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Africa under a warming climate: The role of trade towards building resilient adaptation in agriculture*

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Abstract

The paper reports on evidence on how trade can help Africa adapt to Climate Change (CC) along three dimensions: (i) fast-onset events from short-lived extreme occurrences (floods, extreme temperatures); (ii) slow-onset events (rise in average temperatures and sea-level rise); (iii) trade facilitation policies.

• Fast onset events: Trade reduces the amplitude of extreme events like a drought. But policy reactions to large shocks can increase the amplitude of the shock. During the South African drought of 2015-6, policies had spillovers in neighboring countries. Following the 2008-09 financial crisis, export restrictions by major crop exporters and reduction in tariffs by importers amplified the shock. Policy coordination is needed to control spillover effects.

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Keywords: Climate change; adaptation; Africa; Environmental goods.

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- Slow-onset events: Modelling efforts have concentrated on exploring the 'margins' of adjustment to CC: changes in production levels of existing crops; switches in crops; changes in land utilization; labor relocating to urban areas/migration; adjustments in the volume of trade at different scales (regional or international). All reviewed models show that enlarging the channels of adjustment mitigate the amplitude of the loss in welfare from expected CC over the 21st Century. Decomposing the welfare changes suggests two conclusions. First adjustments in crop selection and in bilateral trade partners contribute approximately equally to reducing the costs of adjustments. Second, the expected sharp increase in food prices resulting from warming is likely to hit SSA most strongly.

- Trade facilitation: A functioning global trading system is a public good to become more valuable under CC. Free and unfettered access to global food (and other key) supplies must be ensured, especially for Africa. This requires a rapprochement between the trade and climate regimes. As an entry point, besides dealing with harmful subsidies (fossil fuels, fisheries), developed countries could conclude a plurilateral Environmental Goods Agreement (EGA) that would be a triple win for trade, for the environment, and for African agriculture that needs tariff-free access to climate-Adaptation related EGs (AEGs). The paper documents the magnitude of tariffs on Environmental Goods.

The paper concludes that African countries could improve the functioning of the continental policy architecture by several measures. First by excluding AEGs from exclusion lists on the AfCFTA while simultaneously reducing their barriers to trade on AEGs and Environmentally Preferable Products (EPPs). Second, preserving the environment should be mainstreamed in the African trade architecture by including environmental provisions in the preambule to the AfCFTA.

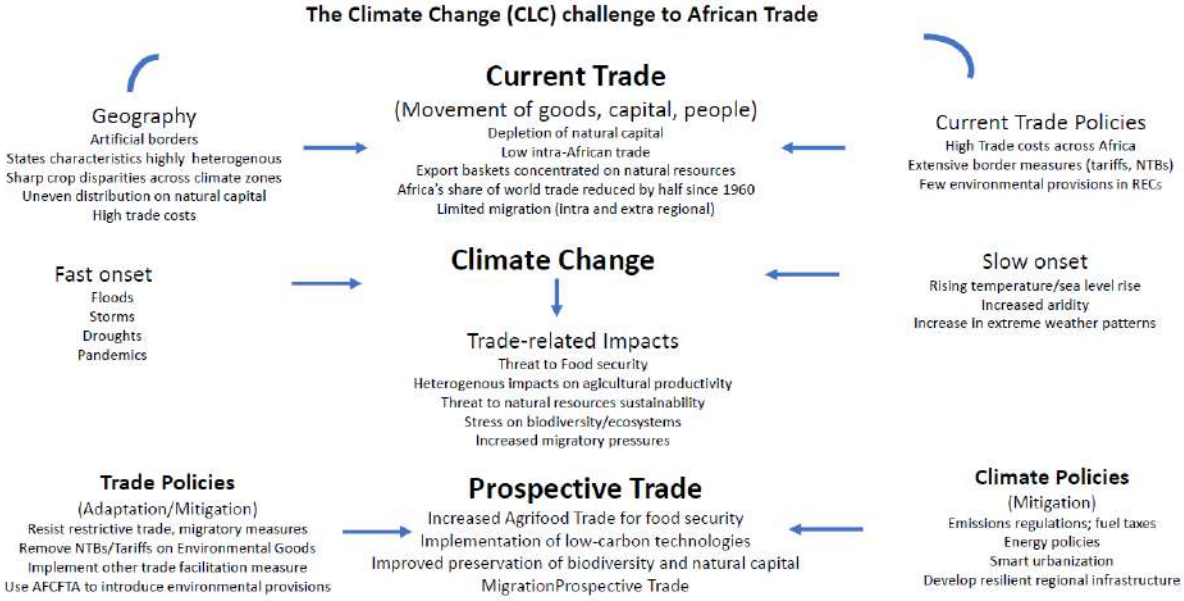
1. Introduction: Africa's Trade Challenge

