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WFP Critical Corporate Initiative: Climate Response Analysis for Adaptation

Burundi

Alliance

Bioversity International

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CGIAR

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Key messages

The majority of Burundians are smallholder farmers facing serious constraints that will be further exacerbated under climate change. Most Burundian agricultural systems are highly vulnerable to climate hazards, including flooding, landslides, water deficit, drought, and erratic rainfall (both in terms of shifting precipitation patterns across time and space and the rapid coupling of drought and torrential rain in the same area). In the next 10 to 30 years, changes in precipitation patterns, increased temperatures, and protracted dry seasons are expected to have significant implications for productivity, crop suitability, and food security. Domestic demand for basic food products will continue to outpace supply resulting in increased import dependence for most key commodities, particularly livestock. Emergency response and resilience programming will be essential for preventing loss in the face of extreme events and for supporting smallholders in the creation of economic, environmental, social, and cultural assets. Reinforcing early warning system capacities and developing or improving supply chain logistics, transportation, and storage systems will play prominent roles in such efforts. Climate resiliency offers several leverage points for strengthening integration between various WFP activities. Potential programmatic and financial partnerships with other countries addressing similar climate challenges, local public and private actors whose work can be scaled up to forge more robust and efficient value chains, and national experts conducting on-the-ground research and development may prove particularly promising for activities that address the root causes of climate impact at a meaningful scale.

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 engaged the *Alliance of Bioversity and CIAT* and the CGIAR to perform a climate risk analysis and recommend programs to address identified needs. The initiative was conducted in Burundi, Guinea, Guinea-Bissau, Haiti, Nepal, Niger, Pakistan, Somalia, and Tanzania. In close coordination with WFP country office staff, the Alliance of Bioversity and CIAT identified livelihood zones (LHZs), 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, 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.

This report begins with an overview of Burundi's people, economy, geography, and wellbeing (Section IV). Section V presents the current and future threats of climate change and its impact on food production, distribution, trade, and broader national outcomes. Section VI examines the enabling and distortionary policy contexts surrounding climate and food in the country. Section VII analyses current WFP activities and how these may be optimized in light of the findings in Sections V and VI. Finally, Section VIII offers recommendations for partnerships that may enable and enhance the opportunities for programmatic optimization.

PART 1.

Country context

1.1 Environment

Burundi is a small, landlocked country in eastern Africa with steep, mountainous terrain and a humid tropical climate influenced by altitude. The nation's capital, Bujumbura, sits on Lake Tanganyika in the western Imbo floodplain near the border with the DRC. Upriver and to the north is Rwanda, bringing streamflow to Lake Rweru in the northeast. Tanzania borders Burundi to the east, sharing nearly 600 kilometers, is a major trading partner,[1] and high traffic zone for migration.[2]

Of the country's nearly 2.6 million hectares of land,[3] approximately 2 million ha (80%) is used for agriculture,[4] and 1.2 million ha (46.7%) is arable.[5,1] Roughly 350,000 ha (17%) of the total agricultural land is under permanent crop production, of which only 23,000 ha (1%) is irrigated.[6] 480,000 (24%) ha of agricultural land is under permanent meadows and pastures.[7]

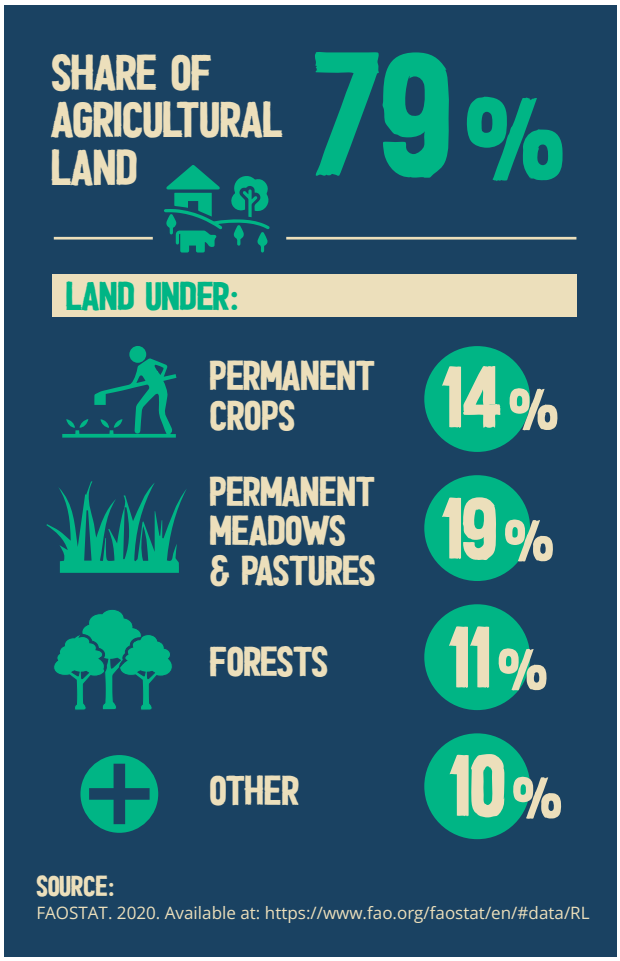
The country has five eco-climatic regions. From west to east, they are the lowlands of the Imbo Plain; the steep region of Mumirwa; the mountainous area of the Congo-Nile divide; the central plateaus; and the Kumoso and Bugesera depressions.[8] The variation in altitudes, ranging from less than 800 m on the shore of Lake Tanganyika in the west to 2,600 m in the mountain ranges and gradually decreasing to 1,200 m in the east of the country, yield significant geoclimatic diversity across each region.[9] Average annual precipitation varies from less than 900 mm in the western plain to more than 1600 mm in the mountainous zones, generally falling during the two wet seasons (February-May and September-December). June-August and a short period in January are usually dry. Average temperatures are higher in the depression areas (21-23°C) and lower in higher-elevation mountainous zones (16-18°C).[10]

Agriculture is at the heart of the Burundian economy, accounting for 40% of the national GDP, employing over 90% of the population, and comprising 30% of total export earnings. Burundi is a major exporter of coffee (21%), valued at US$58 million, second only to gold exports (49%).[11] Other agricultural exports include tea (8%), wheat (4%), processed foods (1%), and tobacco (1%).[12]

Staple food crops include bananas, sweet potato, cassava, legumes, cereals (i.e., maize, rice, and wheat), vegetables, peanuts, livestock, and fish.[13] These crops are overwhelmingly produced by smallholder farmers cultivating landholding parcels of 0.27 ha per household, on average.[14] Livestock plays an important role in the Burundian farming system, contributing 12% to national GDP,[15] and providing income, food, and manure used for fertilizer, as well as a traditional form of household savings for rural families.[16] 70% of households own some type of small livestock, including sheep, goats, guinea pigs, poultry, rabbits, or cows.[17] Fishing is an important industry providing food and jobs to more than 300,000 people around Lake Tanganyika, while aquaculture is increasingly more prevalent, with 153 ha of fishponds and three private aquaculture production stations.[18]

Intensive cultivation and grazing on highly eroding steep hillsides, coupled with high soil acidity and few agricultural inputs, results in low soil fertility and poor agricultural yields. Deforestation further exacerbates soil erosion.[19] Burundi's forests are heavily exploited for firewood, charcoal, and construction materials;[20] increasingly converted to agriculture as population pressure competes for scarcer resources;[21] and cover only 10.9% of the total land.[22]

1 Agricultural land refers to the share of land area that is arable, under permanent crops, and under permanent pastures. Arable land includes 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. (https://databank.worldbank.org/metadataglossary/world-development-indicators/series/AG.LND.AGRI.K2)



1.2 People

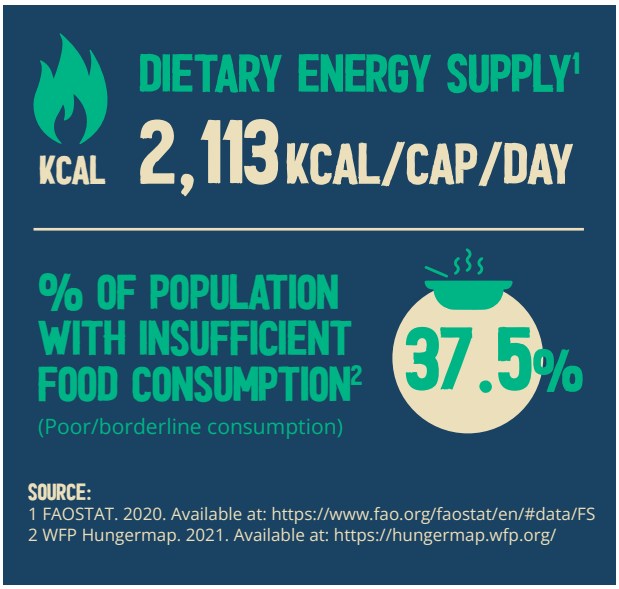
In 2019, Burundi ranked 185 out of 189 countries on the Human Development Index (HDI), with the majority (87%) of its 11.5 million people living in rural areas.[23] Burundi is the second-most densely populated country in Africa, with an average of 435 inhabitants per square kilometer and an annual population growth rate of 3.1%.[24] The population of Burundi is young, with more than 45% under the age of 14, and has an overall life expectancy of 61 years.[25] Burundi ranks 0.999 on the Gender Development Index (GDI),[26] indicating a virtually even ratio between men and women in dimensions of health (life expectancy), education (years of schooling), and earned income.

Burundi is one of the poorest countries in the world.[27] As of 2020, over 70% of Burundians live below the international poverty line of US$1.90/day; almost two-thirds (64%) live below the national poverty line of US$0.88/day[28]; and 65% of the youth are unemployed.[29] In 2019, Burundi's Gender Inequality Index (GII)[2] value was 0.504, ranking it 124th out of 162 countries.[30]

Burundi has experienced several periods of conflict that have crippled economic and agricultural development and exacerbated landscape-level challenges. An ethnically-driven civil war from 1993-2005 killed over 200,000 people and displaced over 550,000, followed by civil unrest and political crisis in 2015 that sent 400,000 Burundians into exile, both undermining economic activity and food security gains.[31] In 2019, the country was rated -1.65 or 181st out of 191 countries on the Political Stability and Absence of Violence Index.[32] Internal displacement from natural disasters or conflict increases pressure on Burundi's already short supply of land. Refugees returning from conflict have found others occupying their land,[33] resulting in frequent land disputes. They are relegated to less suitable drought- and flood-prone regions, further straining fragile host communities, marginal lands, and forests.

Access to services in Burundi is low. In 2018, 89% of the total population did not have access to electricity (with a significant range between 40% in urban areas and 98% in rural areas[34]); 54% of people did not have access to basic sanitation services; and 25% could not access safe drinking water.[35] Literacy and education remain low, with expected years of schooling at 11.1, while people aged 25 or older have an average of only 3.3 years of school.[36] The literacy rate of adult males is 76%, and for females, 61%. In 2019, 3%

2 The GDI is a direct measure of the gender development gap, achieved by measuring female HDI indicators (health, knowledge, and living standards) as a percentage of the male HDI in a given context. The GII indicates the loss in potential human development due to the disparity between female and male achievements in three dimensions (reproductive health, empowerment, and the labor market).



of Burundians had access to the Internet, down from 5% in 2016.[37] Nearly all households (99%) use solid fuels for cooking,[38] which contributes greatly to deforestation. Wood is the primary fuel source used by more than three-quarters (77%) of households for cooking (rural households, in particular, at 85% vs. 16% in urban areas). Charcoal is used more commonly (75%) in urban areas.[39]

Food insecurity in Burundi is alarming, with 35% of people (3.9M) suffering food insufficiency in 2020.[40] The country ranked highest in the Global Hunger Index for child stunting (54%)[41] and 5.1% of children under five are considered wasted.[42] 27% of women within reproductive age (15-49) are anemic.[43] The prevalence of chronic malnutrition in Burundi is the highest in the world, with an estimated economic impact of US$102 million a year.[44]

1.3 LHzs and crops of focus

1.31 Characterization

Four priority LHZs were chosen for analysis of crop suitability and crop-climate hazards in order to identify (hot) spots where climate risks intersect with other factors critical to WFP programming. The zones were chosen based on the relevance of agriculture coupled with environmental hazards aggravated by

