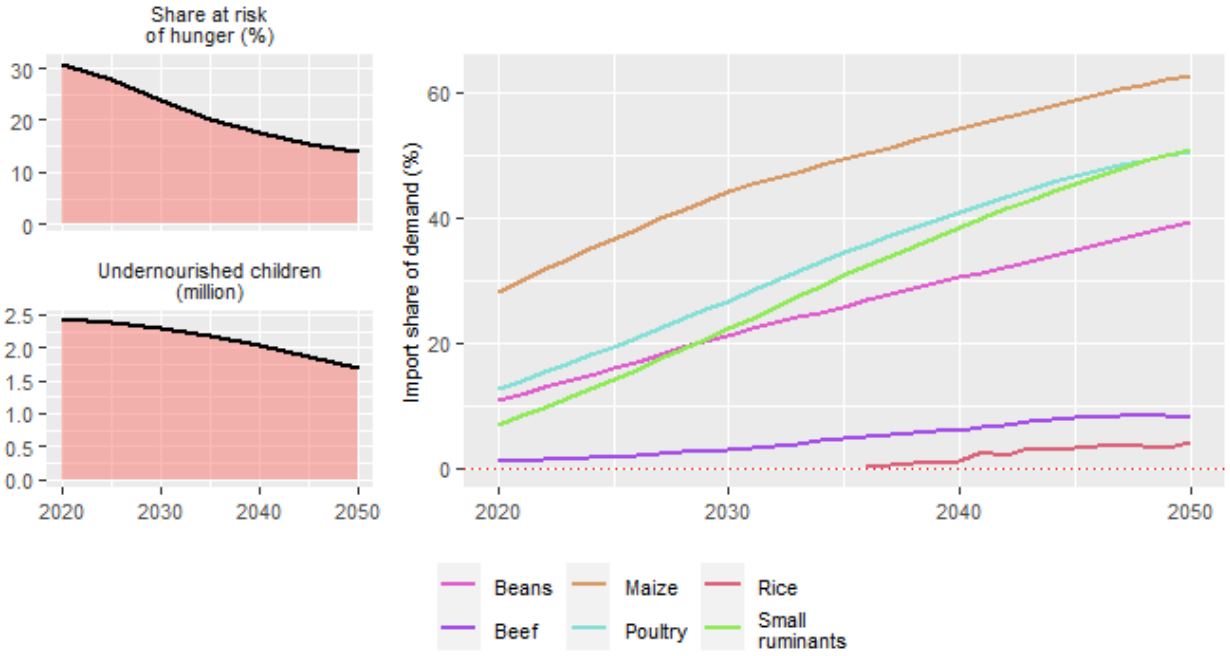



**Figure 24:** Projection of the proportion of Tanzania's population that is at risk of hunger, import dependency, and a high number of undernourished children between 2020 and 2050. Import dependency indicates the percentage of domestic demand for a given imported product.

**kcal/capita/day to 1002 kcal/capita/day in 2030, and then to fall back to 967 kcal/capita/day in 2050.** As a share of one's total diet, starchy staple consumption is projected to decline from about 49% to 47% in 2030, and then fall to 41% in 2050. This is consistent with Bennett's law, an empirical trend often seen in developing nations (Bennett, 1941). The receding starchy share of the diet is replaced by animal products, which are projected to rise from about 13% to 15% of an average Tanzanian's total diet in 2030, and then rise to 21% in 2050. The consumption of pulses like beans, while projected to equal 235 kcal/capita/day in 2030 and then fall to 13 kcal/capita/day in 2050, will rise by only a couple percentage points - from 11% to 13% - in terms of dietary share in 2050.

**The projected increase in total calorie intake per capita is a welcome development vis-a-vis food security.** However, careful attention must be paid to composition. A developing nation's "nutrition transition" from starchy staples to animal calories and other carbohydrate sources is often a transition from starchy carbohydrates to sugary foods and fat calories, with the amount of protein calories remaining constant (Perisse et al., 1969), (Drewnowski & Popkin, 1997), (Kearney, 2010). Care must therefore be taken to replace starchy staples with proteins of animal or vegetable origin, complex carbohydrates, and fibers, while keeping the consumption of saturated and trans fats and free sugars below the World Health Organization's recommended levels of 30% and 10% of the diet, respectively.

## PREVALENCE OF HUNGER AND MALNOURISHMENT

**The percentage of population that is at risk of hunger and high numbers of undernourished children is projected to decline in the coming decades (see Figure 24, left panel).** Because the number of undernourished children is partly a function of education, the projected improvement in this variable is due in part to the chosen socioeconomic pathway, SSP5, which assumes improved education levels around the world. However, import dependence for key commodities is projected to increase substantially between now and 2050 (see Figure 24, right panel). This increase is especially pronounced for maize, beans, poultry, and small ruminants.

