CHAPTER 3

The Impact of Climate Change on African Economies and Opportunities for Agrifood System Transformation

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Introduction

As in the rest of the world, the climate is changing in Africa, with data showing a slightly faster warming trend than the global average of around +0.2°C per decade for the 1991–2022 period. In Africa, the average rate of change of temperature was around +0.3°C per decade between 1991 and 2022, while it was estimated at +0.2°C per decade between 1961 and 1990. In addition, all six African subregions have experienced an increase in warming over the past 60 years compared with the period before 1960. Due to global warming, Africa is observing a change in precipitation patterns, a rise in sea level, and an increase in the frequency and intensity of extreme weather events such as droughts, floods, extreme heat, and cyclones (WMO 2023). For instance, the report on the State of the Climate in Africa in 2022 (WMO 2023) showed that precipitation anomalies were above the 1991–2020 average in northeastern Africa, large parts of West Africa, the eastern Sahel region, Sudan, and parts of South Africa. In addition, several regions experienced rainfall deficits including the western part of North Africa, the Horn of Africa, portions of southern Africa, and Madagascar. Sea level rise in Africa's seven coastal regions has been similar to the global sea level average rate of increase of 3.4 millimeters (plus or minus 0.3 millimeters) per year between 1990 and 2020. In addition, extreme weather events are growing in frequency and intensity. With respect to extreme weather events including droughts, floods, extreme heat, and cyclones, data from the Emergency Event Database in Africa showed that 80 meteorological, hydrological, and climate-related hazards were reported in 2022 (WMO 2023).

Extreme weather events such as droughts, floods, extreme heat, and cyclones are negatively impacting economies and displacing communities (WMO 2023). For example, Morocco was affected by four heat waves, each lasting between five and eight days, between May and July 2022. In addition, the period from September 2021 to August 2022 was recognized as the country's driest agricultural year recorded in the last 40 years, leading to forest fires in the northern region of Morocco (Larache, Tetouan, Ouezzane, and Taza), ravaging an area of 10,000 hectares due to the effect of high temperatures. Throughout Africa, economic damages due to extreme weather events were estimated at US$8.5 billion, and more than 110 million people were directly affected by these disaster events in 2022. Drought was identified as the leading cause of death from climate hazards, while economic damages were mainly attributable to floods. These estimates could be even higher due to underreporting. Climate change poses the greatest threat to poor and highly vulnerable countries, which have contributed the least to global greenhouse gas emissions. Data show that 9 of the 10 most vulnerable African countries are south of the Sahara: Central African Republic, Chad, Democratic Republic of Congo, Eritrea, Guinea Bissau, Liberia, Niger, Sudan, and Zimbabwe (University of Notre Dame 2021). Furthermore, West Africa, East Africa, and Central Africa have been identified as global hotspots of human vulnerability to climate change by the Intergovernmental Panel on Climate Change (IPCC 2022).

Climate change affects development in Africa through several economic channels, with one of the clearest impacts being the decline in crop yields due to changes in temperature and precipitation patterns. Extreme weather events such as droughts and floods are being exacerbated by climate change, causing widespread crop failures, livestock losses, and food shortages in many African countries. Studies have shown that increased temperatures and erratic rainfall are leading to reduced agricultural productivity in countries such as Ethiopia, Kenya, Nigeria, and South Africa (Kumar 2022). In addition, climate change disrupts food supply chains, which puts agrifood systems at the center of climate policy. All these negative effects have direct and grim implications for food and nutrition security, livelihoods, and overall well-being, especially for poor and vulnerable people. These impacts are also exacerbating poverty and inequality, as agriculture is a primary source of livelihood for millions of people in Africa, especially in rural areas. Furthermore, in most African countries, climate change impacts may extend beyond agrifood systems due to the agricultural sector's importance in many African countries' economies and its interlinkages with the rest of the economy. The objective of this chapter is to analyze the impact of climate change on African economies, with an emphasis on the agrifood system and opportunities for its transformation. The chapter's methodology relies on reviewing existing evidence on the impacts of climate change on the macroeconomy and agrifood systems.

The rest of this chapter is organized as follows: the second section reviews the macroeconomic impact of climate change. It discusses the impact pathways of climate change's effects on the macroeconomy and reviews empirical evidence of these macroeconomic effects. The third section focuses on agrifood systems and climate change issues. It provides an overview of characteristics of agrifood systems and examines how climate change affects food system activities and actors. The fourth section identifies select opportunities and barriers for African food systems transformation under climate change. The conclusion summarizes the findings and describes policy implications.

Macroeconomic impacts of climate change

Impact Pathways of Climate Change on the Economy

Climate change threatens the growth of African countries due to their limited resilience against its negative impacts. Climate change can impact economies through several channels, including changes in productivity, employment, prices, and trade. Productivity changes in agrifood systems—especially at the production level—can affect the entire economy, depending on the importance of agriculture and agricultural dependence on rainfall. Changes in agricultural value added will directly affect economic growth and food supply (and hence food security). Therefore, given the dependence of GDP growth on agricultural growth in many African countries, the effect of climate change on economic growth could be significant. Quantitative evidence grounded in empirical data shows that climate change might result in lower economic growth (AfDB 2019). For instance, estimates shows that the decline in rainfall between the 1960s and 1990s in much of Africa south of the Sahara significantly contributed to reduced agricultural production and growth rates. That rainfall decline accounted for a drop of about 9–23 percent in per capita GDP in Africa south of the Sahara relative to levels without such a decrease in rainfall (Barrios 2008). Fiscal balance and government budgeting is another channel through which climate change could affect economies. Under climate change, African governments could experience increasing pressure on budgets and fiscal balances. Climate extremes could lead to increased government expenditure and a reduction in tax revenue, ultimately resulting in an increase in government debt. The negative consequences of climate change could expand further if African countries cannot invest in adequate measures to adapt to long-term changes in precipitation and temperature, or in emergency relief (AfDB 2019). Climate change can also impact employment in the wider economy, since the agrifood system is a significant employer in many African countries. For instance, in West African countries, agrifood systems generate 40 percent of regional GDP, around US$260 billion (Ghins and Zougbédé 2019). In addition, they account for most jobs: around 66 percent of total employment, or 82 million jobs, as of 2017. Of these jobs, 78 percent (64 million jobs) in West Africa are in agriculture, while 15 percent (12 million jobs) are in food marketing, and 5 percent (4 million jobs) are in food processing (SWAC and OECD 2022). Since food prices constitute a significant share of general consumer price in most African countries, changes to food prices directly affect inflation, an important macroeconomic variable.