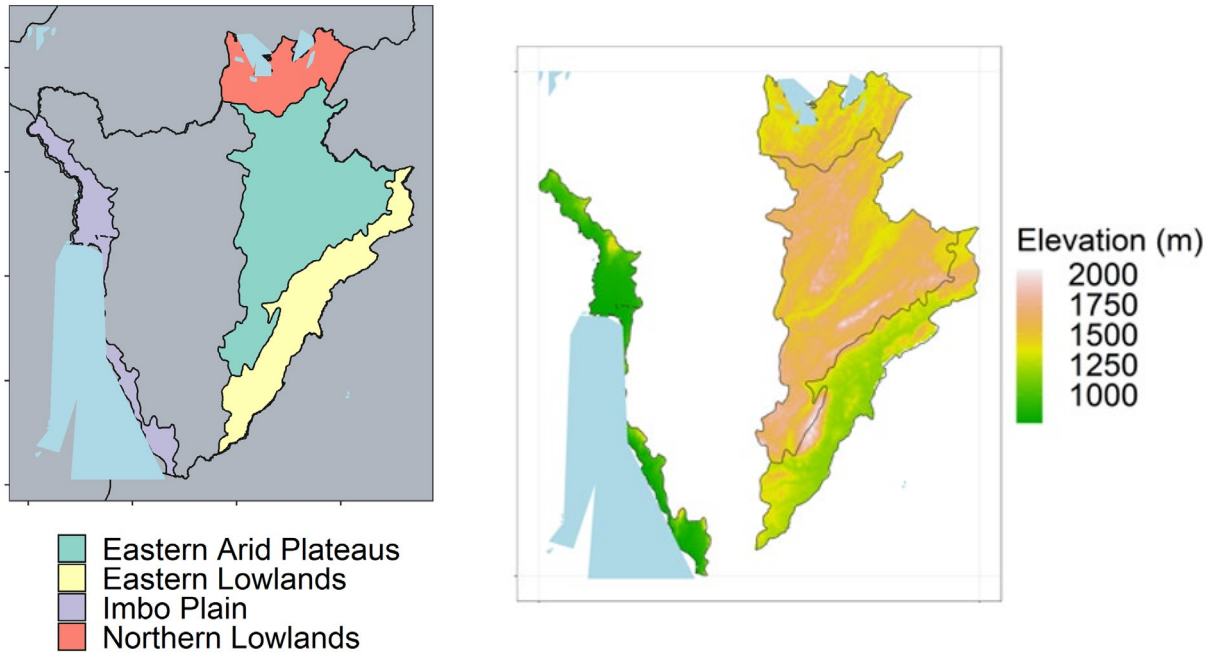
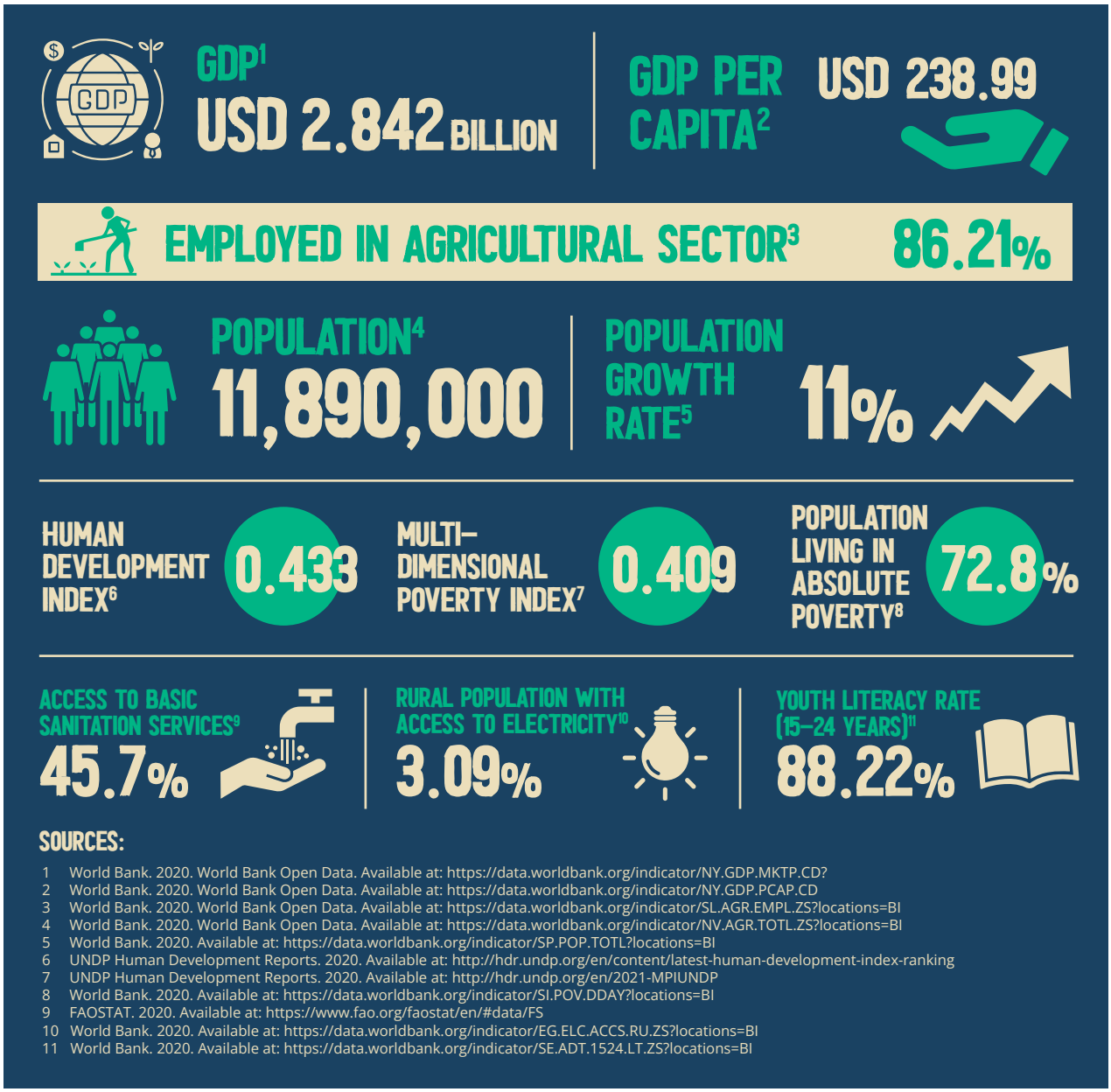


Figure 1. Burundi's Priority LHZs and Elevation Map



climate change. Priority LHZ elevations range from less than 800 m in the western Imbo Plain (Zone 1) to over 2000 m in the Eastern Dry Plateau (Zone 4) on the eastern border with Tanzania (see Figure 1 map). Altitudes greatly influence temperatures and precipitation, with higher temperatures and less rainfall in lowland areas and an inverse in the higher mountain ranges (see Table 1 for details on specific LHZ climates). Focus crops include cassava, beans, corn, rice, and sorghum; priority livestock includes small ruminants (sheep and goats), cattle, and swine.

1.32 Threats to livelihoods

Both climate- and non-climate-related factors with the potential to threaten livelihoods have been identified in Burundi (Table 2). Primary climate-related threats include drought (Zones 2 and 3) and water deficit (Zones 1 and 4), flooding (Zones 1, 2, and 4), and landslides (Zones 1 and 4). Non-climate-related threats include pests such as fall armyworm (FAW) (in all zones) and stinking

Table 1. Details of priority LHZs in Burundi

Zone	Zone 1	Zone 2	Zone 3	Zone 4
Region	Imbo Plain	Eastern Depression	Northern Depression	Eastern Dry Plateau
Altitude	<800 m	1200 m	1400 m	1500-2000m
Temperature	21-25°C	21-23°C	18-20°C	18-20°C
Precipitation	<900 mm			1200 mm
Crops	Rice	Beans	Beans	Cassava
	Corn	Cassava	Sorghum	Beans
	Cassava	Corn	Cassava	Corn
Livestock	Cattle	Goats	Goats	Goats
	Goats	Small ruminants	Cattle	Small ruminants
	Small ruminants	Cattle	Small ruminants	Swine

locusts[3] (especially in Zones 2 and 3); disease prevalence such as malaria (all zones) and cholera (Zone 1); and the negative socioeconomic impacts of COVID-19 (all zones).

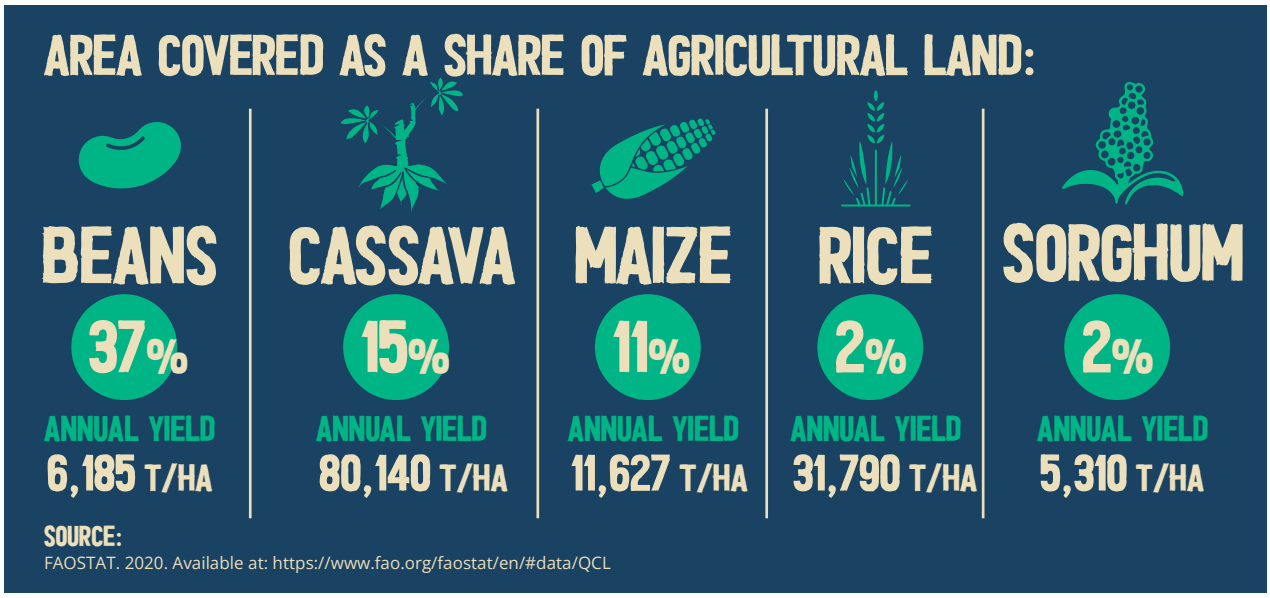
1.33 Socioeconomic factors critical to WFP programming

Socioeconomic factors critical to the success of WFP programming were identified across all zones. Variables include access to water, land, trade with neighboring countries, migration flows (both economic and climate-related), labor, and soil fertility. Factors critical to Zone 1 (Imbo Plain) include access to water, addressing land disputes, and improving exchanges with the DRC and Rwanda. Zone 2 (Eastern Depression) factors include potential irrigation, exchanges with Tanzania and zones of returnees, and land disputes. Zone 3 (Northern Depression) is impacted by exchanges with Rwanda, inland lakes without streams and rivers, and the traditional movements of outgoing economic migrants. Factors most critical to Zone 4 (Eastern Dry Plateau) include casual labor surplus (supply), access to land, and poor soil fertility. Additionally, in the border areas present in all LHZs, cross-border activities crucial to livelihood generation are at risk of disruption due to ongoing political developments, economic protectionism, and COVID-19-related movement restrictions.

3 *Zonocerus variegatus* (Harlequin Locust) is a species of stinking grasshopper that differs from the desert locusts ravaging the Horn of Africa. (Manishatse, "No Migratory Locusts' Invasion in Burundi, Ministry of Agriculture Reassures.")

Table 2. Climate and non-climate-related threats to LHZs

Threats	Affected LHZs	Impacts	Contributing factors
Climate-related threats			
Droughts	2, 3	Reduced yields	Lack of irrigation infrastructure
Water deficits	1, 4	Reduced yields	Water management, sediment management, overexploitation
Landslides	1,4	Road closures/transport impediment	Deforestation, land degradation, heavier rains
Flooding	1, 2, 4	Reduced yields; increased landslides	Poor infrastructure
Non-climate-related threats			
Fall armyworm	1, 2, 3, 4	Crop destruction (esp. corn and sorghum), loss of income	Warmer weather (advances pupal stage)
Stinking (or Harlequin) locusts	2,3	Crop destruction (esp. corn and sorghum), loss of income	Deforestation; heavier and more frequent rains (better conditions for hatching and breeding)
Malaria	1, 2, 3, 4		Water management; health care; and access
Cholera	1		Water management; health care; and access
Covid-19	1, 2, 3, 4	Socioeconomic disruption; supply chain disruptions (e.g., farm inputs)	Health care and access



PART 2.

Climate risk profile

An analysis of the historical climate data and future climate projections, as well as their impacts on crop suitability, was conducted for Burundi using the EcoCrop model.[45] These hazards included extreme hydrological events (including flash floods), landslides, drought, and water deficit. Future climate projections were generated based on an ensemble of multiple Coupled Model Intercomparison Project (CMIP5) models[46] using Representative Concentration Pathway (RCP) 8.5 for two future periods, 2030 and 2050. The results of the climate risk analysis were then overlaid with key socioeconomic data relevant to WFP Country Offices and national priorities. This process helped identify areas in which substantial climate hazards co-occur with other socioeconomic vulnerabilities.

2.1 Analysis of historical trends and projected changes in climate risks

Burundi has historically seen monthly temperatures varying from 15-25°C and two rainy seasons (See Figure 3). The first growing season spans from February to July, with the

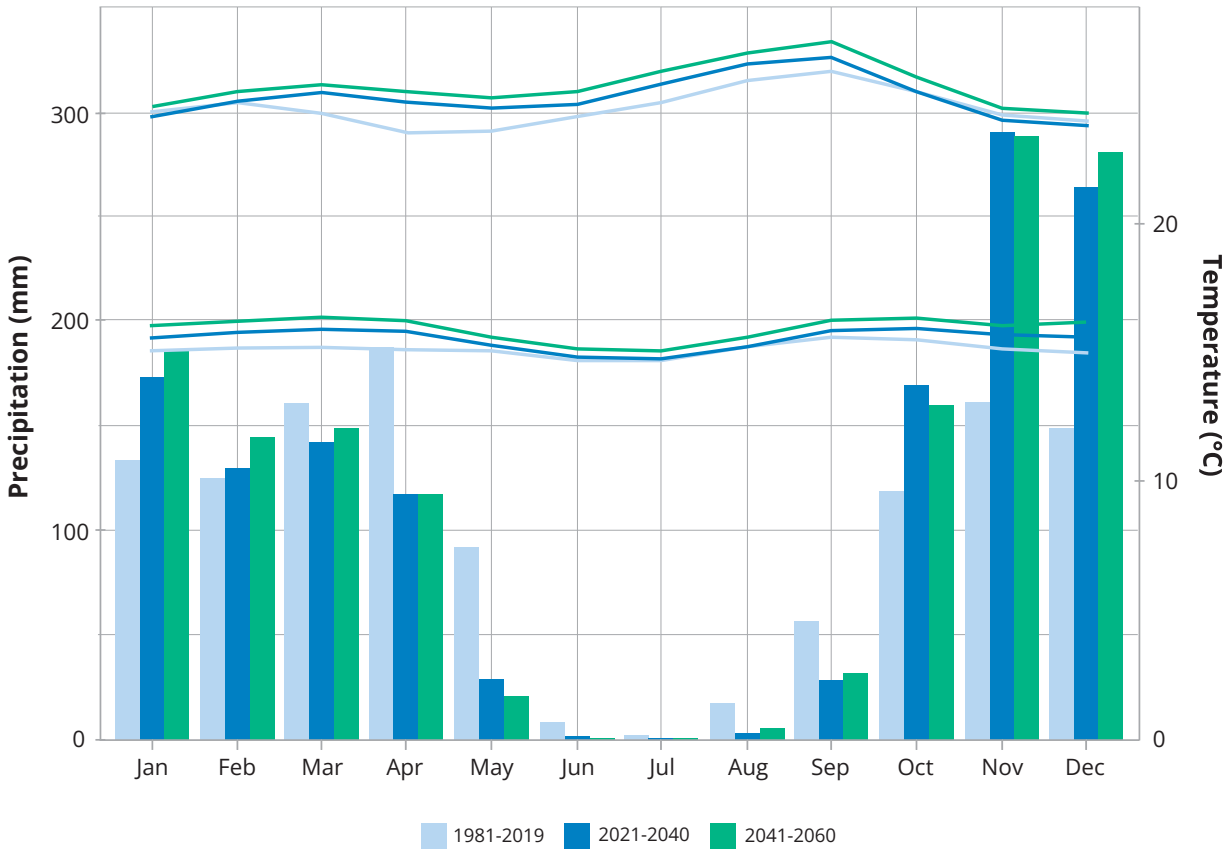


Figure 3. Historical and Projected Annual Mean Temperature and Precipitation in Burundi

highest level of rainfall (180 mm) in April and with temperatures ranging from 15-23°C. The second season covers September through January with comparatively lower levels of rainfall (50-150 mm) and a slightly higher maximum temperature of 25°C in September. The dry season, with less than 30 mm of rain, is experienced during a shorter period running from June through August.

Average temperatures are predicted to increase similarly across all regions during both seasons. Projections of temperature rise show an average increase of 1.5°C, at most 2°C, from 2020 until 2050. Although all zones may see a similar increase in temperature, some areas will be more affected by extreme temperatures than others because they have different average starting temperatures. For example, the Imbo Plain is currently the hottest zone (with averages above 22°C) and will continue to experience higher temperatures that reach upwards of 24°C (See Annex figure Y "Historical and projected temperature trends").