# Annex 2: Hotspots of co-occurring vulnerability indicators

## Methods for using spatial analysis to generate maps

For both primary and additional vulnerability indicators, we created raster map layers to show the total number of indices that were classified as "high" - otherwise known as hotspots - and the breakdown of which indicators showed geographical hotspots. The steps in our analysis were as follows:

### VARIABLE SELECTION BASED ON SPATIAL VARIABILITY

All primary vulnerability variables were tested for sufficient spatial variation across the livelihood zones. However, only variables with sufficient spatial variation (CV>=10%) were included in the analysis. Additional vulnerability variables were selected based on available data for indicators of interest that were identified by the WFP Country Office. The variables were then tested for sufficient spatial variation and either included or excluded from the analysis in the same way as the primary vulnerability variables. An exception was made for food security data, which was included regardless of spatial variation; this was due to the limited number of food security datasets available and the necessity of representing food security in some respect in order to accurately measure overall vulnerability. All primary and additional variables considered for Tanzania, including whether they were included or excluded from the analysis, are included in Table 4.

### BINARIZATION OF VARIABLES

For the included continuous data variables, a binary score of 1 was allocated if any one metric exceeded the 80$^{th}$ percentile of values within the livelihood zones. This indicates a negative outcome. The map shows the sum of these binary layers. Any dataset inputs which were already binary were included where data was present and relevant to WFP's programmes. This was only applicable to additional variables. Exceptions were made in limited circumstances. For example, if all Hunger Map food consumption scores were extremely high, all values would be categorised as "high", or 1, as opposed to only those above the 80$^{th}$ percentile.

### AGGREGATION INTO MAP FIGURES

The hotspots maps seen in Figure 17 were created using sets of these binary raster layers. Figure 17 shows the number of included primary variables that were allocated "high" vulnerability in any given cell. Figure 18a shows the same for the included additional variables. Figure 17b is based on the sum of three binary layers, each of which was calculated as the maximum value of all included binary layers in a given grouping of primary variables. Figure 18b directly shows the combination of additional variables, without the use of any further intermediate layers. If part of a map displays "no areas of high vulnerability", this means that none of the included indicators were categorized as 1, or "high" vulnerability, due to the values in the given cell being below a predetermined threshold for "high" vulnerability. As previously mentioned, this threshold is the 80$^{th}$ percentile of the values of a particular indicator for all cells within the livelihood zones. Higher percentiles correspond to greater vulnerability. All of the variables that have been included in the spatial analysis are labelled as "included" in Table 1.

**Table 4:** Average values for all variables for each livelihood zone, variable inclusion or exclusion with reasons, and data sources. All variables labelled "included" were used in the spatial analysis in Figures 17 and 18.

| Variable grouping | Variable | Central_zone | Lake_zone | Northern_ zone | Included/ excluded from maps for Tanzania | Data source |
|---|---|---|---|---|---|---|
| **Primary variables** | | | | | | |
| **Food insecurity & nutrition** | **FEWSNET food insecurity (current situation, ranked from 1=minimal to 5=famine), 2020** | 0 | 0 | 0 | Included | FewsNet: https://fews.net/fews-data/333 |
| | **WFP Hunger Map food consumption score (mean), September 1019 – June 2021** | NA | NA | NA | Excluded (data not analysed) | Hunger Map https://hungermap.wfp.org |
| | **Wasting prevalence in children under 5 (%), 2000-2019** | 6.26 | 5.38 | 6.13 | Included | Local burden of disease: https://vizhub.healthdata.org/lbd/dbm |
| | **Stunting prevalence in children under 5 (%), 2000-2019** | 42.1 | 42.9 | 42.6 | Excluded (insufficient variation) | Local burden of disease: https://vizhub.healthdata.org/lbd/dbm |
| | **Underweight prevalence in children under 5 (%), 2000-2019** | 15.0 | 14.6 | 17.0 | Included | Local burden of disease: https://vizhub.healthdata.org/lbd/dbm |
| **Gender and educational inequality** | **Education, female (mean years in 15-49 year olds), 2000-2017** | 3.69 | 4.08 | 3.78 | Included | Local burden of disease: https://vizhub.healthdata.org/lbd/dbm |
| | **Education, male (mean years for 15-49 year olds), 2000-2017** | 4.40 | 5.06 | 4.74 | Included | Local burden of disease: https://vizhub.healthdata.org/lbd/dbm |
| | **Education gender gap: (mean years for 15-49 year olds), 2000-2017** | 0.710 | 0.975 | 0.959 | Included | Local burden of disease: https://vizhub.healthdata.org/lbd/dbm |
| **Health** | **Diarrhea prevalence (%), 2000-2017** | 23.6 | 26.4 | 23.7 | Included | Local burden of disease: https://vizhub.healthdata.org/lbd/dbm |
| | **Falciparum (incidence rate), 2019** | 14.6 | 13.5 | 11.8 | Included | MAP: https://malariaatlas.org/explorer/#/ |
| | **Vivax (incidence rate), 2019** | 0.179 | 0.199 | 0.130 | Excluded (insufficient variation) | MAP: https://malariaatlas.org/explorer/#/ |
| | **Under-5 mortality (per 1000 live births), 2000-2017** | 3.01 | 9.46 | 3.19 | Included | MAP: https://malariaatlas.org/explorer/#/ |

