SAVING LIVES
CHANGING LIVES

WFP Critical Corporate Initiative: Climate Response Analysis for Adaptation

Somalia

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Alliance
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Executive summary

This report provides an overview of the projected impacts of climate change in Somalia at the national and local levels–from a livelihood zone perspective. The analysis focused on four livelihood zones the Sorghum High Potential Agropastoral, the Addun Pastoral, the Southern Agropastoral, and the Riverine Gravity Irrigation. These zones were selected based on the frequency of drought and floods, inconsistent rainfall patterns, and their potential for producing staple crops and livestock keeping. At the national level, mean temperatures are projected to increase by 2050, with an anticipated decline in mean precipitation; however, the second season (*Deyr*) is expected to be wetter than the first season (*Gu*). Locally, at the zone level, there will be a substantial increase in mean temperatures by 2050, with an average increase of 2-3°C within all four livelihood zones. This points to a higher probability of heat stress which is likely to affect the Sorghum High Potential Agropastoral, Addun Pastoral, and Southern Agropastoral Zones where livestock production is dominant. While the first season will experience a decline in precipitation by 2050, dominant changes in precipitation are predicted for the second season, particularly in the Riverine Gravity Irrigation Zone. Following the projections on precipitation, the four zones are exposed to flooding and waterlogging risks, especially during the wet months. The Riverine Gravity Irrigation and Southern Agropastoral Zones are high flood risk and waterlogging zones. The impacts of climate risks will affect the production and suitability of major crops, e.g., maize and cowpeas, as well as livestock and livelihood patterns.

Climate change is among the drivers of migration in Somalia due to climate pressures on resources, mainly water and pasture. Extreme weather conditions such as floods, droughts, increasing temperatures, and irregular seasonal patterns lead to livelihood losses and resource scarcity. This, in addition to violence caused by political instability and armed conflicts, form the prominent pathways leading to migration out of Somalia. Pastoral livelihood zones are particularly affected by the resource-scarcity pathway, which disrupts pastoralists' mobility strategies, rendering them vulnerable to food insecurity. South-central agropastoral and riverine livelihood zones are particularly affected by the livelihood-loss pathway, which causes famines and displacement.

An econometric analysis conducted using the International Model for Policy Analysis of Agricultural Commodities and Trade projects that despite climate-induced losses, production and yield will increase the availability and stability of Somalia's food supply through 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, agricultural gains will be suppressed by negative climatic trends that prevent the sector from reaching the maximum potential for productivity. Maize shows low resilience under a climate change scenario and thus faces the gravest threat. Nonetheless, the production quantities and yields of all commodities modeled (i.e., pulses, sorghum, vegetables, sesame, and small ruminants) are adversely impacted by climate change through 2050. These gains may be distributed unevenly, leading to a disparity in areas of impoverishment. A geospatial hotspot analysis of eight vulnerability dimensions found a high number of overlapping vulnerabilities in health, inequality, and food insecurity across all the zones. In the absence of effective interventions, the current vulnerability suggests a prevalence in the future. This points to the urgency of implementing national-level agricultural and/or socioeconomic development strategies at the zonal level.

WFP employs three programming tools to implement climate resilience programming in Somalia: Integrated Context Analysis (ICA), Seasonal Livelihood Programming, and Community-Based Participatory Planning (CBPP). Currently, WFP's climate resilience programming in Somalia, under the Interim Country Strategic Plan 2019-2021, is aligned to Strategic Outcomes 2 (Activity 1) and 4 (Activity 1). These outcomes focus on enhancing the capacity of the most vulnerable groups to enable them to bounce back after climatic shocks or adapt to the changing environment and build resilient food systems. Still, WFP has an opportunity to integrate new activities, or remodel its current activities, following the adaptation options recommended by stakeholders. WFP has a capacity-building component in Strategic Outcomes 2 and 4 and therefore stands a chance of extending the training provided to smallholder farmers. The focus has been on improved productivity and postharvest management; thus, other components that link climate change to environmental management, such as rangeland rehabilitation, water conservation, land management, reforestation, and agroforestry, could be considered. WFP has a platform for improving the linkage between nutrition and climate resilience based on the behavioral change approach in Strategic Outcomes 1 and 3 by creating awareness on climate risks and the nutritional decisions that can increase adaptation among households. Although Strategic Outcome 5 does not delve into climate change, WFP can still take the climate-change perspective in strengthening the capacity of national institutions. There is room to integrate the dissemination of climate information in its programming through actionable seasonal forecasts and early warnings. To effectually implement these recommendations, WFP needs to work closely with the government ministries involved in climate change, international and local NGOs, and the community. Additionally, based on the predicted impacts of climate change, there is a need to mobilize funds from sustainable sources, e.g., from the national government, bilateral development partners, international organizations, and development finance institutions.

Acronyms and abbreviations

ACLED	Armed Conflict Location & Event Data Project
AFDB	African Development Bank
FAO	Food and Agriculture Organization
FEWSNET	Famine Early Warning Systems Network
FGS	Federal Government of Somalia
FSNAU	Food Security and Nutrition Analysis Unit
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
HANPP	Human Appropriation of Net Primary Production
IDMC	Internal Displacement Monitoring Centre
IDP	Internally Displaced Persons
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
ICSP	Interim Country Strategic Plan
IOM	International Organization for Migration
KII	Key Informant Interviews
LZ	Livelihood Zones
OCHA	Office for the Coordination of Humanitarian Affairs
SNDP	Somalia National Development Plan
UNDP	United Nations Development Programme
UNFCC	United Nations Framework Convention on Climate Change
USD	United States Dollars
WFP	World Food Programme
ICSP	Interim Country Strategic Plan

Introduction

The recent *Zero Hunger Strategic Review* of the World Food Programme (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 providing 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 collaboration between the Programme 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 Programmes 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 WFP country 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 conducted using a diverse methodology including desk review, climate change modeling, migration analysis, the *International Model for Policy Analysis of Agricultural Commodities and Trade* (IMPACT) assessment, stakeholder workshops, and key informant interviews (KIIs).

The results are organized herein. The report begins with Part 1 which gives an overview of the national context, including geography, socioeconomics, climate projections, policy environment, and the migration and IMPACT analysis findings. Part 2 provides an overview of the selected livelihood zones (Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Agropastoral), and includes analysis of the current and future threats of climate change, overlaying results with an analysis of prevailing socioeconomic vulnerabilities. The climate-migration nexus across the zones is also highlighted. Part 3 analyzes current WFP activities and how they may be optimized to strengthen climate change adaptation. It also offers recommendations for partnerships that may enhance opportunities for programmatic optimization. Finally, Part 4 provides a synthesis of the main findings from the profile.

PART 1.

National context

1.1 Geography and agroecological characteristics

Somalia is located in the Horn of Africa. It borders the Gulf of Aden to the north, the Indian Ocean in the east, Kenya in the southwest, Ethiopia in the west, and Djibouti in the northwest. It also shares maritime borders with Yemen. The country covers a total surface area of 637,540 km^2. Mogadishu is the designated capital city. Administratively, Somalia is divided into 18 regions, locally referred to as *gobollo*,[1] which are further subdivided into 90 districts (*degmooyin*). Autonomously, Somalia is divided into Puntland, a state under the federal government, and Somaliland, which is a sovereign state (Federal Government of Somalia (FGS), 2013).

Somalia's landscape[2] is mainly comprised of highlands, plateaus, and plains. The highlands, composed of crystalline rocks, are situated in the northwest and northeast regions. High arid plateaus, with an altitude of 600 meters above sea level, are found in the Mudug area. Extensive plains are concentrated in the central and southern regions, and a few regions are covered with thick bushes and forests. Somalia is also characterized by a mountainous coastal zone and distinct river valleys (FGS, 2020).

The bodies of water in Somalia include rivers, swamps, and water reservoirs. The rivers Juba (800 km long) and Shebelle (1,100 km long) drain an estimated area of 98,000 km^2 and 90,000 km^2, respectively, and cross Somalia from the Ethiopian highlands into the Indian Ocean. The flooding of rivers, especially during the rainy seasons, gives rise to swamps and small lakes. There are approximately 240 small reservoirs that aid in irrigation, feeding livestock, preventing floods, and generating electricity.

More than 80% of Somalia's landmass is considered Arid and Semi-Arid Land (ASAL) (United Nations Development Programme (UNDP), 2019). This makes the land unproductive for agricultural production, hence the dominance of pastoralism in the country. Nonetheless, 70% of Somalia's land area (Figure 1) is classified as agricultural land[3] (Food and Agriculture Organization (FAO), 2018), with rainfed and irrigated arable land at 18% of its potential (UNDP, 2019).

About 10% of Somalia's land area is covered by forests (UNDP, 2019). The mist forests in northern Somalia have native species of trees, thus are rich in biological diversity. Somalia has tropical forests in its floodplains that are becoming extinct due to agricultural activities. The forests paved way for smallholder sugar and plantain farming. Somalia is also home to over 3000 species of native plants and 700 species of flowers. However, overgrazing has a negative impact on the structure and growth of these species (FGS, 2013).

Somalia's coastline is the longest in Africa, covering 3,025 kilometers. The southern coast forms part of the 70,000 km^2 marine ecosystem with Tanzania and Kenya. The coastline is conducive for the development of biomass, and the shelf harbors a variety

1 https://dbpedia.org/page/Administrative_divisions_of_Somalia
2 http://www.fao.org/3/t0361e/T0361E07.htm
3 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 (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow.

of mangroves, beaches, meadows, reefs, and estuaries. The most important reef is *bajuni,* which is approximately 125 km long and is constituted of small islands and rocks.

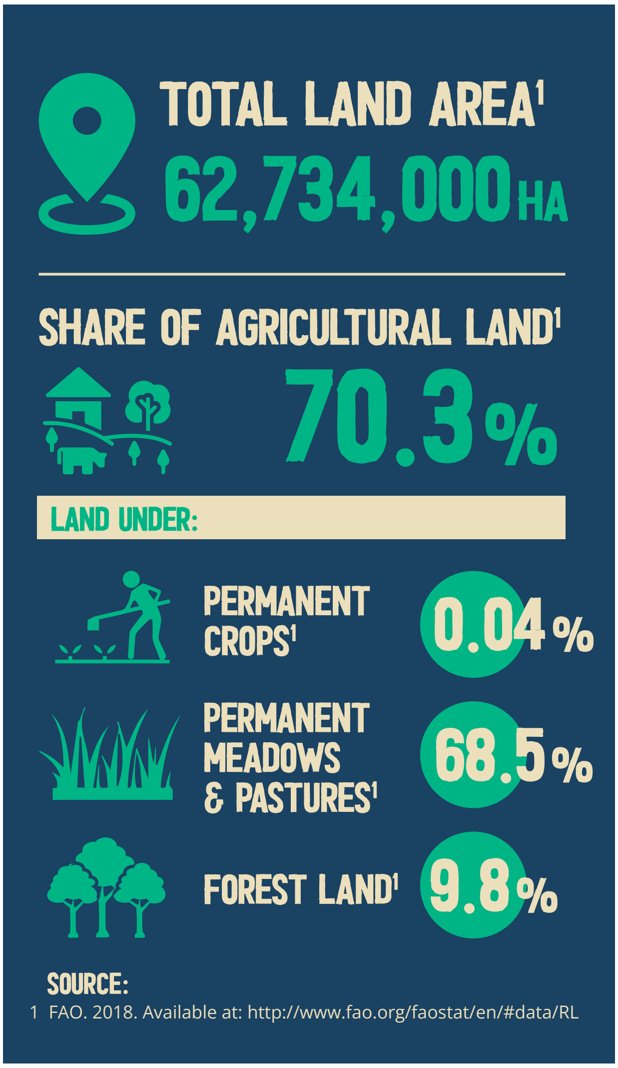
1.2 Socioeconomic context

1.21 Agricultural production

Over the years, Somalia has maintained an informal economy comprised of money transfers, remittances, telecommunications, and agricultural production (UNDP, 2019). The gross domestic product (GDP) is estimated at US$5.9 billion, a 29% increase from 2012 to2018 (Somalia National Bureau of Statistics (SNBS), 2019). Remittances from the diaspora are critical to Somalia's economy, contributing approximately 23-28% of the GDP and supporting 40% of livelihoods. They significantly affect household consumption and labor force participation (World Bank, 2015).

About three-fifths of Somalis are either semi-nomadic or nomadic pastoralists. Less than a quarter of the population are the established farmers who reside in fertile agricultural zones along the rivers Juba and Shabelle (FGS, 2013). Nonetheless, the agricultural sector is the largest driver of the economy. The livestock and crop subsectors contribute to 43.4% and 4.6% of the country's GDP, respectively (FGS, 2020). The livestock subsector provides the largest share of employment to rural nomads and constitutes 80% of total exports in Somalia. Goats, sheep, cattle, and camels are examples of livestock exported to international livestock markets (World Bank, 2015).

The share of the crop subsector contributing to GDP and export earnings has been in decline (FGS, 2020). It, however, plays a critical role in food security. Crop production is concentrated in the country's southern regions by smallholder subsistence farmers owning average land sizes of 0.2–3.0 hectares. Smallholder farmers are responsible for 80% of crop output and 70% of marketing. Mainly cereal crops like maize and sorghum are produced, but other crops of economic significance, e.g., legumes (cowpeas), sesame, and vegetables are also grown. Sesame seeds, fruits, and sugarcane are the main contributors to crop export revenue in Somalia.



AREA COVERED AS A SHARE OF AGRICULTURAL LAND[1]

MAIZE[1] 0.21%
ANNUAL YIELD 1.0968 T/HA

SORGHUM[1] 0.53%
ANNUAL YIELD 0.56 T/HA

SESAME[1] 0.01%
ANNUAL YIELD 0.56 T/HA

LIVESTOCK

	POPULATION[2]	ANNUAL PRODUCTION
SHEEP	10,457,119	MEAT[3] (T): 40,704
GOATS	11,432,240	MEAT[3] (T): 38,526 MILK[3] (L): 372,414
CAMELS	7,230,058	MEAT[3] (T): 47,103 MILK[3] (L): 956,308

SOURCE:
1 FAO. 2018. Available at: http://www.fao.org/faostat/en/#data/QC
2 FAO.2018. Available at: http://www.fao.org/faostat/en/#data/QA
3 FAO.2018. Available at: http://www.fao.org/faostat/en/#data/QL

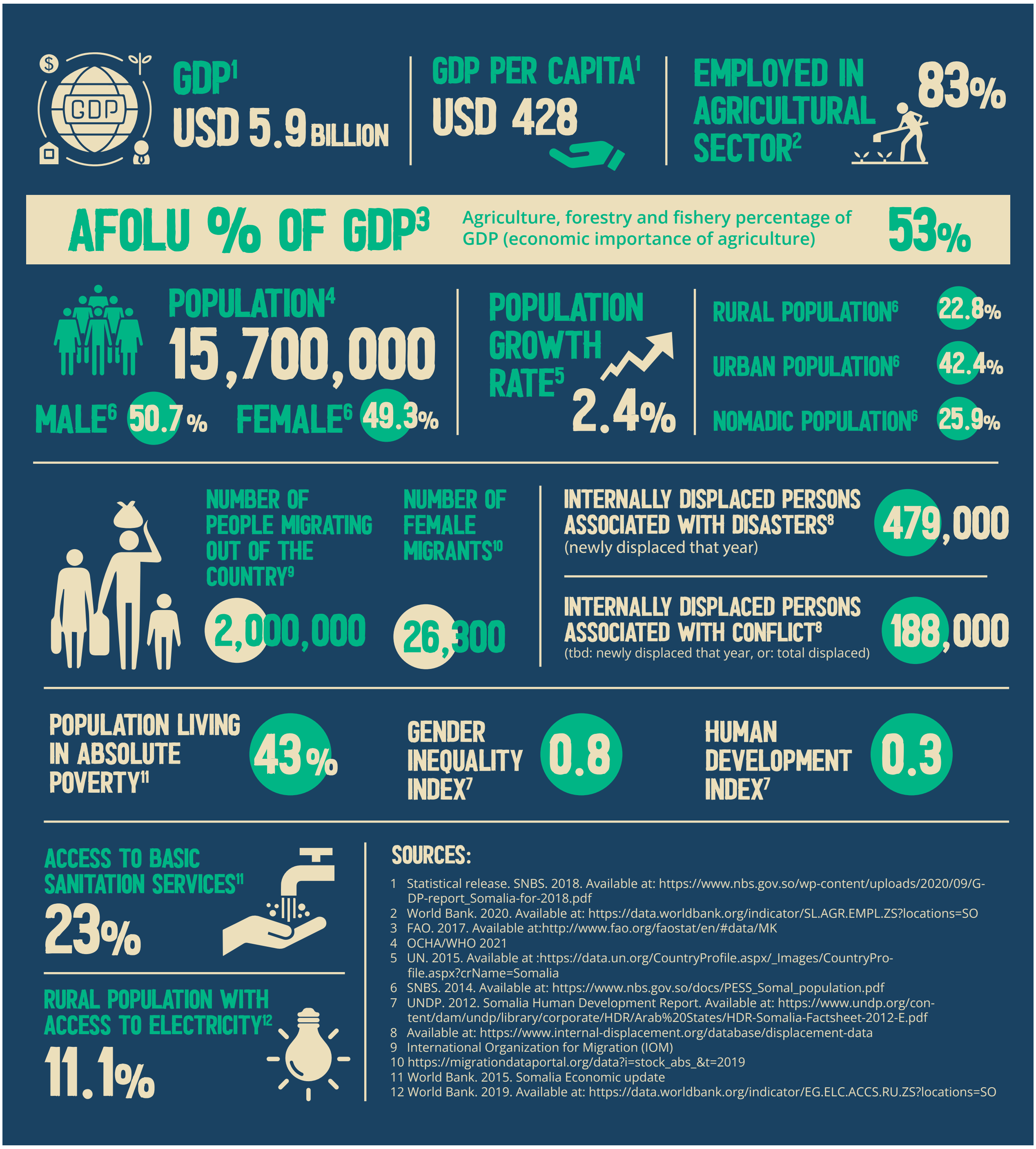
1.22 Basic needs coverage

Somalia has poor basic-needs coverage, evident from the living standards, and limited access to social services among its population (Office for the Coordination of Humanitarian Affairs (OCHA), 2020). Somalia has 15.7 million people and a population density of 24 people per square kilometer. The population comprises slightly more men (50.7%) than women (49.3%), with a majority being young people. About 70% of the population is under 30 years of age (World Bank, 2015). According to World Bank (2019), 36% of Somalia's population has access to electricity. There is, however, a disparity in access whereby only 11.1% of rural households have access to electricity compared to 65% in urban areas.

Over 20% of Somalis need water and sanitation and hygiene (WASH) services. The situation is worse for Internally Displaced Persons (IDPs) who, in most instances, are excluded from humanitarian support. Additionally, IDPs face challenges like exploitation from camp gatekeepers, poor shelter, limited access to basic services and overcrowded and unsanitary conditions. Nationally, 23% and 32% of Somalia's population have access to improved sanitation and water, respectively. Access to water is a greater challenge in Somaliland, whereby only 3% of rural households have access to improved water sources compared to 47% in the urban areas (World Bank, 2015). This is due to poorly constructed water infrastructure and damage to the already existing water systems. About 36% of Somalis cannot access enough water to cover their basic daily needs, i.e., drinking and household chores (OCHA, 2020).

Poor sanitation has resulted in the pollution of water sources. Toilets and septic systems in urban areas release waste into water sources making it unsafe for human consumption (OCHA, 2020). Approximately 38% of Somalis own pit latrines, most of which are shared among two to three households. Only 26% of households can access water and soap while using the pit latrines. This poses a threat to public health as the outbreak of diseases like diarrhea has become rampant. Additionally, rodents and stagnant water around housing areas have brought environmental health concerns. The situation is exacerbated by the lack of access to healthcare facilities, which only 23% of Somalis can access.

Somalia has a low adult literacy rate of 38%. The lowest literacy rates are within rural households and among young women 15-24 years of age. For instance, the literacy rate among young women in Somaliland and Puntland is 44% and 37%, respectively. This is because most schools were demolished during the period of political unrest. Also, Somalia has a weak public education system (World Bank, 2015). OCHA (2020) records that almost 1.3 million children need support to enroll in or stay in schools, including approximately 700,000 girls.

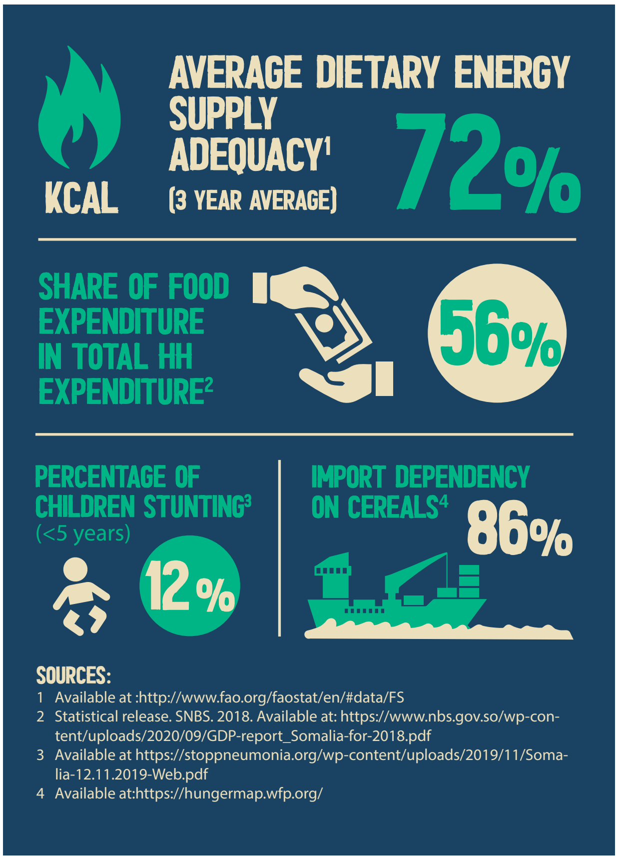


1.23 Food security and nutrition

Somalia has a food-insecure population of over 2.5 million people (FSNAU and FEWSNET, 2020). This is due to frequent droughts, localized floods, and inadequate rainfall, which have resulted in low crop and livestock productivity. The Global Hunger Index (GHI) 2020 ranks Somalia among the countries with a severe hunger level. Somalia is, therefore, in need of humanitarian assistance to prevent food crises in the future.

Food insecurity is widespread but is steadily declining in the northern, southern, and central regions of Somalia. Nonetheless, IDPs, marginalized communities, and poor households have the largest food and nutritional gaps due to livelihood losses (OCHA, 2020). They are, therefore, at a high risk of being pushed to extreme food and nutrition insecurity. Additionally, the supply of food in Somalia is highly dependent on imports, with the export of major cash crops limited by poor quality and certification challenges.