Mean precipitation trends for each season project a general decrease in rainfall in Season 1 (February-July) and a heavy increase in precipitation in Season 2 (September-January). Season 1 reduction in rainfall is expected to lead to increased drought stress, especially toward the end of the season. Less rain and increased instances of drought are expected to be more prevalent in the Northern Depressions and Eastern Dry Plateaus (Zones 3 and 4) (See Figure Y). However, in the same season, the model predicts elevated precipitation intensity in April, leading to increased waterlogging during Season 1 in all LHZs. The second season will become wetter, with more precipitation expected (as seen in the dark blue areas of Figure 4), leading to waterlogging problems for a substantial portion of the country.

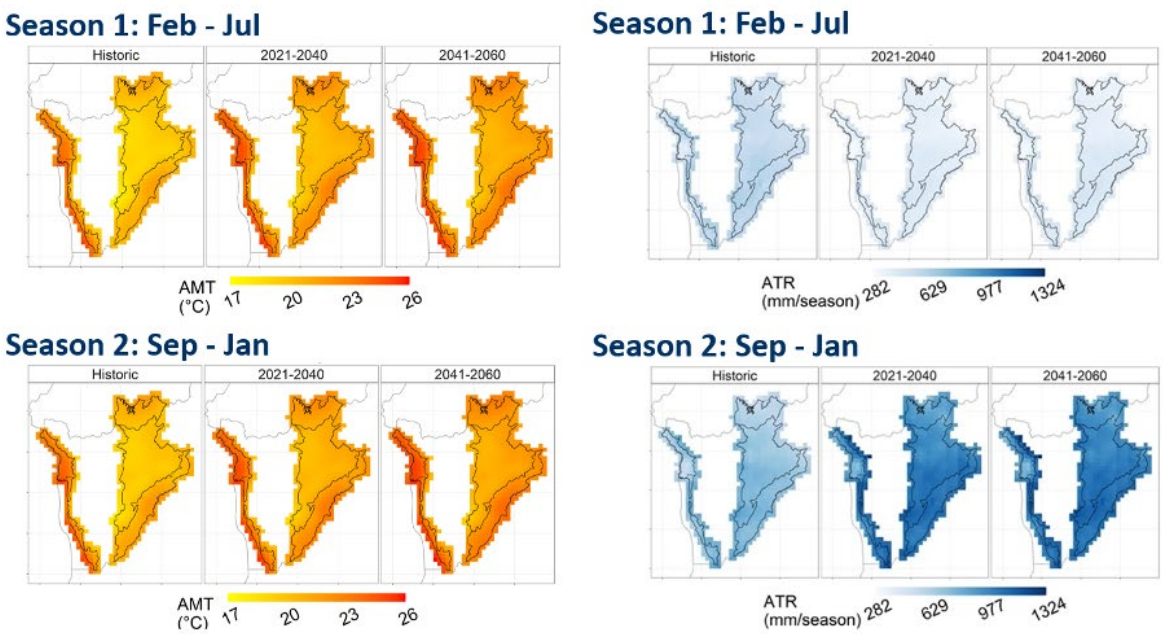


Figure 4. Historical and Projected Annual Mean Temperature and Precipitation in Priority LHZs of Burundi

2.2 Climate hazard analysis for select hazards

Burundi's small-scale subsistence farmers are highly vulnerable to climate change and economic shocks. It is important to consider the seasonal aspects of climate modeling trends; for example, increased precipitation during the second season may negatively impact the crops grown during that season. Beans and corn are sown and cultivated during Season 2 (between September and January), and increased rainfall during these months can lead to waterlogging problems and loss of production for these crops, development of aflatoxins, and an increase in post-harvest rot. Furthermore, the projected decrease of rain in September will force farmers to delay planting crops, adding an additional lean period as food stores from the June-July harvests run low.

The climate hazards detrimental to agriculture include water deficit, landslides, flooding, and drought (Table 3). Flooding and drought may occur frequently over time or as single events within the same year, e.g., a water deficit in Season 1 followed by flooding in Season 2. These climate hazards affect cropping systems and therefore hinder agricultural production and development both directly and indirectly. The direct effects include heat stress, periods of drought, and waterlogging that reduce crop yield. For example, if the season has a false start (i.e., the rain stops at the beginning of the season), priority crops such as maize, rice, legumes, and sorghum will die because drought will kill the seedlings and/or sprouts. The indirect effects include, but are not limited to, a reduction in post-harvest storage ability; increased incidence of pest damage; higher prices for the raw product (without gains for farmers); impaired roadways preventing transport of crops to market; and reduction of food security.

All four LHZs are expected to experience increased extremes in temperature and rainfall, coupled with periods of drought and

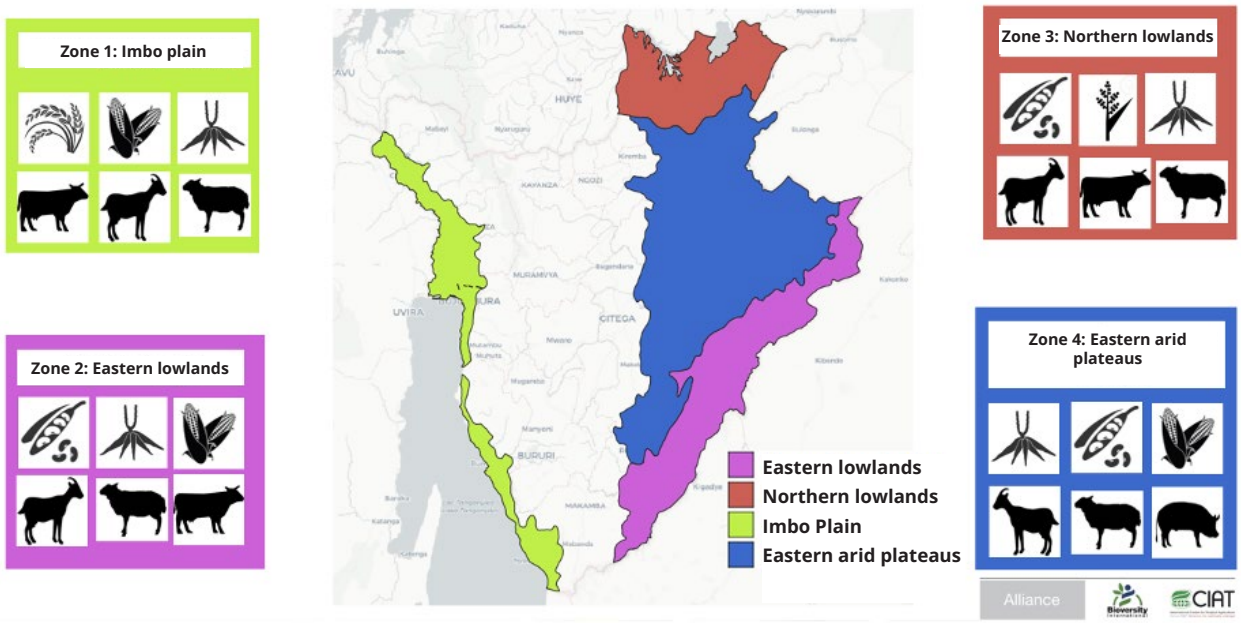


Figure 5. Key production systems across selected LHZs

Table 3. Climate hazards, trends, and impacts in Burundi

	Hazard	Trends	Impacts
LHZ 1: Imbo Plain	**Water Deficit**	Temperatures in Season 1 are projected to increase up to 2°C by 2050.	Higher temperatures increase evapotranspiration and soil moisture loss, resulting in reduced crop productivity. Higher temperatures and heavier rains elevate conditions for pests, such as fall armyworm and locusts, which are particularly harmful to rice and corn.
	Flooding	Precipitation during Season 2 is projected to increase up to 35% leading to more frequent occurrences of flooding and landslides, especially in areas with or nearby steep slopes.	Increased rainfall during Season 2 can lead to waterlogging problems and loss of production for vegetable crops.
	Landslides		Delay of Season 2 rainfall will shift the sowing season later in the year, elongating the lean season and reducing the growing period.
LHZ 2: East	**Drought**	Drought will increase significantly by 2050.	Periods of drought can kill crops entirely.
	Flooding	Waterlogging will increase significantly by 2050.	Increased rainfall during Season 2 can lead to waterlogging problems and loss of production for beans and cassava.
			Flooding during the growing season can increase aflatoxin growth in beans and maize and accelerate post-harvest rot of all crops.
LHZ 3: Northern Depression	**Drought**	Reductions in precipitation lead to increased drought stress, especially towards the end of Season 1.	Periods of drought are highly destructive and can lead to total crop failure.
LHZ 4: Eastern Dry Plateau	**Water Deficit**	Temperatures in Season 1 are projected to increase up to 2°C by 2050.	Higher temperatures increase evapotranspiration and soil moisture loss, resulting in reduced crop productivity. Higher temperatures and heavier rains elevate conditions for pests, such as fall armyworm and desert locusts, which are particularly harmful to corn.
	Flooding	Precipitation during Season 2 is projected to increase up to 35%.	Increased rainfall during Season 2 can lead to waterlogging problems and loss of production for beans and cassava.
	Landslides	Waterlogging and drought will increase by 2030, leading to increased conditions for landslides.	Flooding during the growing season can increase aflatoxin growth in beans and maize and accelerate post-harvest rot of all crops.

waterlogging events, yielding negative impacts on agricultural production and implications for food security. Both the Imbo Plain and Eastern Dry Plateau will experience water deficit, flooding, and landslides, which will reduce the yields and distribution of the priority crops corn, bean, cassava, and rice. Decreased precipitation in the Eastern and Northern Depressions will result in drought incidences that can kill rainfed crops entirely.

Drought events and waterlogging are expected to increase in all LHZs of Burundi, with some areas seeing both events (see Figure 6). Drought risks are highest in the northern part of the Imbo Plain and the eastern part of the country, especially the Eastern Dry Plateau and the Eastern Depression, where drought is coupled with waterlogging risk. Reduced precipitation in May and September gives way to an elongated dry season with increased drought risk towards the end of Season 1 and the beginning of Season 2 (Figure 7) when food security risks are highest. Waterlogging will occur more severely in the east of the country (Figure 7), with more frequent events occurring in Season 2 (Figure 7).

2.3 Risks for focus crops and livestock

Covering a selective range of key crops for the four LHZs in Burundi, the suitability analysis indicates that there will likely be both "winners" and "losers," with bean production taking the hardest hit in the Imbo Plain and Eastern Depression and rice making some gains in these areas. In the absence of any adaptation strategies, the Imbo Plain is most likely to become unsuitable for bean production

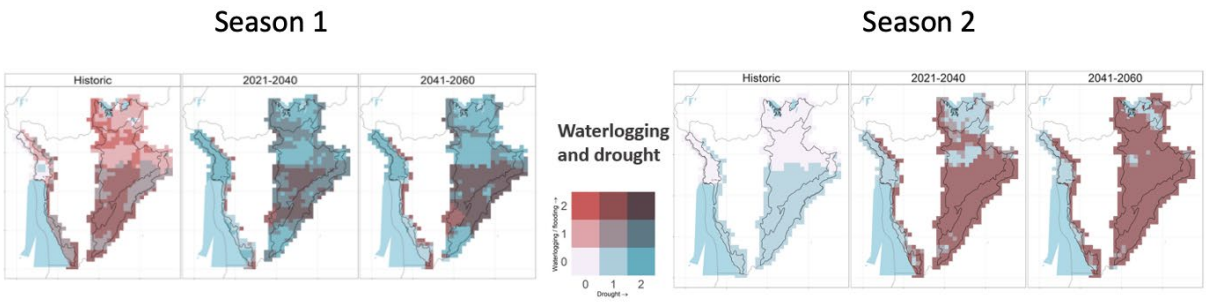


Figure 6. Historical and Projected Waterlogging and Drought Incidences in Burundi

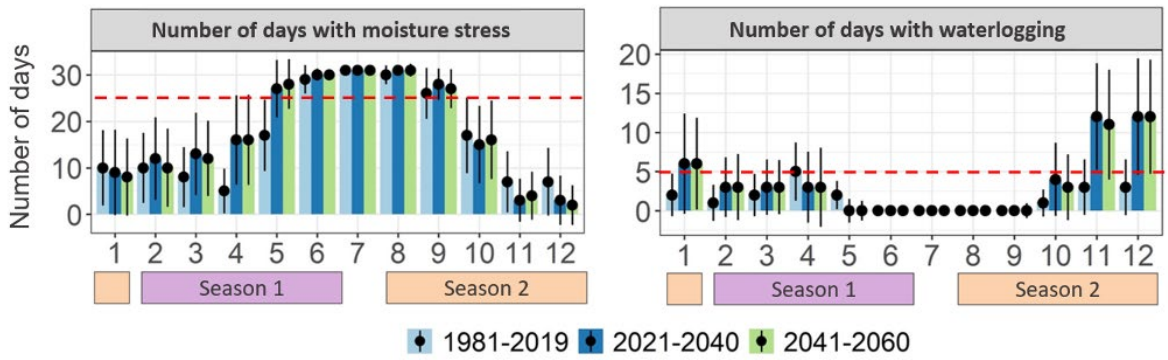


Figure 7. Historical and Projected Number of Days with Moisture Stress and Waterlogging

by 2050. Similarly, beans, a priority crop in the Eastern Depression, are likely to become poorly suited to that zone. The suitability of bean-growing areas in both the Northern Depression and the Eastern Dry Plateaus will remain largely unaffected in the future (see Figure 8). Suitability for rice will improve in all four LHZs but remains in the poor and moderate category for most. The southern part of the Imbo Plain, where rice is a priority crop, will become highly suitable for rice in 2030 and will continue to expand in 2050 (see Figure 8).

Several key commodities are projected to remain or increase in suitability across all four LHZs in the future, including cassava, rice, maize, and sorghum. In the Eastern and Northern Depressions, cassava will greatly increase in suitability (Figure 9); rice will experience slightly increased suitability (Figure 11); maize and sorghum will remain highly suitable (Figure 10); and bean production will become less suitable (Figure 11). In the Eastern Dry Plateau, cassava will greatly increase in suitability; maize, sorghum, and beans will remain highly suitable; and rice will experience slightly increased suitability. In the Imbo Plain, rice will experience slightly increased suitability; cassava, maize, and sorghum will remain highly suitable; and bean production will decrease greatly in suitability.