During the golden age of globalization, Africa's share in world trade fell by half. Even in the absence of the Climate Change (henceforth CC) threat, the challenge of raising a growing population out of poverty is a formidable task for the many countries across the continent that continues to have close to zero adjusted net savings per capita.[1] Embarking on a sustainable development path remains a huge challenge.

Key drivers of this outcome are indicated in the top part of figure 1. As shown at the top on the left side of the figure, Africa's geography is a powerful barrier to trade which is so vital for the many African countries with limited domestic markets. On the right-hand side, extensive restrictive border measures (some informal like road checks) have contributed to the current high trade costs. Measures to protect the environment are largely absent in the Regional Economic Communities (RECs) along which continental integration is taking place.

Intra-African trade has grown from 10% to 16% over the past 20 years but it is still only in the 5-15 percent range of total trade across African regions with a concentration in agricultural products)[2]. Export baskets are highly concentrated in primary products: agricultural products (15%) and minerals and fuels (50%). Limited migration so far, completes this aperçu of Africa's position in global trade.

Figure 1
The Climate Change (CLC) challenge to African Trade



Source: Authors

[1] Adjusted net savings (or investment) is increases in physical capital adjusted for changes in human capital and the stock of natural assets which include geology, soil, water and all living things. See estimates in Lange et al. Eds. (2018)

[2] 20% of intra continental trade is agricultural goods, and close to 25% is fuel.

The middle portion of figure 1 sketches the trade-related impacts resulting from selected slow and fast onset components of CC (for obvious reasons, fast onset events like storms are best documented so far. On the slow-event side, a rise in average temperatures (and associated sea level rise)[3] will be accompanied by increased aridity. A modification in local climate regimes will shift precipitation patterns, temperature, and overall seasonality of weather events. On the fast-event side, the occurrence of extreme events such as heat waves and torrential rains is expected to continue to increase as it has in the recent past[4]. For Africa, shocks are negative (no significant increase in agricultural productivity) but can be dampened by trade and by changes in trade policies (prospective trade in the bottom of the figure), the focus of this chapter.

CC presents an additional barrier to Africa's quest towards greater integration in the global economy. Because of its high expected population growth and urbanization, under current IPPC projections, Africa is expected to be the third largest GHG cumulative footprint by the end of the Century and to account for 20 percent of global CO2 emissions.[5] While its low per capita income and small footprint amply justify following a 'grow first-clean up later' strategy followed across continents so far, the urgency of the CC challenge also calls for efforts at mitigation by all towards a greener development path, efforts needing financial support from high-income countries beyond the pledges made under the Paris Agreement. In short, Africa's resilience to the CC challenge will call for a combination of adaptation and mitigation measures.[6]

For Africa, the threat to food security will be paramount, if only because 59% of Sub-Saharan Africa's (SSA) population lives in rural areas and is still growing (+17% from 2010 to 2020) in spite of ongoing urbanization. Close to 10 percent of the rural population lives in remote less-favored agricultural land or on remote land with poor market access (lack of roads, railways, navigable waterways), That population is engaged in subsistence agriculture, complicating any prospective role for trade to alleviate the threat to food security unless there is a massive increase in infrastructure.