Table 3.1 shows that agriculture represents a significant share (23–35 percent) of GDP in Ethiopia, Kenya, Rwanda, Tanzania, and Uganda. As a result, climate change could potentially have significant effects on economic growth and the macroeconomies of these countries. In addition, food and nonalcoholic beverages have considerable weight in the consumer price index of

TABLE 3.1—SHARE OF AGRICULTURE IN GDP AND FOOD WEIGHT IN FIVE EAST AFRICA REGION COUNTRIES

Country	Population in millions (2020) [% Rural]	Agriculture shares in GDP (2021)	Food and nonalcoholic beverages weight in CPI (2021)	Major exports
Ethiopia	118 (80%)	35%	54%	Coffee, cut flowers, oil seeds, chat/khat, pulses, gold
Kenya	54 (72%)	23%	33%	Tea, cut flowers, coffee spices, vegetables, trees
Rwanda	13 (82%)	27%	27%	Coffee, live bovine cattle, tea, precious metals, pearls, gold, niobium or zirconium ores and concentrates
Tanzania	60 (65%)	30%	28%	Tobacco, coffee, cotton, cashew nuts, tea and cloves, fruit nuts (majors are manufacturing, mineral, etc.)
Uganda	46 (75%)	25%	27%	Coffee, tea, cotton, oil and fish, cereals, pearls, precious stones

Source: Geda et al. (2023).

each country, which shows the significant impact of agriculture (especially food production) on inflation in the East African region.

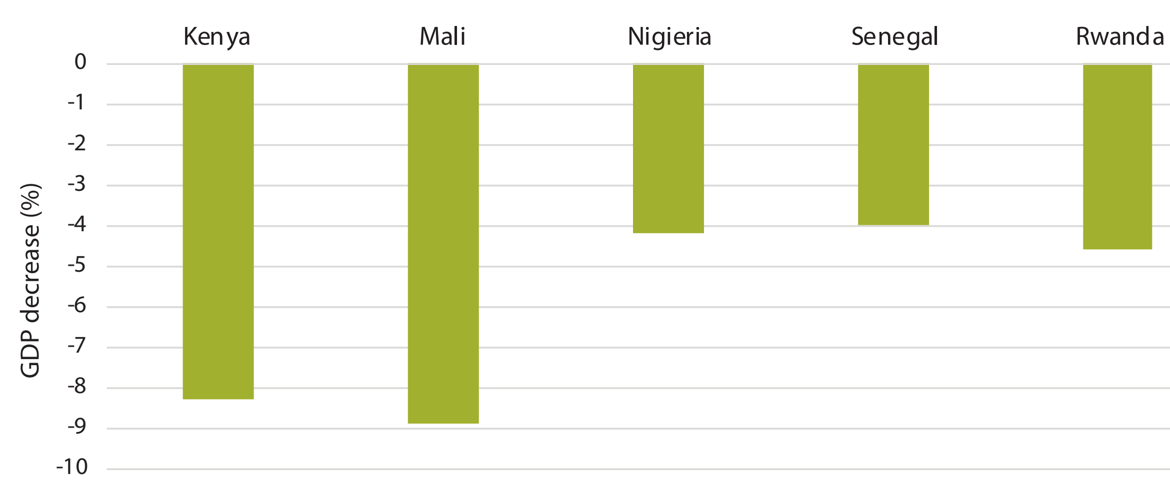
Furthermore, impacts of climate change may be channeled to economies through trade, as African countries depend on exports of agricultural commodities that are crucial to their macroeconomies. Climate change may affect their comparative advantage in the agricultural sector and therefore result in changes in the composition of trade flows as producers respond to new conditions (Mahofa 2021). A study that explored the impact of climate change on agricultural trade, particularly trade in major cereals (maize, millet, rice, sorghum, and wheat), within Africa south of the Sahara found that by the 2050s, climate change will increase most countries' need to import cereals (Mahofa 2021).

Empirical Evidence of the Macroeconomic Effects of Climate Change

The literature on economic growth generally confirms the detrimental economic impacts of climate, though to varying degrees across countries and regions depending on different indicators of climate change and economic health, as well as the existence of mitigation and adaptation policies. Estimates from AKADEMIYA2063 studies show that climate change has a potential adverse impact on GDP and other macroeconomic variables (Fofana 2023a, 2023b; Fofana and Diallo 2024; Okodua et al. 2024; Okodua et al., forthcoming). Figure 3.1 displays the GDP decrease associated with climate change in five African countries: Kenya, Mali, Nigeria, Senegal, and Rwanda. The studies used computable general equilibrium models for ex ante analysis of climate change.

The declines in GDP range from 4.0 to 8.9 percent across the five countries. In addition, the study in Kenya found that the declines in agricultural value added due to climate change have significant implications for the whole economy (Fofana 2023a). The share of agriculture, industry, and services in the Kenyan economy were estimated at 37 percent, 18 percent, and 45 percent, respectively, in 2019. Several nonagricultural industries are adversely impacted by climate change shocks in the agricultural sector through direct exposure (via forward and backward linkages) with the agricultural sector or by indirect exposure through declining overall economic performance. For instance, the chemical and petroleum product industry is also affected by climate change shocks (-6.5 percent decrease of value addition) because of its high dependency on agricultural products (47 percent of total input costs) and the high share of agricultural demand in total industry demand (39 percent). Construction value added also declines substantially (-5.1 percent) because of its dependency on forestry products (13 percent of total input costs). The contraction of the agricultural sector is primarily responsible for the shrinking GDP, contributing up to 68 percent to this decline. The industry and service sectors also contribute significantly to declining GDP (11 percent and 21 percent, respectively). Similarly, in Nigeria, the decline in GDP is mainly due to the shrinking agricultural sector, which contributes about 64 percent to the reduction in GDP, followed by the industrial sector (21 percent) and services sector (15 percent). Furthermore, the study found that the impacts of climate change on employment would disproportionately impact low-skilled laborers, with a decrease of -5.4 percent

FIGURE 3.1—GDP DECREASES ASSOCIATED WITH IMPACTS OF CLIMATE CHANGE



Source: AKADEMIYA2063 studies (Fofana 2023a, 2023b; Fofana and Diallo 2024; Okodua et al. 2024; Okodua et al. forthcoming).

in the number of jobs, compared with their medium-skilled (-4.6 percent) and high-skilled (-4.6 percent) counterparts.