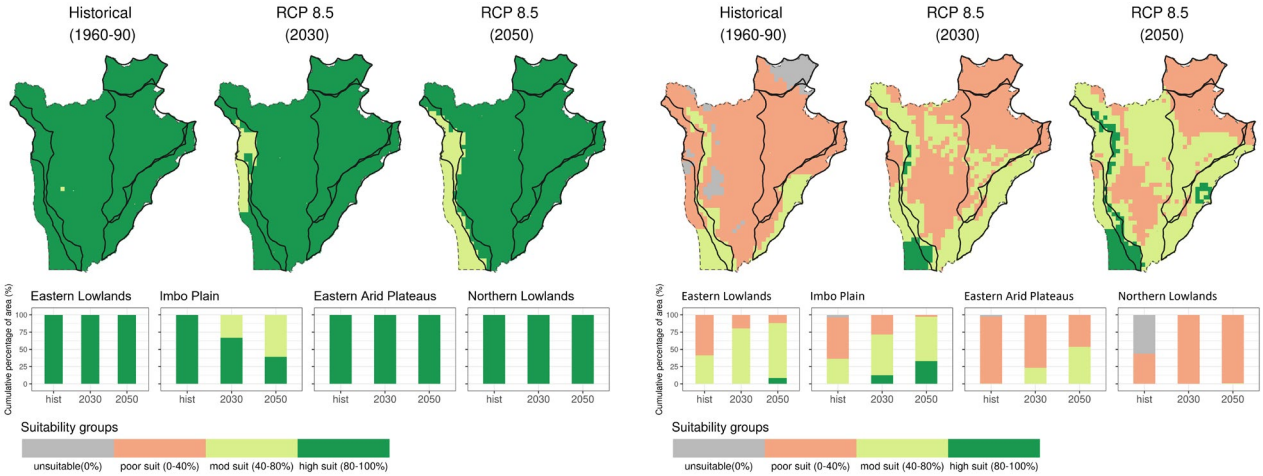


Figure 8. Historical and Projected Suitability Analysis of Bean (left) and Rice (right) Production in Burundi

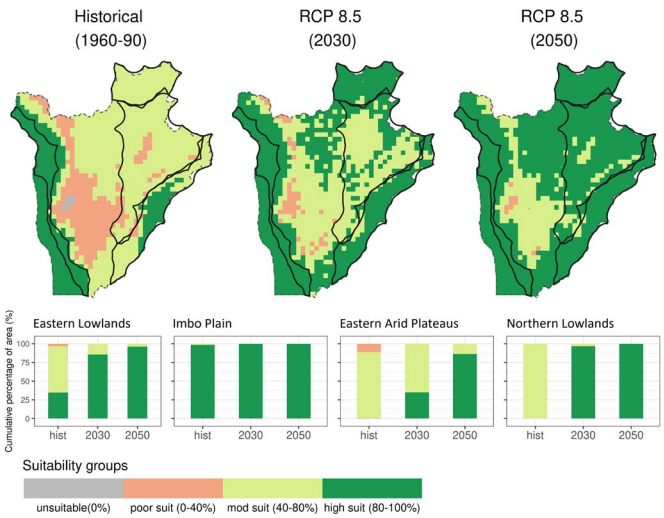


Figure 9. Cassava Suitability in Historical and Future Scenarios (2030 and 2050 – RCP 8.5)

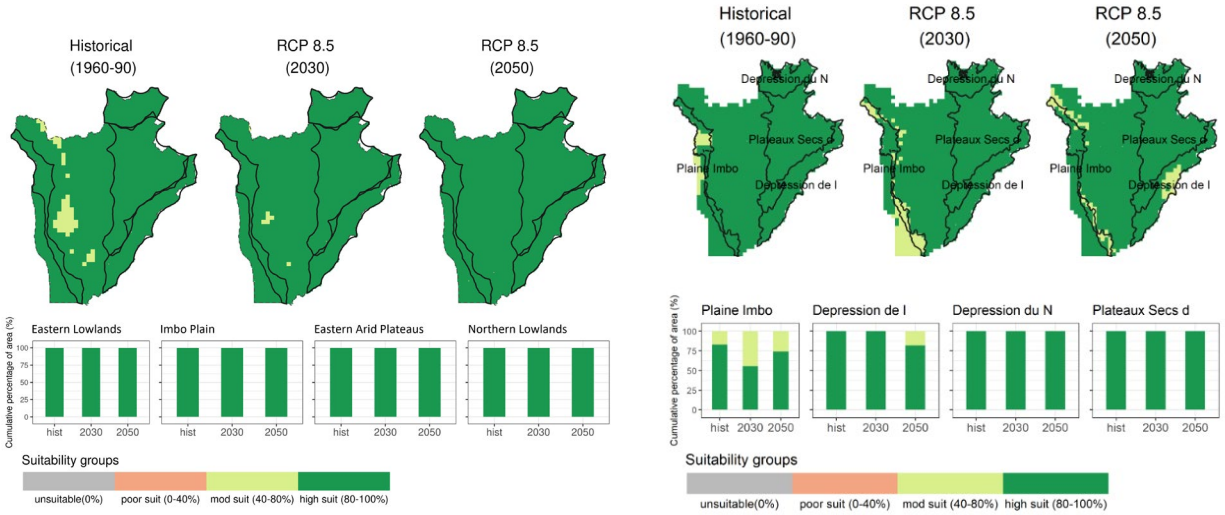


Figure 10. Maize (left) and Sorghum (right) Suitability in Historical and Future Scenarios (2030 and 2050 – RCP 8.5)

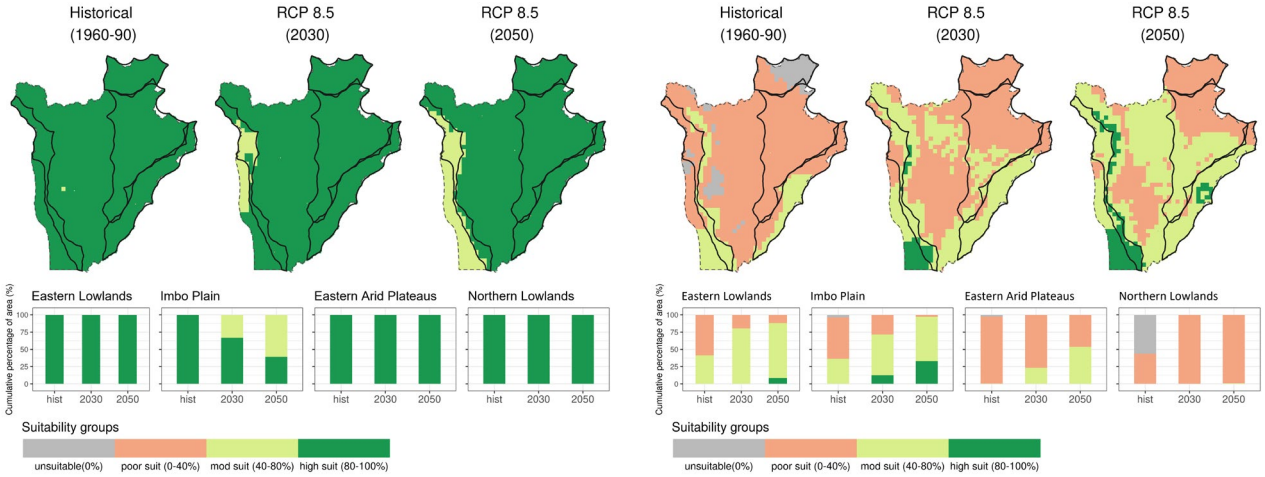


Figure 11. Beans (left) and Rice (right) Suitability in Historical and Future Scenarios (2030 and 2050 – RCP 8.5)

2.4 Economic analyses using IMPACT

The economic analysis presented here uses IMPACT, an exploratory tool for assessing 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 changeRobinson et al., "The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT): Model Description for Version 3.".[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. For this study, RCP 8.5–the most 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 modeled 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.

Because IMPACT results are reported at the country level and not disaggregated by LHZ or demographic/economic group, their relevance lies in the context they provide for local-level decision making. Identifying points of climate resilience and vulnerability within Burundi's agricultural sector equips policymakers with an inventory of agricultural strengths and weaknesses at the national level. This is critical information that can feed into the formulation of strategies to address climate hazards at the livelihood zone-level, which typically involve a rebalancing of investments across NARS programs as well as investments in the 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 Burundi's agricultural sector, particularly in regard to food production

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

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.

2.41 IMPACT model results

In Burundi, the yield, harvested area, and production of beans, cassava, rice, and maize are projected to be higher under climate change than under the No-CC benchmark (Figure 17 in Annex). At the same time, production and harvested area are projected to decrease for other pulses, cereals, and roots and tubers. This may be because the damage caused to these crops by climate change is relatively more severe than for beans, cassava, rice, and maize. The resulting relative scarcity of alternative crops may, in turn, place upward pressure on their demand and prices such that farmers become willing to invest in the inputs necessary to offset the biophysical yield losses from climate change. Sorghum was not analyzed due to a dearth of data.

Rice is predicted to increase in yield and harvested area, with overall gains in production (See Figure 17 in Annex). While rice is projected to have a significant (200%) yield increase, its share of cropland is smallest across the landscape (Figure 16 in Annex), and its magnitude is projected to remain small relative to the other key crops. Per capita consumption of rice is projected to increase in the coming decades (Figure 18 in Annex); however, under CC scenarios, the caloric availability of rice is projected to be significantly lower (Figure 19 in Annex). Imports may be required to cover upwards of 30% of the domestic rice demand by 2030 (Figure 21 in Annex).

IMPACT modeling shows that yield, harvested area, and production of beans are projected to increase considerably in the coming decades (Figure 14 in Annex) and to be higher under climate change than under the No-CC benchmark (Figure 17 in Annex). Beans are projected to occupy the largest share of harvested area out to 2050 **(Figure 16 in Annex)**. Per capita diet composition available from domestic production and international trade indicates an increase in calories from beans in the coming decades, with consumption of pulses, primarily beans, steadily increasing in kcal per capita at about 21% of total calorie intake (Figure 19 in Annex) but remaining a similar share of the diet.[47] However, when accounting for climate change, the per capita consumption of beans will decrease to a small degree (Figure 20 in Annex). The import share of demand for beans is projected to be lower under climate change than it would otherwise be under No-CC scenarios (Figure 22 in Annex).

Despite advances in production and yield, it is expected that imports will be required to meet nearly 60% of the domestic maize demand (Figure 21 in Annex) because demand will continue to outpace supply. Often, import reliance makes basic goods inaccessible to lower-income families. In this case, maize yield and production are projected to increase slightly, while the harvested area is projected to remain steady until 2030 and decrease slightly thereafter (Figure 14 in Annex). Per capita consumption of maize is predicted to increase in the coming decades (Figure 19 in Annex); however, calorie availability for maize is projected to be significantly lower under climate change than under the No-CC benchmark (Figure 20 in Annex).

5 "Raw" CC trajectories, without comparison to No-CC trajectories, are provided in Annex 1.

While production and total consumption of cassava will rise significantly, the per capita consumption is projected to be moderately lower under climate change (Figure 19 in Annex). Yield, harvested area, and production of cassava are projected to increase considerably in the coming decades, especially under the CC scenario, and will occupy the second-largest share of cropland across the country (Figure 16 in Annex). In 2030, total demand for cassava is projected to be 17.5% higher (compared to 2020) and will continue to increase 43.8% by 2050 (Figure 20 in Annex). Cassava is the only key commodity for which import dependence is low and projected to decline (Figure 21 in Annex).

The number of animals, yield, and overall production of small ruminants, such as sheep and goats, are projected to rise considerably out to 2050 (Figure 15 in Annex). The number of small ruminants will increase significantly over other livestock, such as cattle or swine (Figure 15 in Annex). Per capita consumption of small ruminants is projected to increase, contributing over four times the number of calories by 2050 (Figure 19 in Annex), and demand will increase by over 500% (Figure 18 in Annex). Import dependence is projected to increase for livestock commodities, likely due to high increases in demand outweighing domestic production (Figure 21 in Annex).

As with sheep, beef production is increasing in efficiency, with the number of animals, yield, and overall production projected to rise considerably out to 2050 (Figure 15 in Annex). Yield and production quantities of cattle will increase significantly, more than other livestock such as sheep and swine (Figure 15 in Annex), meaning that cows will become larger with more meat to consume per animal. While livestock production is not accounted for in cropland-use trajectory modeling (Figure 16 in Annex), the land area required for feed and pasture dwarfs all other agricultural crops,[48] which may impact reforestation and other conservation efforts. Demand for beef will increase five-fold by 2050 (Figure 18 in Annex), with a similar four-fold per capita increase in the consumption of calories from beef. However, while this projected increase in the consumption of livestock meat is pronounced in percentage terms, it is relatively small in terms of magnitude (45 calories up from 11 per day) (Figure 19 in Annex), and total livestock caloric intake exhibits relative resilience in the face of climate change (Figure 20 in Annex). A significant rise in import dependence is especially pronounced for livestock commodities, including beef (Figure 21 in Annex).

2.5 Impacts of climate change on food security

2.51 Food and nutritional security

Population increase is expected to outpace production gains for nearly all crop and livestock systems analyzed in Burundi, with implications for food availability. Caloric availability for nearly all crops is projected to be significantly lower under climate change (Figure 20 in Annex), despite gains in production and yield for all commodities (Figure 14 in Annex). The decline of calorie intake under climate change is especially pronounced for maize and rice (dark purple), while projected livestock calorie intake, on the other hand, exhibits relative resilience in the face of climate change (no color). The consumption of cassava, other roots and tubers, and beans is projected to be lower under climate change when compared to the No-CC benchmark, although to a lesser degree (light purple).

Overall, consumption of fruits and vegetables (e.g., cassava, maize, cereals, and roots and

tubers) is projected to rise from about 878 kcal/capita/day to 946 kcal/capita/day in 2030 and to 1215 kcal/capita/day in 2050. However, as a share of the total diet, starchy staple consumption is projected to decline from about 55% to 52% in 2030 and then to 47% in 2050 (Figure 19 in Annex). Meat products show the highest demand increase (Figure 18 in Annex), consistent with Bennett's law, an empirical trend often seen in developing nations.[49] The receding starchy share of diet is replaced primarily by the consumption of animal products, which is projected to rise from about 2% to 4% of the total diet in 2050. Consumption of pulses, primarily beans, while steadily increasing in kcal/capita terms, is projected to hold constant at about 21% of total caloric intake.

Import dependence for the procurement of key dietary staples can provide insight into a nation's food access and food security, as it indicates where domestic production may fall short of demand. **Burundi's import dependence is projected to increase for most key commodities, especially for livestock** (Figure 21 in Annex, right panel). However, under climate change, Burundi's import dependence on these commodities is projected to rise less than it would under the No-CC benchmark (Figure 22 in Annex, right panel). One potential reason for this could be neighboring trade partners suffering impacts of climate change, which can make those import commodities scarce if the producing countries have less product to export.