The role of trade in adaptation to CC is complicated by two other factors. First, net food-importing countries (and continents like Africa) are legitimately concerned about dependence on food imports, especially in the present turbulent times. Second the known worldwide distribution of natural assets (renewable like forests, and non-renewable like subsoil) are largely concentrated in Africa. Often, property rights for these assets are poorly defined making them vulnerable to 'tragedy of the commons' outcomes prone to be exacerbated by international trade. Threats to biodiversity, already present, will increase. Here, under weak governance, increased international trade presents a challenge. Migratory pressures will also increase.

The bottom of figure 1 lists trade (and climate) policies needed for trade to contribute to Africa's adaptation to the CC challenge. If successfully implemented, 'prospective' trade will contribute to resilience to climate challenge and to Africa's needed structural transformation. [7]This paper focusses

[3] 1.9 percent of Africa's population is residing at less than 5 meters from the sea level (2010 estimate).
[4] According to the UN, climate-related disasters increased by 83 percent in the first two decades of the 21st century compared to the last two decades of the 20th century—from 3,656 to 6,681 events. Major floods have more than doubled, the number of severe storms has increased by 40 percent, and droughts, wildfires, and heatwaves have become much more prevalent. Cited in Brenton and Chermutai (2021).
[5] Calvin et al. (2016).
[6] Mitigation and adaptation measures often go hand-in-hand so the attribution of climate policies to mitigation is somewhat artificial. Africa's implementation of a low-carbon urbanization strategy would be a major contribution to both mitigation and adaptation. See Bigio (2015).
[7] See ACET's reports on structural transformation. The third report, Integrating to Transform focusses on cooperation for effective delivery of regional public goods on policies (innovation, education), transborder externalities and CC.

on evidence about the role of trade policies to help achieve these prospective outcomes with a focus on agriculture.

Figure 1 is non-exhaustive. Only some of the impacts of CC are included with a focus on those affecting agriculture, the sector the most affected by CC and the most important sector for Africa. The distinction between slow and fast onset events is also blurred even though we have more information about the effects of fast-onset events, if only because CC has only started.[8] However, the distinction serves to organize the discussion.[9]

Section 2 presents the channels through which trade can attenuate the effects of fast-onset climate shocks (droughts and floods)). Past and current examples show how trade helped cushion the impact of extreme weather events (the arrival of the railroad in colonial India and the 2015-6 South African drought) and global crises (2008 food crisis Covid-19 pandemic) but also how uncoordinated policies amplified the shocks.

Section 3 turns to a discussion of predictions about slow onset CC. Thanks to the FAO-IASA Global Agro-Ecological Zones (GAEZ) data on past and projected crop yields at the field level (around 10,000 hectares), agricultural simulation models can now explore the predicted effects of climate change on agriculture under different scenarios. The section reports on results from several models, all based on GAEZ-driven estimates of crop yields.

Section 4 focusses on trade facilitation measures needed for trade to play a greater role in the required adaptative transformation across Africa in a warming world focusing on agriculture. It opens with a plea to 'green' the WTO to bring trade and climate policies closer. For African agriculture, success will also depend on removing trade barriers on green goods (adaptation-related Environmental Goods (AEGs). Estimates of tariffs on AEGs across African regions are provided. Furthermore, at the continental level, phase I of AFCFTA should prevent the inclusion of AEGs on the exception list. Phase II should include environmental provisions to mainstream the environment in Africa's continental trade policy architecture.

2. Trade fosters resilience by limiting Africa's sensitivity to extreme events

CC in Africa is a multi-sectorial threat: to agriculture, tourism, trade infrastructure (port and other trade-related infrastructure) and coastal communities- especially urban ones, that are expected to be the most impacted. Agriculture has been, and will continue to be most affected to climate related shocks. Here we focus on the impacts of climate shocks on the agricultural sector.