In addition, a study of Cameroon using similar approach as the AKADEMIY2063 studies found that the effects of climate change are transmitted to the nonagricultural branches mainly through the intermediate consumption channel. Value added declines significantly in the health and social work sector (between -5.6 percent and -8.6 percent), the food industry (-7.4 percent and -3.6 percent), trade (-1.5 percent and -2.5 percent) and education (-1.2 percent and -2.6 percent). There is also a decline in the value added of the construction sector, which is partly explained by the fact that when household incomes fall, there is less investment in construction. Consequently, there will either be an increase or a decrease in the demand for labor in response to an increase or decrease in value added in the nonagricultural branches. However, value added improves significantly in public administration (1.1 percent and 2.0 percent), livestock and hunting (1.7 percent and 2.9 percent), and forestry (1.6 percent and 2.1 percent). In terms of employment, climate change has a negative effect on workers in formal nonagricultural sectors. Reduced production means formal firms are required to hire less-skilled and unskilled workers. Female workers are the most affected, regardless of their level of skills or the climate change scenario (for the optimistic scenario, -0.4 percent for skilled female formal workers versus -0.2 percent for skilled male formal workers, and -0.4 percent for unskilled female workers versus -0.3 percent for unskilled male workers). Formal workers who could not find work move to the informal sphere. As a result, there is an increase in informal work regardless of the level of skill. At the macroeconomic level, the simulation results reveal a -0.7 percent decline in real gross fixed capital formation and a -0.8 percent decline in real GDP (Takamgno et al. 2023).

Another study of five East African countries (Ethiopia, Kenya, Rwanda, Tanzania, and Uganda) using theoretical models from the macroeconomic and macroeconometric literature confirms that the macroeconomic effects of climate change in the region present a real threat to the economies of these five countries. Specifically, the study found that climate change negatively affects the region's economic growth (total output), agricultural output, exports, food production, and inflation. The effect of climate change on these major macroeconomic variables, which are closely watched by policymakers, has a significant impact on the region's macroeconomy. In addition, in the current and coming three decades (2020–2050), climate change could reduce total GDP and agricultural GDP by 7 percent and 11 percent, respectively. This effect, however, varies significantly across countries due to differences in vulnerability and adaptation capacity: Ethiopia could see the highest reductions in GDP and agricultural output of 14.7 and 20.5 percent, respectively. In contrast, Tanzania would see the smallest effects, with a loss of 2.5 and 3.9 percent in GDP and agricultural GDP (Geda et al. 2023).

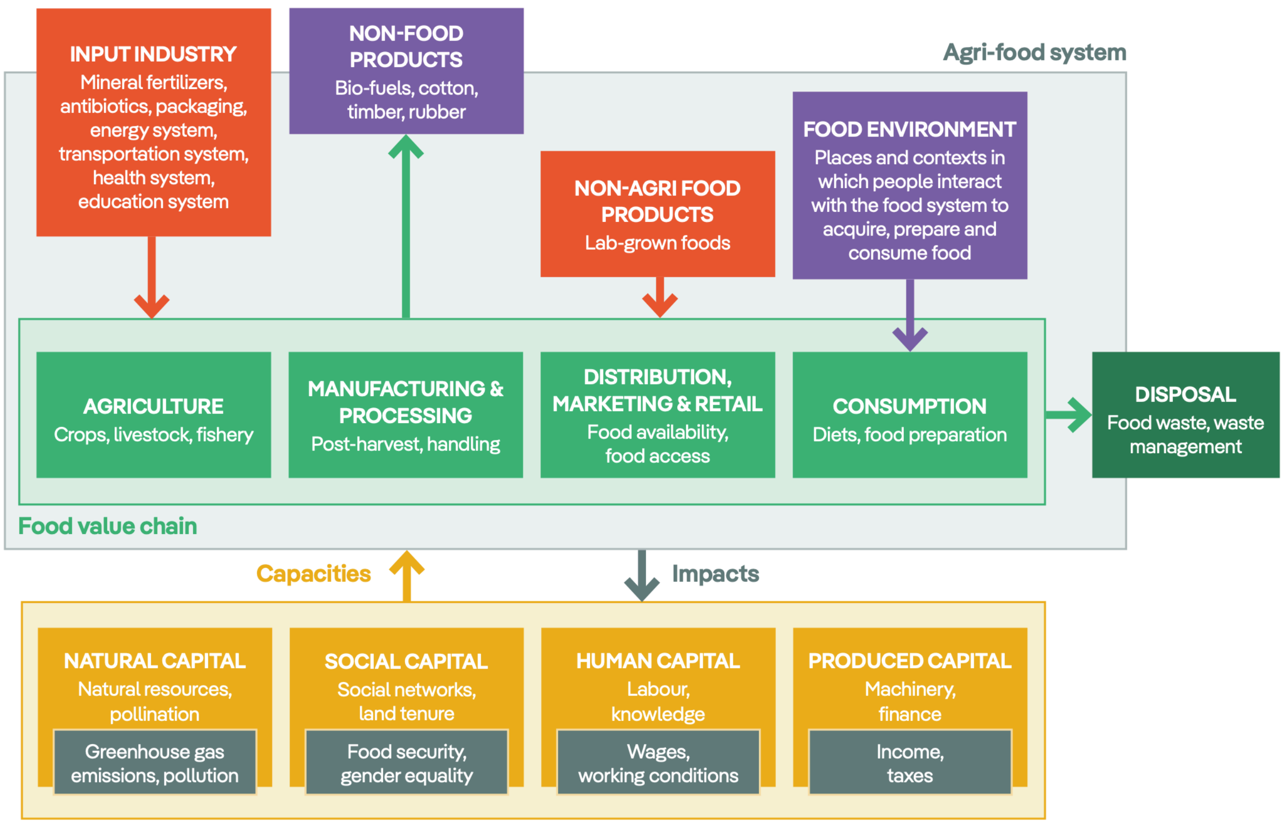
Evidence at the regional level shows that all African regions will be impacted by climate change. For instance, an African Development Bank study in 2019 on the macroeconomic effects of climate change found that negative impacts throughout all African regions would progressively compound and lead to decreasing GDP per capita. The warming scenarios entail losses by 2030 (as compared with a baseline GDP per capita scenario) that range from -0.6 percent in northern Africa in the low-warming scenario, to -3.6 percent in eastern African in the high-warming scenario (AfDB 2019).