The numbers for undernourished children and people at risk of hunger are projected to decline substantially in the coming decades (Figure 21 in Annex, left panel); however, they will be higher under CC scenarios than under the No-CC benchmark (Figure 22 in Annex, left panel).[50] The share at risk of hunger is projected to equalize in the two scenarios by the middle of

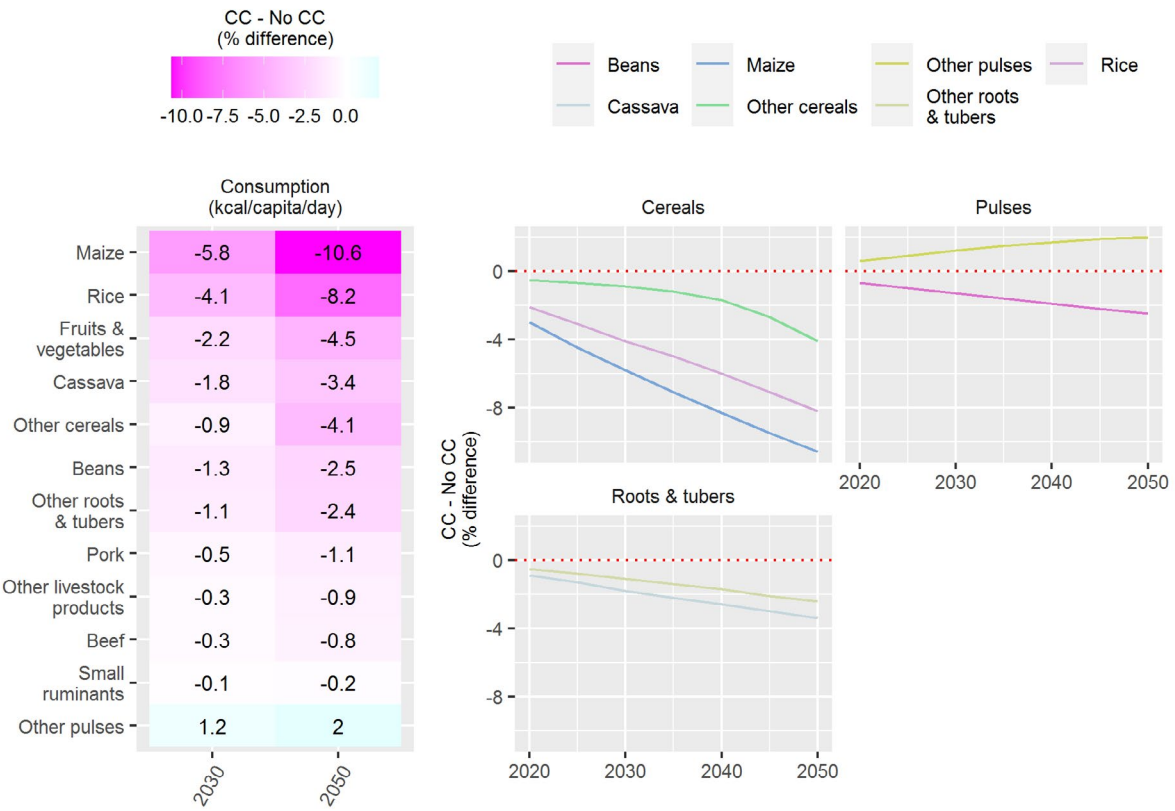


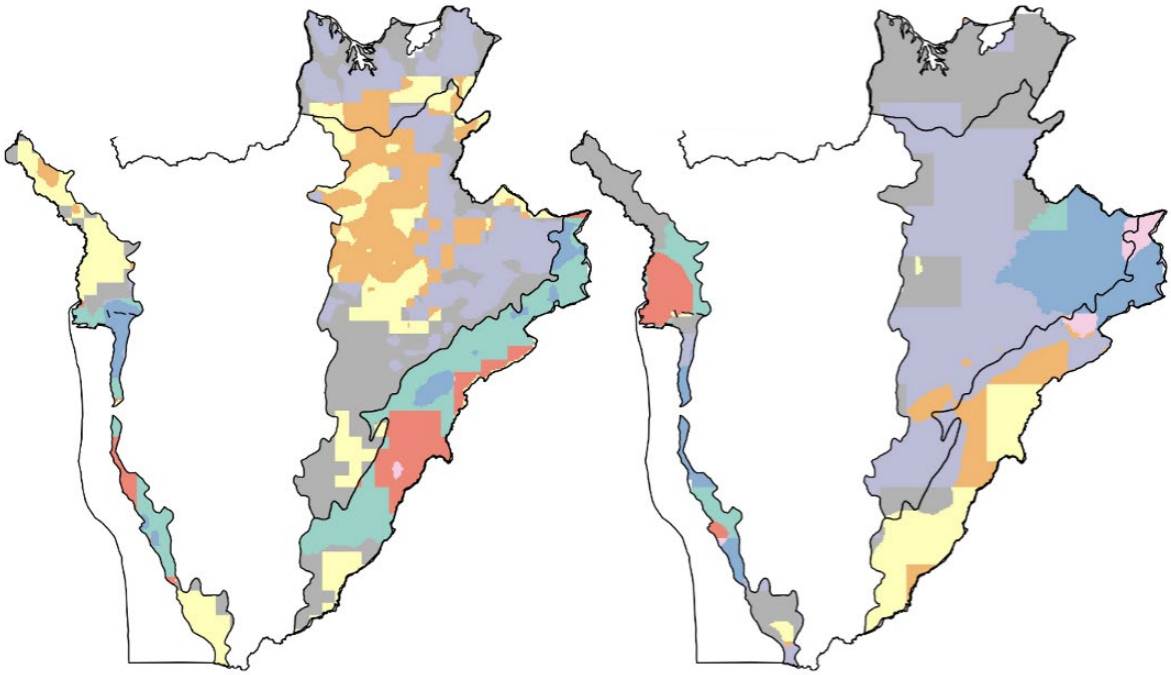
Figure 12. Percentage Difference Between the Consumption (kcal/capita/day) of Key Commodities With and Without Climate Change

the century. This is consistent with the projected calorie intake reductions under climate change seen above.

2.52 Hotspots with co-occurrence of risks

Metrics indicating socioeconomic vulnerability in Burundi's LHZs were assessed using geospatial mapping and overlain with climatic risks to identify 'hotspots' of co-occurrence of risk. For this section, data on a set of indicators were compiled and then mapped. These socioeconomic dimensions are grouped into 'generic' vulnerability indicators (food security and nutrition, inequality, and health) and indicators that are 'country-specific' to WFP's programs of interest (net migration, soil organic carbon content, and irrigated land area). Food security and nutrition were based on direct estimations of food insecurity, food consumption scores, and estimates on child development and nutrition. Inequality was represented by education and education-based gender indicators. Health was represented by a combination of disease prevalence and mortality rates. Country-specific indicators were identified by in-country experts. Indicators were tested to determine whether values from specific LHZs showed sufficient spatial variability to contribute meaningfully to the vulnerability hotspots map.

Socioeconomic challenges further exacerbate vulnerabilities and the negative impacts of climate change in the LHZs of focus. Food insecurity is a predominant vulnerability seen throughout almost the entire Eastern Depression (Figure 13, left panel), co-occurring with the nationwide vulnerabilities of low organic soil carbon and/or low irrigation areas throughout the center and southern part of this zone (Figure 13, right panel). The Eastern Depression also displays areas where all three country-specific vulnerability indicators co-occur, i.e., high out-migration, low organic soil carbon content, and low irrigation areas. Programming in the Eastern Depression tailored to address the causes of these country-specific vulnerabilities (such as supply chain development and training and opportunities for youth) can work to alleviate the generic vulnerabilities in this LHZ. Limited irrigation is the predominant country-specific vulnerability across most of the Eastern Dry Plateau, with significant out-migration co-occurring towards the Tanzanian border. Generic vulnerabilities in this zone include hot spot combinations of inequality and poor health (both together and separately). Some areas of this zone indicate neither country-specific nor generic vulnerability hot spots. Programming in the Eastern Dry Plateau that helps farmers establish irrigation and enhance soil moisture retention can reduce these vulnerabilities and enhance the resilience of priority crops (cassava, legumes, and maize). Similar to the Eastern Dry Plateau, generic vulnerability indicators for the Northern Depression show a combination of poor health and/or inequality. However, there is an absence of co-occurrence with country-specific indicators in this zone, except for a small area in the southern portion of the zone identified as having a low irrigation area. Food insecurity and inequality are the major generic vulnerabilities found in the Imbo Plain, while combinations of high out-migration and low soil organic carbon overlap with country-specific vulnerabilities in the zone. Programming in the Imbo Plain that supports supply chain development, training and opportunities for youth, as well as enhancing soil health, can address the vulnerabilities in this LHZ.



Generic vulnerabilities (combinations)

- no areas of high vulnerability
- food insecurity only
- inequality only
- poor health only
- food insecurity and inequality
- food insecurity and poor health
- inequality and poor health
- food insecurity, inequality and poor health

Country-specific vulnerabilities (combinations)

- no areas of high vulnerability
- high out-migration only
- low soil organic carbon only
- low irrigation area only
- high out-migration and low soil organic carbon
- high out-migration and low irrigation area
- inequality and poor health
- high out-migration, low soil organic carbon and low irrigation area

Figure 13. Concentration of Generic and Country-Specific Vulnerability Indicators in Burundi

PART 3.

National policy and programming

3.1 Current

A review of climate-related and relevant policies and strategies has been mapped against current investments by the government, multilateral donors, bilateral donors, International Financial Institutions (IFIs), and the private sector to highlight gaps and opportunities for WFP programs in alignment with national objectives (Sustainable Development Goals (SDGs) 2, 13 and 17). This effort was undertaken through a literature review, discussions with the WFP country offices, and KIIs.

While several national policies support development strategies in Burundi, existing barriers prevent the successful implementation of these strategies and stifle progress toward economic growth and food security. Lack of financing is a major hindrance, exacerbated by economic sanctions leveraged against the country during recent periods of political uncertainty, further decreasing investor funding. Burundi's economy is highly dependent on international development assistance that finances over 50% of the national budget. Restrictions imposed on direct budget support contributed to an increase in the government's deficit, limiting its capacity to provide basic services to the population.[51] Development strategies are designed on a nationwide scale which can be theoretical and misaligned with the technical capacities at the local level. Frequent staff turnover of government positions and lack of institutional knowledge is another major impediment to the realization of national development strategies. Without cohesive organizational knowledge, activities are often halted when employees leave and take their knowledge and experience with them. Similarly, programming loses direction due to the churn of government staff, making it difficult for partners to enact cohesive action. There are no known private-sector strategies and finance mechanisms.

3.2 Gaps and opportunities

The Burundian government has laid a foundation of plans and strategies for achieving food security that has enabled myriad opportunities for optimizing policy and programming in Burundi. The next step is to begin to implement these in focused and systematic ways. Widespread poverty among the rural population, food insecurity, undernutrition, gender inequality, high demographic growth and population density, and poor economic and development governance are priority issues to be tackled.[52] Funding for implementation is severely lacking; the use of public and international funds to de-risk the private sector could help pave the way for robust climate-resilient local markets. A diversified agricultural economy (that includes value-added production, capitalizes on digital technologies for extension and marketing, and pioneers low-emission energy sources) would support smallholders in monetizing on-farm production, as well as create off-farm career opportunities that would help address unemployment and would diversify household income sources.[53]

Specific challenges across the value chain have been identified via KIIs with in-country experts. The following observations highlight gaps and pinpoint opportunities for targeted programming interventions to help achieve Burundi's development goals.

AT THE PRODUCTION LEVEL:

- Poor soil quality
- High cost of soil amendments and fertilizers.
- Most people lack access to organic manure because they don't have livestock
- Land parcels are too small to support (semi-)/ intensive livestock systems

- Lack of access to organic manure market
- Pesticides are cost-prohibitive; therefore, people struggle to prevent pests and diseases, resulting in low production and low yield
- Lack of irrigation infrastructure leaves crops dependent on rainfall
- Improved and adapted seeds are inaccessible due to lack of income and lack of training
- Poor availability of certified seeds
- At the level of the national seed certification body, few inspectors come to inspect the fields and certify the seeds (especially if they are appointed at the national level, they are less likely to travel to remote rural areas)
- People do not choose seed varieties resistant to climatic hazards (such as heavy rains, drought, etc.)
- Land is in short supply; many people do not have sufficient land to satisfy their income and food production needs
- Young people often migrate away from rural areas, driving a shortage of agricultural labor
- Few people are trained in agricultural activities, especially among young people
- Few organizations are involved in training young people in the agricultural sector; projects and opportunities are low
- Lack of understanding of how to sustainably intensify agricultural production on small plots of land
- Lack of land management technologies to protect the soil.

AT THE PROCESSING LEVEL:

- Lack of access to energy for food processing
- Processing technologies are scarce, and there is a lack of skilled workers to operate them, where they exist
- No transformation, which means that when there is overproduction, prices become derisory
- There are few or no storage warehouses or conservation tools to store
- Production areas are very remote and disconnected from post-harvest storage opportunities
- Lack of phytosanitary equipment and access to cold room/storage facilities.

IN TERMS OF TRANSPORT:

- Lack of organized transport
- Lack of personal transport (e.g., people carry small loads of product to market in hand or on bicycles, resulting in smaller loads available at market at higher prices)
- Agricultural feeder roads are not well constructed, and vehicles cannot access remote areas to transport produce
- Lack of chilled transport contributes to losses and limits marketing opportunities.

AT THE MARKETING LEVEL:

- Lack of clear policies and industrial strategies to promote agricultural value chain development
- Pre-order/contracting does not exist, especially from consumer associations
- Producers lack power in negotiating sale prices with large consumers such as hotels, secondary schools, etc.
- Producers are price takers rather than price makers (e.g., milk producers underprice products to sell before spoilage occurs, resulting in inadequate incomes and product shortages in the market)
- While some cooperatives receive support from a university, they usually don't have the training to negotiate their prices, contracts, or find the market, etc.
- Television and radios are underutilized to raise awareness and encourage behavioral changes and nutritious consumption.

AT THE FINANCE LEVEL:

- Most households do not have access to microcredit (lack of information)
- Interest rates are high: 16-20%
- Traditional microfinancing schemes (e.g., tontines) are usually sums too low to access needed capital for inputs and equipment; more often, loans are used to educate children and buy food, etc., and less for investment in agricultural activities
- Lack of synergy and coordination among public and private organizations.

PART 4.

WFP activities and recommendations for optimization

4.1 Current programmes

WFP Burundi focuses efforts on core programming, concentrating on food distribution and cash transfers used for asset creation and food security (Table 4). The Food Assistance for Assets (FFA) program enables WFP to support activities that restore the land and generate income and food security for communities. This versatile program holds potential for strengthening landscape-level, climate-impact resilience and stimulating local economies while fulfilling the WFP mission to ensure people have access to safe and nutritious foods. Other programming includes food relief to refugees and school children (Table 4). These activities can synthesize achievements in food security and income generation for farmers and their families (P4P) while also investing in nutrition education and access.