Somalia is also faced with severe malnutrition among children, particularly among IDPs. OCHA (2020) shows that over one million children and 10 out of 33 population groups in Somalia are acutely malnourished. The major cause of malnutrition is access to nutritious diets. Staple foods, e.g., maize, wheat, sorghum, rice, and pasta, form a significant component of diets among households in Somalia. Sugar and oil are affordable calorie foods among households who cannot easily access nutritious diets, such as leafy vegetables and foods from animal sources (WFP, 2020). Therefore, the decline in production and price volatility of cereal commodities pose a threat to the food security of many households.



1.24 Socioeconomic challenges

Climate change is exacerbating the extent of existing environmental challenges. The economy of Somalia is linked to natural resources, like forests and water, and activities, like pastoralism and agriculture that are climate-sensitive. Increases in temperature, extreme events of floods and drought, and inadequate rainfall have negatively impacted food security, resulting in the depletion of resources and conflicts. Thus, the predicted increase in these climatic trends poses a threat to the livelihoods of millions of people (FGS, 2020).

Somalia has been faced with over two decades of conflict and fragility (World Bank, 2015). The major source of conflict has been competition over scarce resources (e.g., rangelands, forests, and water) and the unequal distribution of revenues among local communities. Clan-based conflicts and terrorism from the al-Shabaab group and ISIS in the North have also made most parts of Somalia inaccessible. This has limited the implementation of the humanitarian and major economic activities on which most households depend.

Despite improved economic growth, Somalia is still ranked among the world's poorest countries. Somalia has a poverty rate of 73%, with 51% of the population living below the poverty line (US$1.00/day). It is estimated that one out of every three Somalians is suffering from extreme poverty (UNDP, 2019). The Multidimensional Poverty Index (MPI) ranks Somalia 94 out of 104 in terms of health, education, and standard of living (UNDP, 2012). The youthful population is significantly affected by poverty due to lack of employment. Almost two-thirds of youth (aged 14-29 years) are unemployed. Thus, most of the youth are contemplating leaving Somalia in search of better livelihoods (World Bank, 2015).

Women suffer from social and economic inequalities, some of which are embedded in the culture. The Gender Inequality Index (GII) of 0.8 depicts extreme gender inequality (UNDP, 2012). Compared to their male counterparts, women have limited access to production technologies and inputs, healthcare, and education. They are also excluded from empowerment programs and the labor market. Beier & Stephansson (2012) note that women-headed households are highly vulnerable to climatic shocks, especially those associated with livestock losses. Moreover, the culture bestows domestic chores, such as fetching water, as a woman's role; thus, women are constrained in collecting water during scarcity.

Limited access to healthcare has resulted in impoverished health and nutritional well-being of the vulnerable population. Women have inadequate access to maternal healthcare due to poor road infrastructure and transportation facilities and few medical professionals. Poor sanitation and hygiene, and inadequate access to safe water facilities, significantly contribute to the spread of diseases among children in Somalia (Beier & Stephansson, 2012). Additionally, most hospitals and health facilities lack equipment and have weak management capacity. This has resulted in high infant mortality rates (World Bank, 2015).

1.3 National climate profile

Somalia has an arid to semi-arid climate. The northern plains are hot and arid, the central part is mainly semi-arid, and the coastal strip is sub-humid. Rainfall has been erratic over the years, with an annual mean of 250 mm. There are two main rainy seasons in Somalia; the major one is *Gu,* which falls between April and June. This season is relatively hot and wet and is mainly experienced in the southern part of the country. The *Deyr* season, on the other hand, falls between October and November, and most of it falls in the northern and central parts of the country. There is, however, a disparity in rainfall distribution whereby the northern parts receive less than 250 mm of rainfall annually, while the central parts receive a very low rainfall of between 50-100 mm. Therefore, based on the rainfall distribution, Somalia is categorized into the desert, arid, semi-arid, and humid zones (FGS, 2013).

The climate of Somalia has two main rainy seasons (Figure 4). The driest seasons are July to August and January to March. Rainfall is very low, and some months can receive less than 50 mm. Temperatures are high throughout the year, with some months recording over 27°C. Future trends (2021-2040 in dark blue and 2041-2060 in green) show that monthly temperature patterns will remain similar but will increase in some months. While the first season is expected to get significantly drier, the second season will be wetter. These projected trends depict drought conditions and heat stress throughout much of the country.

1.4 Migration in Somalia

Climate change is among other factors like environmental degradation and conflicts that are the main drivers of migration. The phenomenon of climate migration has, in recent years, received increasing attention. Mobility in the face of climate pressures has been framed as an issue of climate risk management. Thus, there is a need to develop integrated approaches to minimize and address displacement related to the adverse effects of climate change (United Nations Framework Convention on Climate Change (UNFCC), 2015). Climate processes can be both fast-onset and slow-onset, and while climate change may occur on a global scale, exactly how its effects will play out will be locally defined and experienced. This complexity feeds into a broad and disaggregated typology of climate migration. Climate-induced migration is usually temporary (Black et al., 2011) but can be either short-term (seasonal and circular) or long-term (life cycle) (Brsozka and Frohlich, 2016), and may be intra-rural, rural-urban, urban-rural, or international in nature.

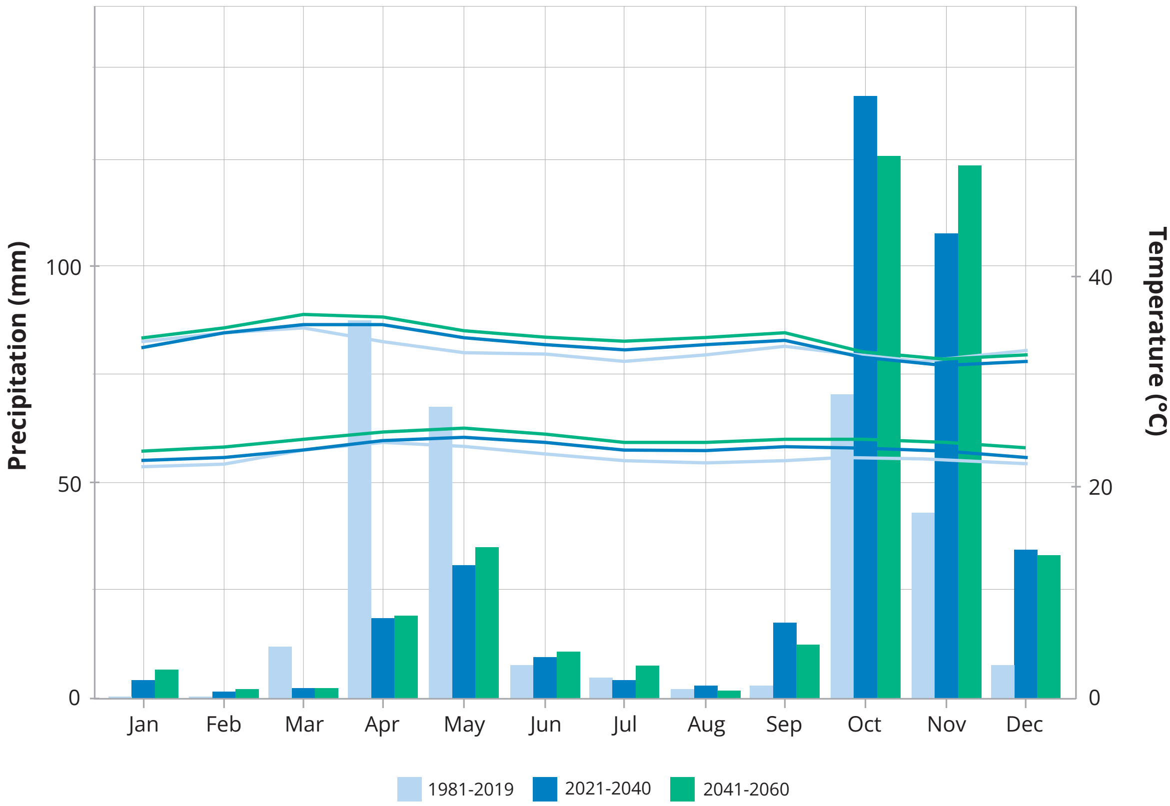


Figure 4: Historical (1980-2019) and future (2021-2060) temperature and precipitation trends in Somalia

The presence of climate change and violence are significant in explaining migration within Somalia and outside. Somali migration is characterized by emigration and displacement. Internal and intra-regional displacement is particularly widespread, as conflicts and natural disasters lead to forced mobility towards proximate regions. In particular, high temperatures and violence are positively associated with international migration, where migrants seek more hospitable places to live.

1.41 International migration flows

Annually, approximately two million Somalis emigrate internationally (International Organization for Migration (IOM), 2020). They migrate either voluntarily (Figure 5a) to seek out better socioeconomic conditions due to Somalia's high unemployment rate, financial problems, and lack of sufficient livelihood options, or forcibly due to conflicts, insecurity, and livelihood losses (IOM, 2017). The majority of internationally displaced Somalis, including both refugees and asylum seekers, move towards Kenya, Yemen, Ethiopia, Uganda, and South Africa, while some reach Europe and America (Figures 5b and 5c). In turn, yearly, 45,000 immigrants seem to come to Somalia from Ethiopia, Eritrea, and Yemen (United Nations, Department of Economic and Social Affairs (UNDESA, 2019).

The majority of internationally displaced Somalis are children. Adult males and females are evenly distributed, implying that Somali international displacement involves the movement of families together (Figure 6).

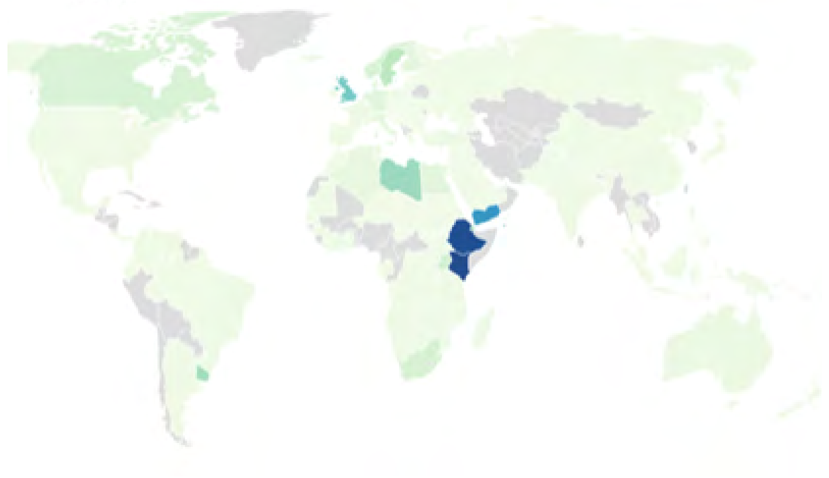
a.
Somali emigrations (2015-2020)

Voluntary migrations from Somalia by country of detsination

Migration flow

0 **941,389**

Source: UNDESA - Created with Datawrapper



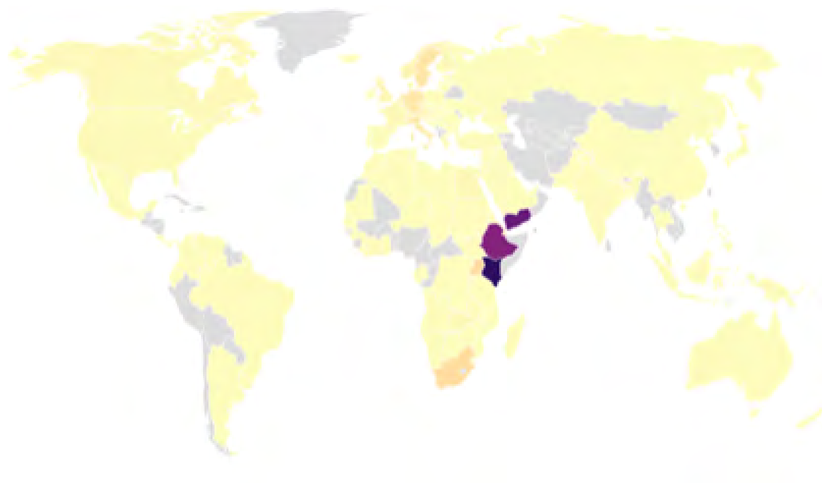
b.
Somali refugees (2015-2020)

Displaced refugees from Somalia by country of detsination

Refugee flow

0 **1,793,318**

Source: UNDESA - Created with Datawrapper



c.
Somali asylum seekers (2015-2020)

Displaced asylum seekers from Somalia by country of detsination

Asylum seekers flow

0 **63,753**

Source: UNDESA - Created with Datawrapper

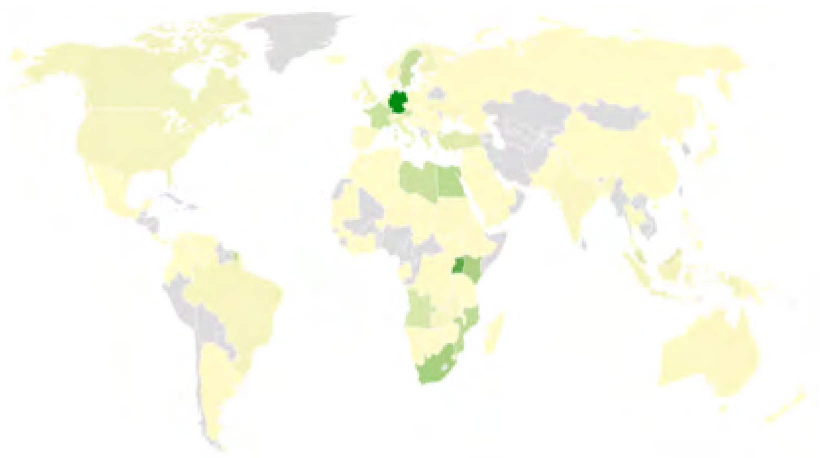


Figure 5: Somali international migration and displacement flows between 2015 and 2020 by country of destination (a: Somali voluntary migrations, b: Somali displaced refugees, c: Somali displaced asylum seekers)

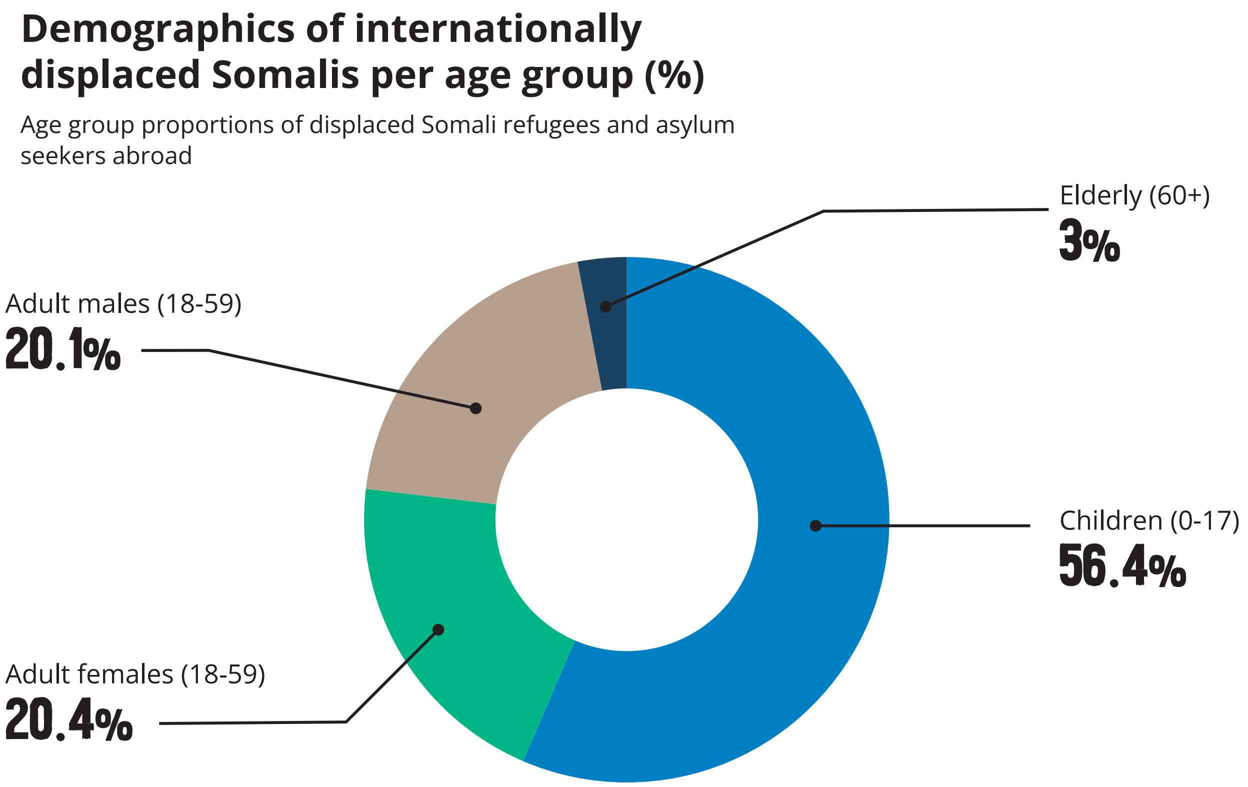


Figure 6: Demographics of Somali internationally displaced people per age group

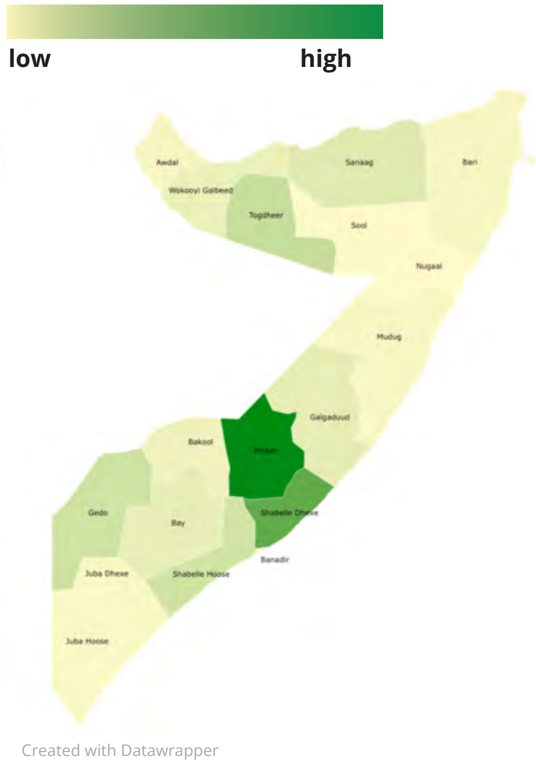
1.42 Internal migration flows

Internal displacements in Somalia are a result of intercommunal and clan tensions, armed conflicts, and violence against civilians. This is in addition to increasing extreme weather events and natural disasters ravaging livelihoods (Internal Displacement Monitoring Centre (IDMC), 2019) (Figure 7). While 547,000 displacements were due to natural disasters in 2018, almost 90% of Somalia's displaced people moved because of conflicts between 2008 and 2019 (IDMC, 2020). The United Nations High Commissioner for Refugees (UNHCR) (2021) estimated 2.6 million Somalis were internally displaced in February 2021, including 13,247 asylum seekers, 11,478 refugees, and 131,633 refugee returnees.

Most Somali internal displacement occurs in south-central regions, particularly Hiraan, Bay, Bakool, Gedo, Shabelle Dhexe, Shabelle Hoose, Juba Dhexe, and Juba Hoose (World Bank, 2014). These regions are mostly controlled by al-Shabaab armed groups and endure constant threats of violence (Armed Conflict Location & Event Data Project (ACLED), 2021). These are also the regions most affected by extreme weather events such as droughts and floods, which cause high yield and livestock losses in rural areas, expose millions of people to food insecurity, and lead to internal displacement (IDMC, 2020). Out-migration from southern-central regions, mostly remaining within south-central Somalia, is thus both climate- and conflict-induced. Mogadishu (Banadir) hosts the largest IDP population (World Bank, 2014).

a.
Somali climate-induced in-migrations (2016-2020)

Internal flows of incoming displaced people due to climate - regional level



b.
Somali conflict-induced in-migrations (2016-2020)

Internal flows of incoming displaced people due to conflicts - regional level

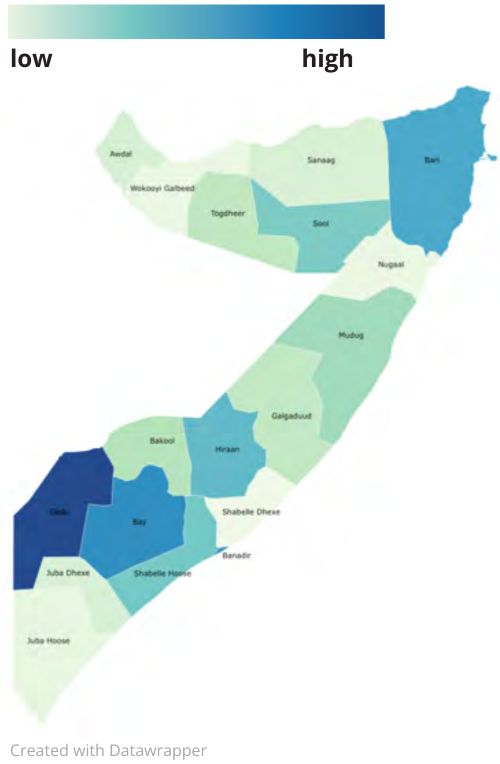


Figure 7: Somali internal displacement between 2016 and 2020 – regional level (a: climate induced migrations, b: conflict-induced displacement)

1.43 The climate migration nexus in Somalia

The most prominent pathways leading to migration in Somalia are violence (Figure 8, in red) caused by political instability and armed conflicts; livelihood loss (in turquoise) caused by extreme weather conditions such as floods, droughts, and irregular seasonal patterns; and resource scarcity (in dark blue) caused by extreme weather conditions such as droughts and increasing temperatures. Conflicts in Somalia, led by Al-Shabaab, clans, and Somali military forces, lead to conflict-induced internal displacement, mostly in the regions of Gedo, Bay, Banadir, Bari, Hiraan, and Shabelle Hoose. Livelihood loss and resource scarcity lead to climate-induced displacement, mostly in the regions of Hiraan, Shabelle Dhexe, Shabelle Hoose, and Gedo. The natural resource scarcity and conflict pathways create push factors leading Somalis to leave resource-scarce and hostile environments and to modify preexisting migration strategies such as traditional pastoral routes. The livelihood-loss pathway creates both push and pull factors leading Somalis to leave lost livelihoods or to seek better ones elsewhere.