Agrifood System Transformation and Climate Change

Characterization of Agrifood Systems

Given that climate change may severely affect agrifood systems, which are important components of economies, further understanding of these systems is needed to mitigate the macroeconomic impacts of climate change. According to the Food and Agriculture Organization of the United Nations, the agrifood system includes the entire range of actors and their interlinked value-adding activities in the primary production of food and nonfood agricultural products, as well as in food storage, aggregation, postharvest handling, transportation, processing, distribution, marketing, disposal, and consumption, as displayed in Figure 3.2 (FAO 2022). Therefore, the agrifood system is broader than the food system. The agrifood system depends on several nonfood supply chains for the purchase of inputs (such as fertilizer, pesticide, and farm and fishing equipment) and the provision of intermediate inputs to produce nonfood commodities (such as maize for biofuel production or cotton for textiles). Therefore, the key actors in agrifood systems include producers, those providing postharvest services (such as storage, transportation, food processing, food distribution and marketing [wholesale and retail]), and the final consumers, as well as input providers (FAO

FIGURE 3.2—CONCEPTUAL FRAMEWORK OF AGRIFOOD SYSTEMS



Source: FAO (2022).

2022). The contribution of the agrifood system to GDP and employment varies from one country to another. For instance, data from Ethiopia show that the agrifood system accounted for more than 48.0 percent of the country's national GDP and 77.2 percent of employment. In addition, primary agriculture alone contributed more than one-third of GDP and two-thirds of employment (Diao et al. 2023a). However, data from Zambia show that the agrifood system accounted for 15.4 percent of Zambia's national GDP and 51.1 percent of employment in 2019. Primary agriculture was only 3.1 percent of total GDP and accounted for 37.3 percent of total employment (Diao et al. 2023b).

The agrifood system and its diverse production systems are influenced by broader economic, social, and natural environments. Therefore, the agrifood system evolves as an economy undergoes transformations as part of a country's development (Diao et al. 2010). During the earliest stages of development, agriculture is dominated by subsistence farming. Following an increase in agricultural productivity, surplus production is supplied by farmers to markets, creating job opportunities for workers in the nonfarm economy both within and outside the agrifood sector (Haggblade et al. 2007). Then, demand for more diverse products is generated due to rising rural incomes, leading to more nonfarm activities such as processing, packaging, transporting, and trading. In other words, the agricultural sector drives rural—and even national—economic growth during the early stages of transformation. However, urbanization, the nonfarm economy, and nonagricultural incomes are the engine of agrifood system development, with urban and rural nonfarm consumers creating most of the demand for agricultural outputs via value chains that connect rural areas to towns and cities. In addition, the exact nature of this transformation process varies across countries because of the diverse structure of their economies and the unique growth trajectories of their various agrifood and nonfood subsectors (Diao et al. 2023a).

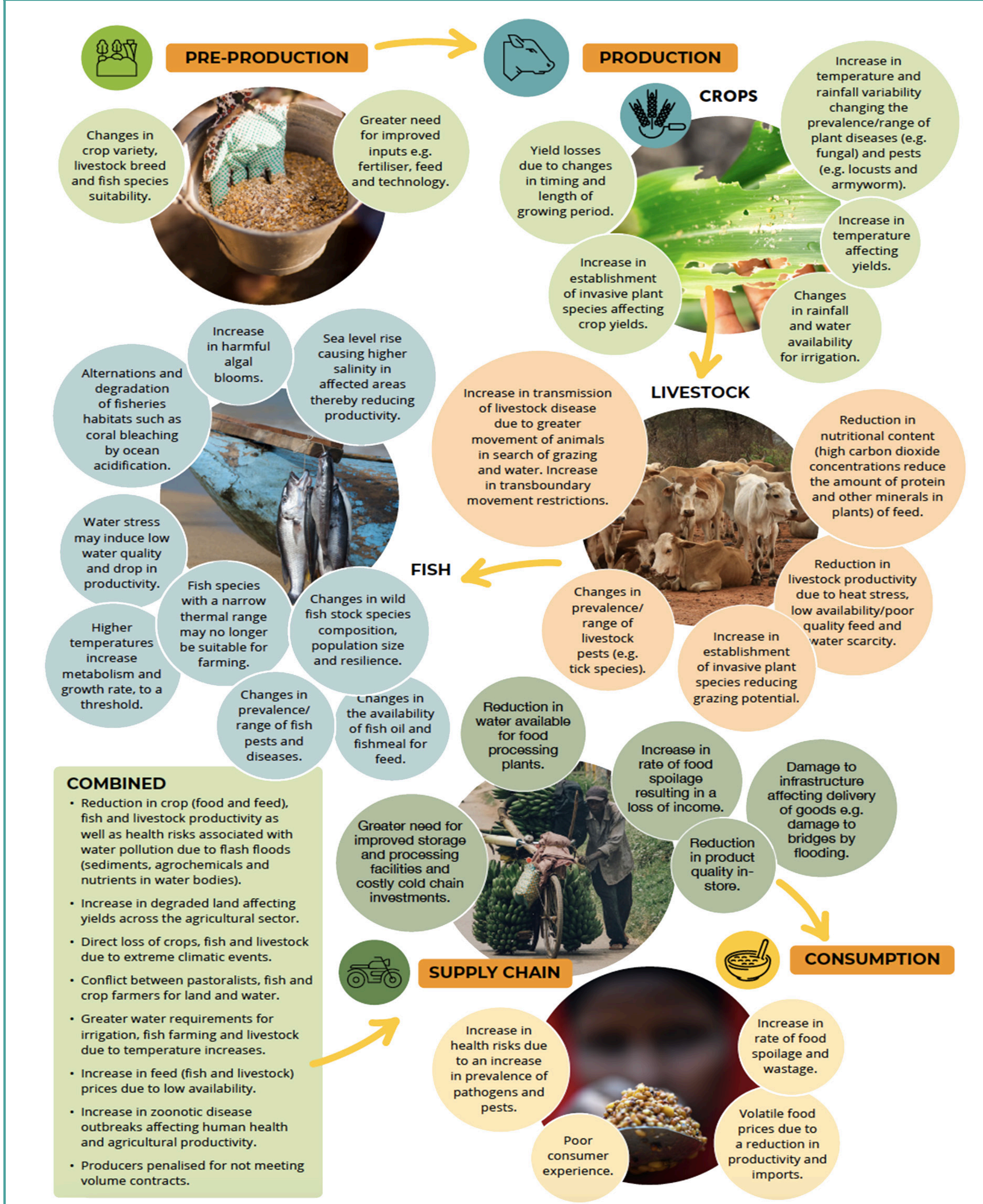
As agrifood systems gradually develop and evolve amid the transformation of economies, three stages can be identified—traditional, transitional, and modern—even though these are not distinct or clearly delineated stages, given that transformation is a continuous process. Traditional agrifood systems are mainly located in rural and coastal areas and serve local populations; modern agrifood systems focus on serving urban populations from diversified sources, including global markets; and transitional agrifood systems are in a phase of change from traditional to modern (FAO 2021). In addition, there are not only differences across countries, but agrifood systems within countries may be at different stages of development depending on location or the sectors of the economy they serve. Differences can occur in terms of structure or access to markets and services, or interactions with other systems. The ability of agrifood systems to prevent, anticipate, absorb, adapt, and transform rapidly in the face of shocks and stresses depends on their characteristics. For instance, traditional agrifood systems are vulnerable to local shocks due to their lack of adequate infrastructure and access to inputs, markets, and services such as credit and their higher vulnerability to weather conditions. The occurrence of a shock such as a flood affects the whole system, including actors, who may be severely affected by negative short- to long-term implications for food security and livelihoods. However, modern and transitional agrifood systems may be affected by the same event in different ways, depending on their scale of operations, the structure and contracting process between actors, the level of "risk-proofing" of infrastructure and capacities, and access to inputs and services such as climate risk insurance. However, modern and transitional food systems may be more vulnerable to shocks transmitted from elsewhere due to the higher interconnections and interdependences of activities and actors within them (FAO 2021).