Table 4. Current relevant WFP Burundi activities

Name	Years	Objective	Activities
Burundi Interim Country Strategic Plan	2018-2020	Support achievement of the country's objectives in addressing poverty and undernutrition and ending hunger.	Ensured the timely provision of emergency assistance to the most severely food- and nutrition-insecure populations; food fortification and climate adaptation initiatives; strengthen national safety nets and social protection mechanisms that enable vulnerable people, communities and systems to recover from crisis and prepare better for shocks; increase the food security and incomes of poor rural households, particularly those of women and smallholders; strengthen national-level policies, strategies and sector plans related to zero hunger.
Protracted Relief and Recovery Operation PRRO 200655	2014-2017	Meet the lifesaving needs of refugees, expelled migrants and returnees, and to help rebuild and establish the livelihoods of expelled migrants and returnees, facilitating their integration into host communities.	Provided food and nutrition assistance to Congolese refugees living in camps; Burundian returnees from neighboring countries; and other vulnerable, food-insecure households facing food crisis or sudden shocks.
Country Programme CP 200119	2011-2017	Support the government's efforts to improve food and nutrition security as well as promote sustainable development.	Provided school meals to preschool and primary school children in food-insecure areas; supported smallholder farmers through purchase-for-progress (P4P); supported nutrition activities aimed at preventing stunting for children aged 6-23 months, pregnant and nursing women and girls, and people living with HIV on antiretroviral treatment.

In examining the aforementioned climate risks, climate impacts, current policies, and funding mechanisms, several high-potential food security interventions in alignment with the WFP mandate become clear. These interventions were validated through KIIs and an online workshop. They offer insights into the most impactful potential next steps for WFP activities.

4.2 Climate-proofing current programmes

Emergency response and resilience programming will be essential for preventing the loss of gains made for smallholder support and asset creation if emergency situations or extreme climate events arise. As part of this analysis, in-country stakeholders were convened to identify the most prominent activities toward this end, including the following: energy interventions that reduce the consumption of wood and forestry products for heating and cooking; landscape-level programming that aims to improve resource management of water and soil; adoption of climate-smart agricultural practices and technologies; weather forecasting that prepares farmers for extreme weather events; digital agriculture technologies that expedite knowledge sharing; and private-sector irrigation supply chains. Based on these stakeholder consultations, several opportunities exist to increase resilience and reduce risk within WFP programs and activities and develop cross-sector synergies in achieving national climate change planning goals (Table 5).

Table 5. Reducing climate risk vulnerabilities in current WFP programs

WFP Program	Climate Risks Addressed and Priority LHZ	WFP Activities	Key Risk Reduction Opportunities	Potential Cross-Sector Synergies
School Feeding Programs	Flooding; Landslides LHZ: 1, 2, 4	Improved stoves (clean energy)	Reduce exploitation of wood fuels	Energy; Forestry
		"Energizing school feeding" program	Allows access to energy for food security within community cooperatives near schools	Energy; Value Chain Development
			Enables access to the news	
		Solar furnace initiative Electric cooking in urban and semi-urban areas	Decrease pressure on forests	Energy; Forestry; Education
		Planting fruit trees	Protect the land	Food security

WFP Program	Climate Risks Addressed and Priority LHZ	WFP Activities	Key Risk Reduction Opportunities	Potential Cross-Sector Synergies
Alternative fuels production project	Drought; Water deficit LHZ: 2, 3, 4	Use of crop residues as fuel	Energy; Forestry	
Food for Assets	Drought; Water deficit LHZ: 2, 3, 4	Composting	Generate soil amendment to improve crop yield and soil quality	Agriculture; Soil Health; Food Security
	Flooding; Landslides; Drought; Water deficit LHZ: 1, 2, 3, 4	Community forestry Efficient land management	Improve resource management	Soil Health; Forestry; Watershed Management
	Flooding; Landslides LHZ: 1, 2, 4	Plant high-power absorption plants/ trees	Buffer around flood infrastructure Fight erosion	Soil Health; Forestry
		Promoting clean energy (e.g., biogas, solar ovens)	Decrease pressure on forests	Forestry; Energy
	Flooding; Landslides; Drought LHZ: 1, 2, 3, 4	Planting fruit trees	Build resilience (nurseries, etc.)	Agriculture; Food Security; Nutrition; Forestry; Soil Health
Cash Transfers	Water deficit LHZ: 4	Finance stables for livestock	Reduce ecosystem damage from open livestock grazing; improve livestock production	Forestry; Food Security; Value Chain Development
	Drought; Water deficit LHZ: 2, 3, 4	Improved Seeds (via Partnership with FAO)	Increase production and crop resilience	Agriculture; Food Security
Smallholder Farmer Support (P4P)	Drought; Water deficit LHZ: 2, 3, 4	Large-scale development of short-cycle crops with high nutritional value (e.g., Market gardening)	Improve household nutrition and increase income	Agriculture; Food Security; Nutrition; Value Chain Development
	Flooding; Landslides; Drought; Water deficit LHZ: 1, 2, 3, 4	Improving crop and post-harvest management practices Facilitate access to state-subsidized agricultural inputs and equipment	Intensify production per unit of land; reduction of post-harvest losses and crop conservation	Food Security; Value Chain Development

WFP Program	Climate Risks Addressed and Priority LHZ	WFP Activities	Key Risk Reduction Opportunities	Potential Cross-Sector Synergies
Smallholder Farmer Support (P4P)	Drought; Water deficit LHZ: 2, 3, 4	Processing and small transformation techniques	Strengthen capacity of small producers	Food Security; Value Chain Development
	Drought; Water deficit LHZ: 2, 3, 4	Operationalize alternative energy strategies for food security	Improved conservation technologies	Value Chain Development; Energy; Forestry; Food Security
	Flooding; Landslides LHZ: 1, 2, 4		Decrease pressure on forests	
	Drought LHZ: 2, 3, 4	Expand opportunities for fresh fruits & vegetables	Strengthen marketing channels and increase incomes	Agriculture; Value Chain Development; Food Security
	Drought; Water deficit LHZ: 2, 3, 4	Storage hangars & cold rooms	Improve post-harvest storage infrastructure and reduce post-harvest losses	Food Security; Value Chain Development
	Flooding; Landslides; Drought LHZ: 1, 2, 3, 4	Transport logistic support	Support producers with supply chain efficiency and logistics	Food Security; Value Chain Development
	Water deficit LHZ: 4	Reinforce early warning system capacities	Raise awareness among small producers of seasonal variability	Agriculture
	Drought LH: 2, 3, 4		Develop crop insurance framework (FbF)	
	Water deficit LHZ: 4	Development and promotion of small-scale irrigation and hill irrigation	Promote off-season crops	Agriculture; Value Chain Development; Food Security
			Partner with experienced organizations (e.g., IFAD)	
			Improvement of vegetable gardens	
	Water deficit LHZ: 4	Digital agriculture	Increase productivity and strengthen marketing channels	Agriculture; Value Chain Development; Food Security
Refugee Assistance	Flooding; Landslides LHZ: 1, 2, 4	Improved stoves (clean energy) Waste management	Decrease pressure on forests Increased soil productivity	Energy; Forestry

Reinforcing early warning system capacities creates opportunities for farmers and communities to prepare for climate hazards and react to climate events. Support for weather forecasting, including raising awareness of technology applications for small producers and improving access to energy for devices that provide weather information, will provide farmers with an understanding of local seasonal variations and the resulting impacts on crops. Programming that considers climate-based predictions, such as the Forecast Based Financing (FbF) pilot program, can safeguard WFP activities and achievements by triggering anticipatory actions before a shock occurs. WFP intends to expand the investments from 2020 that have started to establish an anticipatory action system for floods by widening the scope to include FbF for droughts, epidemics, and human-made disasters.

Opportunities exist for increasing resilience against climate and other shocks by improving or developing logistics and transportation systems. These activities include value chain development, improving cold chains, strengthening road networks, optimizing transport, support for processing associations, bulk-buying with contracted retailers, warehouse receipts, barcoding to trace contaminations back to the source, and blockchain tracing, among others. WFP expertise in supply chain logistics can help farmers gain entry to the economies of scale that cooperative and producer groups provide, yield higher and more secure returns, and tap into funding opportunities for warehouse and other infrastructure needs.

4.3 Leveraging climate-proofing for greater integration

Climate resilience offers several leverage points for strengthening integration between different WFP activities. Offering farmers guaranteed pre-season contracts would help link efforts to increase productivity and incomes with school and refugee camp food distribution

programs. Contracting with farmers before sowing enables producers to strategically decide what and when to plant and how to stagger their crops, encouraging diversification of fruit and vegetable crops and allowing for synchronization with local market demand. Where necessary, increased energy requirements should be met by upscaling the generation of renewable energy at the community level. WFP can leverage experience contracting with local cooperatives and private companies for logistics to develop more robust transport and storage networks; improve post-harvest systems; and expand support for the private sector such as milk producers, entrepreneurial agri-producers, small processing units at the community level, and associations transforming local crops into flour (e.g., rice, corn, sorghum, porridge flour, etc.), juice, and rice, etc.

Promoting clean energy, including biogas, solar ovens, and alternative fuels, would help refugee communities and schools better access affordable energy for cooking and lighting. It would also provide direct benefits to the wider community through Food for Assets programming, which can be operationalized to build and promote clean energy technologies by growing and harvesting sustainable fuel alternatives. Additionally, enhanced access to renewable energies would help agricultural cooperatives implement clean production and conservation initiatives. Decreasing exploitation of wood fuels and the accompanying pressure on forests can help to further efforts for resource-management activities such as community forestry and tree planting initiatives. Several stakeholders acknowledge that Burundi is yet well-positioned for biogas programming, which requires a minimum amount of manure and green waste per household. Interim efforts toward biogas feasibility may include agroforestry, silvopastoral systems, and livestock intensification, all of which help augment access to bioresidues.

Training opportunities in agricultural sciences, food processing technologies, supply chain management, and marketing can help increase food production, conservation, storage, and access while creating jobs, especially for youth. Burundi's education system has shown notable progress, with expected years of schooling 6.6. years higher today than in 1990,[54] indicating that more of the population is, and will have, the basic skills necessary to enter a diversifying economy. Robust extension services are needed to help farmers make landscape- and production-level changes to mitigate the risks of climate hazards, increase the efficiency of production, and earn higher returns. Off-farm training in logistics and marketing can cultivate specialists and entrepreneurs that open novel pathways for mitigation and adaptation solutions.

The projected increase in Burundi's total calorie intake per capita (Figure 20 in Annex) offers the opportunity to focus on diet composition. A developing economy's "nutrition transition" from starchy staples to animal calories and other carbohydrate sources is often a transition from starchy carbohydrates to sugary foods and fat calories, with the protein-calorie share of diet remaining constant. Care must, therefore, be taken to promote the replacement of the declining starchy staple share of the diet with the consumption of proteins (whether of animal or vegetable origin), complex carbohydrates, and fibers while keeping the consumption of fats (especially saturated and trans fats) and free sugars below the World Health Organization's recommended levels of 30% and 10% of the diet, respectively.

Climate resiliency efforts have broad stabilizing effects. For example, COVID-19 has drastically impacted WFP activities as a new and constant consideration in programming and has halted the development of some programs. Building resilience for climate and non-climate related risks, including disease, can help put into place the necessary infrastructure, skills, and training needed to increase production and safeguard supply chain networks.

Need of additional contents: .....

PART 5.

Scoping of WFP programmatic partnership opportunities

Based on the opportunities discussed above, several potential programmatic and financial partnerships may prove particularly promising for WFP activities that address the root causes of climate impact at a meaningful scale. Facilitating cooperation with Burundian entities (national and local governments, NGOs, research institutions, civil society groups) and engaging with other developing countries can support progress towards SDG 2 to end hunger and promote sustainable agricultural development. WFP is well-positioned to facilitate several direct exchanges of knowledge, experience, skill, resources, and technical innovation to help address climate and food security challenges in Burundi (Table 6). These activities address gaps at various points of the value chain (discussed in Section 5B) and align particularly with cross-sector synergies in national plans and strategies for energy, forestry, and agriculture. Partnerships can also help ensure that programming outside of WFP's remit, such as agricultural extension services, are effectively implemented in Burundi.

Table 6. Potential programmatic partners and opportunities for South-South cooperation with WFP Burundi

Country/Region/ Organization	Programmatic Area	Of Note
Asia	Increased agricultural production	Development of short-cycle crops; sustainable intensification of agricultural production
China	E-commerce	
	Rice production	High priority for the Burundian government
	Solar energy for food fortifications	Milling, cooling, and drying
Uganda	Increased agricultural production	Small-scale irrigation techniques that could be imported in Burundi
	Biofortified beans	How to leverage procurement to provide more nutritious food and stimulate the market (inception in Rwanda)
Sahelian countries	Increased agricultural production	Management of water deficit issues
Private operators	Post-Harvest	Processing and conservation of agro-pastoral products
Cooperatives and associations	Training/Knowledge	Strengthen processing units for local products instead of exporting raw (explore industrial opportunities)
	Post-Harvest	
University of Burundi	Research/Extension	Research and development of climate-smart technologies
Polytechnic University Gitega		
Climate investment funds (Green Climate Fund, Adaptation Fund, Global Environment Facility, etc.)	Long-term adaptation initiatives	Agricultural value chain development; livelihood diversification; climate information and advisory services; de-risking of the agricultural sector; renewable energy production; upgrading of rural infrastructure

PART 6.

Synthesis

Agriculture plays a key role in livelihoods and food security in Burundi. The country is dependent on rain-fed agriculture and suffers from declining farm sizes and soil fertility, high input costs, lack of training and extension programming, and a dearth of supply chain organization and integration opportunities. Adding to these and other development obstacles, smallholders will increasingly face challenges from climate variability and change with negative impacts on food security, nutrition, and the economy. Temperatures and annual total rainfall are expected to rise, bringing changing patterns, increased incidences of drought and water deficit, flooding, an extended dry (lean) period, and the exacerbation of pests and diseases. Demand for food and per capita caloric intake is expected to increase, creating a reliance on imported products where local production cannot meet rising demand.

To increase climate-resilient practices that can safeguard farmers from these hazards, smallholders must be appropriately equipped with information and tools to help plan and adjust their agricultural activities. Landscape-level programming can help farmers conserve and use water more efficiently; improve and expand natural resources such as forests and watersheds; implement integrated soil and land use management practices; and develop feed formulation and enclosures for livestock. Community-wide energy programming should deter reliance on wood fuels that decrease ecosystem services provided by forests. At the production level, farmers need awareness of and access to improved seed stock; extension services promoting improved crop and post-harvest management practices; early-warning weather information; development of short-cycle crops with high nutritional value; and promotion of small-scale irrigation. Training farmers in how to increase production on small land parcels can support producers in realizing better returns and provide novel opportunities for youth employment. Off-farm activities include support for producer organizations and processing associations to enable economies of scale and link farmers to markets; improved conservation technologies that utilize alternative energy and benefit from value addition; and storage facilities and cold chain development to reduce post-harvest losses and aid food security. Uptake of crop, livestock, health, and weather insurance bundles can reduce risk and aid in crisis intervention.

Burundi is well-versed in the global conversation on climate mitigation and adaptation needs. Numerous national strategies and plans have been designed to guide Burundi's development activities; the challenge is to find alignment across sectors and among actors in achieving climate and development goals holistically. Programming gaps were elicited through stakeholder interviews and workshops. Opportunities for climate-proofing current programming and leveraging climate strategies for great integration across programs are identified. Promising activities include supporting early weather warning systems, developing robust supply chain logistics, promoting clean energy, and implementing extension and technical training programs. Programmatic and financial partnerships with other developing countries, as identified by in-country experts, are another strategy to help Burundi in achieving Zero Hunger and other SDGs.