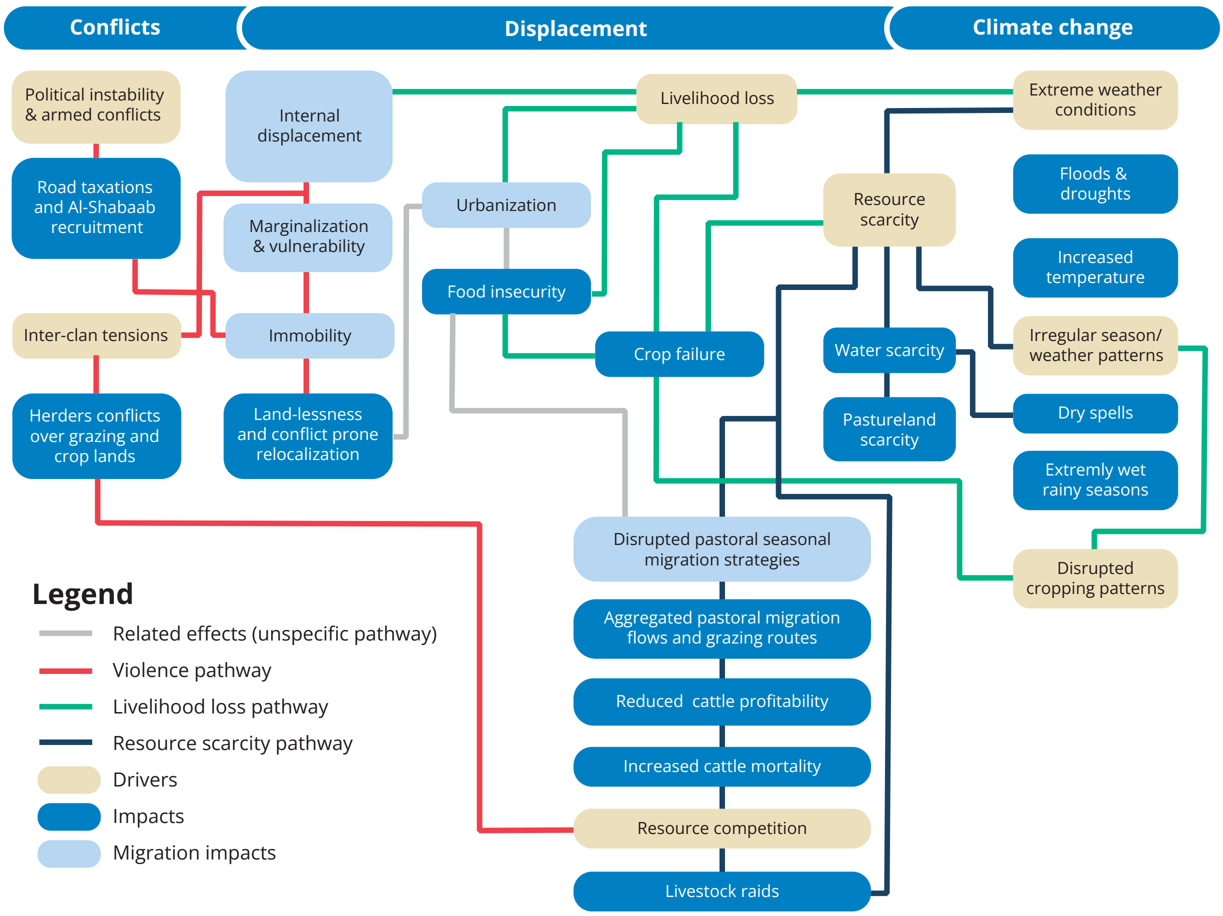


Figure 8: Diagrammatic presentation of the impact pathways for migration in Somalia

1.44 Empirical analysis of migration drivers in Somalia

A regression analysis was conducted using a binary model to understand the dynamics of migration. This involved profiling international and internal migrants, gender profiling in regards to presence of threat multipliers, and interaction between climate and conflict influence from a gender perspective. The analysis also looked at how climate and security risks affect international and internal migration flows. The dependent variables are the gender of the individual migrant and their stated final destination, whereas the controls are the socio-economic characteristics of the migrant. Other variables of interest include the intensity of conflict and the climate indexes (droughts, floods, extreme temperatures, length of the growing season, etc.). In addition to the binary model, the study conducted a Network Analysis –¬ often referred to as Social Network Analysis –¬ which is the study of social relationships using networks and graph theory. It defines network structures in terms of nodes (e.g., individual actors, people, or things within the network) and the edges or links (e.g., relationships or interactions) that connect them (Otte and Rousseau, 2002).

The presence of conflict is negatively and significantly correlated with the likelihood of female migration. In particular, more violent conflicts seem to a have higher and more significant impact on the likelihood of women migrating. Women tend to be less mobile than men in conflict situations (Macklin, 2009; Jolly et al., 2005), which could be due to the higher vulnerability of women, or due to changes in women's households and social roles led by the men casualties (Buvinic et al., 2013; The World Bank, 2011).

Positive rainfall anomalies have a slightly positive and significant effect on female migration. Positive anomalies capture wetter months, and thus it could capture more favorable months for rural activities such as pastoralism and agriculture. More profitable months can increase the chance of migration due to higher capacity to invest in labor migration as a different earning strategy (Warner, 2012; Mastrorillo et al., 2015). Negative rainfall anomalies (drier months) have an opposite effect on rural economic activities as compared to positive anomalies. Drier climate conditions could lead to economic losses that would result in less capacity to move (Maystadt & Ecker, 2014; Food Security and Nutrition Analysis Unit Somalia (FSNAU), 2011). Maximum temperature anomalies have a positive and extremely significant effect on female migration. Extreme drought conditions could lead women to forcibly move from areas in which the economic activities are no longer sustainable (Abebe, 2014; Omolo, 2010; Waithaka, et al., 2013).

The interaction between climate anomalies and violent conflict is significantly and negatively correlated with the likelihood of female migration. Women seem to be significantly less mobile than men. This is consistent among the different specifications of conflict and anomalies. The conflicts have a significant impact on international and internal migration. Climate anomalies have a significant impact. The greater the temperature anomalies, the more likely internal migration will occur. The greater the rainfall anomalies, the more likely international migration will occur.

Women tend to migrate internally, while men tend to migrate internationally. Education is positively associated with international migration. This is in line with the literature, where skilled workers living in developing countries are likely to migrate abroad as national economies have low demand for skilled jobs (Adams, 2003). International migrants tend to travel alone and self-fund the cost of the journey.

1.5 Economic analyses using IMPACT

The 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 the 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, and with little effort to mitigate the impacts of climate change (Robinson et al., 2015).[4] 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 incidences of extreme weather events (Robinson et al., 2015). For this study, RCP 8.5 – the most

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

pessimistic carbon concentration scenario available – is assumed, which projects a mean global temperature rise of 1.4-2.6°C over the 2005 level by 2050. . Overall, the combination of SSP5 with RCP 8.5 envisions a bleak outlook for climate change, 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 (No-CC) scenario is also modeled as a benchmark against which to compare the impacts of climate change.

In IMPACT, yield is modelled as a function of both biophysical and economic factors, meaning that negative climate impacts can be offset by technological improvements (related to, for example, germplasm and farm management) and 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 in respect to one another and of the comparative advantages of nations trading in these commodities. This rebalancing, in turn, shapes the price signals driving changes in economic yield and productive decisions at farm level.

It is important to note is that IMPACT results are reported at the country level and not disaggregated by livelihood zone. The relevance, therefore, lies in the context they provide for making decisions at the zonal level. Understanding climate vulnerability at the national level provides critical information to policymakers to formulate climate change and agricultural development strategies that can be implemented at the livelihood zone level (*see examples in Part 1.6*). The 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 (CC scenarios) out to 2050 for supply, demand, and food availability of key crop and livestock commodities are compared against their respective No-CC benchmark trajectories. This comparison is made to identify points of vulnerability and resilience in Somalia's agricultural sector, particularly as regards food production and availability.[5] The commodity focus is chosen by in-country experts based on relevance to the country's diets and farms, especially regarding current and future food/nutritional security.

1.51 Impact of climate change: supply side

The comparison of climate change scenarios against a No-CC benchmark 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, thereby altering yield levels and areas harvested. 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 the biophysical yield loss.

5 "Raw" CC trajectories, without comparison to No-CC trajectories, are provided in Annex 2.

In Somalia, the production of key crops is projected to be 2-16% lower in 2030 under climate change than under the No-CC benchmark (Figure 9). This due to lower yields relative to the no climate change trajectory. The lower outlook relative to the no climate change trajectory is especially pronounced for maize. This offers an insight into the vulnerability or resilience of crops to the effects of climate change, confirming that sorghum has a high resilience compared to maize.

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

1.52 Impact of climate change: diet trajectory

Per capita consumption of key commodities is projected to be 1-5% lower in 2030 under climate change than under the no climate change benchmark (Figure 10). The lower outlook relative to the no climate change trajectory is especially pronounced for maize. Similarly, caloric availability is projected to be significantly lower under climate change than under the no climate change scenario. The projected impact on sesame, maize, and other cereals, excluding sorghum, is especially pronounced.

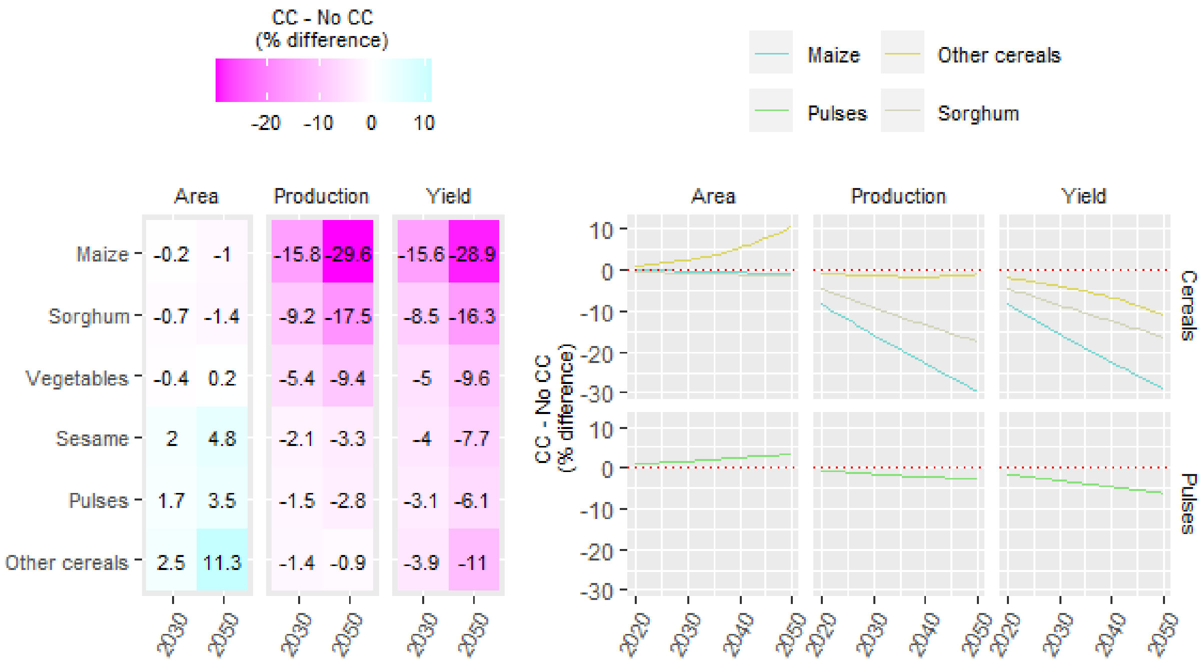


Figure 9: Difference between climate change and no climate change scenarios for production, area, and yield of key crops. For each year, the difference is calculated as the percentage difference between the CC value and the No-CC value.

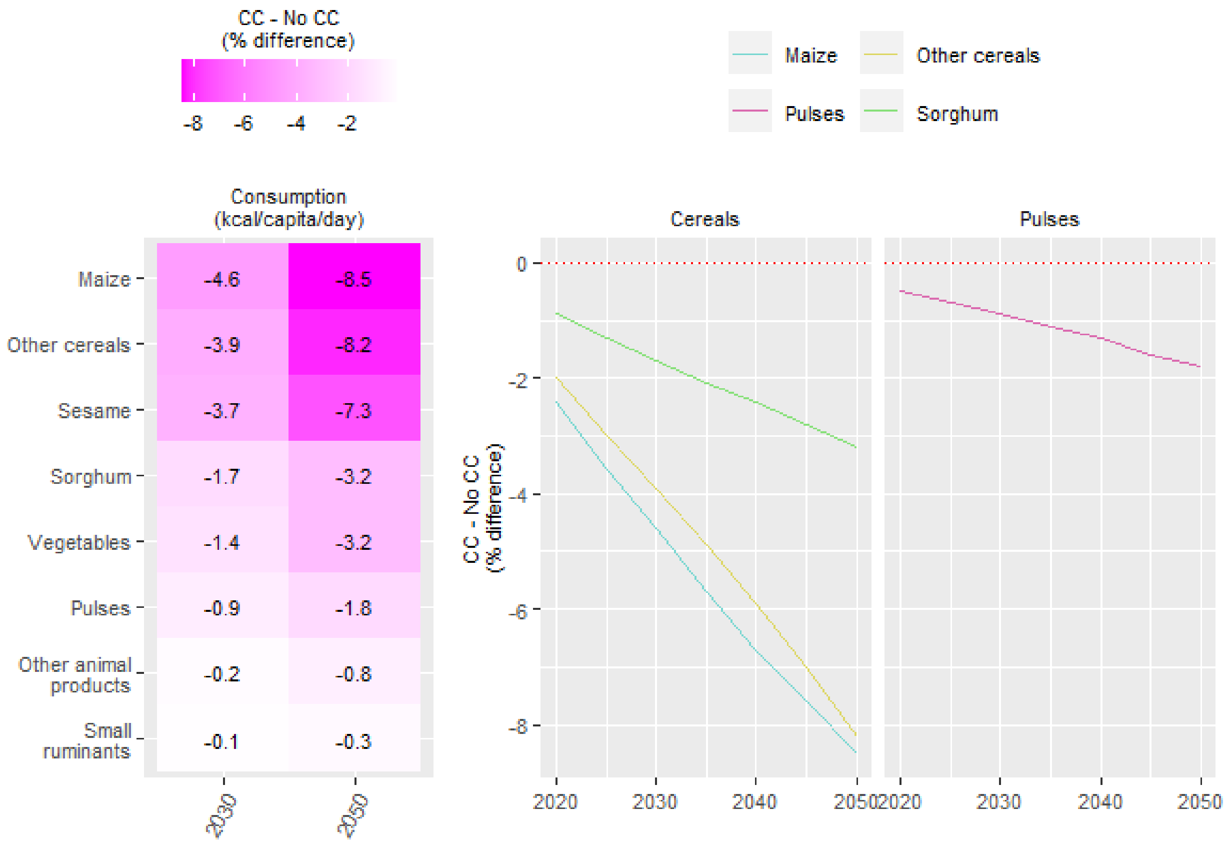


Figure 10: Percentage difference between the consumption (kcal/capita/day) of key commodities with and without climate change.

However, the projected climate change impact on per capita availability of sorghum and vegetables is moderate. Availability of livestock calories, on the other hand, exhibits relative resilience, differing only slightly from the no climate change benchmark.

1.53 Impacts of climate change: prevalence of malnourishment

The number of undernourished children is projected to be increasingly higher under climate change than under the no climate change scenario (Figure 11). This is consistent with the lower projected calorie intake under climate change seen above. Import dependence for maize is projected to be considerably higher under climate change, and the impact of climate change on import dependence for other key commodities is projected to be slight.

1.54 Conclusions and recommendations based on IMPACT

While maize depicts a high vulnerability to climate change, sorghum shows high resilience. This is evident from the decline in

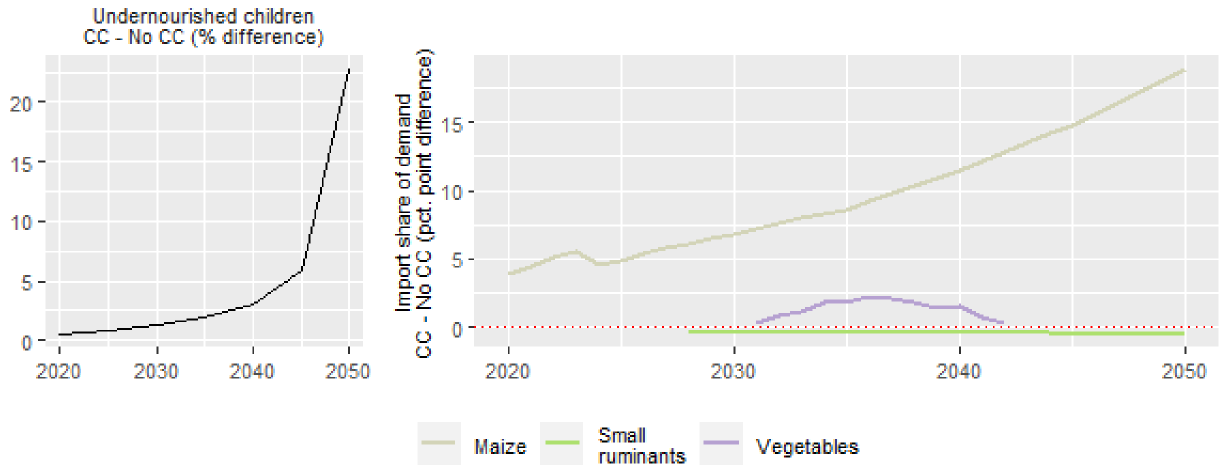


Figure 11: Difference between climate change and no climate change number of undernourished children (left) and import dependence (right).

the yield and production of maize compared to sorghum under future climate scenarios. The implication is that since crops like maize are prone to drought, there has been a tendency to shift to crops like sorghum, which are not only drought-resistant but are also considered cash crops. The case is similar to the increasing number of farmers engaged in the production of vegetables like tomatoes, which mature faster. Interventions that can help boost the production of maize during dry seasons should therefore be considered. For instance, adaptation measures such as the use of line water pans for water conservation have been useful for storing water for use in the dry season. This has helped a number of households produce key commodities like maize during the dry season.

The high vulnerability of maize to climate change is related to low-caloric availability hence the prevalence of undernourishment. This points to a reduction in the starchy share of the diet, which is likely to be replaced by the consumption of animal products. The consumption of animal products is projected to rise from about 50% to 56% of the total diet in 2030 and then by 74% in 2050. The trend could be explained by the dominance of livestock keepers, as compared to crop producers, since the livestock reared (i.e., goats and camels as opposed to cattle or sheep) is well adapted to harsh climatic conditions. However, care must be taken when promoting the replacement of the declining starchy-staple share of the diet with the consumption of animal proteins.

1.6 National climate change and development strategies

This section highlights how climate change has been mainstreamed into sectoral policies and activities in Somalia. This was achieved through a literature review, discussions with WFP country offices, and key informant interviews (KIIs) with government line ministries and representatives from NGOs working in Somalia. Current investments on climate change from the government, multilateral donors, bilateral donors, International Financial Institutions (IFIs), and the private sector are also discussed to underline the gaps and opportunities for future WFP programming activities.

1.61 National climate change strategies and finance mechanisms

The Government of Somalia recognizes that enhancing environmental resilience and improving economic stability is fundamental to coping with the effects of climate change. In the recent past, the government has been actively involved in the formulation of national and sub-national (state-level) policies to help improve the country's adaptive capacity towards climate change. The Directorate of the Environment is responsible for overseeing the development and implementation of climate change initiatives in the country. Formulated in 2020, the National Climate Change Policy (NCCP) provides Somalia with a framework for implementing and prioritizing climate change activities. Apart from mainstreaming climate change, this policy document addresses cross-cutting issues on climate change, e.g., capacity building, technology and innovation, information dissemination and communication, education, and awareness creation (Federal Republic of Somalia, 2020).

The country's first national communication to the UNFCCC was submitted in January 2019. In line with UNFCCC, Somalia has prepared its Intended Nationally Determined Contributions (INDC) 2015 to help put in place mitigation and adaption mechanisms to cope with the effects of climate change in the country (FGS, 2015). The INDC is among the strategic documents and reporting channels that will inform the National Adaptation Plan (NAP) process. Through UNDP funding (under the climate promise initiative), Somalia has continuously participated in climate action initiatives that align with the objectives of the NAP process.[6] In 2020, the first NAP inception workshop was conducted to deliberate its implementation from 2020-2023. The aim of the NAP is to help oversee both long- and medium-term climate adaptation planning in Somalia. Following the NAP process, Somalia will have the opportunity to enhance its national coordination capacity and initiate a legal framework for climate change adaptation. Furthermore, the NAP will help devise national financial plans and coordination mechanisms for climate change adaptation. The National Climate Change Strategy (NCCS),[7] which is in its development stage, is also guiding the prioritization of adaptation options and creating a platform for raising finances for climate change adaptation.

Disaster preparedness and risk management have also been given policy considerations. The National Adaptation Programme of Action (NAPA), 2013) is already facilitating the integration of climate change adaptation into the country's development plans. The aim is to reduce vulnerability and increase preparedness for the effects of climate change (FGS, 2013). The Somali National Disaster Management Policy (NDMP) 2018 was developed to improve resilience and preparedness towards climatic disasters and to enhance disaster risk governance. The Drought Recovery and Resilience framework (2017) underscores the

6 https://www.adaptation-undp.org/resources/project-brief-fact-sheet/national-adaptation-plans-focus-lessons-somalia
7 https://www.greenclimate.fund/sites/default/files/document/readiness-proposals-somalia-undp-adaptation-planning_0.pdf

importance of planning and the management of natural resources affected by drought. It aims at integrating disaster risk reduction in building resilience (FGS, 2018). The National Drought Plan (2020) was developed to create the mechanisms and systems that would enable government partnerships with the relevant stakeholders mitigating the impacts of frequent droughts in the country. The goal is to establish a resilient society that can combat drought shocks. At the state level, the Puntland Disaster Management Framework (2011) was developed to provide a framework for stakeholder disaster management and response. Policies on the management of natural resources, e.g., the National Environment Policy (NEP) 2019 and the recently endorsed environmental management bill also address climate change.

1.62 National development strategies and finance mechanisms

Somalia has been faced with violence for over two decades; thus, the government has been constrained in developing general sectoral policies. Nonetheless, notable efforts have been made in the country regarding development policies that target improved access to basic needs, food and nutrition security, and agricultural production. With the growth in the number of IDPs (*see Part 1.4*) and the rising population living under poverty (*see Part 1.2*), the Government of Somalia formulated the Social Protection Policy in 2019 to help vulnerable groups overcome poverty and manage risks through transitional safety nets. Cross-cutting various sectors of the economy, this policy will help the country strengthen its social protection system. This is one of the policies that has garnered both technical and financial support from the donor community and the private sector, particularly from the UN, NGOs, and the Italian Cooperation. The FGS is committed to collaborating with development partners in creating appropriate and sustainable funding mechanisms for social protection interventions. Among the proposed sources of funding from the government for anticipated recurrent safety nets included are public expenditures and the National Disaster Management Fund (FGS, 2019).

