Harvesting Change: The Impact of Climate Change on Africa's Agri-Food Systems

Valeria Piñeiro, Juan Pablo Gianatiempo, Brian McNamara, Timothy Thomas and Fousseini Traore

Introduction

Africa is one of the most exposed continents to climate change. While global temperature has risen by 0.2°C per decade since 1991, in Africa the rate is faster, reaching 0.3°C (WMO 2022). Yet Africa contributes only modestly to climate change. Indeed, the continent emits 7 times less greenhouse gas compared to Europe and 15 times compared to North America (IPCC, 2023). In addition to rising temperatures, climate change affects Africa through several channels, including an increase in ocean levels, variations in precipitations (droughts and heavy rains), plant pests and animal diseases. Climate change is also expected to contribute to a significant reduction in arable land in the continent (IPCC, 2023). The new CAADP strategy and action plan for 2026-2035 recognizes that Africa is the hardest hit by climate change and that the phenomenon is one of the major threats to Africa's agricultural systems and food security in the coming years.

All of these changes will affect agricultural production, a major challenge for Africa, as African economies and livelihoods remain heavily dependent on agriculture. Agriculture still represents 16% of Africa GDP with contributions ranging from 3% in Southern Africa to 25% in the eastern part of the continent. Due to the low level of labor productivity in agriculture, the sector's contributions to total employment are higher than those of other sectors. By inducing structural changes in agricultural production, climate change will also affect trade flows by shifting comparative advantages between and within continents. Prices will also be affected. This Policy Brief i shows how Africa's agricultural production and trade patterns are altered by climate change. It highlights the large impacts of climate change on agricultural production, reinforcing results from other work. It shows that the impacts on prices compound the production impacts on African economies and people given many countries in the region are net importers. However, the work also shows that there are substantial differences across the region in the size of the impacts.

Methods

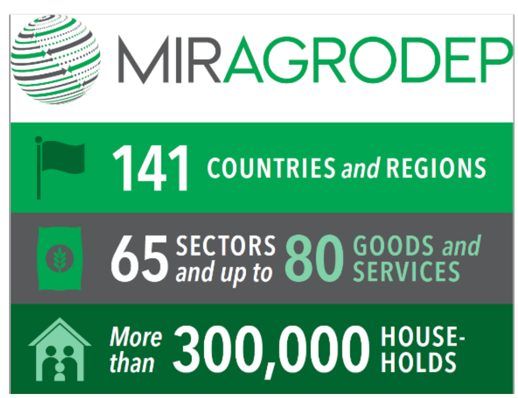
The following results are based on combined analysis from the two models described in this section.

The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) has been used since the mid-1990s to study future global supply, demand, and trade in the agriculture and food sectors. Now in version 3, it has climate change embedded as a fundamental component.

IMPACT is a multimarket and partial equilibrium model that solves global prices that equate supply and demand for every year and commodity in the model. IMPACT has 159 regions and 154 water basins, which combine for 320 FPUs. IMPACT has 62 commodities, including 39 crops, 6 types of livestock, and 17 processed foods. IMPACT finds annual solutions for 2005 through 2050.

Underlying the analysis are climate models that are taken from the CMIP6 models used by the IPCC's AR6 reports. The climate models feed into the crop simulation models and water models (hydrology, water basin management, and water stress models). IMPACT relies on demographic and GDP projections development by a global team of experts and consolidated into a single database by IIASA (2018).

MIRAGRODEP is a Computable General Equilibrium (CGE) model based on the MIRAGE (Modelling International Relationships under Applied General Equilibrium) model. In its standard version, MIRAGRODEP is a recursive, dynamic multi-region, multisector model. In MIRAGRODEP, the government is explicitly modeled as different from private agents. Government income consists of taxes collected on production, on factors of production, on exports, on imports, on consumption, and on households' income.



The Armington assumption (Armington 1969) allows the model to capture product differentiation, including varying levels of substitution of products by origin and destination, and it is a robust way to represent bilateral and intersectoral trade flows. In this study, Armington elasticities are drawn from the GTAP database and follows three levels of nesting varying across regions depending on the product mix of each sector.

The model includes three important assumptions:
the external account closure, for which it assumes a constant current account surplus/deficit

in terms of individual country GDP and an endogenous real exchange rate. For the government account closure; government surplus/deficit assumed constant in terms of domestic GDP with endogenous adjustment of a domestic consumption tax The third one, the investment-savings closure (saving driven model).

For this study, the main source of data comes from GTAP 11 v2 version.