PART 7.

Annex

Figure 14. IMPACT 2020-2050 Projection of Percentage Changes in Yield, Production, and Area or Animal Numbers for Key Crop and Livestock Commodities

Figure 15. IMPACT Projected Yield, Production, and Area or Animal Numbers for Key Crop and Livestock Commodities in 2020, 2030, and 2050

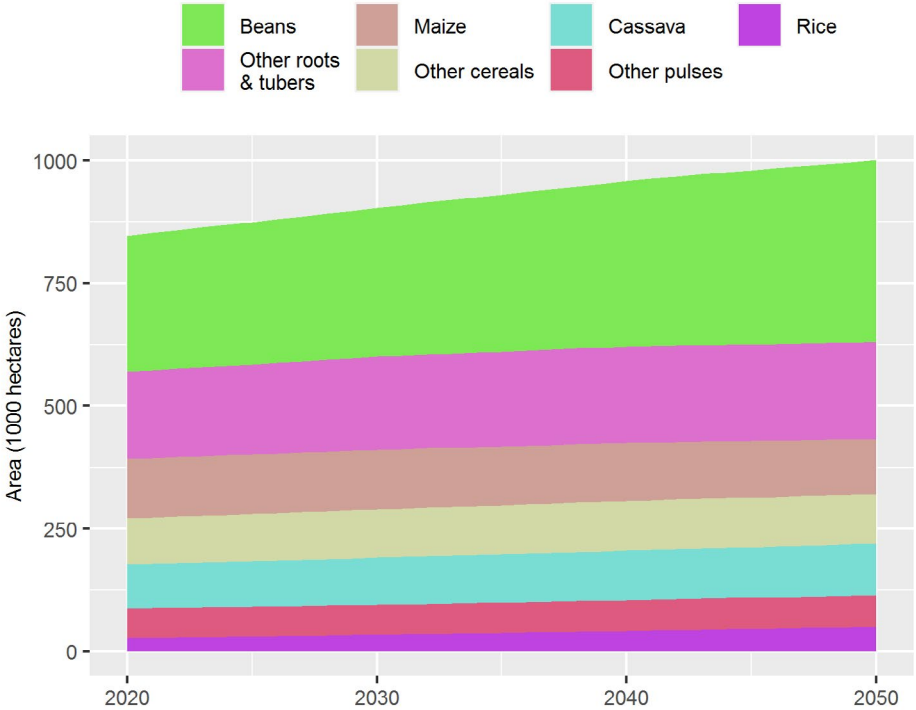


Figure 16. IMPACT 2020-2050 Projection of Harvested Area for Key Crops and Residual Categories

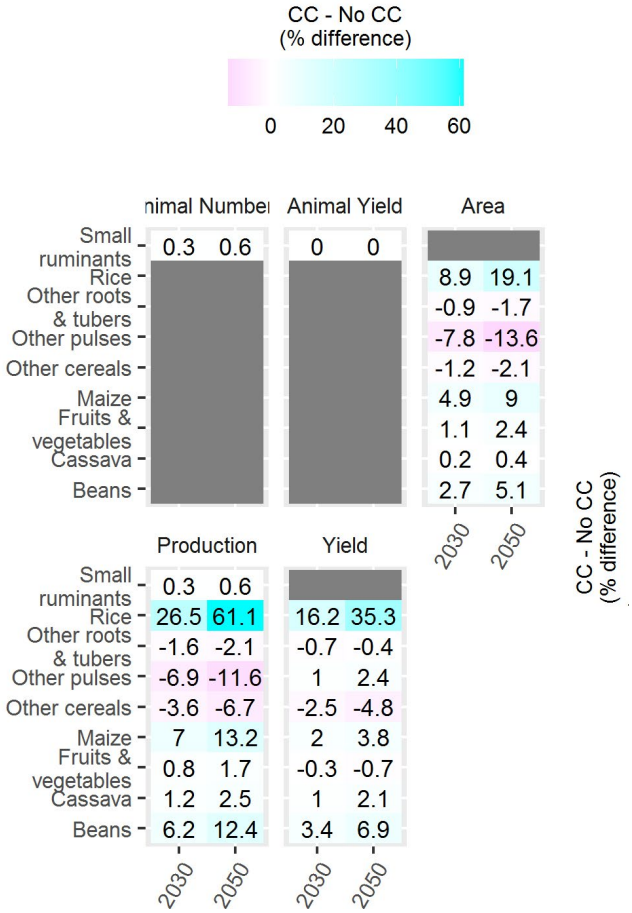


Figure 17. Difference Between CC and No-CC Scenarios for Production, Area, and Yield of Key Crops and Livestock

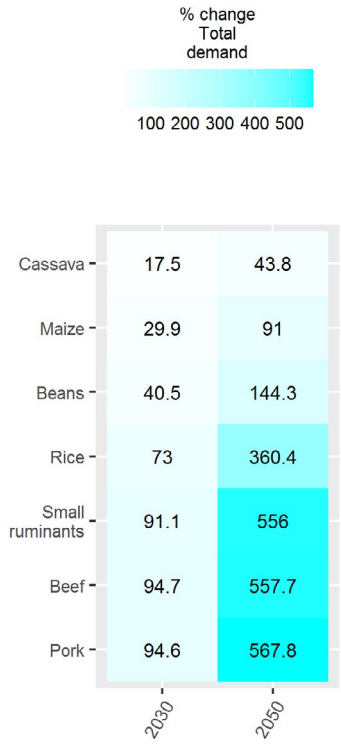


Figure 18. IMPACT 2020-2050 Demand Profiles for Key Crops. The "Other Demand" category "summarizes all other demands for agricultural products from sectors outside of the focus of IMPACT (for example, seeds, industrial use)" (Robinson et al., 2015).

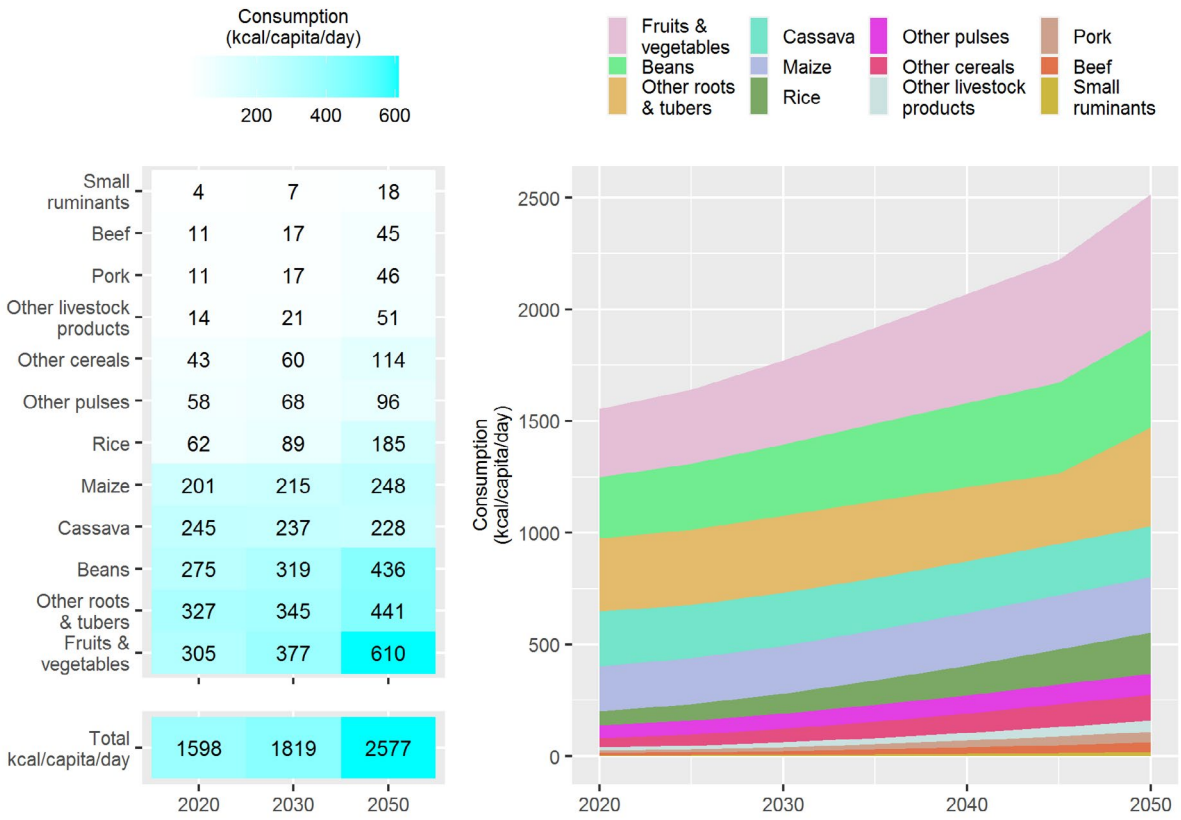


Figure 19. IMPACT 2020-2050 Projection of kcal/capita/day for Key Commodities

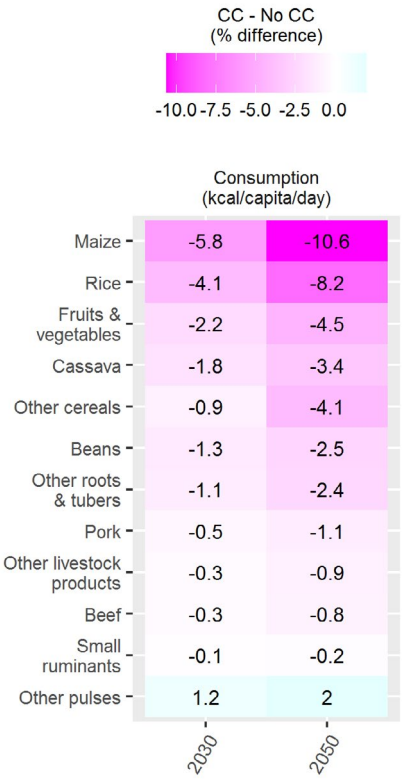


Figure 20. Percentage Difference Between the Consumption (kcal/capita/day) of Key Commodities With and Without Climate Change

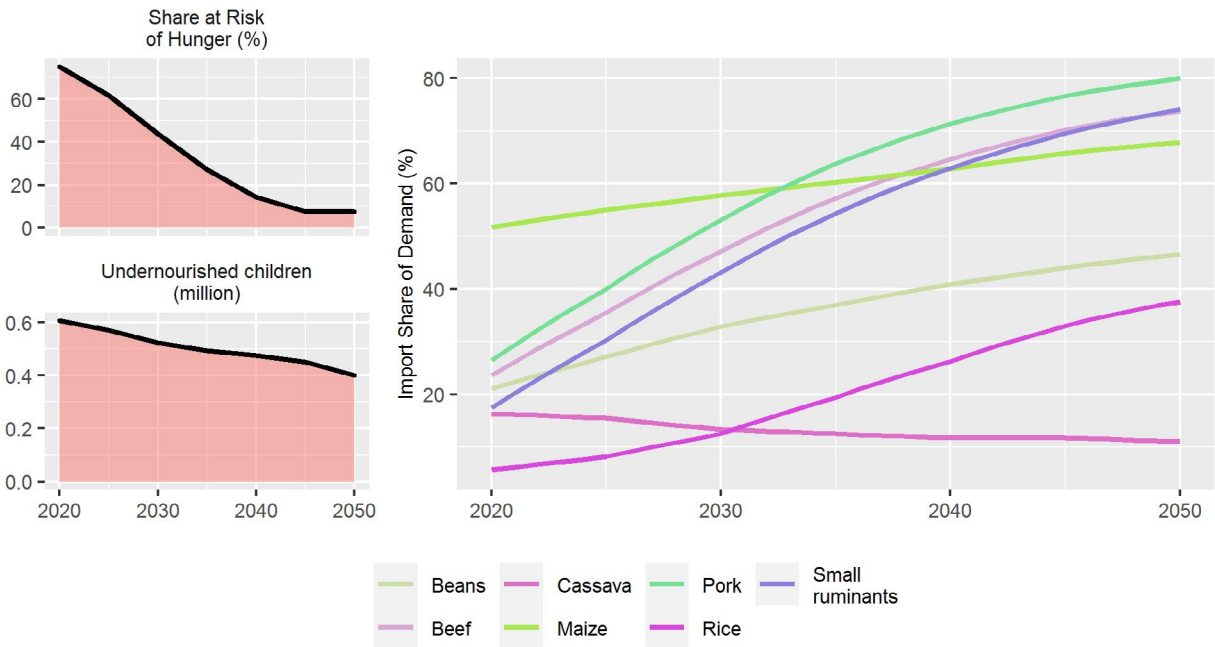


Figure 21. Clockwise from top left: IMPACT 2020-2050 Projection of Undernourished Children, Import Dependence, and Share of Population at Risk of Hunger

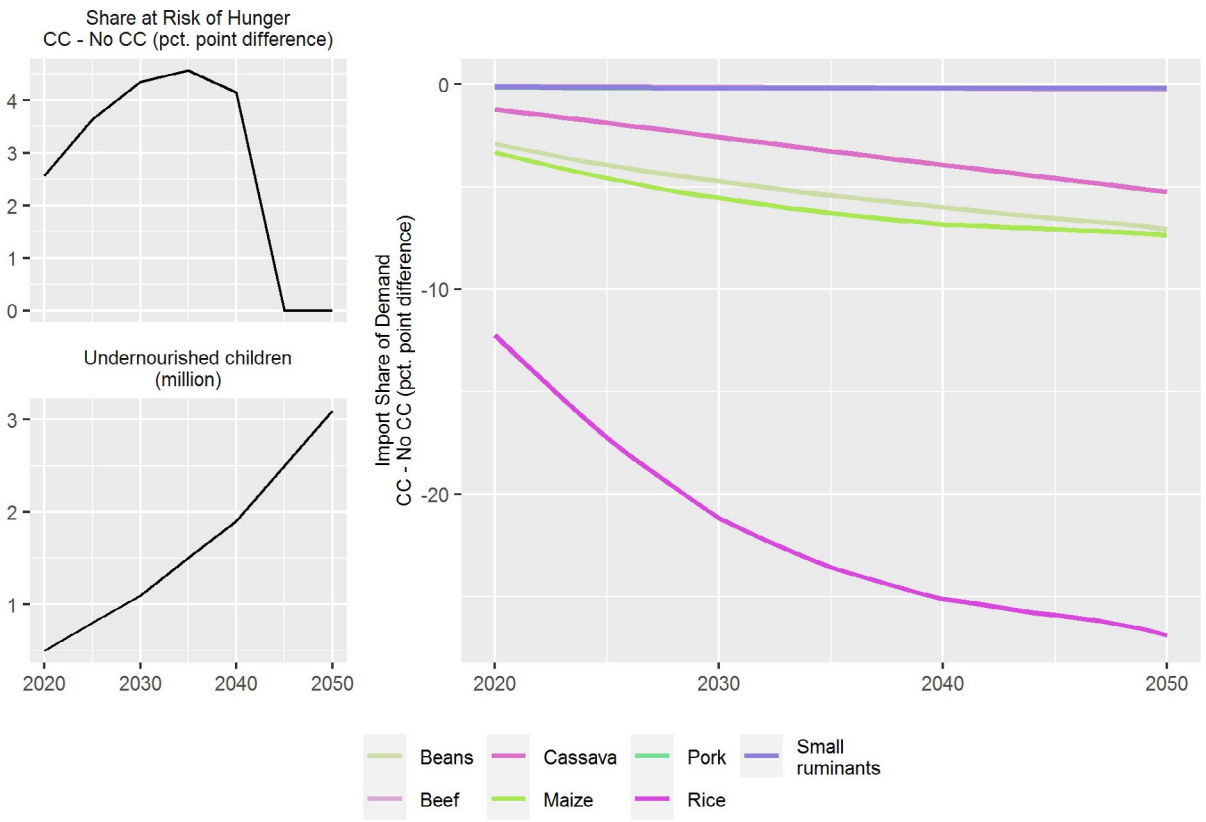


Figure 22. Difference Between CC and No-CC Trajectories for Key Food Security Indicators and Commodities

PART 8.