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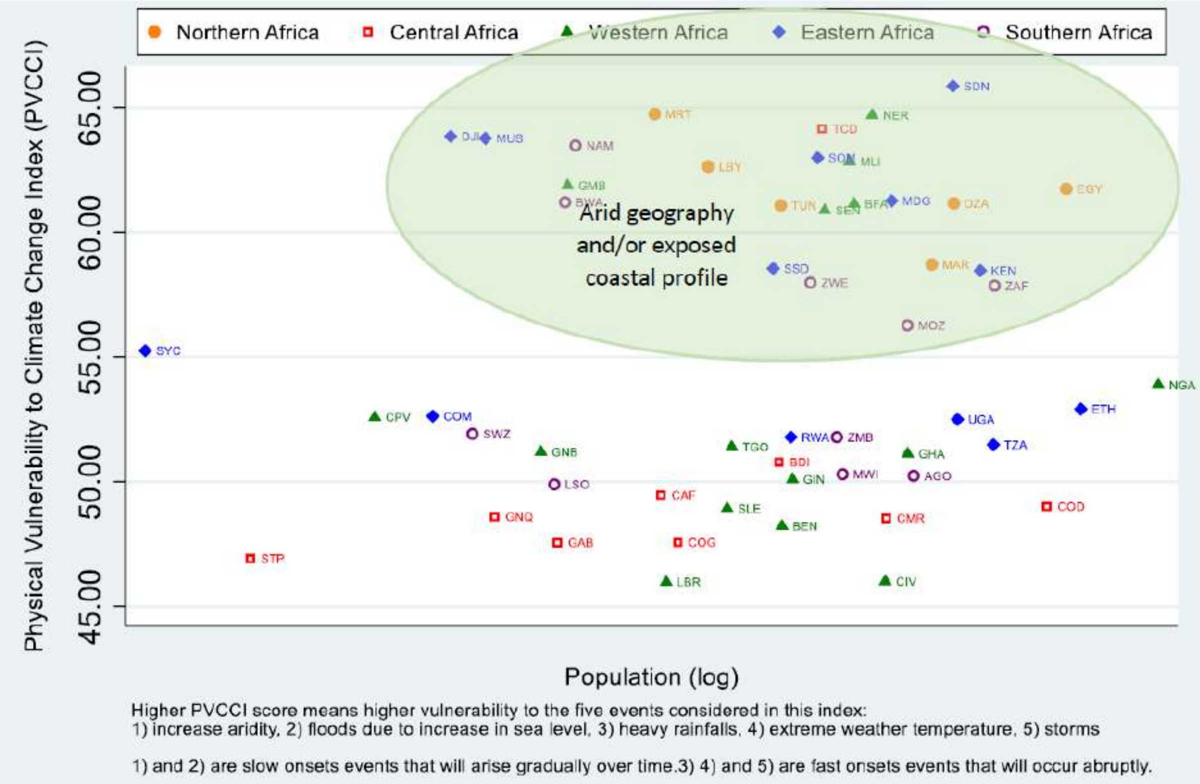
[8] Stern (2013) reports that since an increase of +3◦ Celsius has not been experienced for around 3 million years, we are in uncharted territory when it comes to modelling these likely effects (which are expected when the concentration of carbon dioxide in the atmosphere increases from the current 400ppm to 750ppm. He lists the effects that might emerge strongly at +3◦ Celsius.

[9] Space limitations call for choices. Figure 1 does not cover the direct effects of trade on GHG emissions. This precludes discussion of the often-held populist view that trade "is simply bad for climate change" even though it provides benefits for high-income countries of embodied GHG emission through imports (recall that GHG emissions are reported on a production rather than a consumption basis). Second, trade and especially migration policies of high-income countries will be a crucial determinant of Africa's effective adaptation to CC. These are briefly mentioned in section 4.