IMPACTS OF CLIMATE CHANGE

What has been illustrated?

The scenario simulated aimed to assess the future trajectory of Africa's agricultural sector, taking into account key disruptors affecting agri-food systems. It was developed based on the significance of these disruptors in shaping agriculture, the likelihood of their occurrence, and the speed at which they could impact the sector and food systems by 2040. The quantitative, model-based analysis primarily focused on the effects of climate change on agricultural productivity. This was achieved by integrating outputs from the IMPACT partial equilibrium (PE) model into the MIRAGRODEP computable general equilibrium (CGE) model.

The impact of climate change is incorporated into MIRAGRODEP through the above-mentioned linkage with IMPACT, which, in turn, considers the agricultural productivity impact based on the climate models. Climate change is included in the model by considering its impact on agricultural yields and land cultivated, as this is considered a prime driver of the impact of climate change in Africa. The climate change damage functions included in the analysis cover land and yield losses and are reflected in yield losses. Specifically, the effect of climate change on yields was evaluated by comparing the yield projections arising from a business-as-usual scenario and those simulated by climate change scenarios for the year 2040, assuming no fertilization. Other impacts of climate change such as labor productivity loss due to heat stress, human health impacts, air pollution, biodiversity loss, invasive species spread and impacts on tourism, and energy demand are not considered. It is important to note that the model looks at the impact of the change in temperature and precipitation trends and does not model random weather shocks, which could result in supply chain disruptions, or sea-level rise.

It is important to note that the scenarios used in this brief are hypotheses that allow for the analysis of adjustments based on certain hypothetical scenarios, and are not future forecasts. Using the methodology described, the simulations evaluate how the productive and trade systems of Africa would adjust to climate change.

What have we learned?

The climate change disruption scenario used in the study drives differential impacts on agriculture across countries. Temperate countries with cold temperatures and short growing seasons may benefit from higher yields in some crops, while tropical countries might experience reduced yields due to extreme heat. Changes in crop productivity will alter comparative advantages, causing adjustments in production and trade patterns. It is supposed that market-mediated adjustments may mitigate some negative impacts of climate change, by arbitrage.

As mentioned, the model's limitations include the absence of random shocks and natural disasters, and the exclusion of significant other environmental and economic factors. Despite the absence of random shocks, natural disasters, and other environmental factors, the study suggests market mechanisms (including through trade) would reverse some welfare effects from productivity impacts, through an arbitrage mechanism. Net food-exporting regions like LAC and Oceania might benefit from rising food prices – as they are food net exporters -, while net-food-importing regions such as Asia, Europe, and the Middle, Eastern and Northern Africa face increased burden. Poor, African countries reliant on imports and vulnerable to yield shocks are particularly at risk, because of their current situation.

Subregional impact

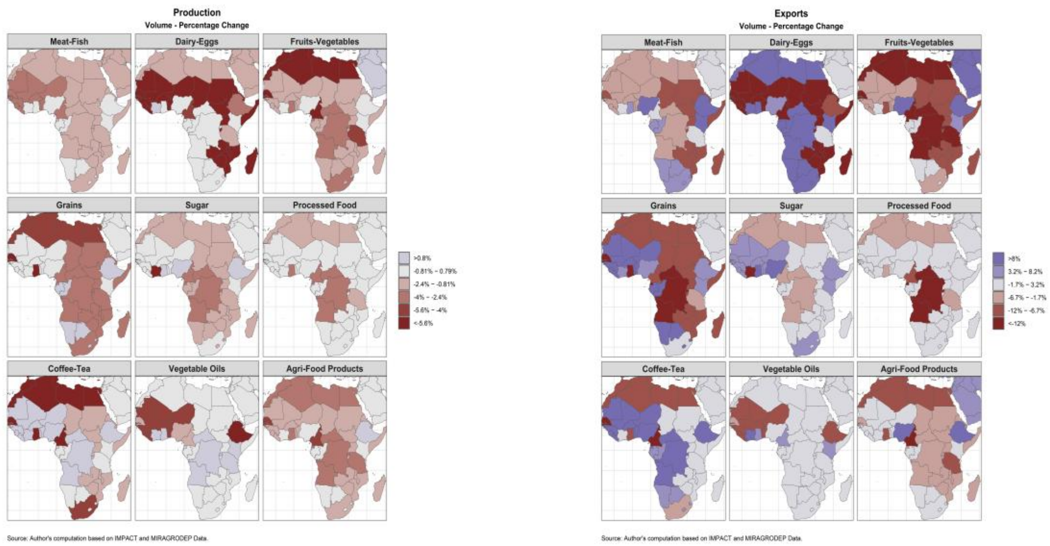
The impact in each country depends on potential yield changes in essential crops, the agricultural sector's GDP share, and the level of traded agricultural production.