References

References

African Development Bank. "Burundi Economic Outlook." Text. African Development Bank - Building today, a better Africa tomorrow. African Development Bank Group, 2021. https://www.afdb.org/en/countries/east-africa/burundi/burundi-economic-outlook.

Bennett, M. K. "International Contrasts in Food Consumption." *Geographical Review* 31, no. 3 (1941): 365–76.

Burundi, MPBGP, Burundi, MSPLS, Burundi, (ISTEEBU, and ICF. "Troisième Enquête Démographique et de Santé 2016-2017," Décembre 2017.

Daley, P. "Gender, Displacement and Social Reproduction: Settling Burundi Refugees in Western Tanzania." *Journal of Refugee Studies* 4, no. 3 (1991): 248–66. https://doi.org/10.1093/jrs/4.3.248.

"Gender, Displacement, and Social Reproduction: Settling Burundi Refugees in Western Tanzania." *Journal of Refugee Studies* 4, no. 3 (1991): 248–66.

Drewnowski, A., and B. M. Popkin. "The Nutrition Transition: New Trends in the Global Diet." *Nutrition Reviews* 55, no. 2 (February 1, 1997): 31–43. https://doi.org/10.1111/j.1753-4887.1997.tb01593.x.

Embassy of the Republic of Burundi. "About Burundi," 2021. https://burundiembassy-usa.com/index.php/about/burundi.

FAO. "AQUASTAT Database," 2021. http://www.fao.org/aquastat/statistics/query/results.html.

"Burundi," 2019. http://www.fao.org/faostat/en/#country/29.

"Crop Ecological Requirements Database (ECOCROP)," 2021. https://www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/es/c/1027491/.

Food Security Information Network. "Global Report on Food Crisis 2019," 2019. https://www.fsinplatform.org/sites/default/files/resources/files/GRFC_2019-Full_Report.pdf.

Grebmer, K. von, J. Bernstein, M. Wiemers, K. Acheampong, A. Hanano, B. Higgins, R. Ní Chéilleachair, et al. "2020 Global Hunger Index: One Decade to Zero Hunger - Linking Health and Sustainable Food Systems," 2020.

Index Mundi. "Burundi - Forest Area (% of Land Area)," 2019. https://www.indexmundi.com/facts/burundi/indicator/AG.LND.FRST.ZS.

ISTEEBU. "Burundi - Enquête Sur Les Conditions de Vie Des Ménages 2013," 2013. https://catalog.ihsn.org/index.php/catalog/6495.

Jeníček, V., and Š. Grofová. "Least Developed Countries - The Case of Burundi." Agricultural Economics (*Zemědělská Ekonomika*) 61, no. 5 (June 6, 2016): 234–47. https://doi.org/10.17221/48/2014-AGRICECON.

Kearney, J. "Food Consumption Trends and Drivers." *Philosophical Transactions of the Royal Society B: Biological Sciences* 365, no. 1554 (2010): 2793–2807.

La Banque Mondiale. "Access to Electricity (% of Population) - Burundi," 2019. https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?view=chart&locations=BI.

"Individuals Using the Internet (% of Population) - Burundi," 2019. https://data.worldbank.org/indicator/IT.NET.USER.ZS?locations=BI.

"Land Area (Sq. Km) - Burundi," 2018. https://data.worldbank.org/indicator/AG.LND.TOTL.K2?locations=BI.

"Life Expectancy at Birth, Total (Years)," 2019. https://data.worldbank.org/indicator/SP.DYN.LE00.IN?locations=BI.

"Literacy Rate, Adult Male (% of Males Ages 15 and above) - Burundi," 2020. https://data.worldbank.org/indicator/SE.ADT.LITR.MA.ZS?view=chart&locations=BI.

"People Using at Least Basic Sanitation Services (% of Population) - Burundi," 2017. https://data.worldbank.org/indicator/SH.STA.BASS.ZS?locations=BI.

"Population Ages 0-14 (% of Total Population) - Burundi," 2019. https://data.worldbank.org/indicator/SP.POP.0014.TO.ZS?view=chart&locations=BI.

"Population Density (People per Sq. Km of Land Area) - Burundi," 2018. https://data.worldbank.org/indicator/EN.POP.DNST?locations=BI.

"Population Growth (Annual %) - Burundi," 2019. https://data.worldbank.org/indicator/SP.POP.GROW?view=chart&locations=BI.

"Population, Total - Burundi," 2019. https://data.worldbank.org/indicator/SP.POP.TOTL?locations=BI.

"Poverty Headcount Ratio at National Poverty Lines (% of Population) - Burundi," 2019. https://data.worldbank.org/indicator/SI.POV.NAHC?view=chart&locations=BI.

"Prevalence of Anemia among Women of Reproductive Age (% of Women Ages 15-49) - Burundi," 2019. https://data.worldbank.org/indicator/SH.ANM.ALLW.ZS?locations=BI.

Manishatse, L. J. "No Migratory Locusts' Invasion in Burundi, Ministry of Agriculture Reassures." *IWACU English News Burundi* (blog), February 11, 2020. https://www.iwacu-burundi.org/englishnews/no-migratory-locusts-invasion-in-burundi-ministry-of-agriculture-reassures/.

Ministère de l'Environnement, de l'Agriculture et de l'Elevage. "Stratégie Nationale et Plan d'Action REDD + Burundi." Bujumbura, October 2019. https://bi.chm-cbd.net/sites/test-bi/files/2020-03/strat-nat-plan-act-redd%2B.pdf.

Ludgate, N., and S.J. Tata. "Integrating Gender and Nutrition within Agricultural Extension Services Burundi Landscape Analysis." USAID, September 2015. https://www.agrilinks.org/sites/default/files/resource/files/ING%20Landscape%20Study%20%282016%29%20Burundi%20-%20published%202015_09_28.pdf.

Niyongabo, P., and T. Makonese. "Analysis of Household Energy Uses in Mubuga Informal Settlement, Gitega, Burundi." *Journal of Human Ecology* 57, no. 1–2 (February 2017): 38–46. https://doi.org/10.1080/09709274.2017.1311653.

Observatory of Economic Complexity. "Burundi," 2020. https://oec.world/en/profile/country/bdi?depthSelector1=HS4Depth&depthSelector2=HS4Depth&tradeScaleSelector1=tradeScale0&tradeScaleSelector2=tradeScale0.

Périssé, J., F. Sizaret, and P. Francois. "The effect of income on the structure of the diet." F.A.O. *Nutrition Newsletter* 7, no. 3 (1969): 1–9.

Popkin, B. "Nutritional Patterns and Transitions." *Population and Development Review*, 1993, 138–57.

Republique du Burundi Ministère de l'Environnement, de l'Agriculture et de l'Elevage. "Stratégie Agricole Nationale Du Burundi." Republique du Burundi, 2018. http://extwprlegs1.fao.org/docs/pdf/Bur190783.pdf.

Robinson, S., D. Mason-D'Croz, T. Sulser, S. Islam, R. Robertson, T. Zhu, A. Gueneau, G. Pitois, and M.W. Rosegrant. "The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT): Model Description for Version 3," 2015.

Statista. "East Africa: Extreme Poverty Rate by Country," 2021. https://www.statista.com/statistics/1200550/extreme-poverty-rate-in-east-africa-by-country/.

The Global Economy. "Political Stability by Country, around the World," 2019. https://www.theglobaleconomy.com/rankings/wb_political_stability/.

Tilasto. "Total Area Equipped for Irrigation (Hectare) for Burundi," 2018. https://www.tilasto.com/en/topic/geography-and-agriculture/irrigated-land/total-area-equipped-for-irrigation/burundi.

UNDP. "Gender Development Index (GDI)." Human Development Reports, 2019. http://hdr.undp.org/en/content/gender-development-index-gdi.

Human Development Report 2020: The Next Frontier - Human Development and the Anthropocene. Human Development Report. United Nations, 2020. https://doi.org/10.18356/9789210055161.

WFP. "Burundi," 2021. https://www.wfp.org/countries/burundi.

"HungerMap LIVE," 2021. https://hungermap.wfp.org/.

"World Food Program Burundi Annual Country Report 2019," 2019.

Wirsenius, S., C. Azar, and G. Berndes. "How Much Land Is Needed for Global Food Production under Scenarios of Dietary Changes and Livestock Productivity Increases in 2030?" *Agricultural Systems* 103, no. 9 (November 2010): 621–38. https://doi.org/10.1016/j.agsy.2010.07.005.

World Bank Group. "Burundi Historical Climate Data." Climate Change Knowledge Portal, 2020. https://climateknowledgeportal.worldbank.org/.

World Data Atlas. "Burundi: Arable Land as a Share of Land Area, 1960-2020." Knoema, 2018. https://knoema.com//atlas/Burundi/topics/Land-Use/Area/Arable-land-as-a-share-of-land-area.

PART 9.

Endnotes

1. Daley, "Gender, Displacement and Social Reproduction."
2. Daley, "Gender, Displacement, and Social Reproduction: Settling Burundi Refugees in Western Tanzania."
3. La Banque Mondiale, "Land Area (Sq. Km) - Burundi."
4. FAO, "Burundi."
5. La Banque Mondiale, "Land Area (Sq. Km) - Burundi"; FAO, "Burundi"; World Data Atlas, "Burundi: Arable Land as a Share of Land Area, 1960-2020."
6. FAO, "Burundi"; Tilasto, "Total Area Equipped for Irrigation (Hectare) for Burundi."
7. FAO, "Burundi."
8. Ministère de l'Environnement, de l'Agriculture et de l'Elevage, "REDD+ Strategy Burundi."
9. Embassy of the Republic of Burundi, "About Burundi."
10. World Bank Group, "Burundi Historical Climate Data."
11. Observatory of Economic Complexity, "Burundi."
12. Observatory of Economic Complexity.
13. Republique du Burundi Ministère de l'Environnement, de l'Agriculture et de l'Elevage, "Stratégie Agricole Nationale Du Burundi."
14. Republique du Burundi Ministère de l'Environnement, de l'Agriculture et de l'Elevage.
15. Jeníček and Grofová, "Least Developed Countries - The Case of Burundi."
16. Republique du Burundi Ministère de l'Environnement, de l'Agriculture et de l'Elevage, "Stratégie Agricole Nationale Du Burundi."
17. Nargiza Ludgate and S. Joyous Tata, "Integrating Gender and Nutrition within Agricultural Extension Services Burundi Landscape Analysis."
18. Republique du Burundi Ministère de l'Environnement, de l'Agriculture et de l'Elevage, "Stratégie Agricole Nationale Du Burundi."
19. Niyongabo and Makonese, "Analysis of Household Energy Uses in Mubuga Informal Settlement, Gitega, Burundi."
20. Jeníček and Grofová, "Least Developed Countries - The Case of Burundi."
21. Nargiza Ludgate and S. Joyous Tata, "Integrating Gender and Nutrition within Agricultural Extension Services Burundi Landscape Analysis."
22. Index Mundi, "Burundi - Forest Area (% of Land Area)."
23. UNDP, "Gender Development Index (GDI)"; La Banque Mondiale, "Population, Total - Burundi."
24. La Banque Mondiale, "Population Density (People per Sq. Km of Land Area) - Burundi"; La Banque Mondiale, "Population Growth (Annual %) - Burundi."
25. La Banque Mondiale, "Population Ages 0-14 (% of Total Population) - Burundi"; La Banque Mondiale, "Life Expectancy at Birth, Total (Years)."
26. UNDP, *Human Development Report 2020*.
27. WFP, "World Food Program Burundi Annual Country Report 2019."
28. ISTEEBU, "Burundi - Enquête Sur Les Conditions de Vie Des Ménages 2013."
29. Statista, "East Africa"; La Banque Mondiale, "Poverty Headcount Ratio at National Poverty Lines (% of Population) - Burundi"; African Development Bank, "Burundi Economic Outlook."
30. UNDP, *Human Development Report 2020*.
31. Food Security Information Network, "Global Report on Food Crisis 2019."
32. The Global Economy, "Political Stability by Country, around the World."
33. Jeníček and Grofová, "Least Developed Countries - The Case of Burundi."
34. Burundi, MPBGP et al., "Troisième Enquête Démographique et de Santé 2016-2017."
35. La Banque Mondiale, "Access to Electricity (% of Population) - Burundi"; La Banque Mondiale, "People Using at Least Basic Sanitation Services (% of Population) - Burundi"; FAO, "AQUASTAT Database."
36. UNDP, *Human Development Report 2020*.
37. La Banque Mondiale, "Literacy Rate, Adult Male (% of Males Ages 15 and above) - Burundi"; La Banque Mondiale, "Individuals Using the Internet (% of Population) - Burundi."
38. Burundi, MPBGP et al., "Troisième Enquête Démographique et de Santé 2016-2017."
39. Burundi, MPBGP et al.
40. WFP, "HungerMap LIVE."
41. von Grebmer et al., "2020 Global Hunger Index: One Decade to Zero Hunger - Linking Health and Sustainable Food Systems."
42. FAO, "Burundi."
43. La Banque Mondiale, "Prevalence of Anemia among Women of Reproductive Age (% of Women Ages 15-49) - Burundi."
44. WFP, "Burundi."
45. FAO, "Crop Ecological Requirements Database (ECOCROP)."

46. Taylor et al., (2012) "An Overview of CMIP5 and the Experiment Design".

47. Popkin, "Nutritional Patterns and Transitions"; Kearney, "Food Consumption Trends and Drivers."

48. Wirsenius, Azar, and Berndes, "How Much Land Is Needed for Global Food Production under Scenarios of Dietary Changes and Livestock Productivity Increases in 2030?"

49. Bennett, "International Contrasts in Food Consumption."

50. Périssé, Sizaret, and Francois, "The effect of income on the structure of the diet"; Drewnowski and Popkin, "The Nutrition Transition"; Kearney, "Food Consumption Trends and Drivers."

51. WFP, "World Food Program Burundi Annual Country Report 2019."

52. WFP.

53. WFP.

54. UNDP, *Human Development Report 2020*.