Figure 2: Vulnerability to climate change differs across Africa



Source: Authors' from Feindouno, Guillaumont, Simonet (2020)

Notes: The Physical Vulnerability to Climate Change Index (PVCCI) is built on the basis of a distinction between two types of risk due to climate change: the risks linked to progressive shocks and those related to the intensification of recurrent shocks. Performance scores are distributed from 0 to 100 for the 5 indexes using the min max standardization procedure that consists in rescaling data based on minimum and maximum values. All 5 indexes have similar weights and are aggregated using quadratic mean to determine the PVCCI score for 191 countries. The lowest score reflects the best situation (least vulnerable).

Figure 2 shows the heterogeneity in the vulnerabilities of African countries to both fast and slow onsets events captured by a Physical Vulnerability to Climate Change Index (PVCCI) [10]. At the continental level, vulnerabilities are heterogeneous, but present some continuity at the regional level. For regions that present diverse geographies (like Western Africa and Eastern Africa), one can detect distinct regroupings across geographical similarities with region grouped around several relatively homogenous clouds. Furthermore, the more vulnerable group of countries all present either extended arid/semi-arid settings or have exposed coastal profiles (to rising sea level or storms). In sum, the distribution of hazards differs across regions and is expected to do so in the future, a reason for facilitating trade across African regions which is eased by open trade policy regimes and performing infrastructure (ports, roads, railroads).

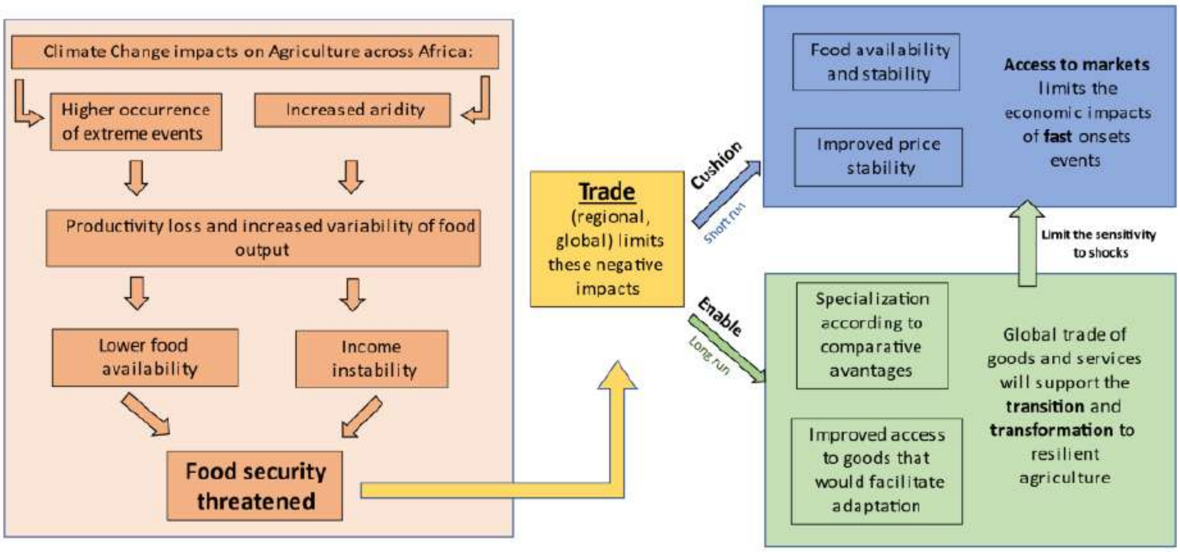
[10] By focusing on the physical aspect to climate vulnerabilities, the PVCCI removes the socio-economic part of vulnerability. The elements in this composite index are vulnerabilities to 5 expected impacts of climate change: increase aridity and sea level rising for the slow onset events; storms, heavy rainfalls and extreme temperature episode for the fast onset events. The vulnerability score is obtained by the quadratic mean of these 5 sub-indexes which is less sensitive to extreme values that a simple average.