While Africa is heavily dependent on agriculture in general, the contribution of the sector to GDP presents an heterogenous pattern. Indeed, agriculture contributes to almost 25% of GDP in both eastern and western Africa against 15%, 11% and 3% in the middle, northern and southern regions, respectively. In addition, within the agriculture sector, another layer of heterogeneity is present. In west Africa cereals represent 24% of agriculture production against 12% in middle Africa. In northern Africa, fruits and vegetables represent 40% of production, while their contribution in west Africa is only 16%. Furthermore, not all regions/countries show the same degree of openness and exposure to world markets. For instance, in Southern Africa 31% of cereals and 81% of fruits and vegetables produced are exported against 16 and less than 1% in West Africa, respectively.

Adaptations, including supply-side adjustments and trade reallocations, mitigate adverse shocks. A general overview of the results in African countries reveals that climate change will negatively affect the yields of most agricultural products, leading to significant decreases in production volumes.

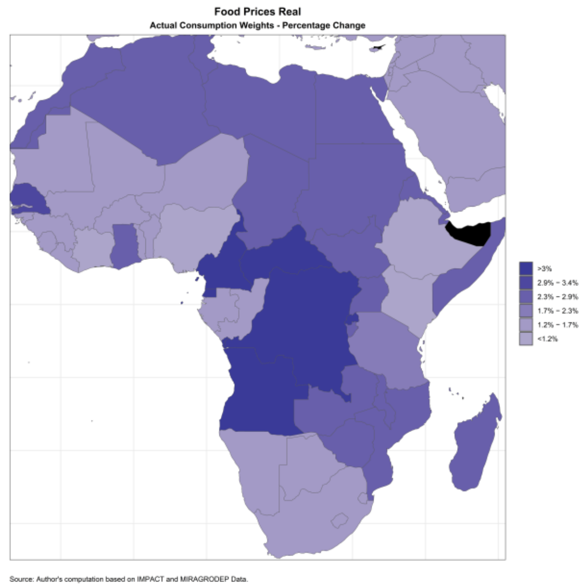
However, as mentioned previously, heterogeneous results are observed depending on countries/regions and product groups. A greater negative impact is recorded in the Northern and Middle Africa regions for fruits and vegetables, grains and stimulants (coffee and tea). In North Africa the production of stimulants and fruits and vegetables fall by 8.4% and 8%, respectively. In central Africa, Cameroon appears as the most impacted country with stimulants production falling by 13.4% while fruits and vegetables production decline by 6%. However, disaggregating the results shows that these regions would have slightly positive to neutral impacts on vegetable oil production. The Western region, which generally faces slightly negative impacts, shows variation across product groups. Negative effects are seen in grains, dairy-egg and vegetable oils production, while positive impacts are observed for coffee and tea. Senegal is the most affected with its dairy-egg and grains production falling by 14.4 and 11%. Eastern Africa exhibits significant variability among its countries. While Ethiopia and Kenya experience positive to neutral impacts, the rest of the Eastern Africa faces negative effects, while the most moderate results are recorded in Southern Africa, influenced by the weight of South Africa in the region.

Figure 1: Changes in production and exports under climate change



Given the decline in production, export volumes are expected to decrease under the climate change scenario, leading to higher food prices, particularly in Middle and Northern Africa with price increases above 5 and 2%, respectively, all amplified by the fact that agrifood products are mostly (demand) inelastic. Food purchasing power would be reduced in these regions and in certain countries such as Senegal, Madagascar, Somalia, and Ghana. These outcomes are especially concerning for Middle Africa, where the prevalence of undernourishment reached 31% in 2023 according to FAO data, the highest on the continent.