| Variable grouping | Variable | Central_zone | Lake_zone | Northern_zone | Included/ excluded from maps for Tanzania | Data source |
|---|---|---|---|---|---|---|
| **Additional variables** | | | | | | |
| **N/A** | **Mean soil pH at 30cm depth (pH * 10), 2019** | 59.0 | 64.0 | 67.8 | Included | Soil Grids: https://soilgrids.org |
| | **Mean soil organic carbon at 30cm depth (dg/kg), 2019** | 108 | 183 | 184 | Included | Soil Grids: https://soilgrids.org |
| | **Total area of irrigated land (ha), 2005** | 127,292 | 131,028 | 1,404,826 | Excluded (not specific to country) | FAO irrigated area map: http://www.fao.org/aquastat/en/geospatial-information/global-maps-irrigated-areas/latest-version/ |
| | **Conflict events (number of events), 2018-2021.** ***N.B.*** *Table shows fatal and non-fatal events; map shows fatal events only.* | 7 | 13 | 11 | Excluded (not specific to country) | ACLED Dashboard: https://acleddata.com/dashboard/#/dashboard |
| | **Mining concessions (number), 2020** | 0 | 0 | 0 | Excluded (not specific to country) | Global Forest Watch: https://data.globalforestwatch.org/datasets/26a457ee3b584824bb930f2ec791b60d_0/data?geometry=73.285%2C-11.038%2C-106.715%2C73.865 |
| | **Protected area land coverage (% of land), 2021** | 42.0 | 18.4 | 50.7 | Excluded (not specific to country) | IUCN: https://www.iucn.org/theme/protected-areas/our-work/world-database-protected-areas |
| | **Active fires (count), 2019** | 11,991 | 5,195 | 1,031 | Included | https://modis-fire.umd.edu/pubs.html https://firms.modaps.eosdis.nasa.gov/active_fire/#firms-shapefile |
| | **Ethnic group diversity (number of dominant groups that coexist), 2010** | 10 | 11 | 17 | Excluded (not specific to country) | Georeferencing of Ethnic Groups (GREG) database: http://worldmap.harvard.edu/maps/1894 |

| Variable grouping | Variable | Central_zone | Lake_zone | Northern_ zone | Included/ excluded from maps for Tanzania | Data source |
|---|---|---|---|---|---|---|
| NA | **Ethnic group type (dominant group category), 2010** | Iraku, Sandawe, Wasagara, Iraku, Tatog, Irangi, Wanyaturu, Wagogo, Wahehe, Hadzapi, Wanyamwezi | Barundi, Joluo, Baluhya, Masai, Banyaruanda, Joluo, Banyoro, Baluhya, Barundi, Baha, Masai, Wanyaturu, Baluhya, Banyoro, Banyoro, Baluhya, Hadzapi, Wanyamwezi, Banyaruanda | Wadjagga, Swahili, Wanyika, Masai, Baluhya, Baluhya, Wadjagga, Wapare, Wateita, Wanyika, Swahili, Iraku, Washambala, Wasagara, Masai, Irangi, Iraku, Tatog, Irangi, Wanyaturu, Wagogo, Hadzapi, Wanyamwezi | Excluded (not specific to country) | Georeferencing of ethnic groups (GREG) database - http://worldmap.harvard.edu/maps/1894 |
| | **Time to nearest city (minutes), 2015** | 246 | 177 | 224 | Excluded (not specific to country) | https://malariaatlas.org/research-project/accessibility-to-cities/ |
| | **Human appropriation of net primary productivity (% reduction), 2000** | 13.4 | 14.1 | 17.6 | Excluded (not specific to country) | Haberl et al, 2007: https://boku.ac.at/wiso/sec/data-download |
| | **Access to improved water source (% of population), 2000-2017** | 51.9 | 55.4 | 57.6 | Excluded (not specific to country) | IHME: ata.org/record/ihme-data/lmic-wash-access-geospatial-estimates-2000-2017 |

# Photo credits

**Cover:** ©CIAT/Georgina Smith, accessed from www.flickr.com

**p.5:** ©CIAT/Georgina Smith, accessed from www.flickr.com

**p.7:** ©CIAT/Georgina Smith, accessed from www.flickr.com

**p.10:** ©CCAFS/C. Schubert, accessed from www.flickr.com

**p.24:** ©CIAT/Georgina Smith, accessed from www.flickr.com

**p.39:** ©CIAT/Georgina Smith, accessed from www.flickr.com

**p.41:** ©CIAT/Neil Palmer, accessed from www.flickr.com

**p.44:** ©CCAFS/C. Schubert, accessed from www.flickr.com

**p.58:** ©CIAT/Neil Palmer, accessed from www.flickr.com