Impact of Climate Change on Agrifood Systems

The heavy dependence on climatic, biological, physical, and chemical processes makes agrifood systems potentially vulnerable to multiple climate shocks, including extreme weather events, pest and disease outbreaks, water scarcity, and deteriorating natural resources. In addition, existing structural deficiencies such as inadequate roads, power, irrigation, clean water, processing, storage, and marketing infrastructure amplify the effects of climate shocks on agrifood systems. These deficiencies act as geographic and economic barriers that limit opportunities to develop businesses and access services, as well as creating high exposure to local weather conditions. In addition, the impacts of climate change on different components of the agrifood system vary due to the diverse characteristics of these systems, level of risk, and inherent vulnerabilities and capacities, all of which determine their susceptibility to adverse shocks and stresses. In other words, the same shock or stress may have different impacts across different components. For instance, the agricultural sector is disproportionately vulnerable to adverse climate-related events, especially droughts, floods, and storms, due to its reliance on natural processes. A study comparing climate change and business-as-usual (BaU) scenarios through the use of a computable general equilibrium model found that shocks from climate change have a significant impact on Kenya's agricultural productivity (Fofana 2023a). While BaU scenarios predict a 2.4 percent average annual increase in productivity compared with 2019 levels, climate change scenarios forecast a severe decline of 9.7 percent annually. This translates to a decline of 12.1 percent to 15.3 percent in productivity under climate change scenarios compared with BaU scenarios. All agricultural activities are affected, with fisheries and forestry being the most impacted, followed by livestock, coffee, tea, cereals (except rice), oil seeds, and vegetables. However, rice, fruit, nuts, and sugarcane exhibit lower susceptibility to climate change shocks. Another study from Mali using a similar approach also found a significant reduction in agricultural productivity due to climate change shocks. Under BaU scenarios, agricultural productivity would experience a slight increase, while climate change shocks would lead to a severe decline of 13.3 percent on average. This results in an average annual decrease of 14.2 to 16.7 percentage points in agricultural productivity under climate change scenarios compared with BaU scenarios. All agricultural activities are affected, with maize, oilseeds, fisheries, and livestock being the most impacted, followed by rice, vegetables, sugarcane, and roots and tubers. Cotton and forestry activities are less affected by climate change shocks (Fofana et al. 2023). In addition, the interlinked nature of agrifood system components means that their characteristics will determine how each is affected as the impact of a shock or stress reverberates through the system. The degree of diversity and connectivity of food distribution networks also shapes the impacts of shock events.

Figure 3.3 shows that climate change affects agrifood systems through multiple channels, and all components are likely to be affected to varying degrees (Thornton et al. 2022). At the preproduction or planning level, climate change affects the suitability of crop varieties, livestock breeds, and fish species. Therefore, there will be a greater need for improved inputs such as fertilizer, feed, and technology. At the production level, crops, livestock, and fish production are all affected. The impacts on crops include yield losses due to changes in timing and length of the growing period, as well as an increase in invasive plant species. Climate change also causes changes in rainfall and water availability for irrigation, as well as increases in temperature, which all affect yields. Estimates show that without substantial additional investment in irrigation, the share of people at risk of hunger in Africa could increase by 5 percent by 2030 and by 12 percent by 2050 due to climate change (Ringler et al. 2021). Furthermore, the increase in temperature and rainfall variability changes the prevalence or range of plant diseases (such as fungal pathogens) and pests (such as locusts and armyworm). Studies show that climate change has caused a reduction in crop yields for key staples such as maize and wheat in the tropics, and that for every 1°C increase in temperatures above historical levels, crop productivity declines by 5 percent (Challinor et al. 2014). For livestock, climate change increases the transmission of disease due to greater movement of animals in search of grazing area and water. It also changes the prevalence or range of livestock pests (such as tick species) and increases the establishment of invasive plant species, thus reducing grazing potential. Climate change also reduces livestock productivity due to heat stress, low availability or poor quality of feed, and water scarcity. With respect to the fish sector, impact pathways include sea level rise that causes higher salinity in affected areas, thereby reducing productivity. Climate change also causes an increase in harmful algal blooms, alterations, and degradation of habitats such as coral bleaching by ocean acidification. Water stress may induce low water quality and decreased productivity, while higher temperatures impact metabolism and the growth rate of fish species (for example, fish with a narrow thermal range may no longer be suitable for farming). Other potential impacts on fisheries include changes in prevalence or range of pests and diseases; in the composition, population size, and resilience of wild fish stocks; and in the availability of fish oil and fish meal for feed. At the postharvest level, climate change