The effectiveness of the social protection policy is reliant on its integration into the country's national development framework. Social protection is well articulated in the Somalia National Development Plan (SNDP) 2020-2024, which presents a framework for incorporating social care and social protection services, and safety net programming. The plan is compliant with Sustainable Development Goals and recognizes that socioeconomic development can only be achieved through social cohesion and ensuring that a majority of the population has access to the required standard of living (FGS, 2020). Given that the FGS has a very minimal budgetary allocation for development, the pillars of the NDP have been funded by development partners. By 2018, the SNDP had a donor expenditure of approximately USD1135 million, with the largest proportion being spent on resilience due to its component of social protection (FGS, 2020). Social protection is also aligned with the Somalia Nutrition Strategy (SNS) 2011-2013, which was developed with support from the World Health Organization (WHO) and the United Nations International Children's Emergency Fund (UNICEF). The goal of the strategy is to address the triple burden of malnutrition in Somalia. It lays emphasis on improving micronutrient deficiencies within vulnerable populations, mainly women and children under five years old (FGS, 2011). The National Food Security Policy that was submitted in 2020 is intended to provide a framework for enhancing food security in Somalia, thus building up social protections. Other national policies that accentuate the gravity of social protection include the Somalia Health Policy of 2014, National Gender Policy 2018 (draft), National Policy on Refugee-Returnees and IDPs 2018 (draft), National Youth Policy 2017, and the National Employment Policy 2019 (draft).

1.63 International alliances and finance mechanisms

International organizations, particularly the UNDP, have supported Somalia on climate change adaptation, resilience, and financing. Guided by the country's NDP and the Resilience and Recovery framework of 2018, UNDP works with UN partners, development institutions, e.g., the World Bank, local authorities, and civil society organizations, to help Somali communities adapt to climate change impacts and reduce risks. Shaped by the main global agreements (i.e., the Paris Agreement on Climate Change, the Sendai Framework on Disaster Risk Reduction, and the Agenda 2030 for Sustainable Development), a number of climate change projects and programs have been implemented in Somalia through multilateral funds. With US$7.8 million in funding from UNDP, the United Nations Multi Partner Trust Fund for Somalia, under the Ministry for Energy, rolled out a five year (2016-22) joint program on sustainable charcoal reduction.[8] The goal is to provide alternative sources of clean energy and livelihoods, thus reducing demand for charcoal. The main component is to create awareness on environmental issues linked to charcoal production and build the capacity of local, national, and regional stakeholders to influence policy development. In 2020, the Green Climate Fund (GCF) under the FGS and UNDP launched the US$2.7 million program, *Strengthen Climate Change Adaptation Planning.*[9] This is the first GCF-funded program that will guide Somalia's adaptation to the impact of climate change across various sectors of the economy. It will also form a basis for the establishment of funding mechanisms for tackling climate change issues from either domestic or international sources.

The Global Environment Facility (GEF), under the Least Developed Country Fund (LDCF), has implemented two major projects in partnership with UNDP. In the period from 2014 to 2019, approximately US$8 million and US$64.8 million were disbursed, respectively, for a project covering the Puntland, Somaliland, South West, and Galmudug states.[10] The aim was to boost the resilience of ecosystems and vulnerable communities to climate change. In 2019, UNDP and FGS launched a US$10 million GEF-funded project, with US$8.8 million from GEF and US$1.5 million from UNDP. The project targets improved access to scarce water resources and adaptations for droughts and floods among pastoralist communities. This will help the country tackle challenges in water management. Under the Directorate of Environment and Climate and the Ministry of Energy and Water Resources, the project is set to benefit 360,000 farmers and pastoralists. Among the objectives of the project is the establishment of a national

8 https://www.so.undp.org/content/somalia/en/home/projects/joint-programme-on-charcoal/
9 https://reliefweb.int/report/somalia/federal-republic-somalia-launches-gcf-financed-climate-change-adaptation-planning
10 https://www.adaptation-undp.org/projects/ldcf-somalia

hydro-meteorological service, putting in place forecasting and early warning tools, and installing monitoring equipment and automatic weather stations across Somalia. Communities will also be trained on managing floods, water conservation, and sustainable agricultural production.

1.64 Policy gaps and opportunities

Somalia lacks a central government body to tackle environmental issues. Climate change is directly linked to environmental issues; however, there are limited environmental management policies, plans, or strategies. The Somaliland and Puntland states played a significant role in the formulation of national climate change and environmental policies, e.g., NAPA. However, the stakeholders interviewed highlighted inadequate government capacity, which is key for the implementation of deforestation and land degradation initiatives. Methods for improving coordination among the states to develop inclusive policies for managing environmental and natural resources should be considered, for example, creating a common platform to facilitate communication among stakeholders.

The existence of the FGS and state governments (Puntland and Somaliland) challenges the implementation of climate change programs. At the moment, Somalia has very few local/ regional policies on climate change. Where such policies exist, they are inhibited by gaps. For example, there is a lack of regulatory tools for existing legislation and approved laws directly linked to climate change and the environment. The government needs support in building the capacity of regional and national institutions to enable it to implement already existing policies.

Somalia has inadequate human and financial capacity limiting its ability to respond to climate change disasters. Increasing the government's budgetary allocation to facilitate more climate change activities, and tapping into global climate change funds, could help expand Somalia's financial capacity. Human capacity building towards various aspects of climate change (e.g., planning, research, and response) should be prioritized for improved adaptation towards climate change (Beier & Stephansson, 2012). Additionally, staff working on climate change should be given intensive training on climate change impacts and approaches for harmonizing climate change issues with existing national plans and strategies.

PART 2.

Context within selected livelihood zones

2.1 Livelihood zones with rationale for selection

A livelihood zone (LZ) is an area concentrated with people sharing similar patterns for accessing food and markets (FSNAU, 2016). Livelihood patterns may vary within areas, and factors such as climate and soil may influence these patterns. Somalia is divided into 19 LZs, out of which 18 are considered rural. However, this profile prioritized four LZs (Figure 12) for the analysis, the Sorghum High Potential Agropastoral (SO15), Addun Pastoral (SO09), Southern Agropastoral (SO12), and Riverine Gravity Irrigation (SO13). Major crops (maize, sorghum, sesame, and cowpeas) and livestock (sheep, goats, and camels) were selected for analysis across all LZs. The selection was based on climatic factors such as frequency of drought and flood occurrence and inconsistency in rainfall patterns. Production factors such as the dominance in producing staple crops, such as maize and sorghum, and the potential for producing leafy vegetables were also considered. The characteristics of the LZs are discussed based on the FSNAU (2016) report and information provided from the key expert interviews.

SORGHUM HIGH POTENTIAL AGROPASTORAL ZONE

The Sorghum High Potential Agropastoral Zone (SO15) is referred to as Somalia's Sorghum Basket. The zone is characterized by fertile soils and high rainfall, with an average annual range of 400-500 mm. Sorghum is cultivated in a rain-fed production

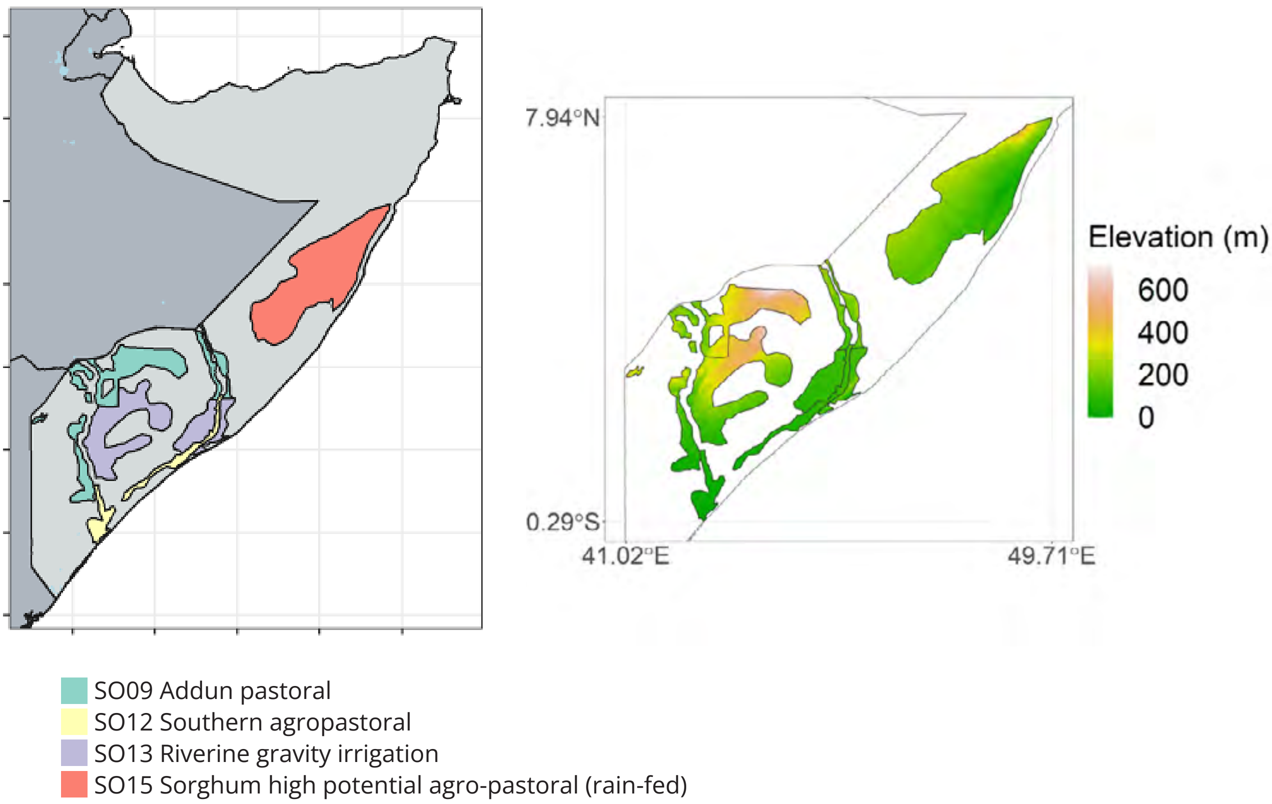


Figure 12: Map and elevation of selected LZs in Somalia

system as the major cereal crop. The Bay region supplies Somalia with over 60% of its annual sorghum demand. Maize is also grown but in smaller quantities. Pulses like cowpeas are inter-cropped with sesame, groundnuts, and cereal crops both for home consumption and for sale.

Livestock sales are a major source of income, while crops are a source of food. However, during periods of scarcity, crop sales supplement livestock sales. Cattle and goats are the main livestock reared among poor households. On the other hand, wealthy households keep camels. This zone has a developed market infrastructure due to the sorghum trade, which creates linkages to major urban market centers. Cattle are sold in intermediary markets, e.g., Baidoa, Beletweyn, and Kenya (Garissa town). High-quality cattle and goats are exported to the Gulf countries. Camels are sold in Mogadishu and trekked to other smaller or regional markets, which have a high demand for milk and ghee.

The zone has experienced food and livelihood insecurity for the past twenty years. This is a result of violence, shortages in the food supply, hiked food prices, displacement, and restricted movement within grazing areas. Crop and milk production and food purchases constitute the bulk source of calories. During seasons of peak production, own crop production can provide 60- 83% of the caloric requirements within households.

ADDUN PASTORAL ZONE

The Addun Pastoral Zone (SO09) is the largest in terms of land size. However, it has a low population density. The zone is characterized by an arid plateau and sandy soils. Vegetation consists of scattered trees and grasses and hard bushes that offer vast grazing grounds for livestock. Rainfall is low and unreliable, with an average annual range of 100 to 200 mm. Wheat, rice, and sorghum are the main staple grains found in this LZ and cover about 65% of the annual household food needs. Oil and sugar are also important food commodities in this zone, mostly from purchased sources.

The economy is dominated by pastoralism consisting of a nomadic population. Livestock is the main commodity sold; hence, livestock sales are a primary source of income for most households in this zone. Ownership of goats and camels determines the wealth status of households. The zone is referred to as “the house of goats” since goats comprise up to 70% of the combined goat holdings. Camels are sold in large cities like Mogadishu, while goats are sold in towns like Galkayo and Hobyo. There are smaller markets and water points around villages used as temporary collection centers for livestock before they are transported to their destination. Some of the stock is exported to Saudi Arabia, Yemen, and Dubai. The zone is curbed with poor road infrastructure and limited storage capacities restricting the marketing of commodities.

The Addun Pastoral Zone is facing a food insecurity crisis. This is a result of frequent droughts, water scarcity, inadequate rainfall, and civil unrest. Over 85% of the households residing in this LZ are in need of food assistance; 18% are facing an acute food crisis; and 13% are on the borderline of food insecurity. Interventions such as the distribution of food aid helped relieve food insecurity among households owing to improved security in this zone.

SOUTHERN AGROPASTORAL ZONE

The Southern Agropastoral Zone (SO12) is found in the south-central drylands of Somalia. The zone is mainly semi-arid, characterized by stony, saline, and infertile soils. Much of the area is covered under a limestone-sandstone plateau consisting of shrubs and woodland vegetation. Rainfall has a bi-modal distribution with an average annual range of 300-350 mm. Annual daytime temperatures can be as high as 27°C. Agricultural production is very low; nevertheless, camels, cattle, goats, and sorghum are major commodities among the agropastoral communities. In most instances, the production of sorghum supplements livestock production. Natural depressions are sometimes used for water catchment, which facilitates the production of sorghum for some households.

The Southern Agropastoral Zone has been facing food insecurity for the past two decades. This is a result of low rainfall, high grain prices, conflicts, and livestock diseases. Overall, the zone has high cereal deficits. For instance, in 2015, the zone faced the highest rate of food insecurity due to a 45% decline in marginal cereal harvest. The consumption of livestock products (milk and meat) provides approximately 16-28% of households' food energy supply. Some households collect wild vegetables for nutritional variety.

Livestock production is the backbone of local communities. On average, 80% of the households' cash income is from livestock sales (milk and ghee), which aids in the purchase of staple foods. Some households are involved in the sale of honey and bush products. Households in these zones have accessible markets. For example, livestock is exported to the Middle East and sold regionally to countries such as Kenya. Locally, village and district markets offer a platform for selling livestock products through wholesalers and retailers. Large-scale traders provide transportation.

RIVERINE GRAVITY IRRIGATION ZONE

The Riverine Gravity Irrigation (SO13) is a semi-arid zone. Annual average daytime temperatures are estimated at 27°C, with the minimum annual rainfall averaging between 350-500 mm. Most of the areas are rich in good soils, but some have sandy, vertisol, and saline soils. The land bordering the river and the coastal area has little or no vegetation. This is an agricultural zone served by rivers Juba and Shabelle. Both rainfed and pump irrigation facilitates the production of a wide variety of food and cash crops. Maize and sorghum are the main food crops, while onions, tobacco, and sesame are major cash crops. Fruits and vegetables such as tomatoes, bananas, mangoes, and sugarcane are also produced in this zone.

Agriculture is the most important source of income in this LZ. It meets between 60-75% of farmers' annual income. Staple grains are sold mainly in local markets, while fruits and vegetables are sold in urban markets. Some cash crops are sold along the borders of Kenya. There are a few livestock holdings in this zone. Cattle, sheep, goats, and chickens are reared in some homesteads through zero grazing. Crop residues, cowpea leaves, and grain stalks are the main sources of fodder, some of which are sold to neighboring agropastoralists. Fishing, agricultural labor, and the sale of bush products also provide supplementary income to households.

Despite its high agricultural potential, households still face food insecurity. Nonetheless, the zone has experienced a food surplus in most years. Both homegrown and purchased food provide the food energy needs for wealthy and poor households. Fish, wild meat from guinea fowl, and vegetables provide a dietary diversity.

2.2 Climate analysis across the livelihood zones

Analysis was done for climatic risks related to rainfall and temperature. The analysis is compounded on indices corresponding to the climatic risks affecting the Sorghum High Potential Agropastoral (SO15), Addun Pastoral (SO09), Southern Agropastoral (SO12), and Riverine Gravity Irrigation (SO13). 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) indicative of flood risks. Waterlogging was based on the number of days during the growing season with waterlogging on soils (NWLD). Lastly, the number of dry days (NDD) during the growing season with precipitation less than 1 mm a day was used for drought.

2.21 Mean climatic projections

The Annual Total Rainfall (ATR) trends show that historically (1980-2019), all the LZs have experienced low precipitation, with some areas in these zones receiving less than 100 m of rainfall (Figure 13). The first season receives less rainfall and is drier compared to the second season. Projections between 2021-2040 show that precipitation in the first season is expected to decline, particularly in the south-eastern parts. In

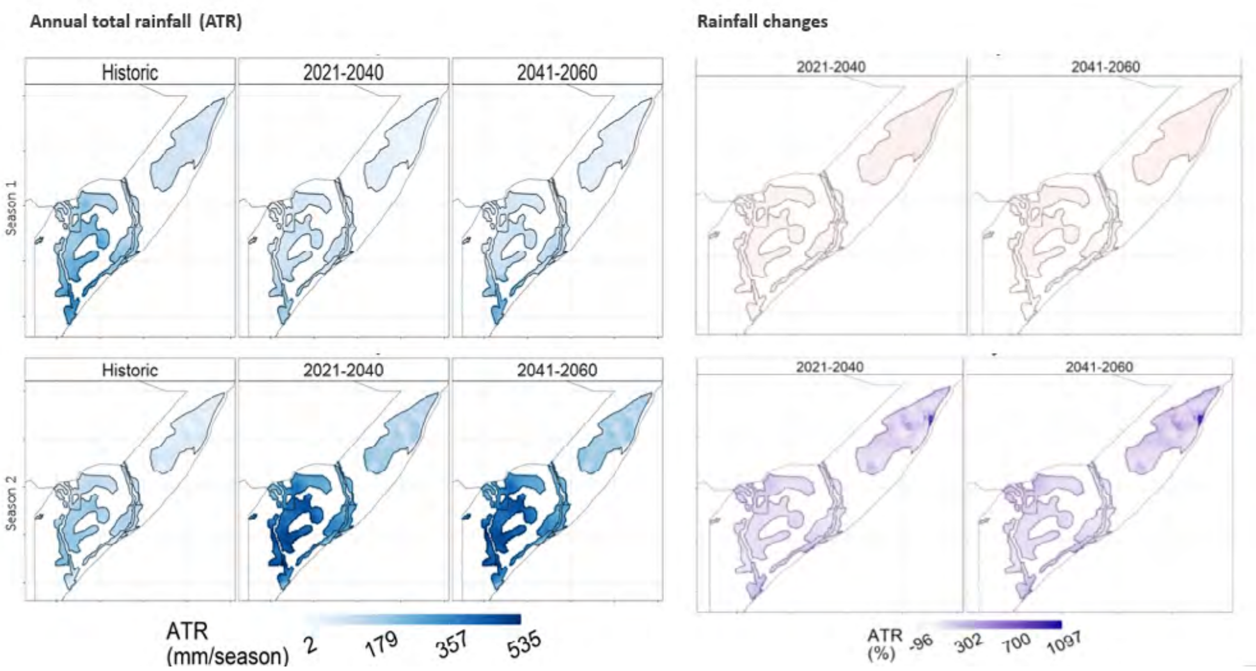


Figure 13: Historical (1981-2019) and future (2021-2060) annual total precipitation across the Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Zones of Somalia

contrast, the second season will become significantly wetter across all the LZs. Most dominant changes in precipitation will be experienced in the southern regions, especially along the Riverine Gravity Irrigation Zone.

Temperature trends show historical (1981-2019) high annual mean temperatures (AMT) across the LZs (Figure 14). An annual mean temperature of more than 24°C has been recorded in all the zones, with some areas recording a maximum of 31°C. The first season has, however, been warmer and hotter compared to the second season. Future projections from 2021-2040 show temperatures are expected to increase in both seasons, with an average increase of 2-3°C over all zones. Some locations will experience temperature increases as high as 5°C by 2060.