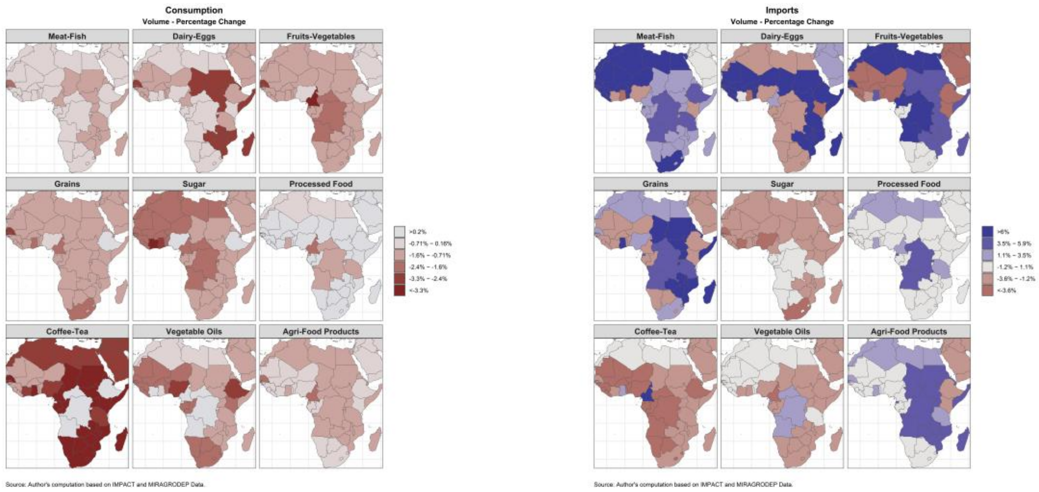
Figure 2: Changes in real food prices under climate change



Net importing countries, which constitute the majority of African countries (85% according to 2022 FAO data), will be the most affected, due to the double effect of lower quantities produced and higher prices. A drop in production leads to higher imports, but at the same time the effect of price increases restricts consumption, and consequently, imports. The final effect on imports will vary depending on the country and product group.

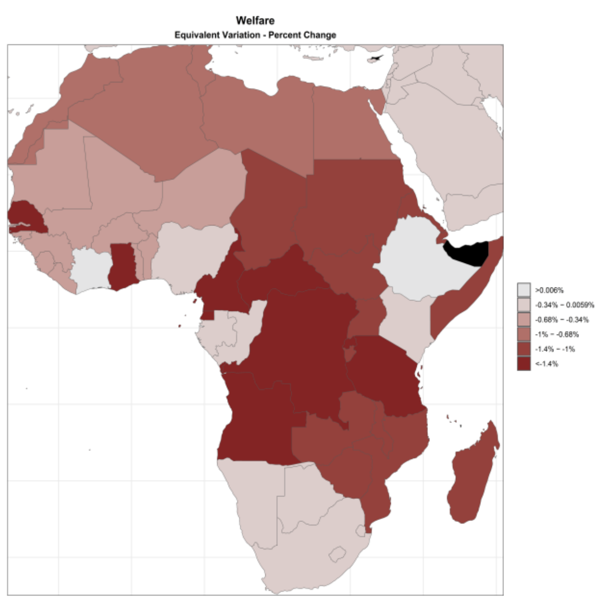
According to the results, consumption of fruits and vegetables, grains, sugar and coffee-tea are the most negatively affected products in Africa. Vegetable oils and dairy-egg consumption have negative impacts in specific groups of countries in Eastern, Southern, and Western Africa. Regarding imports, Northern and Middle Africa are the regions experiencing the largest increases, particularly in grains, meat-fish, and fruits-vegetables. Imports of dairy-eggs would rise in Eastern and Western Africa, while imports of coffee-tea and sugar would generally decline.

Figure 3: Changes in consumption and imports under climate change



Under the climate change scenario, food prices will increase throughout Africa. This increase will have a significant impact on the purchasing power for food and, ultimately, on the general welfare of the population. However, the effects are more pronounced in the Eastern, Middle, and Northern Africa regions. The impact on Eastern and Middle Africa is particularly alarming, as these regions are the most food insecure on the continent, characterized by high levels of malnutrition, heavy reliance on food imports due to low self-sufficiency, and rapidly increasing food demand.

Figure 4: Changes in welfare under climate change by region/country.



A major lesson learned from the analysis is that Northern, Eastern and Middle Africa are highly vulnerable to the adverse effects of climate change, particularly in key sectors like meat-fish, grains, and fruit-vegetables. These regions (Northern and Eastern) face heightened risks due to their dependence on climate-sensitive agriculture, limited infrastructure, and significant exposure to extreme weather events. Alarmingly, most of the regions significantly affected by climate change are also the ones with the highest levels of food insecurity. This dual challenge—climate vulnerability and food insecurity—requires urgent and targeted policy interventions.

What can be done?