FIGURE 3.3—CLIMATE CHANGE IMPACTS ON AGRIFOOD SYSTEM COMPONENTS



Source: Adapted from Thornton et al. (2022).

affects agrifood supply chains by increasing the need for improved storage and processing facilities and costly cold chain investments. It also reduces water available for food processing plants. Actors may also face an increased rate of food spoilage, resulting in a loss of income. Trade may be severely hindered by damaged infrastructure, such as roads and bridges, that affects delivery of goods. At the consumption level, climate change increases health risks due to the higher prevalence of pathogens and pests, and causes food spoilage and waste. It also can also lead to volatile food prices resulting from reductions in productivity and disruptions to trade. In addition to these sector-specific impacts, climate change has combined cross-sectoral effects, which include increases in degraded land, affecting yields across the agricultural sector; direct losses of crops, fish, and livestock due to extreme climate events; and competing demand for land and water between pastoralists and fish and crop farmers. There is also a risk of increased zoonotic disease outbreaks affecting human health and agricultural productivity (Thornton et al. 2022).

Climate change also has varied effects on actors within and between the different components of agrifood systems (FAO 2021). Understanding differences in vulnerability to various shocks and stresses, as well as the resilience capacities of agrifood systems, is necessary to identify specific measures that build resilience. For instance, at the production level, the livelihoods of small-scale agricultural producers are more likely to be adversely affected by a shock because these actors have less access to resources than large-scale producers. At the supply chain level, it is more likely that actors who are well connected to supply chains, have various sources, and deal in diverse food products will overcome supply shortages and recover from disturbances more quickly than smallholders (FAO 2021). Similarly, actors in formal markets who benefit from government regulation and programs, access to safety nets, finance, insurance, and other risk and impact mitigation mechanisms will be less affected than those in informal markets. At the consumption level, the poorest households will be more impacted by rising food prices because food represents a larger share of their household budget compared with nonpoor households. In addition, limited capacity to access credit and savings or to liquidate assets to cover deficits may worsen impacts on these households. Nutritional impacts are also possible as households reduce spending on food by shifting toward cheaper, less nutritious items, which increases vulnerability to food insecurity and malnutrition. Furthermore, declining demand for agrifood products due to shocks could potentially disturb other components of agrifood systems, ultimately affecting the flow of products. In the medium and longer term, the structure of entire systems could be affected in countries with a high proportion of vulnerable households.

Opportunities for African Food Systems Transformation Under Climate Change

Transforming African agrifood systems under climate change requires identifying and tapping into available opportunities and overcoming barriers. First, modern technologies for climate change adaptation and mitigation should be promoted in African agrifood systems for their sustainable transformation. A robust science, research, and technology system will play an important role in addressing the challenges facing Africa's agrifood systems, such as the need to improve crop and animal productivity and nutrition, tackle pests and diseases, improve storage technologies and methods, raise food safety standards, and adapt to and mitigate impacts of climate change. Despite major advances in science, technology, and engineering, current progress on these issues is not sufficient to ensure the effective transformation of agrifood systems (Hall et al. 2010). Most agricultural science, research, and innovation systems in Africa have not kept pace with developments in the sector. Despite an increasing number and diversity of actors in agrifood systems, institutional frameworks and funding have remained largely unchanged, or worse, have deteriorated (Lynam et al. 2016). To meet the current challenges facing agrifood systems under climate change, Africa's agricultural science, research, and innovation systems need to be updated. For instance, the increasing complexity of agrifood systems requires adopting an interdisciplinary and demand-driven approach in research and innovation (Horton et al. 2017). A dynamic, innovation ecosystem would foster close strategic partnerships between national agricultural research systems and private sector enterprises to scale up the production, distribution, and adoption of seeds, fertilizers, feed and fodder, new animal breeds, and locally appropriate machinery and technologies (Badiane and Collins 2020). One successful approach has been the redesign of Uganda's research system through the National Agricultural Advisory Services program. Initiated in 2001, the program rebuilt relationships from the farm level through to regional chiefs, district coordinators, and private or semi-private service delivery companies. In this way, farmers defined demand and were able to have their research and innovation needs met through a national coordination network combined with the private sector, initially at a modest cost that gradually rose to at least 50 percent of investment cost (Mbabu and Ochieng 2006). This new configuration has led to substantive positive impacts on the availability and quality of advisory services provided to farmers and the adoption and use of modern production technologies and practices, including greater use of postharvest technologies. Farmers also ventured into commercial marketing of commodities, thereby transitioning out of purely subsistence farming (Benin et al. 2007). Another example is Senegal's West Africa Agriculture Productivity Program (WAAPP), which is building a more resilient and productive agrifood system that helps mitigate climate change through climate-smart agriculture. Under WAAP, scientists have developed seven new high-yielding, early maturing, and drought-resistant varieties of sorghum and pearl millet adapted to local growing conditions. On average, the new varieties yield 1.5–2 tons per hectare—significantly more than the 0.5 ton per hectare yields that are the norm from traditional varieties. The seeds have been distributed to farming cooperatives around the country, which have been charged with producing more seeds and selling them back at a price higher than the market standard. Farmers around the country are also taught climate-smart planting techniques such as alternate wetting and drying, which raised rice productivity by 5–10 percent, reduced water use, and cut methane emissions. Greater productivity and resilience, with a concurrent reduction in fertilizer use (sustainability), is helping to deliver the triple win (World Bank 2015).