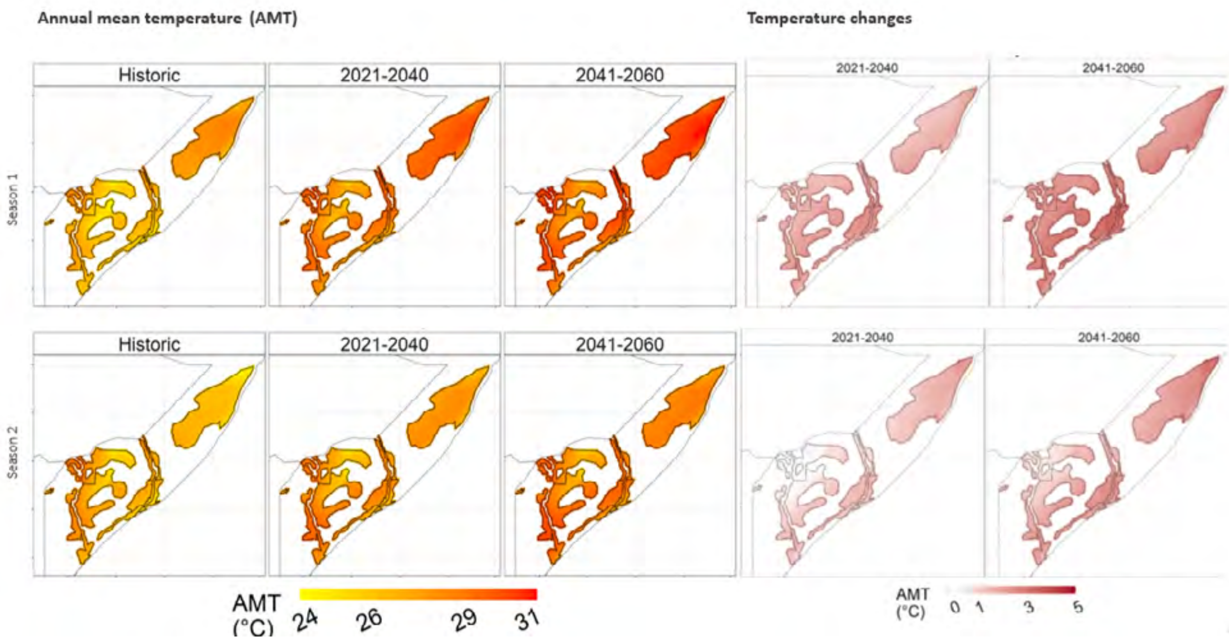


Figure 14: Historical (1981-2019) and future (2021-2060) annual mean temperatures across the Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Zones of Somalia

2.22 Climate risk analysis

FLOOD RISKS AND WATERLOGGING

Given the precipitation trends, historical risk of floods and waterlogging have been experienced both in the first (*Deyr*) and second (*Gu*) season. Overall, the risk for flash floods is similar to regular flooding (based on the maximum 5 day running average rainfall). As indicated in the graph below (Figure 15), the risk of flood occurrence is higher in the second season and is more pronounced in the months of October and November. Flood risks decline during the first season, especially towards the end of the season in June and at the onset of the season in September. The highest incidences of waterlogging are experienced during the months with high flood risk. During the dry months (January to March and the month of August), almost all zones have zero occurrences of waterlogging (Figure 16). As shown by the P5D and NWLD indicators, the seasonality of the flooding and

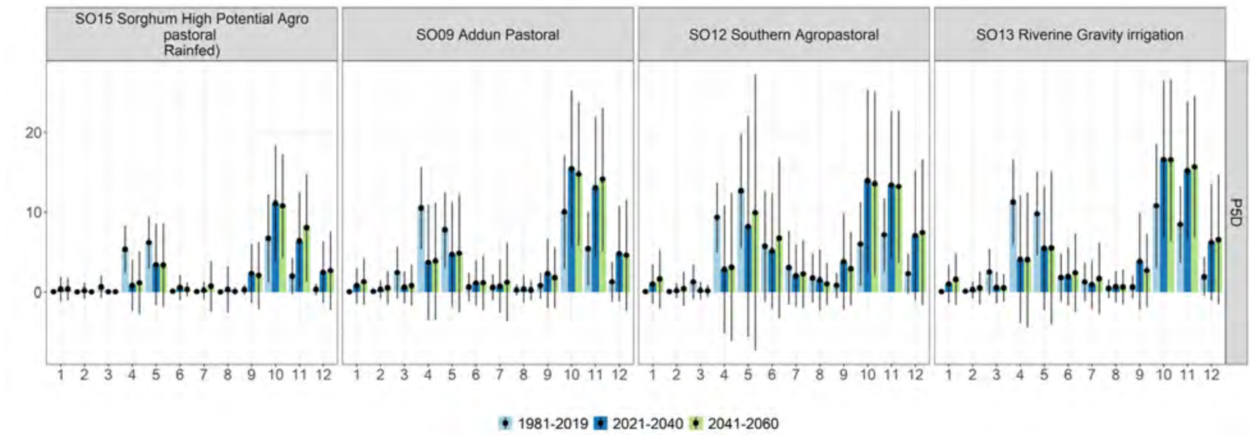


Figure 15: Historical (1981-2019) and future (2021-2060) projections of flood risks across the Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Zones of Somalia

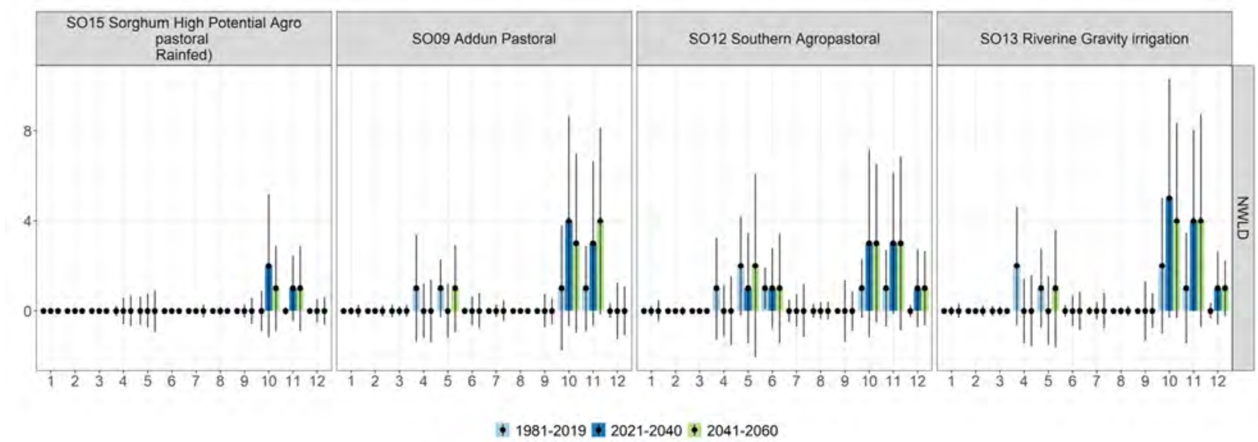


Figure 16: Historical (1981-2019) and future (2021-2060) projections of waterlogging risks across the Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Zones of Somalia

waterlogging risks will remain the same in the future. The Riverine Gravity Irrigation and the Southern Agropastoral Zones are high flood risk and waterlogging zones compared to the other two zones.

HEAT STRESS

With the anticipated increase in temperature, there is a high probability of the risk of heat stress across all the LZs. Analysis of the THI (Figure 17) shows that historically (1981-2019), heat stress has been experienced throughout the year in almost all the months. Future projections indicate that heat stress will continue to be a challenge, with severity in some months. Heat stress risk is extremely important in livestock production; thus, it is expected to affect the Sorghum High Potential Agropastoral, Addun Pastoral, and Southern Agropastoral Zones where livestock production is dominant.

DROUGHT RISK

The predicted increase in the number of dry days within a season is an implication of drought risk. Drought risk (Figure 18) is

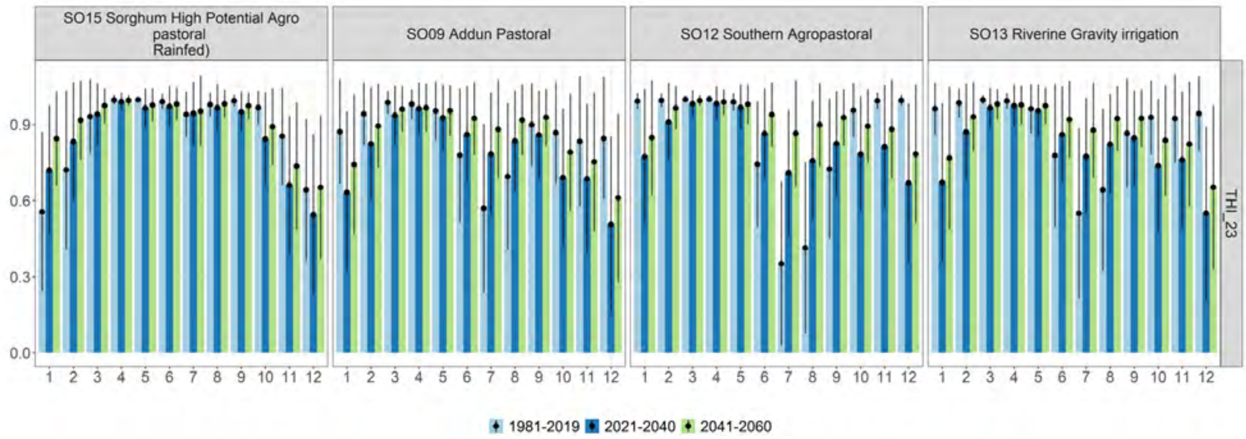


Figure 17: Historical (1981-2019) and future (2021-2060) probability of heat stress occurrence (which affects cattle) across the Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Zones of Somalia

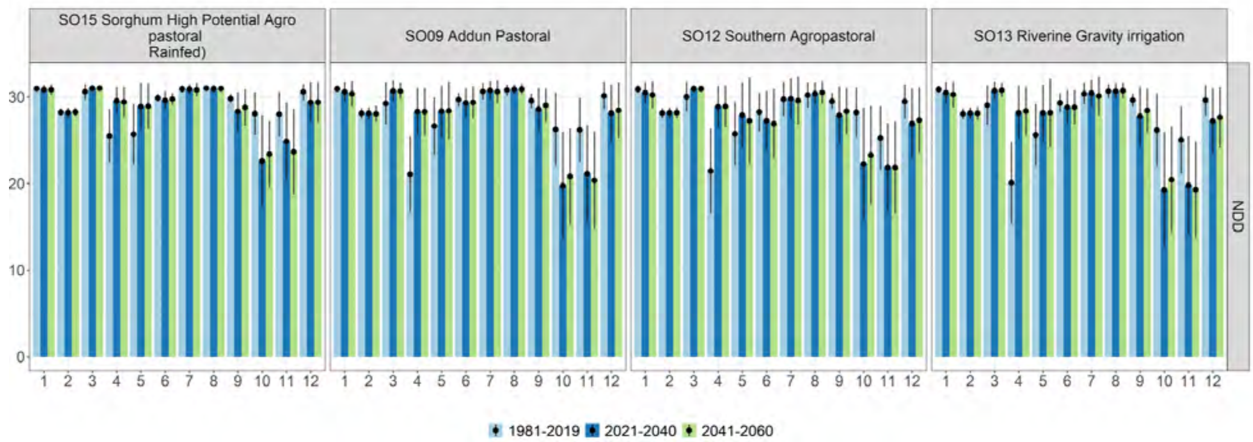


Figure 18: Historical (1981-2019) and future (2021-2060) projections of drought occurrence across the Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Zones of Somalia

spread across all the months of the year and across all the LZs. The number of dry days in a month has been over 20, with some months (approximately five months in a given year) having more than 30 days. Future projections depict a continuity in drought risks throughout the year. Both historical and future trends show that October and November will experience fewer dry days compared to the other months.

CO-OCCURRENCE OF HAZARDS

The co-occurrence of drought and heat stress has been experienced in both seasons but with varying intensities (Figure 19). In future years, there will be increasing co-occurrence of both heat stress and drought. Their co-occurrence is expected to grow in intensity by 2060, particularly during the second season in the Sorghum High Potential Agropastoral Zone. Some areas in the Riverine Gravity Irrigation Zone and Addun Pastoral Zone are expected to witness an increase of drought risk in the future, while heat stress risk remains low altogether. Co-occurrence of flooding/ waterlogging and drought risk has historically been in the first season, concentrated in the Addun Pastoral, Southern Agropastoral, and Riverine Gravity Irrigation Zones (Figure 20). There is a significant co-occurrence of drought in the second season with minimal risk of flooding/ waterlogging in all zones. In the future (towards 2040 and 2060), all zones, with the exception of a few areas in the Sorghum High Potential Agropastoral Zone, will have a higher co-occurrence of drought and flooding/waterlogging in the second season.

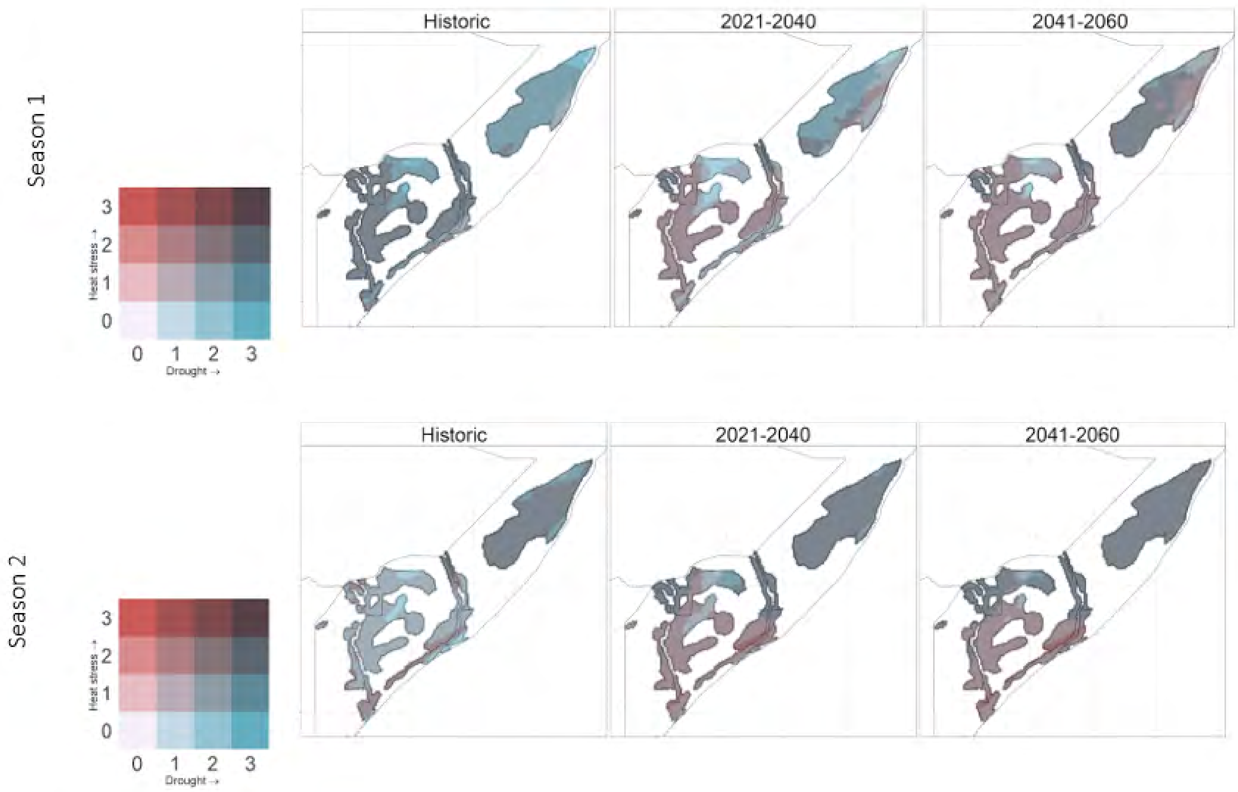


Figure 19: Historical (1981-2019) and future (2021-2060) co-occurrence of drought and heat stress across the Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Zones of Somalia

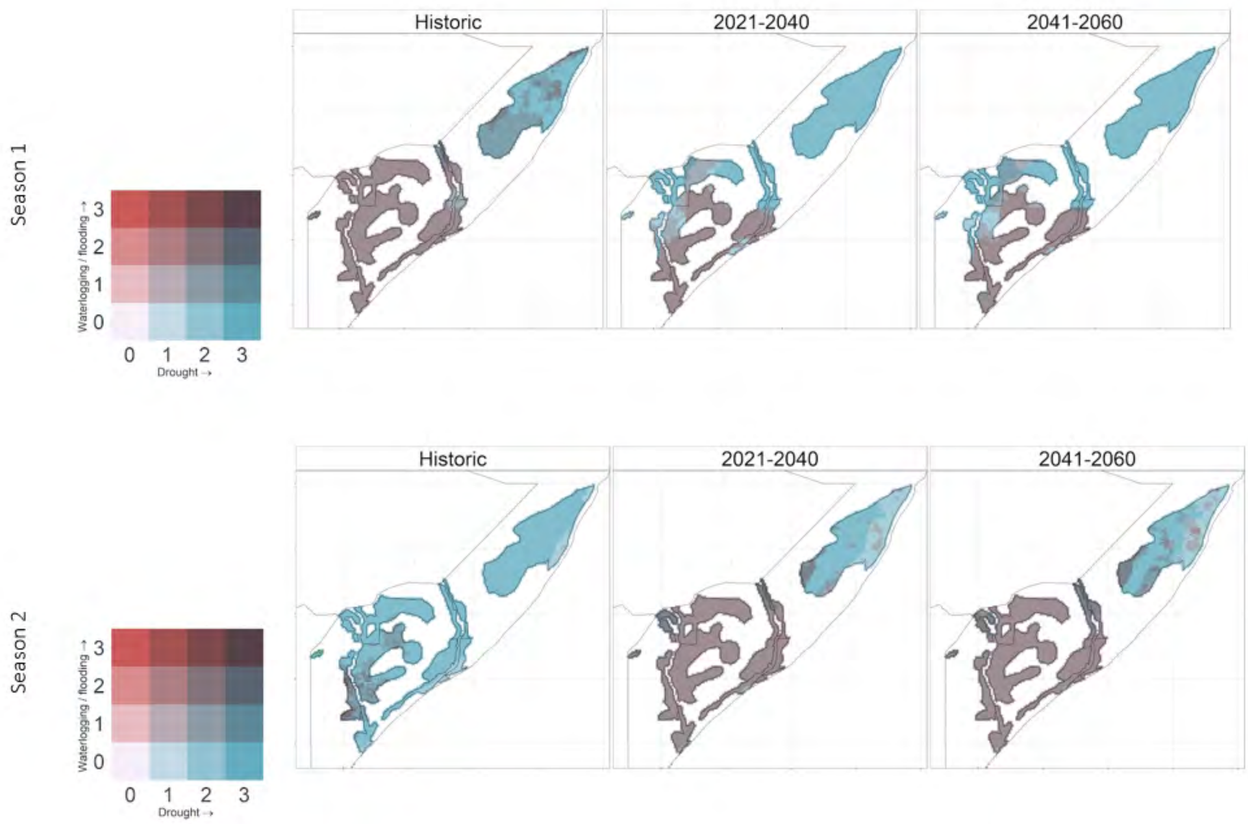


Figure 20: Historical (1981-2019) and future (2021-2060) co-occurrence of drought and waterlogging across the Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Zones of Somalia

2.23 Risk for focus crops: suitability analysis

The EcoCrop model (Ramirez-Villegas et al., 2013) was used to find the areas suitable for crop production under current and future climate conditions in Somalia. Eco-Crop 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 estimated across a spatial resolution of 5 by 5 km. For Somalia, the suitability analysis was carried out for cowpea and maize.

Historically (1960-1990), changes in climatic conditions have affected the suitability of crops (Figure 21).[11] The Southern Agropastoral Zone had some moderately suitable areas for maize production. Very few areas in the Addun Pastoral Zone are suitable for maize production. The remaining two zones have been unsuitable for maize production. The Riverine Gravity Irrigation and Southern Agropastoral Zones have been highly suitable for cowpea production with 60% and 80% suitability, respectively.

In the future (2030 and 2050), there will

11 Crop suitability is measured as the cumulative percentage of area under a crop

be a negligible change in maize suitability. This indicates that the maize growing areas in all LZs will remain unsuitable or poorly suitable for production. Unlike maize, cowpea will maintain suitable production in all LZs in the future. The Sorghum High Potential Zone will continue to be poorly suitable for cowpea production (Figure 21).

2.24 Threats to livelihoods

Both climatic and non-climatic hazards are a threat to livelihoods in the four LZs. The threats discussed below are highlighted by FSNAU (2016) and are from the KIIs conducted with government ministries and representatives from organizations operating in Somalia.

Recurrent droughts affect both pastoral and agropastoral communities residing in these LZs. For over two decades, rainfall has declined, with most areas receiving less than the normal average. The main impact has been pasture reduction and water shortages. In the Addun Pastoral Zone, prolonged dry conditions have led to the deterioration of livestock and productivity of milk. This has largely affected the income and food security of households, causing them to migrate to other LZs. In 2002, the Southern Agropastoral Zone reported losses of up to 40% of cattle and 10-15% of goats. Drought-induced hunger led to displacement and high mortality rates among the population. In the Sorghum High Potential Zone, drought has caused a reduction in crop yields, lowering the local demand for agricultural labor and thus a reduction in income.

Floods and flash floods have a destructive impact on livelihoods. Flood events have had a negative impact on livelihoods in the Riverine Gravity Irrigation, Sorghum High Potential, and Southern Agropastoral Zones through the destruction of essential infrastructure, e.g., roads, bridges, dams, and communication networks. This has been a major hindrance to the distribution of food aid, humanitarian activities, and trade flows. Consequently, community assets, crops, and livestock have been destroyed, leading to food insecurity, human displacement, and migration. Positive effects of flooding have been experienced in the Riverine Gravity Irrigation and the Sorghum High Potential Zones, where it is associated with increased

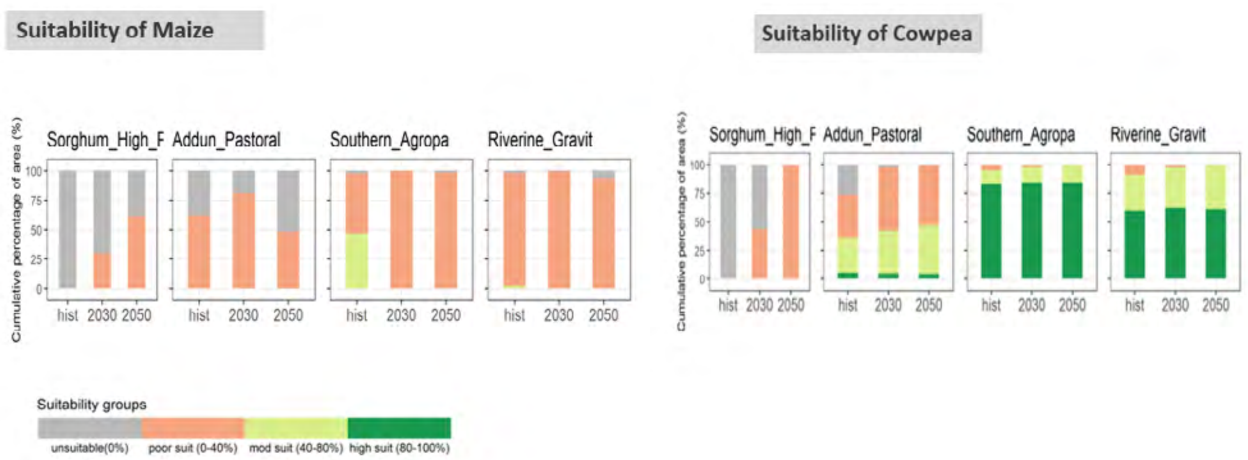


Figure 21: Historical (1960-1990) and future (2030-2050) suitability of cowpea and maize in the Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Zones of Somalia

soil fertility from alluvial deposits and provides ground for replanting. Nevertheless, it takes longer for households to recover from flooding losses.

The overall changes in climatic conditions are associated with increased incidences of pests and diseases. In the Addun Pastoral Zone, the main livestock diseases are pneumonia, sheep or goat pox, and parasites, which undermine animal body conditions and reduce livestock sales, causing a significant loss in household income. In the Southern Agropastoral Zone, disease outbreaks are common between drought and the onset of rains. Major outbreaks of Rift Valley fever and foot-and-mouth disease resulted in high mortality among cattle. The Riverine Gravity Irrigation Zone is characterized by heavy insect and bird infestations, which cause seasonal crop losses. In the Sorghum High Potential Zone, limited access to pest control services and veterinary attention has exposed households to tick-borne diseases, parasites (e.g., gooriyan), diarrhea, lumpy skin disease, and respiratory infections affecting shoats.

Environmental degradation is increasingly a concern, especially in the Addun Pastoral Zone. The concentration of people in areas with abundant resources during dry spells is the major cause of environmental degradation through loss of vegetative cover. This is due to overcrowding and overgrazing. Deforestation in the Southern Agropastoral Zone is alarming as communities are involved in charcoal burning and illegal logging. Such activities are steadily degenerating rangelands and destroying biodiversity. Both deforestation and overgrazing cause soil erosion and increased rates of evapotranspiration that further dry out the vegetative base.

Market disruption is a threat to livelihoods and food security. Poor road infrastructure makes roads inaccessible, especially in the Addun Pastoral and Southern Agropastoral Zones. This raises transportation costs and causes shortages in food supply, thus price increments for food commodities. Export bans, that were, for example, imposed on livestock to Gulf states in the 2000s affected the Addun Pastoral Zone due to its reliance on livestock sales.

Though to a varied extent, all LZs have been affected by conflicts. In general, conflicts disrupt the supply of farm inputs and trading routes, thus reducing crop and livestock sales. It is also a major hindrance to humanitarian and food distribution activities that support millions of livelihoods. The Riverine Gravity Irrigation Zone has experienced conflicts with the pastoralist community due to encroachment of grazing land during the dry seasons. Most areas in the Sorghum High Potential Zone were worst hit by the armed conflicts experienced in the first and second decades in Somalia.