2.1 The Climate change – food security – trade nexus

Adaptive capacity of populations in rural Africa where poverty is greatest, is low. Resulting economic losses from extreme events will be amplified especially in remote, arid and semi-arid areas where they reside[11]. For example, in the past, when a cyclone, flood, or drought hit Mozambique, per capita food consumption dropped by up to 30 percent—about 0.4 fewer meals per day per person (Baez et al 2018). In Zambia, the drought that accompanied the 2015/16 El Niño season decreased affected households' maize yields by about 20 percent and their income by up to 37 percent (Alfani et al 2019). More broadly, evidence reviewed in Hallegate et al. (2016) and Brenton and Chermutai (2021) shows that the adverse impacts of natural disasters tend to disproportionately affect vulnerable groups of society: the poor and marginalized; women; and micro, small and medium-sized enterprises, many concentrated in rural areas.

Except for a few regions in East Africa, no benefits are expected from a warmer climate across African agriculture. The leading position of the agricultural sector in Africa (52,9% of employment in SSA) makes the rural sector the main transmitter of climate shocks, threatening food availability and households' livelihoods across the country.

Figure 3: Agriculture as cushion and enabler towards resilience to climate



Source: Authors

The left-hand side of figure 3 identifies the channels through which CC affects food security, and the right-hand side, how trade (the difference between consumption and production in net food importers) contributes to adaptation.[12]

The right-hand side of figure 3 identifies two "crucial" roles for trade in supporting Africa's food systems. In the short-run, trade **cushions** the volatility of food markets by reducing the amplitude of a drought or a flood. In the longer-run, in addition to the ongoing urbanization, the effects of warming and increased aridity call for changes in crop and livestock patterns. Trade then **enables** changes in comparative advantage helping the transformation of Africa's agriculture sector towards more

[11] Barbier (2020) shows that the most remote population in Africa lives off the least productive lands and is also the poorest with reduced access to health and education.

[12] Food security, is a sine qua non to avoid famines. distinguish three pillars to food security: Food availability (the 'supply side of food security'), food access (intra-nation and intra-household) and stability (minimization of price hikes) (Brown et al. 2017).

resilience. In the long-run, however, countries also need to adopt policies towards their extent of food self-sufficiency taking into account their circumstances.[13] The remainder of this section reviews evidence on extreme (fast-onset events) from past and current episodes. Section 3 turns to “evidence about the future”.

2.2 Evidence on food security under droughts and global crises: evidence from the past

The most famous example of the role of trade to alleviate food insecurity comes from recent evidence on how the arrival of the railroad in colonial India altered the climate-excess mortality relationship.[14] This example also serves to underlie the importance of the hard infrastructure (ports, railroads, roads) needed to allow trade to cushion the effects of disaster events. Below, we discuss two examples of trade and trade policies in response to disasters. The recent global shocks of 2007-08 and the ongoing pandemic. Both illustrate how uncoordinated policies can magnify the amplitude of shocks.

2.2.1. Food security under droughts: the South-African drought of 2015-6

During global crises threatening food security, trade barriers are raised in exporting countries and lowered in food importing countries. Trade policy is also activated under episode of regional droughts. Box 1 illustrates the changes in trade patterns and policy reactions during the acute 2015-6 drought episode in South Africa. The region switched from net food exporter to net food importer. Policy responses to help consumers included the lowering of barriers on food imports. For cattle herders and farmers, support policies included increases in subsidies to key inputs and the temporary removal of the export ban of live cattle in Botswana which aggravated the situation of cattle herders in other countries in the region.