To effectively mitigate the impacts of climate change and enhance food security, policies must focus on promoting sustainable and inclusive agricultural practices, climate adaptation strategies, and investments in resilient food systems. The current global landscape presents a unique opportunity to align agricultural policies with climate action, ensuring that food production systems are better equipped to withstand climate disruptions. Strategies should first target reducing production risks through efficient use of water, improving soil fertility with a bigger role for organic matter, and the development of new cultivars (drought resistant crops). Filling the knowledge and information gaps will also be key in developing insurance mechanisms and early warning systems. Prioritizing these efforts will help build a more resilient agricultural sector that can meet the challenges of climate change while supporting long-term food security. All these efforts are aligned with the new CAADP framework which calls for innovative, smart and sustainable solutions to mitigate climate challenges while filling the productivity gaps with the rest of the world to build long-term resilient agrifood systems.

For net food importing countries, sound trade policies are required in order not to exacerbate the impact of climate change on food systems. When prices rise countries tend to impose export bans but this creates price volatility and policy uncertainty which discourages the type of investment in production that is needed. Investments in reducing trade costs—such as through investments in infrastructure and logistics and regulatory reform to increase competitiveness in trucking—can reduce domestic prices mitigating the negative impacts of rising food prices and stabilizing domestic food markets when weather shocks occur as these shocks are not uniformly distributed across the continent. The latter will require a significant reduction in trade costs (both formal such as non-tariff measures and transportation infrastructure cost and informal like illegal payments and bribes along transportation corridors) within the continent.

Repurposing existing subsidies and financial resources towards climate-smart agriculture and food security initiatives is essential for maximizing the effectiveness of these efforts, particularly in Africa, where budgets are often limited or unavailable. However, repurposing should not be seen as a means of eliminating existing policies, but rather as an opportunity to improve and adapt them to better address contemporary challenges. This approach allows for more efficient use of existing infrastructure and frameworks, ensuring that resources are optimized to tackle the urgent issues of food insecurity and climate change.

Two remaining challenges are not addressed in this Brief and should require more attention. The first one is the impact of climate change on agricultural labor productivity and extreme weather shocks. Indeed, due to heat stress, Africa appears particularly vulnerable to this aspect, both for human labor and animal work. Since traditional agriculture with high labor intensity still dominates the continent, extra negative impacts are to be expected on food availability. Second, as previously mentioned in the introduction of this Brief, Climate change will induce more pests and crops and livestock diseases and put more pressure on food supply.

Future research should also focus on different scenarios on the role of trade integration n mitigating the impact of climate change in Africa. There is indeed a contribution of trade to reduce and even reverse the negative impact of climate change in the continent, provided that trade flows are not capped at their current levels and (internal) trade costs are significantly reduced (Porteus, 2025; Gouel and Laborde, 2021). The African Continental Free Trade Agreement (AfCFTA) launched in 2021, represents such an opportunity.

References

Gouel, C., and D. Laborde. 2021. "The Crucial Role of Domestic and International Market-Mediated Adaptation to Climate Change." *Journal of Environmental Economics and Management* 106: 102408.

Piñeiro et al. forthcoming. Food Systems Beyond Borders: Trade and Food Security with a Latin America and the Caribbean perspective. IADB. Washington DC.

Porteus, O. 2025. Agricultural trade and Adaptation to climate change in Sub-Saharan Africa. Mimeo. Department of Economics , Middlebury College.

Thomas, T. S.; and Robertson, R. D. 2024. Climate change and agriculture in eastern and southern Africa: An updated assessment based on the latest global climate models. IFPRI Discussion Paper 2239. Washington, DC: International Food Policy Research Institute.

Thomas, Timothy S. 2024. "The Impact of Climate Change on Agriculture", Chapter 6 in Advancing the Climate and Bioeconomy Agenda in Africa for Resilient and Sustainable Agrifood Systems, ReSAKKS Annual Trends and Outlook Report 2024, ed. by Getaw Tadesse, Katrin Glatzel, and Moumini Savadogo. AKADEMIYA2063 and International Food Policy Research Institute. https://doi.org/10.54067/9798991636902

WMO (2022). State of the Global Climate 2022. Report https://library.wmo.int/records/item/66214-state-of-the-global-climate-2022

This work is part of the CGIAR Science Program on Policy Innovations. We thank all funders who supported this research through their contributions to the CGIAR Trust Fund.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
A world free of hunger and malnutrition
1201 Eye Street, NW, Washington, DC 20005 USA | T. +1-202-862-5600 | F. +1-202-862-5606 | ifpri@cgiar.org | www.ifpri.org | www.ifpri.info