2.3 Vulnerability analysis: hotspots with co-occurrence of risks

To assess the spatial distribution of vulnerabilities across selected LZs, and identify areas prone to their co-occurrence, data was compiled on a set of indicators in Somalia and then mapped. A group of indicators, i.e., food insecurity and nutrition, inequality, and poor health, were selected to best represent the three primary pillars of vulnerability, as summarized in Table 1. Food security and nutrition were based on either direct estimates of food insecurity or food consumption scores, alongside estimates of child development and nutrition. Inequality was represented by proxy, using education and gender-based education indicators. Nutrition and health were represented by a combination of disease prevalence and mortality rates. Indicators were then tested to determine whether values covering the LZs showed sufficient spatial variability to meaningfully contribute to the vulnerability hotspots map. For those variables which did meet these criteria, values were binarized according to a threshold used to categorize values demonstrating *'high'* vulnerability from those which did not meet this criterion. **The resulting binary layers were then summed to show the prevalence of indicators displaying high vulnerability (figure 22a) and aggregated at the variable grouping level to show the combination of food security and nutrition, gender-based educational inequality, and poor health which contribute to societal vulnerability.** A similar process was used to produce maps showing 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 22 and 23, *'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 analysis are shown as 'included' in Table 1, and further methodological explanation is detailed in Annex 3.

Table 1: Indicators considered to derive the vulnerability hotspot maps in Figs 17-18, including their categorization. All included indicators are identified as such and the reason for any exclusions is shown.

Variable specificity	Variable grouping	Variable	Inclusion status
Primary	**Food insecurity & nutrition**	Food insecurity	Included
		Wasting prevalence	Excluded (insufficient variation)
		Stunting prevalence	Included
		Underweight prevalence	Excluded (insufficient variation)
	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	Included
		Under-5 mortality rate per 1000 live births	Included
		Diarrhea prevalence	Included
Additional	**NA**	Human appropriation of net primary productivity	Included
		Net out-migration	Included

The concentration of high vulnerability indicators is highest in the southern LZs, especially Riverine Gravity Irrigation Zone and Addun Pastoral Zone. Food security is low across almost all LZs, with the exception of parts of the Addun Pastoral Zone. Poor health is generally prevalent across the Riverine Gravity Irrigation Zone and Southern Agropastoral Zone. The majority of the Riverine Gravity Irrigation Zone is subject to food insecurity, high inequality, and poor health.

Additional vulnerability indicators include Human Appropriation of Net Primary Production (HANPP) percentage reduction or high out-migration (Figure 23). The Sorghum High Potential Agropastoral Zone shows no vulnerability to HANPP and high out-migration. The northern tip, however, has a slight vulnerability to high out-migration. The vast majority of the Southern Agropastoral Zone and easternmost part of the Riverine Gravity Irrigation Zone is subject to high out-migration and high HANPP percentage reduction. Although there are scatterings of high out-migration or high HANPP reduction across the remainder of the Riverine Gravity Irrigation Zone and Addun Pastoral Zone, the geographic extent is minimal in comparison.

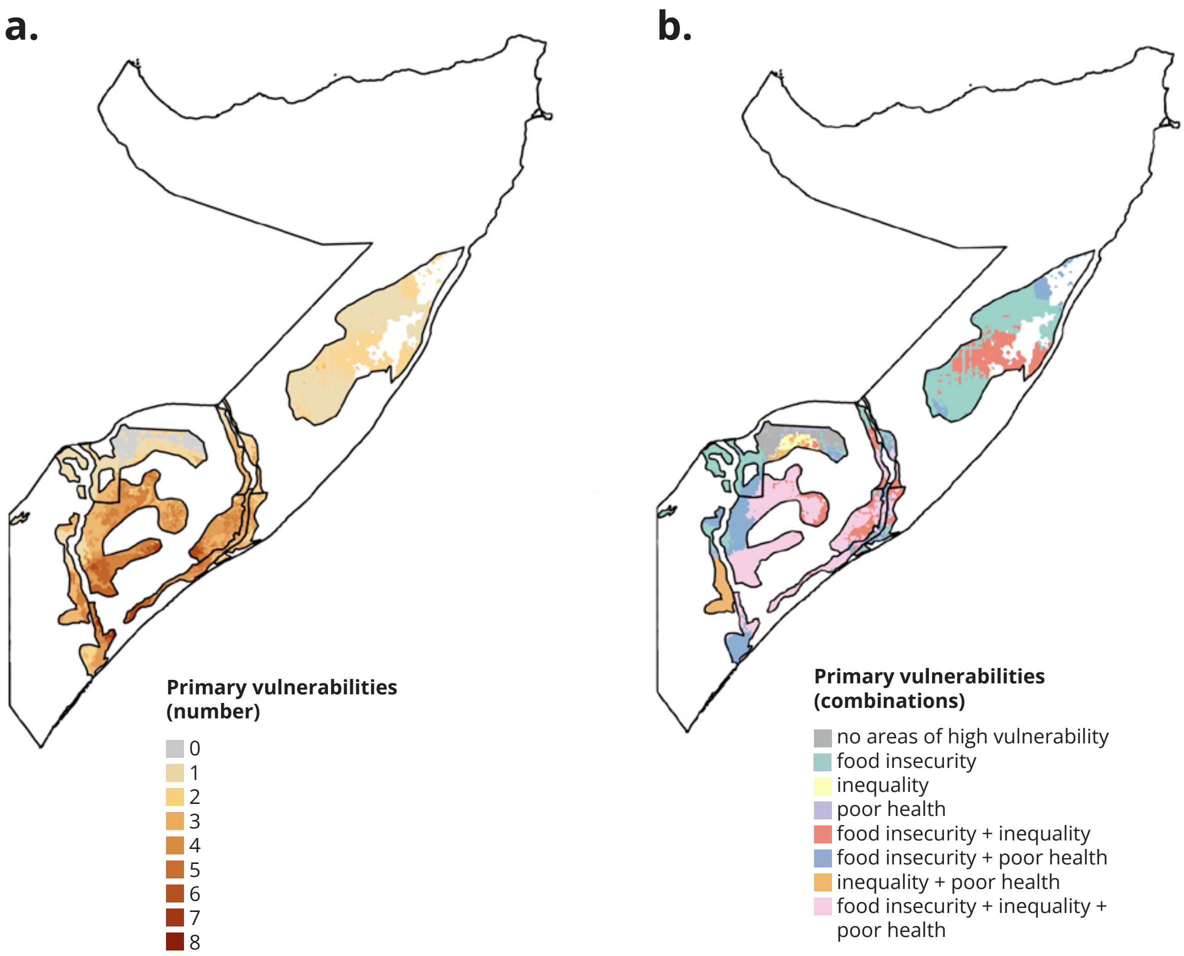


Figure 22: (a) Total number of high vulnerability metrics which span food security and nutrition, health, and inequality; (b) Food security and nutrition, inequality, and health hotspots across the livelihood zones, shown as combinations of vulnerability metrics. The specific vulnerability metrics used are shown as 'included' in Table 1.

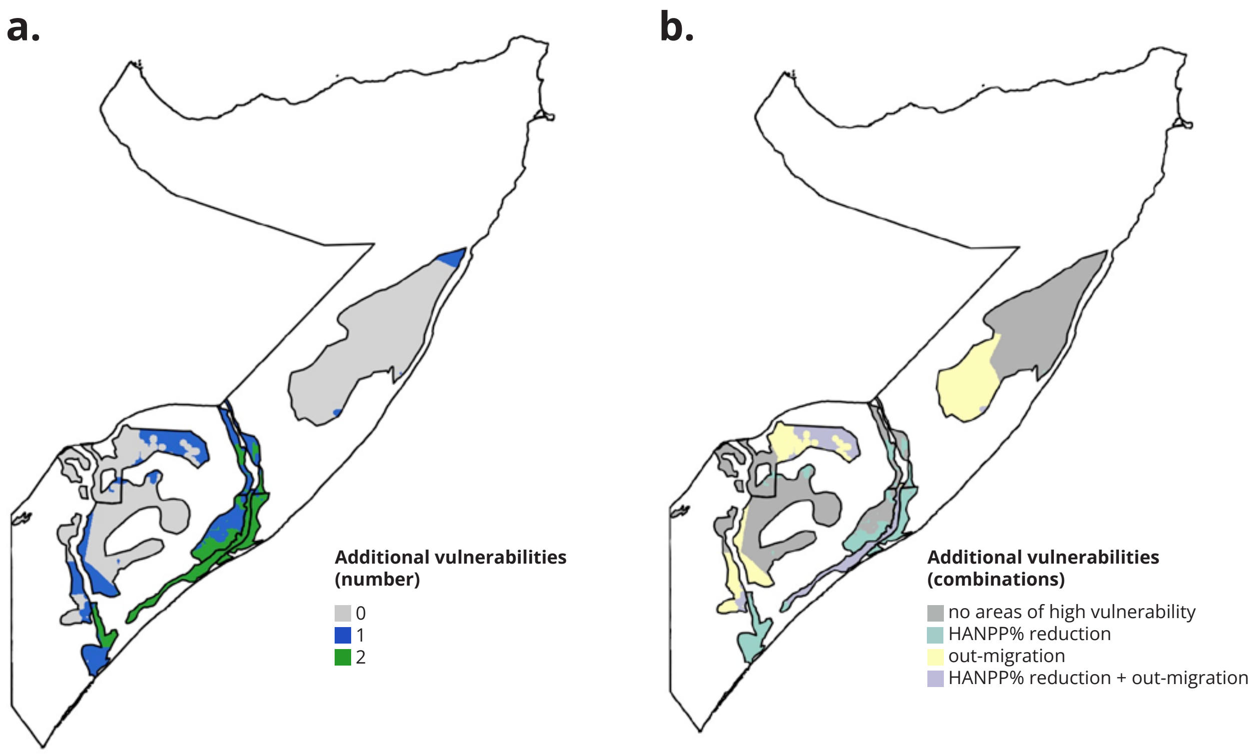


Figure 23: (a) Total number of additional vulnerability metrics classified as 'high' (negative outcome) in a given area; (b) Combinations of additional vulnerability hotspots across selected livelihood zones. The specific vulnerability metrics used are shown as 'included' in Table 1.

2.4 Climate security nexus across livelihood zones

Building on *Part 1.4 - Analysis of Somalia's climate-migration-security nexus,* this section assesses Somalia's varying social and climatic conditions to predict how the climate-migration-conflict nexus is likely to unfold differently across the four LZs (Table 2).

Pastoral LZs are particularly affected by a resource-scarcity pathway of migration which disrupts pastoralists' mobility strategies, rendering them vulnerable to food insecurity. The pastoral and agropastoral LZs are widespread across all regions, with 20% of the population migrating internally through resourceful grazing routes (Krieger et al., 2020). These LZs are affected by slow-onset climate changes, such as seasonal variability and desertification, as well as sudden ones, such as floods and droughts (Eklöw & Krampe, 2019). Reduced rainfall, increasing temperatures, and desertification in the Addun Pastoral LZ cause pasture and water scarcity, leading to reduced milk production and excess livestock mortality (FSNAU, 2012). Water scarcity, exacerbated during periods of drought, leads pastoralists to alter traditional migration patterns, in turn, saturating grazing routes. This increases competition for resources, livestock theft, and conflicts while reducing market prices for cattle (Krieger et al., 2020; Eklöw & Krampe, 2019).

Agropastoral and riverine LZs are vulnerable to livelihood-loss and resource-scarcity pathways of migration. This normally displaces rural communities towards urban centers, leading them to insecure, marginalized, and immobile conditions. In the southern and central agropastoral LZs, delayed and poor rainfall causes crop failure and declining yields, leading to increased staple food prices and, ultimately, to famines and displacement (FSNAU, 2012; Salama et al., 2012). El Niño events increase the frequency of floods, especially in Riverine LZs, due to heavy rainfall and increased water levels (FSNAU, 2012). Flooding also disrupts crop production and market activity along the Juba and Shabelle rivers, leading to livelihood losses and the sudden displacement of farming communities, often toward urban centers or other rural areas in search of land (Eklöw & Krampe, 2019; Ahmed, 2020).

Table 2: Climate impact pathways across the selected livelihood zones

	Pastoral livelihood zone	Agropastoral livelihood zone	Riverine livelihood zone
Climate hazards	Reducing rainfall patterns, increasing temperature, desertification	Inconsistent rainfall patterns, delayed and declining rain seasons, floods, and soil erosion	Flood, changing rainfall pattern
Impact pathways	Resource scarcity	Resource scarcity, livelihood loss	Resource scarcity, livelihood loss

PART 3.

Review of World Food Programme activities and recommendations for optimization

The programmatic recommendations highlighted in this section were derived from key informant interviews, a validation workshop that was held with experts working in government ministries and institutions, and local and international NGOs in Somalia. These interventions offer insight into potential WFP programming activities geared towards building climate-resilient communities.

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

WFP conducts its programmatic operations in Somalia following its Interim Country Strategic Plan (ICSP) 2019-2021 (WFP, 2018). Presently, the ICSP has six strategic outcomes (SOs), which address Sustainable Development Goal (SDG) 2 on eliminating hunger, and SDG 17 on partnerships for sustainable development. Through emergency response during periods of crisis, the first strategic outcome (SO1) focuses on improving food and nutritional security among people in disaster-stricken areas. The second strategic outcome (SO2) aims to tackle food insecurity by providing safety nets within households that enable them to withstand shocks. Strategic outcome three (SO3) focuses on food and nutritional security among vulnerable groups (e.g., children and pregnant and lactating mothers) through malnutrition prevention and treatment in areas with high malnutrition rates. In its fourth strategic outcome (SO4), WFP works towards the rehabilitation of infrastructure and strengthening of the food system. Among the

beneficiaries of SO4 are national institutions, private sector actors, and smallholder farmers. The center of attention for strategic outcome five (SO5) is strengthening the capacity of national institutions to enable them to support vulnerable food-insecure communities. This is mainly through capacity building and effective policies. Lastly, strategic outcome six (SO6) offers support among the humanitarian community to enable them to respond to the needs of vulnerable people. Important to note is that these outcomes are interrelated and mutually reinforcing.

WFP employs three program-analysis tools to support its programming activities. The first is the Integrated Context Analysis (ICA) tool, which is used to determine the most appropriate strategies for a given area based on historical trends in food security, natural shocks, and land degradation. The Seasonal Livelihood Programming tool is a consultative process that draws together government, local, and international partners to support the development and design of multisectoral operational plans. Community-Based Participatory Planning (CBPP) specifically brings together communities to help develop multisectoral plans to ensure they reflect local priorities and ownership by communities.

WFP's SO2 explicitly addresses climate change focusing on resilience-building. The activities center on enhancing the capacity of the most vulnerable groups to enable them to bounce back after climatic shocks or adapt to the changing environment. This makes them more resilient. Some of the activities that WFP has undertaken to achieve this outcome include the provision of vocational training among young people in urban and peri-urban areas so that they can secure future employment. This also includes supporting cross-learning to introduce new innovative livelihood ideas among communities. Most areas in Somalia have benefited from safety net assistance in the form of cash or food transfers as part of the initiatives under SO2. Key government ministries have been instrumental in implementing the initiatives under SO2.

Similarly, SO4 focuses on resilience-building through investments that support food systems. The main activities in this outcome target smallholder farming households and national institutions. The aim is to build their capacity through training and promoting alternative means for livelihoods. The major activities that have been implemented include training on innovative and efficient water storage practices; capacity building on production and postharvest loss management; promoting climate-smart livelihoods; provision of farm inputs and equipment, e.g., solar-powered fridges; and supporting farmers' cooperatives in marketing and networking to strengthen their productive capacity. Some initiatives are at a higher level; for example, engagement in innovative partnerships with relevant stakeholders to support production and food systems (e.g., quality and safety assurance and food fortification).

The activities of SO2 and SO4 complement or support each other. WFP, therefore, has an opportunity to integrate new activities or remodel its current activities, especially at a localized scale. As discussed in *Part 2.1* above, climate hazards such as drought, floods, and high temperatures have impacted all LZs but with differing intensities. Households living in these LZs have ongoing adaptation measures that are enabling them to cope with the negative impacts of these climate hazards.

The adaptation measures, however, are limited by a low adaptive capacity, mostly due to financial constraints and the lack of awareness of climate change. Still, there is a need to promote adaptation measures that are specifically targeted to the hazards affecting LZs. A number of adaptation options that can be streamlined with WFP programming (based on ongoing activities) were identified by local experts and stakeholders from government entities. Nonetheless, these interventions require different scales of interventions (Table 3).

Table 3: Adaptation options for climate resilience across the LZs

Livelihood zone	Hazard	Recommended interventions	Scale of intervention	Link to WFP programming
Sorghum High Potential Agropastoral	**Drought and inadequate rainfall**	• Training farmers on production of alternative crops besides livestock farming, e.g., fruits and vegetables • Training on water trucking in arid soils, climate smart irrigation	Household level	SO2 - Activity 1 SO4 - Activity 1
		• Invest in new agricultural technologies to enhance production systems • Enforcement of policies on charcoal burning and management of grazing rangelands • Invest in weather and climate monitoring systems, communication and preparedness	Policy level	SO4 - Activity 1 SO5 - Activity 1
Southern Agropastoral	**Drought and inadequate rainfall**	• Government should develop strategies on modern agriculture techniques • Enhance resilience and disaster management programs • Develop acts and laws on business investment	Policy level	SO5 - Activity 1
Riverine Gravity Irrigation	**Floods**	• Establish early warning and response committees • Allocate resources for disaster management • Training on climate risks and environmental management • Distribution of food and water • Investment in water catchment, retention, and storage	Community level	SO1 - Activity 1 SO2 - Activity 1 SO3 - Activity 1 SO4 - Activity 1
		• Waste management, especially along rivers • Rehabilitate breakages along riverbanks • Develop strategies for flood prevention • Human rights advocacy	Policy level	SO5 - Activity 1
Addun Pastoral	**Drought and inadequate rainfall**	• Establish disease surveillance committees • Establish early warning committees • Training pastoralists on fodder production and Natural Resource Management • Creating awareness among pastoral and agropastoral communities on Livestock Insurance	Household level	SO2 - Activity 1 SO4 - Activity 1
		• Developing strategies (short, medium, long) on resilience programs • Developing disease surveillance mechanisms • Creating resilience programs for pastoral communities • Allocate resources for emergencies	Policy level	SO4 - Activity 1 SO5 - Activity 1

3.2 Recommendations for WFP climate-resilience programming based on current activities

Food and nutrition behavioral change forms a significant component of SO1 and SO3. This offers WFP a platform for improving the linkage between nutrition and climate resilience. With the food and nutrition behavior change intended for adolescent girls, men and young boys, and pregnant and lactating women and girls, WFP stands a chance of creating awareness on climate risks and nutritional decisions that can increase adaptation among households. The awareness component could be incorporated into the capacity-strengthening activities among community workers and leaders using the Trainer of Trainers (ToT) model. Alternatively, WFP could collaborate with various agencies (working directly with communities) that disseminate information to schools as there are already efforts to integrate climate change information into education (primary, secondary, and college/university) curriculum.

The activities in SO2 and SO4 targeting climate resilience complement each other. This presents an ideal venue for introducing new and enhanced adaptation options, particularly among smallholder farmers. Presently, the attention is on improving agricultural productivity, postharvest management, and creating market linkages. The food systems approach holds great potential to address the gaps between food production, climate change, and environmental management. The impacts of the risks associated with flooding and drought cannot be overstated, hence the need for environmental management. Training and awareness on activities that support rangeland rehabilitation, water conservation, land management, reforestation, and agroforestry would be key in reducing impacts of climate change such as soil erosion.

In its current programming activities under SO5, WFP has an opportunity to expand its scope of work in strengthening the capacity of national institutions. This outcome is aligned with the institutions and resilience chapters highlighted in the SNDP (2020-2024). Since the establishment of political structures in 2012, Somalia's institutions have endured transformations that have strengthened their capacity to manage large-scale ventures (WFP, 2018). This has enabled Somalia to improve food security, social protection, and safety nets of vulnerable groups amid the prevailing climate risks. Notwithstanding, the conceptualization of disaster risk management remains nascent. According to the UNDP (2017), poor management and preparedness towards climate risks result from a lack of climate information. To strengthen Somalia's capacity for disaster risk management, WFP can integrate the dissemination of climate information into its programming through actionable seasonal forecasts and early warnings. There are existing dissemination channels for weather information in Somalia, for example, through elders and local radio stations. WFP will, however, need to create awareness on how to use climate information as the use of this information remains a challenge.

3.3 Scoping of WFP programmatic partnership opportunities

The FGS has been an instrumental partner, particularly on projects/programs that address climate change. The Ministry of Environment (MoE), under the Directorate of Environment - Office of the Prime Minister, has been given a clear mandate for climate change in Somalia. With the limited capacity to manage issues on climate change, WFP should consider collaborating with the MoE by providing technical expertise. Other government ministries that support the MoE in addressing climate change issues (directly or indirectly) are also potential partners. These include the Ministry of Natural Resources, Ministry of Planning, Investment and Economic Development, Ministry of Education, Ministry of Labor and Social Affairs, the Ministry of Finance, and the Ministry of Agriculture and Irrigation.

International and local non-governmental organizations (NGOs) are putting a lot of emphasis on adaptation towards climate change. This presents opportunities for partnerships with WFP. Due to their large presence in Somalia, UN agencies have paved the way for mainstreaming climate change in

development projects, e.g., the UNDP and FAO under the Joint Resilience Programme. FEWSNET, FSNAU, and SWALIM have been key players in the analysis and dissemination of climate information through early warning bulletins. Somalia has a consortium of resilience-focused NGOs with which WFP could partner in expanding its climate resilience programming, for example, Save the Children, World Vision, and Bricis.

WFP's community-based participatory approach requires a strong partnership with community-based organizations (CBOs). This is because some climate change interventions require agencies like CBOs, which can actively engage and work with the local communities, e.g., interventions that involve translation or repackaging information for the locals. Flood responses, such as nature-based approaches to floods, have been coordinated by local committees, emphasizing the need for CBOs.

3.4 Funding opportunities for climate-resilient programming

There is a global competition for funding that is affecting not only Somalia but also most developing countries. With the current humanitarian crisis and the quest for peace and stability, Somalia has limited financial resources to address climate change. The development of a strategy and action plan for adaptation to climate change and risk mitigation gives Somalia a competitive edge for successfully mobilizing funds. Nevertheless, the government still stands a chance of funding climate change from public expenditure, the Somalia Infrastructure Fund (SIF), and the National Disaster Management Fund. Somalia needs to tap into funding from development finance institutions, particularly the AFDB. The AFDB has provided impactful funding for African countries, especially the ACCF[12], which was established in 2014 by the Government of Germany. The funding focuses on resilience-building and sustainable low-carbon growth. The ACCF has approved approximately US$8 million in small project grants in more than 16 countries in Africa. WFP, therefore, has the capacity to access ACCF funding given its capacity to implement small-scale climate resilience programs/projects. Further funding can be obtained from international development banks, including the World Bank, the Asian Development Bank, and the International Fund for Agricultural Development (IFAD). The UK Government is a potential source of funding following its contribution to and interest in the Somalia Partnership Agreement. The GCF and the GEF present an important source of funding for African countries with limited resources to finance. As highlighted in Part 1.6, Somalia has projects funded by the GCF and GEF. As the demand for projects delving into environmental protection and sustainable development is on the rise, WFP could consider extending its scope of work to attract such funds. The UNDP has been instrumental in funding climate change initiatives and linking Somalia to major sources of climate change funds like the GCF. Other organizations, like the Swedish International Development Cooperation Agency (SIDA), FAO, and UNEP that are already working on climate change in Somalia, could fund smaller projects.