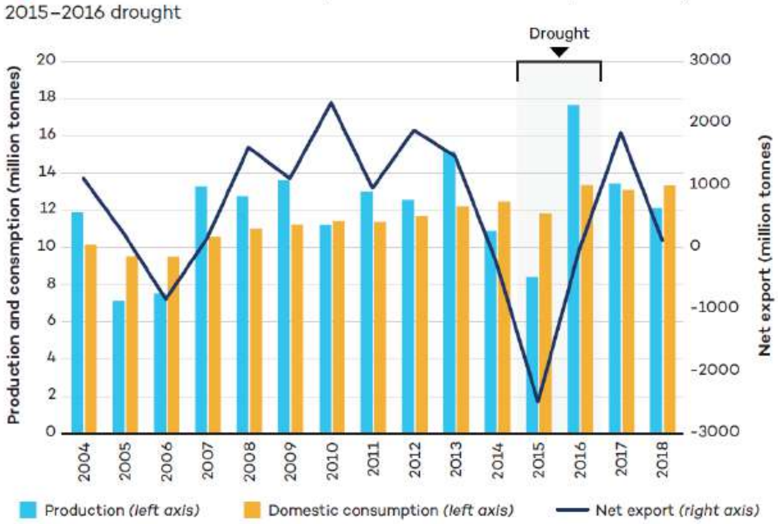
Box 1: Agriculture during the Southern African Drought 2015-16 [1]

Droughts in Africa affect more people than any other natural hazard, especially the poor. With 43% of its area classified as arid, Southern Africa was particularly hard-hit by the 2015-16 El Niño induced drought. At least 11 million required urgent assistance as the decline in food production brought food insecurity, malnourishment and stunting affecting 30% of all children. The spatial extent of drought has increased in Southern Africa, the region is warming at a faster rate than the global average, and the IPCC (2014) anticipates that droughts will intensify in magnitude and intensity across the region. Deficits in staple crops like maze (30% of calorie intake) forced poor pastoral households to purchase imported maze (see figure below) whose prices had increased sharply because of the drought-induced currency depreciation. However, sufficiently developed infrastructure allowed trade to help cushion the drought shock. Import restrictions on maze were lifted, improving food availability on domestic markets and attenuating price hikes.

[13] For example, Mali and Senegal have endorsed food sovereignty in their national agenda. Clap (2015) presents the choice of stance as a continuum between food self-sufficiency and free trade with countries along the continuum depending on country characteristics.

[14] Burgess and Donaldson (2010) construct a data base on the progressive advent of the railroad in colonial India across 125 districts during the period 1875-1919. Using their constructed index of railroad presence, they show that CC productivity shocks in the form of rainfall shortages- estimated to have caused between 15 and 30 million deaths during the period 1875-1919-- almost entirely disappeared with the arrival of the railroad. Burgess and Donaldson conclude that “...the ability of rainfall shocks to cause famines almost disappeared after the district has been penetrated by the railroad” (10 p. 452). The arrival of railroads also significantly reduced the exposure of agricultural prices and real incomes to rainfall shocks (Donaldson (2008).

Figure 1. Southern Africa's maize imports rose as domestic output fell during the 2015–2016 drought



Source : Hepburn et al. (2021, figure 1). Southern Africa included Botswana, Eswatini, Lesotho, Namibia, and South Africa.

Drought sharply affected livestock, estimated to account for 35% of African agriculture. Government support relief packages included subsidies on livestock feed and subsidies on crop production inputs improved seeds, fertilizers, and farming implements. For example, in Botswana, to support the sector, the government doubled its subsidies to livestock feed to 50% and the export of live cattle was allowed to avoid cattle mortality. This put further pressure on struggling farmers in South Africa.

This episode shows that governments need ability and flexibility by among other increasing support and relaxing trade restrictions during droughts. In the longer-run, as documented in the study, governments need to support the provision of national and regional public goods like research for more resilient plant varieties to held boost yields sustainably, early warning systems to better inform about extreme weather events (and other disasters like locust invasions).

[1] Source: Hepburn et al. (2021, section 2.2)

This example shows how policy reactions to large shocks generate strong spillovers that require collective action to be controlled. This was also the case with the global crisis of 2008 and the Covid-19 pandemic.