Trade is also an important driver of agrifood transformation under climate change. National and external trade, if managed carefully, can transform food systems by generating new and much-needed employment opportunities, thereby improving socioeconomic development and livelihoods across the continent ((Malabo Montpellier Panel, 2020). Increasing food demand through trade can drive specialization and intensification and thus increase productivity, supply, and incomes (UNECA et al. 2019). In addition, where trade barriers are eased, food trade can provide greater diversity in supply, potentially helping to address malnutrition, particularly undernourishment (Bonuedi 2020). Trade liberalization can also counterbalance global price fluctuations and lower domestic food prices, thereby improving access to food (Sibindi 2020). Consequently, food trade can increase resilience to shocks at the micro and macro levels and serve as an important risk management tool. A study comparing the variability of cereal production in individual countries with the average regional production volatility in the Common Market for Eastern and Southern Africa, Economic Community of West African States (ECOWAS), and Southern African Development Community (SADC) showed the potential of intraregional trade to stabilize food supplies through greater market integration. The study found that national production variability was considerably higher than regional-level variability for most countries in the three regional economic communities. The Democratic Republic of Congo and Côte d'Ivoire were the only countries experiencing lower variability in cereal production than the regional variability in SADC and ECOWAS. Moreover, in Guinea-Bissau, yearly domestic supply of cereals was 70 times more volatile than the consolidated African supply, while in Nigeria, local supply was 60 percent more volatile (Badiane et al. 2014). This suggests that both small and larger economies can gain from regional trade. Rising global temperatures, changing rainfall patterns, and more extreme weather events sparking more frequent and intense floods and droughts will continue to disrupt food production. Estimates show that without substantial additional investment in irrigation, climate change could increase the share of people at risk of hunger in Africa by 5 percent by 2030 and 12 percent by 2050 (Deason et al. 2014). The reliance of African farmers on rainfed agriculture makes them particularly vulnerable and susceptible to extreme weather events. In addition, interannual rainfall variation means that the size of local harvests can vary from year to year. Because there is considerable heterogeneity in the impacts of climate change across countries, farmers in countries that are less severely affected by particular weather outcomes may be able to sell excess supply to meet demand from consumers in more severely affected regions. Trade can thus serve as an important risk management strategy by mitigating the impact of negative shocks on domestic markets (Malabo Montpellier Panel 2020).

With climate change, access to information is more important than ever for agrifood system actors. Farmers are already battling the adverse impacts of climate change (Malabo Montpellier Panel 2019), and digital solutions that offer them access to weather information could be a game changer in transforming Africa's agrifood systems. Due to a lack of access to reliable weather information, most farmers make decisions based on traditional knowledge about the weather and seasons. Most weather stations are outdated and lack historical or up-to-date meteorological data. When farmers have access to reliable weather information and forecasts through modern weather station technology and improved weather forecasting, in combination with clear communication through mobile or online services, they can make more informed decisions about when to sow, plow, or harvest. Faster and more accurate forecasts are available through new weather technologies and prediction models. They are mainly accessible through text messaging (SMS), but also as interactive voice response (IVR) and interactive messaging services (unstructured supplementary service data, or USSD). For instance, a farmer can call and communicate with a computer to obtain the needed information through an IVR service, while a USSD service enables interactive text messaging between computer and a farmer (Malabo Montpellier Panel 2019). Some countries are making progress in gathering and sharing information with farmers. For example, Nigeria successfully launched two earth observation satellites in 2011, which are used to monitor the weather and predict and manage flood areas (Malabo Montpellier Panel 2019). In addition, Ignitia, a Swedish company, developed a tropical forecasting model with an accuracy rate of 84 percent for West Africa. The model provides daily weather forecasts to farmers in their local languages via SMS for just a few US cents per day. Farmers engaging with the service in Côte d'Ivoire, Ghana, Mali, Niger, Nigeria, and Senegal use the localized rainfall predictions to better cope with and withstand weather variabilities (Rateng 2016). Furthermore, in Ethiopia, a pilot project provided local weather forecasts, including information on temperature and rainfall, to 1,500 sesame farmers via SMS in two local languages. Ninety-six percent of farmers rated the accuracy of rainfall forecasts as being close to very accurate. With this forecast information, farmers were able to better plan when to sow, weed, apply fertilizer, and hire seasonal labor (Rateng 2016). As a result, weather information may also help to achieve higher yields under rainfed agriculture or allow farmers to extend the growing season (FAO 2018).

Another requirement for transformation is the establishment of social protection programs to benefit workers in agrifood systems (FAO 2022). In addition to being impacted by climate events, African workers in agrifood systems are affected by multiple disruptions along the food supply chain, including economic fragility, conflict, and global shocks such as COVID-19 and the Russia–Ukraine conflict, which limit access to agrifood system production inputs and cause postharvest losses. Agrifood system workers and their households are in clear need of social protection, which has been proven to positively impact food security, nutrition, and human development. Moreover, social protection can play a crucial role in reducing the vulnerability of the poorest and most marginalized communities, which often rely on negative coping mechanisms to generate and protect their assets and enhance their economic and productive capacity (Hoddinott et al. 2012). Adapting social protection schemes for agricultural workers in terms of availability, affordability, accessibility and quality is necessary to respond to many of these risks and disruptions, (Sato and Mohamed 2022). Social protection programs can be made relevant to agrifood systems workers in several ways, including providing income-generating activities, linking school feeding programs to local production, and strengthening shock-responsive elements that build resilience against climate and environmental changes. Social protection is thus a powerful risk management tool to reduce the economic vulnerability of households. In Malawi, the provision of improved seeds and fertilizer to farmers in 1998 through the universal Starter Pack program, under which every smallholder farmer received enough seeds and fertilizer to plant 0.1 hectares of land, contributed to an estimated 67 percent increase in maize output, with maize production reaching 2.5 million tons (Levy 2005). Similarly, sorghum production has increased among recipients of the Lesotho Child Grants Programme (CGP), in which members of poor and vulnerable households receive an unconditional cash transfer quarterly, with the requirement that the money be spent on children (Pellerano et al. 2014). The program helps smooth consumption patterns and builds basic capacity by improving access to a variety of social services, such as education, housing, income transfers, and food provision (Van Ginneken 2005). At the same time, the regularity and predictability of social protection instruments help households improve their resilience to shocks and engage in more profitable livelihood and agricultural activities. The lack of access to funds to invest in livestock and agricultural inputs remains a major barrier to production, but evidence from conditional and unconditional cash transfer programs demonstrates that social protection programs can also increase livestock ownership and use of agricultural inputs. For example, in Ethiopia, the Productive Safety Net Program has led to an increase in livestock holdings in participating households (Andersson et al. 2011). Similarly, the Zambia Child Grant led to a 36 percent increase in worked land as well as an increase in the use of agricultural inputs such as seeds, fertilizers, and hired labor (FAO 2014b). In addition, the Lesotho CGP has resulted in an increase in the use of agricultural inputs such as pesticides (FAO 2014a).