12 https://www.afdb.org/en/topics-and-sectors/initiatives

PART 4.

Synthesis

High temperatures, floods, and droughts present grievous threats to Addun Pastoral, Southern Agropastoral, Riverine Gravity Irrigation, and Sorghum High Potential Zones of Somalia. An analysis of historical and future climatic trends points to increased temperatures and decreasing rainfall, especially in the first season. Similarly, increased flooding/waterlogging, heat stress and drought risks are expected by 2050. The impact and severity of these risks, however, vary across livelihood zones. For instance, heat stress is expected to have the highest impact on Sorghum High Potential Agropastoral, Addun Pastoral, and Southern Agropastoral Zones due to the dominance in livestock production. The Riverine Gravity Irrigation and Southern Agropastoral Zones are at a higher risk of flooding and waterlogging. Climate change is projected to impact food availability and utilization. The results of the IMPACT analysis show climate resilience for crops like sorghum. However, the production of staple crops critical to food security, for example, maize, will be negatively impacted by climate change. Calorie availability will decline, which is likely to affect food availability. This is projected to influence consumption patterns of households, whereby most households will substitute starchy staples with animal calories (fats). The population at risk of undernourishment (food utilization) is therefore expected to increase in the future under climate change scenarios. Besides impacting agricultural production, these climatic hazards are associated with migration and livelihood losses, for instance, the destruction of infrastructure (roads and bridges), increased incidences of animal and human pests and diseases, scarcity of water resources resulting in conflicts, and accelerated deforestation. The impacts of climate change are exacerbated by high poverty rates, limited access to healthcare, and social and economic inequalities.

The Government of Somalia has shown its commitment to improving the country's adaptive capacity towards climate change through the formulation of national and sub-national (state-level) policies. However, a lack of regulatory tools for existing legislation and approved laws and inadequate institutional, human, and financial capacity inhibit the implementation of the climate change programs and activities stipulated in these policies at the zonal level. Improved coordination among stakeholders, building the capacity of regional and national institutions, and training staff on approaches for harmonizing climate change issues into existing national plans and strategies are among recommendations for improved policy execution. Based on WFPs experience and expertise in supporting national governments in developing countries, Somalia would benefit from technical support from WFP.

Partnerships between the government and development partners are key to building a climate-resilient Somalia. For example, WFP has been working with government ministries to implement climate activities designed for smallholder farmers and vulnerable groups like children under five years old, school-aged children, and pregnant and lactating mothers. Based on the climate resilience activities outlined in WFP's Strategic Outcomes, there is room to expand programmatic activities by aligning them to the adaptation options recommended by stakeholders (Table 3). Given that the stated climatic risks impact regions with different intensities, the recommendations point to specificity in interventions at the household, community, and policy levels. The priority areas of intervention include capacity building through training and awareness creation, policy enactment, disaster management, distribution of food and water, and resource allocation. The implementation of these initiatives, however, calls for strong partnerships with the government, international and local NGOs, and communities, as well as funding from bilateral development partners, international organizations, and development finance institutions. A synthesis of the analysis is summarized in Table 4 below.

Table 4: Summary of findings from the review and climate analysis

	Livelihood Zone		Sorghum High Potential Agropastoral	Riverine Gravity Irrigation	Southern Agropastoral	Addun Pastoral
Analytical Insights	**Current climate hazards**	**Drought**	X	X	X	X
		Low rainfall	X	X	X	X
		Floods	X	X	X	X
		High temperature	X	X	X	X
	Projected climate changes through 2050	**Temperature**	- High annual mean temperatures throughout the year - First season warmer and hotter compared to the second season - Projected increase in temperatures (average of 2-3°C) in both the first and second season			
		Precipitation	- Generally low rainfall, first season drier than the second season - Precipitation in the first season will decline, the second season will be wetter - Most changes expected in southern regions			
		Flooding/ waterlogging	- Higher flood risks in the second season (October and November), reduced risks in the first season - High incidences of waterlogging during flood risk season - Riverine Gravity Irrigation and the Southern Agropastoral Zones are high flood and waterlogging risk areas			
		Heat stress	- Heat stress has been experienced in almost all the months of the year - Projections show that heat stress will persist with severity in some months			
		Drought	- Drought risk is spread across all months of the year - Projections show that drought risks will continue to be experienced - The months of October and November have had fewer dry days compared to the rest, and will continue to do so			
	Migration analysis	**Drivers of migration**	- Violent conflicts have a significant impact on the migration of women - Negative rainfall anomalies (drier months) result in less capacity to move, thus decreasing migration chances - Maximum temperature anomalies have a positive and extremely significant effect on the migration of women - Temperature anomalies are associated with internal migration while rainfall anomalies are associated with international migration - Education is positively associated with international migration			
	Hotspot analysis of current non-climate vulnerabilities	**Primary vulnerabilities**	- Food insecurity - Poor health - Gender-based educational inequality			
		Additional vulnerabilities	- Out-migration	- Out-migration - HANPP reduction		

<table>
<tr><th colspan="3">Livelihood Zone</th><th>Sorghum High Potential Agropastoral</th><th>Riverine Gravity Irrigation</th><th>Southern Agropastoral</th><th>Addun Pastoral</th></tr>
<tr><td rowspan="2">Analytical Insights</td><td rowspan="2">IMPACT analysis of climate change on food access and stability through 2050</td><td>Food availability considerations</td><td colspan="4">(+) Production for sorghum is projected to exhibit resilience in the face of climate change, thus its production should be promoted
(+) Yields for maize, sesame, sorghum, and goats projected to increase out to 2050
(-) Calorie availability/diet trajectory is generally lower under CC relative to the No-CC benchmark for staple crops especially sesame, maize, and other cereals. Availability of sorghum and vegetables will be moderate, while livestock will be higher</td></tr>
<tr><td>Food utilization and stability consideration</td><td colspan="4">(-) Import dependence for maize under CC will be higher
(-) Negative climate trends (heat stress, drought, and flooding) can disrupt food supply and increase commodity prices
(-) The numbers of undernourished children will be relatively higher under CC relative to the No-CC benchmark</td></tr>
<tr><td rowspan="9">Cross-cutting recommendations</td><td colspan="2">Partnership opportunities</td><td colspan="3">Local and international NGO's: UN agencies (UNDP, FAO, FEWSNET, FSNAU, SWALIM), Save the Children, World Vision, Bricis.
National government: Ministry of Environment, Ministry of Planning, Investment and Economic Development, Ministry of Education, Ministry of Labor and Social Affairs, Ministry of Finance, Ministry of Natural Resources, and the Ministry of Agriculture and Irrigation
Community-based organizations and Business communities</td><td></td></tr>
<tr><td colspan="2">National-level policy support</td><td colspan="4">National Adaptation Plan (NAP)
INDC
National Climate Change Policy + National Climate Change Strategy</td></tr>
<tr><td colspan="2">State-level policy support</td><td colspan="4">State level disaster risk reduction strategies and frameworks, e.g., Puntland Disaster Management Framework; Policy implementation support</td></tr>
<tr><td colspan="2">Improving capacity for climate change adaptation</td><td colspan="4">Human capacity building towards various aspects of climate change; creating a communication platform among stakeholders; increasing the government's budgetary allocation; institutional capacity building for effective policy implementation</td></tr>
<tr><td rowspan="5">Climate resource mobilization</td><td>National government</td><td colspan="4">Ministry of Finance (public expenditure), Somalia Infrastructure Fund (SIF), the National Disaster Management Fund</td></tr>
<tr><td>Bilateral development partners</td><td colspan="4">Government of Germany, UK Government</td></tr>
<tr><td>Development finance institutions</td><td colspan="4">World Bank, African Development Bank, Asian Development Bank, International Fund for Agricultural Development (IFAD)</td></tr>
<tr><td>Multilateral funds</td><td colspan="4">Green Climate Fund (GCF), Global Environment Facility (GEF), African Climate
Change Fund (ACCF)</td></tr>
<tr><td>International Organizations</td><td colspan="4">United Nations Development Programme (UNDP), Food and Agriculture Organization (FAO), United Nations Environmental Program (UNEP), Swedish International Development Cooperation Agency (SIDA)</td></tr>
</table>

	Livelihood Zone		Sorghum High Potential Agropastoral	Riverine Gravity Irrigation	Southern Agropastoral	Addun Pastoral
Programmatic recommendations	**Climate adaptation**	**Flooding**		Recommendations linked to SO1 - Act 1; SO2 - Act 1; SO3 - Act 1; SO4 - Act 1 & SO5 - Act 1 (Table 3)		
		Drought and inadequate rainfall	Recommendations linked to SO2 - Act 1; SO4 - Act 1; SO5 - Act 1 (Table 3)		Recommendations linked to SO5 - Act 1 (Table 3)	Recommendations linked to SO 2 - Act 1 & SO4 - Act 1
	Household and community level		Recommendations linked to: SO1 – Act 1; SO 2 - Act 1; SO3 – Act 1;SO 4 - Act 1 (table 3)			
	Policy level		Recommendations linked to: SO 4 - Act 1 & SO 5- Act 1 (table 3)			

PART 5.

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PART 6.

Annexes

Annex 1. Quantification of the climate-migration-security nexus

The objective is to qualify and quantify the climate-migration-conflict nexus, and to understand the characteristics in the departure area that shape the gender composition of the migration flow. In particular, how climate and conflict increase or decrease the likelihood of a migrant being male or female. It aims to unveil the specific patterns, channels, and trends that link climate and social political insecurities to migration, and to understand whether drivers (socioeconomic) and threat multipliers (climate and conflict) lead towards a more gender-balanced migration flow.

This research will use the Flow Monitoring Survey (FMS) provided by the Displacement Tracking Matrix (DTM). This system is designed to capture, process, and disseminate information regularly and systematically to provide a better understanding of the movements and evolving needs of mobile populations in places of displacement or transit. In particular, the FMS collects detailed information on the populations transiting through the FMPs (Flow Monitoring Points). The questionnaire contains information on needs, difficulties encountered, risks, vulnerabilities, socioeconomic profiles, intentions, and flow information (e.g., departure country, arrival country, and vehicle). Additionally, this study uses the climate data source Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) as it provides historical temperature and rainfall 0.05° resolution satellite imagery. Finally, conflict data will be extracted from ACLED, which collects real-time data on the locations, dates, actors, fatalities, and types of all reported political violence and protest events.

EMPIRICAL STRATEGY

The empirical strategy involves the use of both a linear probability model and a logit/probit model. In the linear probability model, a simple OLS, will be applied to a binary variable (sex) in order to predict the likelihood of migration being male or female based on the socioeconomic variables and the presence of conflict/climate extremes in the original area. Furthermore, to understand how the presence of these threat multipliers shape the decision to move internally or internationally, the same set of regressions will be applied to the intended destination. For the logit or probit model, a binary response model will be used since the main dependent variables would be a discrete binary variable, firstly identified by the sex of the individual and subsequently by looking at the intended destination stated by the individual. The dependent variables of this study are, therefore, the gender of the individual migrant and their stated final destination, whereas the controls are the socioeconomic characteristics of the migrant. Other variables of interest include the intensity of conflict and the climate indexes (drought, floods, extreme temperatures, length of the growing season, etc.).

The first empirical strategy applied is a Linear Probability Model, that is a multiple regression model where the dependent variables are binary variables. The model is described in the following equation:

$$Y_{i\,t} = \beta_0 + \beta_1 C_{i\,t-1} + \beta_2 A_{i\,t-1} + \beta_3 Z_i + FE + \varepsilon_{it}$$

Y_{it} is the binary dependent variable that captures the group membership of the individual in a certain category. In this project, Gender and Destination are the two main dependent variables that are analyzed. In case of Gender, Y_{it} takes value of 1 when the individual migrant is a woman and 0 otherwise. The Destination dependent variable is derived from the stated intended destination of the individuals, which takes value of 1 if it is outside Somalia and 0 otherwise. The variable is a vector that captures different conflict episodes that happened 12 months before in the individual's place of departure. It captures the presence and the intensity of climate anomalies at the same time and space as conflict 12 months before the migrant decided to leave. It is a vector of an individual's demographic information such as age, education, marital status, and employment prior to departure. In this case, the time term is not indicated because it contains variables both at time t and t-1. FE stands for the time and space invariant fixed effects. They are included in the model to control for unobservable specific time and space characteristics. To conclude, ε_{it} is the error term. Because Y is always binary, the coefficients must be considered as the change in the probability of Y = 1 associated in a unit change in one regressors holding the other constant. So, the model can be described as follows:

$$\Pr(Y_{it} = 1 \mid C_{i\,t-1}, A_{i\,t-1}, Z_i, \ldots) = \beta_0 + \beta_1 C_{i\,t-1} + \beta_2 A_{i\,t-1} + \beta_3 Z_i + FE + \varepsilon_{it}$$

Table 5: Summary statistics of female and male migrants

Variables	Women Sample		Men Sample		P-Value
	Mean	SD	Mean	SD	
Individual Information:					
Age (years)	35.96	0.13	35.75	0.16	
Married	0.63	0.01	0.55	0.01	***
Language Somali	0.63	0.01	0.67	0.01	***
Highest Education completed:					
None Education	0.47	0.01	0.37	0.01	***
Primary Education	0.17	0.01	0.16	0.01	
Secondary Education	0.23	0.01	0.36	0.01	***
Other Educations	0.13	0.01	0.11	0.00	***
Employment Status before leaving:					
Unemployed, not looking for a job	0.32	0.01	0.19	0.01	***
Employed or Self-employed	0.34	0.01	0.44	0.01	***
Looking for a job	0.23	0.01	0.25	0.01	*
Other Employments	0.11	0.00	0.12	0.00	*
Reason to Travel:					
Economic reason	0.26	0.01	0.49	0.01	***
Environmental problems	0.08	0.00	0.03	0.00	***
Family visit/reunion	0.20	0.01	0.16	0.01	***
Conflict	0.09	0.00	0.11	0.00	***
Others	0.38	0.01	0.21	0.01	***
Travel Information:					
Destination	0.40	0.01	0.59	0.01	***
Self-Paid	0.67	0.01	0.59	0.01	***
Travel Alone	0.22	0.01	0.37	0.01	***
Want to return home	0.29	0.01	0.28	0.01	
Have been assaulted	0.01	0.00	0.00	0.00	
Forcibly Displaced	0.41	0.01	0.24	0.01	***
Obs.	4418		4477		

* The variables presented above, excluding years, have all the same unit that is equal 1 in case the single individual presents the characteristic 0 otherwise. The last column report the statistical level obtained by testing statistically the two sample's mean. *** p<0.01, ** p<0.05, * p<0.1 are the three different level of significance reported.

Table 6: Summary statistics of international and internal migrants

Variables	International migrants		Internal migrants		P-Value
	Mean	SD	Mean	SD	
Individual Information					
Gender = Female	0.41	0.01	0.60	0.01	***
Age	34.26	0.16	37.48	0.15	***
Married	0.48	0.01	0.73	0.01	***
Language Somali	0.63	0.01	0.61	0.01	
Highest Education completed:					
None Education	0.31	0.01	0.51	0.01	***
Primary Education	0.16	0.01	0.17	0.01	
Secondary Education	0.38	0.01	0.21	0.01	***
Other high Educations	0.15	0.01	0.11	0.01	***
Employment Status before leaving:					
Unemployed, not looking for a job	0.18	0.01	0.37	0.01	***
Employed or Self-employed	0.38	0.01	0.35	0.01	***
Looking for a job	0.28	0.01	0.20	0.01	***
Other Employments	0.16	0.01	0.08	0.00	***
Reason to Travel:					
Economic reason	0.14	0.01	0.50	0.01	***
Environmental problems	0.54	0.01	0.17	0.01	***
Family visit/reunion	0.03	0.00	0.10	0.00	***
Conflict	0.20	0.01	0.10	0.00	***
Others	0.10	0.00	0.13	0.01	***
Travel Information:					
Self-Paid	0.57	0.01	0.69	0.01	***
Travel Alone	0.33	0.01	0.20	0.01	***
Want to return home	0.24	0.01	0.36	0.01	***
Have been assaulted	0.01	0.00	0.01	0.00	*
Forcibly Displaced	0.24	0.01	0.38	0.01	***
Obs.	3833		3855		

Table 7: Analysis of drivers of migration. Summary table of the results of the econometric analysis showing drivers of female vs male migration as well as international vs internal migration.

	General Category	Variables	Gender = Women (1)	Destination = International (2)
Variables of Interest	*Rainfall Anomalies*	Rainfall Anomalies (12)	*ns*	***
		Postive Anomalies	*	***
		Negative Anomalies	*	***
		Extreme Rainfall Anomalies = Drought	*ns*	***
		Extreme Rainfall Anomalies = Flood	*ns*	***
	Temperature Anomalies	Temperature Anomalies (12)	***	***
	Conflicts	Battles (12)	**	*ns*
		Explosions-remote violence (12)	***	*ns*
		Protests (12)	*ns*	*
		Riots (12)	*ns*	***
		Strategic developments (12)	**	*
		Violence against civilians (12)	*ns*	**
		Total Conflicts (12)	**	*ns*
Interaction between variables	*Conflicts * Rainfall Anomalies (12)*	Battles (12) x Rainfall anomalies (12)	*ns*	***
		Explosions-remote violence (12) x Rainfall anomalies (12)	***	*ns*
		Protests (12) x Rainfall anomalies (12)	*ns*	**
		Riots (12) x Rainfall anomalies (12)	*ns*	***
		Strategic developments (12) x Rainfall anomalies (12)	*ns*	***
		Total Conflicts (12) x Rainfall anomalies (12)	*	*ns*
	*Conflicts * Temperature Anomalies (12)*	Battles (12) x Temperature anomalies (12)	**	*ns*
		Explosions-remote violence (12) x Temperature anomalies (12)	***	*ns*
		Protests (12) x Temperature anomalies (12)	*ns*	***
		Riots (12) x Temperature anomalies (12)	*ns*	***
		Violence against civilians (12) x Temperature anomalies (12)	***	*ns*
		Strategic developments (12) x Temperature anomalies (12)	***	*ns*
		Total Conflicts (12) x Temperature anomalies (12)	***	*ns*
	*Conflicts * Extreme Rainfall Anomalies = Floods*	Battles (12) x Floods	**	**
		Explosions-remote violence (12)x Floods	***	*ns*
		Violence against civilians (12) x Floods	***	*ns*
		Total Conflicts (12) x Floods	***	*ns*

Highly Positive
Medium Positive
Medium Negative
Highly Negative

***	p<0.01
**	p<0.05
*	p<0.1

Annex 2. IMPACT results

YIELD, HARVESTED AREA, ANIMAL NUMBERS, AND PRODUCTION

Future projections (2020-2050) show that the production of maize, sesame, sorghum, and goats will increase. This is due to a projected increase in both yield and area harvested (Figure 24). The greatest changes (i.e., increase) in area/number, production, and yield are observed for vegetables and goats, which show a more than 200% increase in production and 90% in yield by 2050.

Future projections in terms of percentage changes can present a misleading picture of the relative prevalence of commodities if not interpreted against their underlying baseline and future magnitudes. This is especially true if the baseline magnitudes are small. For this reason, a companion table of projections expressed as magnitudes gives a detailed view of harvested area shares, production, and yield (Figure 25). For instance, it is estimated that area harvested under sorghum will be 830,000 ha by 2050.

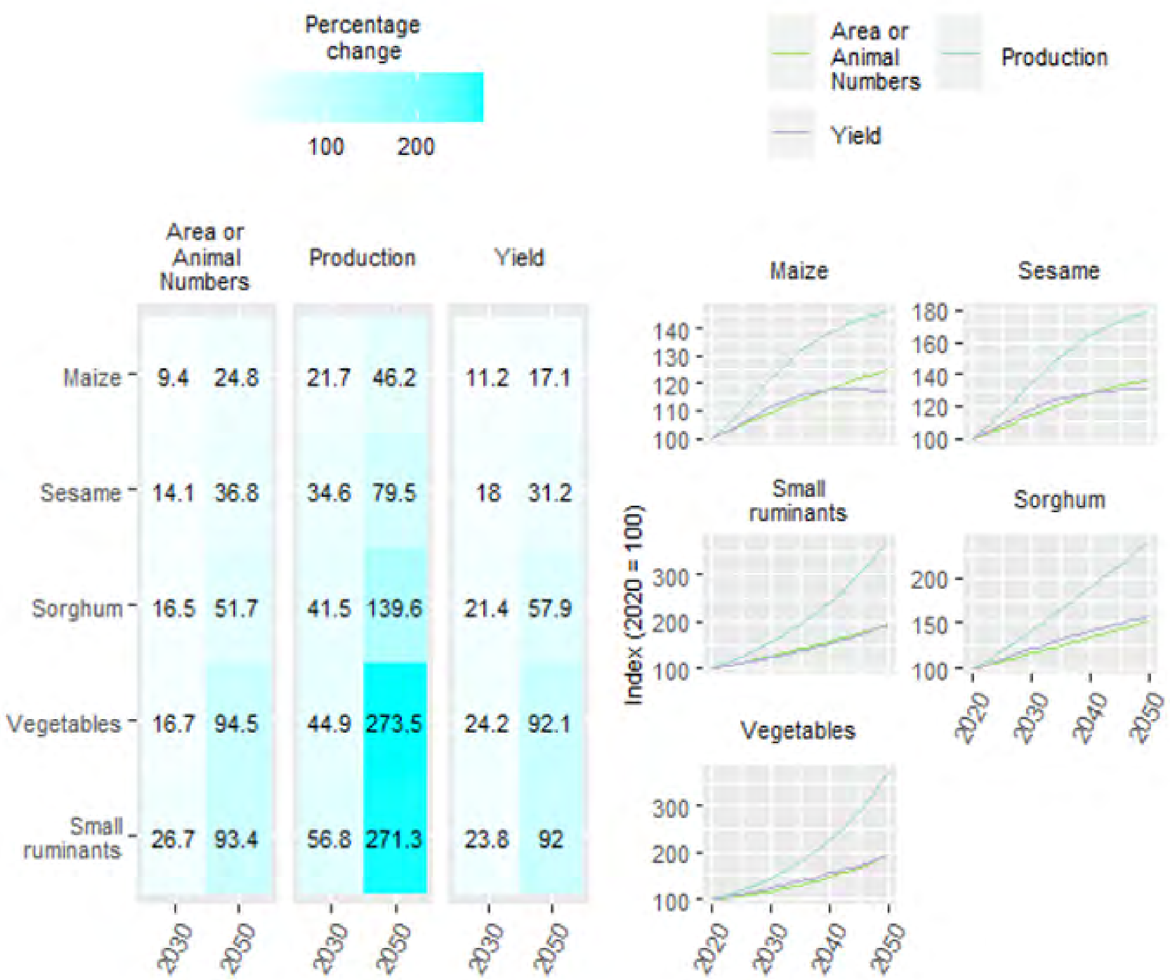

Figure 24: IMPACT 2020-2050 projection of percentage changes in yield, production, and area or animal numbers for key crop and livestock commodities.

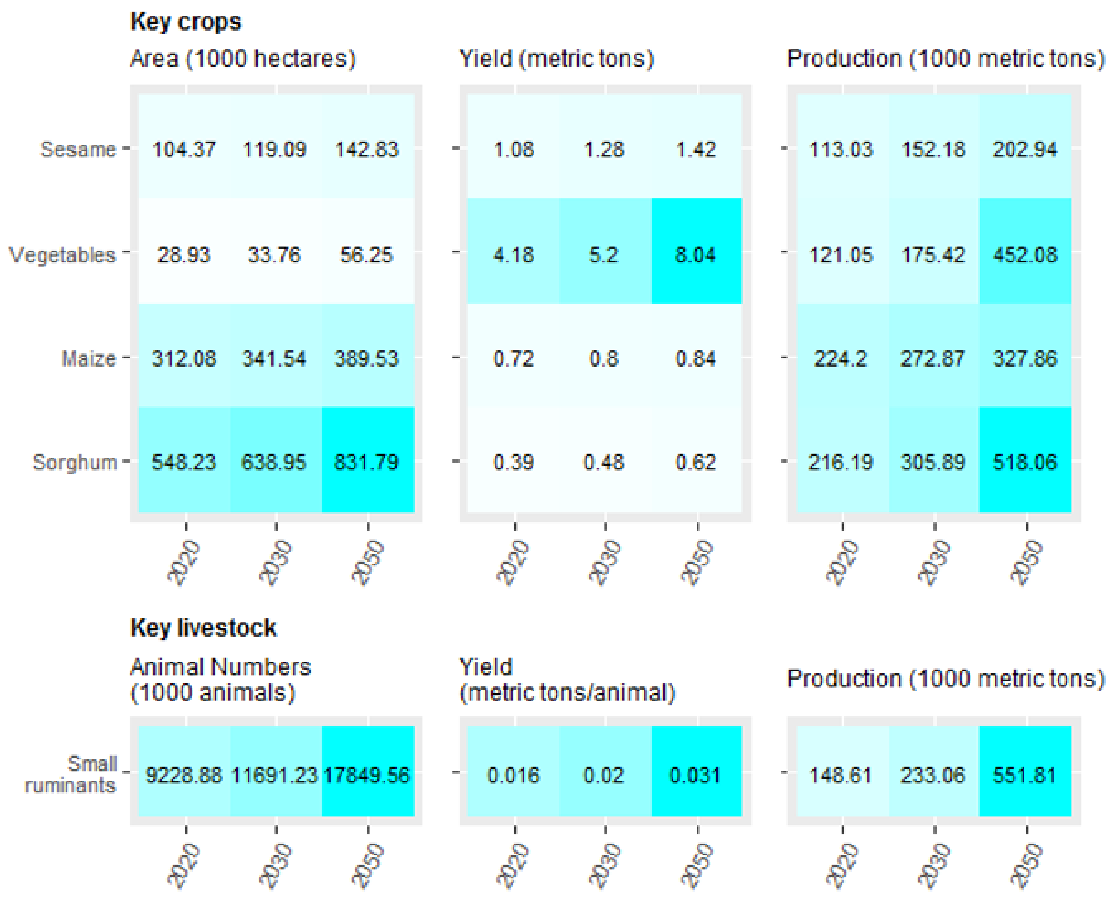

Figure 25: IMPACT projected yield, production, and area or animal numbers for key crop and livestock commodities in 2020, 2030, and 2050.

CROP TRAJECTORIES

The overall cropland is projected to expand in the coming decades. Nonetheless, minimal changes are expected on the shares of cropland allocated to key commodities. Sorghum and maize are projected to occupy the largest share of harvested area out to 2050, followed by sesame and vegetables (Figure 26). Land area allocation among crops was modeled on the relative values and productivity of the crops. An exogenous area growth factor,[13] based on historical trends and expert consultation regarding future trajectories, was also included. This resulted to a detailed view of future cropland use trajectories. For comparison, a residual category of "other cereals" was also included.

TOTAL AND DISAGGREGATED DEMAND

Demand for key crop and livestock commodities is projected to grow considerably out to 2050 (Figure 27). This is primarily due to a large projected increase in rural household demand. Export demand is projected to play an increasing role for sesame and sorghum, and livestock feed demand is projected to play an increasing role in the case of maize. This points to competition between human and animal consumption for maize in the coming years.

13 These are factors other than direct market effects, such as government programs encouraging cropping expansion, contraction due to soil degradation, or conversion of land from agriculture to non-agricultural uses (Robinson et al. 2015).

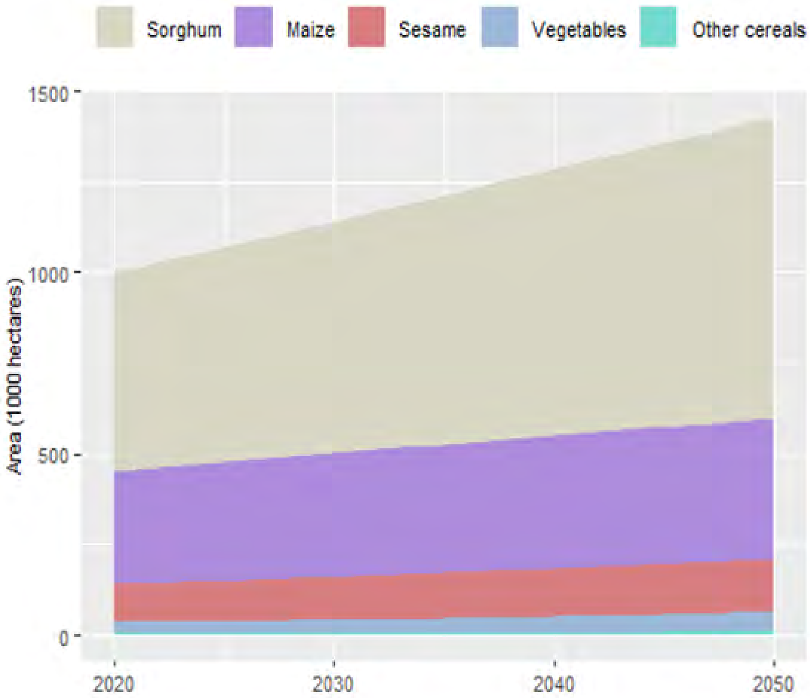

Figure 26: IMPACT 2020-2050 projection of harvested area for key crops and residual categories.

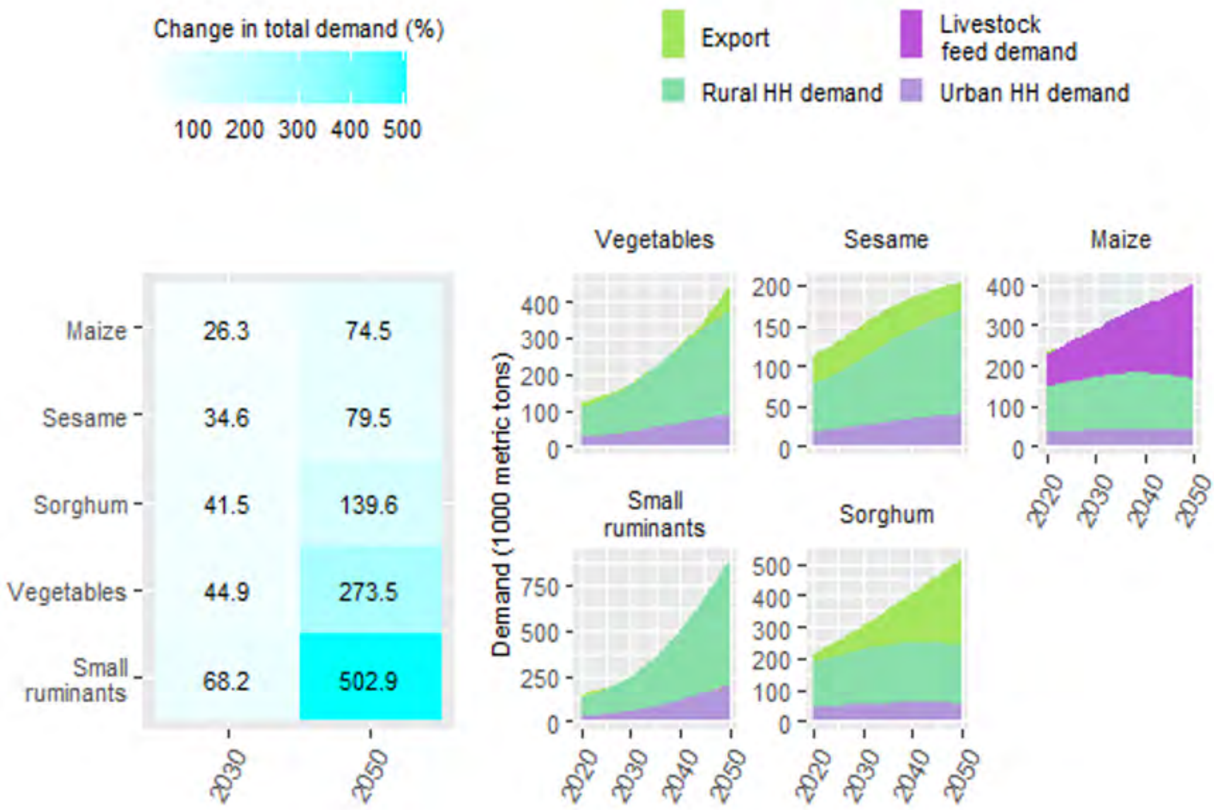

Figure 27: IMPACT 2020-2050 demand for key crop and livestock commodities in Somalia.

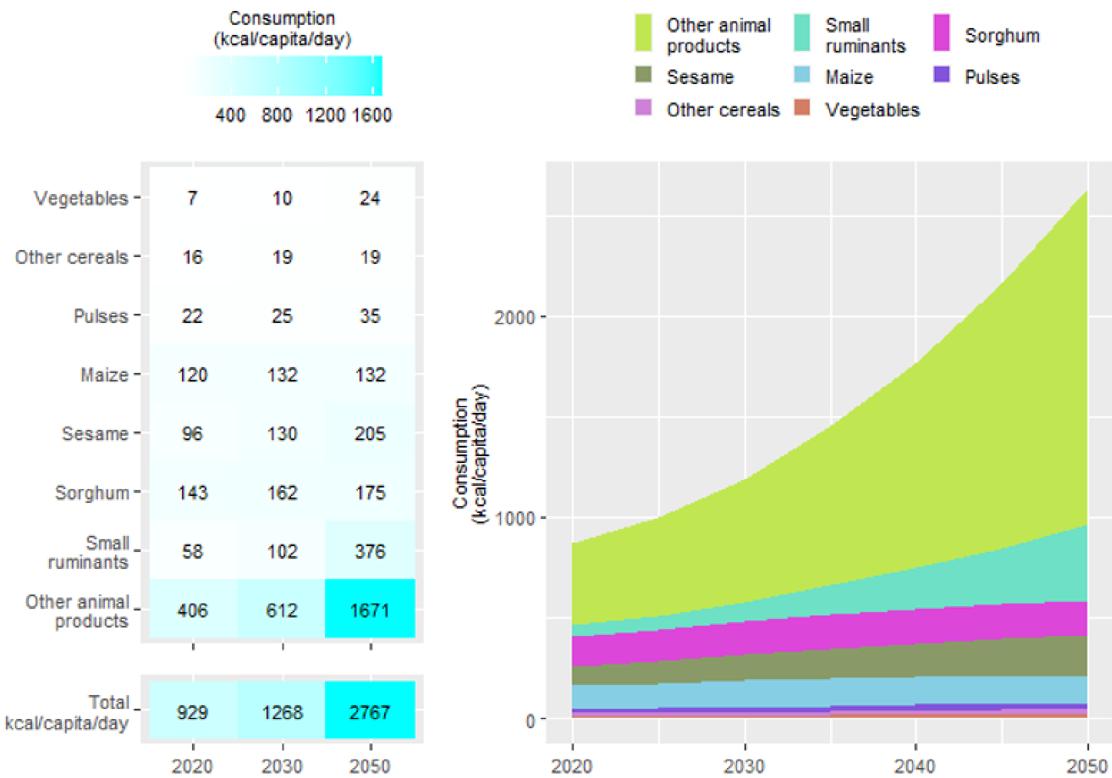

Figure 28: IMPACT 2020-2050 projection of calorie consumption (kcal/capita/day) for key commodities.

DIET TRAJECTORY

Per capita consumption of all key food commodities is projected to increase considerably up to 2050 (Figure 28). This accounts for food available from both domestic production and international trade. The residual categories "other cereals" and "other animal products" are included for context. The projected increase in availability of animal products, including small ruminant meat, is especially pronounced. It is expected that the primary source of calories will be animal products, including small ruminant meat, followed by sorghum, sesame, and maize. In more aggregate terms, consumption of starchy staples (cereals, roots and tubers) is projected to rise from about 137 kcal/capita/day to 151 kcal/capita/day in 2030, and then to hold steady at that level out to 2050. As a share of total diet, starchy staple consumption is projected to decline from about 15% to 12% in 2030, and then to 5% in 2050. This is consistent with Bennett's law, an empirical trend often seen in developing nations (Bennett, 1941).

PREVALENCE OF MALNOURISHMENT

The number of undernourished children is projected to decline substantially in the coming decades (Figure 29, left). This is 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. Import dependence for maize and small ruminants (goats) is projected to remain slight up to 2030, but to grow considerably thereafter (Figure 29, right).

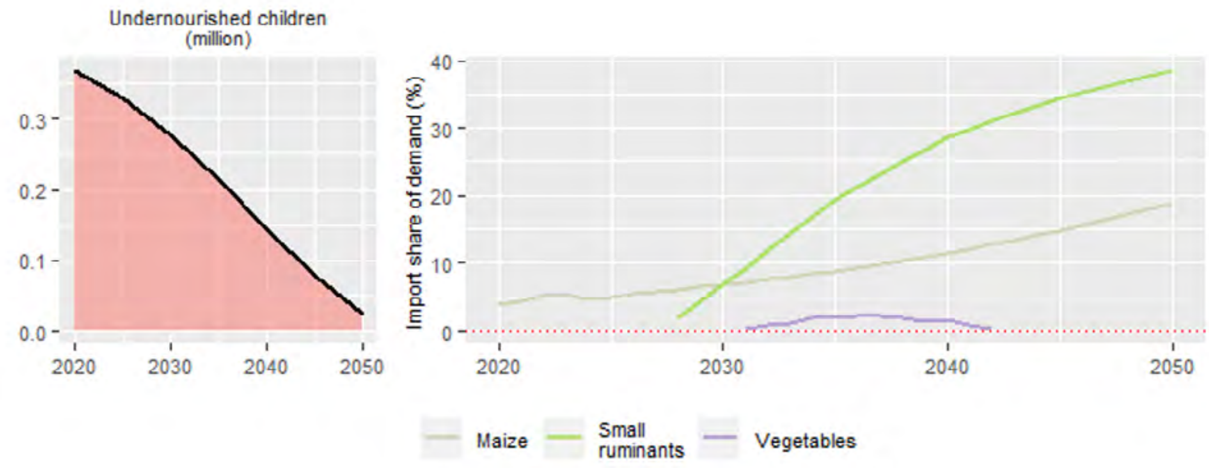

Figure 29: IMPACT 2020-2050 projection of number of undernourished children (left) and import dependence (right).

Annex 3. Hotspots of vulnerability co-occurrence

Methods for spatial analysis to generate maps

For both primary and additional vulnerability indicators, we created raster map layers to show a.) the total number of indices classified as 'high' (i.e., hotspots) and b.) the breakdown of which indicators showed geographical hotspots. 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 LZs. 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 identified by the WFP Country Office. They 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 always included regardless of spatial variation. This was due to the limited number of food security datasets available and the necessity to represent food security in some respect to accurately capture overall vulnerability. All primary and additional variables considered for Somalia, including whether they were included or excluded from the analysis, are shown in Table 8.

BINARIZATION OF VARIABLES

For the included continuous data variables, a binary score of 1 was allocated if any one metric exceeded the 80th percentile of values within the LZs (indicating a negative outcome); the map shows the sum of these binary layers. Any dataset inputs which were already binary (only applicable for additional variables) were always included where data was present and relevant to WFPs programs. Exceptions were made in limited circumstances, e.g., if all Hunger Map food consumption scores (a continuous dataset) were extremely high, all values would be categorized as 'high' (i.e., 1), as opposed to only those above the 80th percentile.

AGGREGATION INTO MAP FIGURES

The hotspot maps seen in Figures 22 and 23 were created using sets of these binary raster layers. Figure 22 (a) shows the number of included primary variables allocated 'high' vulnerability in any given cell. Figure 23 (a) shows the same for the included additional variables. Figure 22 (b) is based on the sum of three further binary layers, each of which was calculated as the maximum value of all included binary layers in a given grouping of primary variables (food security and nutrition; inequality; and health). Figure 23 (b) shows the combination of additional variables directly, 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 indicators we included were binarized as 1 (high vulnerability) due to the values in the given cell/s being below a predetermined threshold for 'high' vulnerability. As previously mentioned, this threshold is the 80th percentile of the values for a particular indicator for all cells within the LZs, with the higher percentiles corresponding to greater vulnerability. All of the variables which have been included in the spatial analysis are presented as 'included' in Table 1.

Table 8: Average values for all variables for each livelihood zone, variable inclusion/exclusion from figures 22-23 maps with reasons, and data sources. All variables labelled 'included' were used in the spatial analysis in figs 22-23.

Variable grouping	Variable	Addun Pastoral	Riverine_Gravity_Irrigation	Sorghum_High_Potential Agropastoral	Southern Agropastoral	Included/excluded from maps for Somalia	Data source
Primary variables							
Food insecurity & nutrition	FEWSNET food insecurity (current situation, 1=minimal to 5=famine), 2020	1	2	2	2	Included	FewsNet https://fews.net/fews-data/333
	WFP Hunger Map food consumption score (mean), Sep'19-Jun'21	NA	NA	NA	NA	Excluded (data not analyzed)	Hunger Map https://hunger-map.wfp.org
	Wasting prevalence in under 5s (%), 2000-2019	17.3	15.1	17.0	13.8	Excluded (insufficient variation)	Local burden of disease https://vizhub.healthdata.org/lbd/dbm
	Stunting prevalence in under 5s (%), 2000-2019	27.6	30.6	26.1	33.1	Included	Local burden of disease https://vizhub.healthdata.org/lbd/dbm
	Underweight prevalence under 5s (%), 2000-2019	26.8	25.4	25.4	24.3	Excluded (insufficient variation)	Local burden of disease https://vizhub.healthdata.org/lbd/dbm

Variable grouping	Variable	Addun Pastoral	Riverine_ Gravity_ Irrigation	Sorghum_ High_ Potential Agropastoral	Southern Agropastoral	Included/ excluded from maps for Somalia	Data source
Gender and educational inequality	Education, female (mean years in 15-49 year olds), 2000-2017	1.066	0.926	1.257	1.040	Included	Local burden of disease https://vizhub.healthdata.org/lbd/dbm
	Education, male (mean years in 15-49 year olds), 2000-2017	2.74	2.91	2.53	2.74	Included	Local burden of disease https://vizhub.healthdata.org/lbd/dbm
	Education gender gap (mean years in 15-49 year olds), 2000-2017	1.67	1.98	1.28	1.70	Included	Calculated from the Local burden of disease https://vizhub.healthdata.org/lbd/dbm
Health	Diarrhea prevalence (%), 2000-2017	30.0	32.5	31.7	35.0	Included	Local burden of disease https://vizhub.healthdata.org/lbd/dbm
	Falciparum incidence (incidence rate), 2019	13.40	15.80	9.98	13.84	Included	MAP https://malariaatlas.org/explorer/#/
	Vivax incidence (incidence rate), 2019	0.179	0.199	0.130	0.175	Included	MAP https://malariaatlas.org/explorer/#/
	Under 5 mortality (per 1000 live births), 2000-2017	2.041	6.263	0.973	25.114	Included	MAP https://malariaatlas.org/explorer/#/
Additional variables							
NA	Net out-migration (number of people), 2010	-7,684	-15,878	-2,870	-13,940	Included	WorldPop https://www.worldpop.org/geodata/listing?id=26
	Mean soil pH at 30cm depth (pH * 10), 2019	78.0	77.4	79.1	77.7	Excluded) (not specific to country)	Soil Grids https://soilgrids.org
	Mean soil organic carbon at 30cm depth (dg/kg), 2019	146	148	148	144	Excluded) (not specific to country)	Soil Grids https://soilgrids.org
	Total area of irrigated land (ha), 2005	63,720	319,957	1,700	1,442,429	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	250	763	156	1,507	Excluded) (not specific to country)	ACLED Dashboard https://acleddata.com/dashboard/#/dashboard

Variable grouping	Variable	Addun Pasto-ral	Riverine_ Gravity_ Irrigation	Sorghum_ High_ Potential Agropas-toral	Southern Agropas-toral	Included/ excluded from maps for Somalia	Data source
NA	Active fires (count), 2019	31	75	2	88	Excluded) (not specific to country)	https://modis-fire.umd.edu/pubs.html, https://firms.modaps.eosdis.nasa.gov/active_fire/#-firms-shapefile
	Ethnic group diversity (number of dominant groups coexisting), 2010	1	1	1	1	Excluded) (not specific to country)	Georeferencing of ethnic groups (GREG) database - http://worldmap.harvard.edu/maps/1894
	Ethnic group type (dominant group category), 2010	Somalis	Somalis	Somalis	Somalis	Excluded) (not specific to country)	Georeferencing of ethnic groups (GREG) database - http://worldmap.harvard.edu/maps/1894
	Time to nearest city (minutes), 2015	197	142	417	114	Excluded) (not specific to country)	https://malariaatlas.org/research-project/accessibility-to-cities/
	Human appropriation of net primary productivity (% reduction), 2000	36.2	40.7	28.6	47.6	Included	Haberl et al, 2007 https://boku.ac.at/wiso/sec/data-download
	Access to improved water source (% of population), 2000-2017	91.6	90.3	97.0	89.9	Excluded) (not specific to country)	IHME ata.org/record/ihme-data/lmic-wash-access-geospatial-estimates-2000-2017

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