Amid changing market and climate conditions, smallholders must constantly adapt their farming and livelihood systems to ensure resilience and sustainability. Similarly, small and medium enterprises (SMEs) processing raw materials supplied by smallholders need to adapt to changing market, technological, and political conditions. Such adaptations require multiple resources, including short-term finance for working capital, medium- to long-term finance for natural capital and infrastructure improvements, and technology with associated investments. However, financial markets are often not adapted to the realities and needs of smallholders and agricultural and forest SMEs (Louman et al. 2020). While microfinance has become increasingly available for smallholders over the past two decades, it is usually short term, limited to nominal amounts, and may be intended to cover operational or subsistence costs. Attracting investments in any business of a larger scale, on the other hand, usually requires a credit record, collateral, and the promise of secure returns, making such investments less accessible for smallholders and SMEs in agricultural and forest sectors. Viable strategies are needed to reduce perceived or real financial risks for smallholders and SMEs in the agriculture, forestry, and other land use (AFOLU) sectors. Recent years have seen a surge of innovative risk reduction strategies accompanying innovative finance schemes such as government guarantees, first loss loans, or shared risks that mix public and private money (known as "blended finance"). While these elements make it more acceptable to invest in higher-risk ventures and thus may increase access to finance for smallholders and SMEs in AFOLU sectors, they tend to address the risks of investors rather than those of smallholders, SMEs, and the local lending institutions or programs interacting with them. However, innovative approaches aim to facilitate access to finance to Africa's smallholders and SMEs in AFOLU sectors. For instance, Nigeria's Incentive-based Risk Sharing System for Agricultural Lending (NIRSAL), a US$500 million fund generated entirely by public resources, was launched in 2013 through a joint initiative of the Central Bank of Nigeria, the Nigerian Bankers' Committee, and the Federal Ministry of Agricultural & Rural Development. NIRSAL's corporate mandate is to "forge partnerships between agriculture and finance; maximizing the potential of agriculture for food security, job creation, and economic growth" (FAO-IFAD-AGRA 2021). NIRSAL focuses on high-potential value chains by de-risking agricultural value chains and agricultural finance and building long-term capacity of value chain actors and other stakeholders. In addition, it institutionalizes incentives for agricultural finance and value chain performance. Through its partial credit guarantee facility of US$300 million, NISRAL provides loan-level, first-loss coverage on banks' losses ranging from 30 percent to 75 percent of a loan's face value depending on the value chain segment. Credit facilities extended to all segments of agricultural value chains are eligible for individual, loan-level risk sharing coverage. In addition, its insurance facility of US$30 million aims to expand agricultural insurance products and outreach to retail and meso-level players, with a specific focus on moving away from traditional indemnity-based products to parametric, index-based solutions that provide risk transfer products to protect producers against yield and price risk. NISRAL also has a technical assistance facility (TAF) of US$60 million intended to provide supply- and demand-side technical assistance to address various knowledge, operational, and technical gaps so that financial institutions can lend sustainably to the agricultural sector. TAF also supports farmers to adopt good agricultural practices, technological advancements and know-how, and business upgrades to make them more bankable. Furthermore, NISRAL's bank rating scheme of US$10 million rates participating financial services providers and state governments on the effectiveness and outreach of their agricultural lending and social and environmental performance, providing cash and noncash rewards to further incentivize performance. Finally, it has a bank incentives scheme of US$100 million to provide cash, which, along with its bank rating scheme, incentivizes continued outreach and builds long-term capabilities to lend to agriculture (FAO-IFAD-AGRA 2021).

Conclusion

The climate is changing in Africa, as in the rest of the world, and its impacts are real. Africa is experiencing a change in precipitation patterns, a rise in sea level, and an increase in the frequency and intensity of extreme weather events such as droughts, floods, heat, and cyclones. These extreme weather events are negatively impacting economies and displacing communities. Understanding the impact of climate change on economies and opportunities for agrifood system transformation is crucial for sound policies in the context of the post-Malabo Agenda. This chapter aims to achieve that objective by first reviewing the macroeconomic effects of climate change through an analysis of relevant impact pathways and available empirical evidence. In addition, the chapter highlights issues related to agrifood systems and climate change by analyzing the characteristics of agrifood systems and discussing the impacts of climate change on food system activities and actors. The study also identifies both opportunities and barriers to transforming African food systems under climate change.

The chapter shows that the detrimental impact of climate change on economies is generally confirmed by likely reductions in GDP, especially in the agricultural sector. Economies could be impacted through several channels including productivity change, employment, price change, and trade. Further analysis of agrifood systems as important economic components identified three types of agrifood systems: traditional, modern, and transitional (that is, moving from the traditional to the modern category). The ability of agrifood systems to prevent, anticipate, absorb, adapt, and transform rapidly in the face of shocks and stresses depends on their stage of development. The heavy dependence on climatic, biological, physical, and chemical processes makes agrifood systems potentially vulnerable to multiple climate shocks, including extreme weather events, pest and disease outbreaks, water scarcity, and deteriorating natural resources. Existing structural deficiencies, such as inadequate roads, power, irrigation, clean water, processing, storage, and marketing infrastructure, also exacerbate climate shocks on agrifood systems. These shocks will likely affect, to varying degrees, all components of the agrifood system, including production, processing, trade, and consumption. Climate change also has diverse effects on actors within and between different components of agrifood systems. This chapter highlights certain opportunities and barriers to transforming the African agrifood system under climate change, including modern African technologies for climate change adaptation and mitigation, an increase in trade, digital solutions for climate information, the establishment of social protection programs to benefit agrifood system workers, and access to finance. Policies aiming to deal with the impacts of climate change must consider macroeconomic effects, with an emphasis on agrifood systems. Investing or repurposing support to relevant interventions is also crucial for economic resilience, allowing agrifood systems to better adapt to climate change.