2.2.2 Price hikes during global crises: 2008 food crisis and Covid-19 pandemic

The major exporters of rice and wheat restricted exports during the 2006-08 crisis. Restrictions on exports of medical equipment took place during the early phases of the Covid-19 crisis, and of vaccines more recently. Both episodes harmed African countries. Collective action to dampen the crisis failed in both cases. In the case of the price hikes for rice and wheat during 2006-08, Martin and Anderson (2014) attribute 45% of the rise in the price of rice and 30% of the rise in the price of wheat to the insulating behavior by major exporters.[15]

Compared with the 2008 food crisis, export restrictions during the Covid pandemic were less pervasive and short-lived. The affected goods only accounted for 5% of the world market of calories, down from 18% during the previous global food crisis. Critically, all restrictions were short lived as almost all of

[15] Martin and Anderson (2014) note that this collective action problem is akin to a situation when a crowd stands up in a stadium to get a better view. No one gets a better view by standing, but any that remain seated get a worse view. In the case of restrictions on food exports, as net importers, African countries have small shares so reductions on import tariffs would help them individually, but have small effects on world prices.

them were lifted or expired by the end of April 2020. It is encouraging that ASEAN major exporters of rice quickly removed restrictions on exports of rice.

But suppose restrictions had been greater. As an indication, simulations of the effects of an export ban on rice and wheat during 2020 accompanied by relief in importing countries via a reduction in import tariffs of 25 percentage points, would have raised the average world price of these cereals by over 10% resulting in an increase of 5 million at risk of hunger in SSA.[16]

The Covid-19 crisis is also an interesting example on needed cooperation. Faced with the fall in availability of essential goods (medical supplies, but also food) on international markets, countries have tried to secure these goods by reducing import barriers while simultaneously restricting exports (see the contributions in Baldwin and Evenett (2020)). Global level estimates by Espitia et al. (2020) for food suggest that uncooperative trade policies could have multiplied the initial COVID-19 shock on trade by a factor of 3 with food-dependent low-income countries in Africa hit hardest. To remedy this prisoner's dilemma situation, Evenett and Winters (2020) proposed a time-limited WTO-consistent bargain. Exporting countries would commit to limit their restrictions on exports in return for importing countries keeping their import restrictions at current low levels.

2.3 Lessons from fast-onset events

Historical and contemporary evidence shows that in the short-run, the possibility to trade reduces the amplitude of a drought. Historical evidence from colonial India also shows the key role of hard infrastructure in allowing trade to cushion the impact of rain shortfalls. Also, policy reactions to large contemporary shocks have increased the amplitude of the shock. During the South African drought of 2015-6, policies had spillovers in neighboring countries. Following the 2008-09 financial crisis, export restrictions by major crop exporters and reduction in tariffs by importers amplified the shock. These contemporary fast onset events show that cross-border externalities are prevalent in African CC events implying gains from cooperation across countries.

3. Exploring the margins of adjustment to lower crop yields: simulation estimates

Since a return to autarchy is neither desirable nor feasible, trade will be a major component of any successful adaptation strategy to CC. This section reports on results from a selection of modelling efforts concentrating on agriculture, exploring the 'margins' of adjustment. All derive from a CC shock captured by the Global Agro-Ecological Zones (GAEZ) project which gives potential crop yield at the 1^0 x 1^0 plot level (about 100 km^2 at the equator) for 35 crops at different time scales.[17] For reference, GAEZ estimates of the average percentage reductions in crop yield across crops for 2080 are: [-13.3% (world)]; [-39.8% (SSA)];-[34.5% (LA)];[-26.0% (MNA)];[-10.7 (Europe)];[-8.8% (Asia)]; [-20.8% (OCEANIA)]; [-16.1% (NA)]; [-2.8% (CIS)].[18]

[16] The simulations are from the IFPRI IMPACT model which links information from climate models (earth systems and water models) to multi-market partial equilibrium models of the agricultural sector for simulation of changes in biophysical systems, socioeconomic trends, technologies and trade policies. See Robinson et al. (2015) for the model description and Sulser and Dunston (2020) for discussion of the results cited here.

[17] Time scales include 1975-2000 and predictions over the 21st. C. at 20 year intervals under different IPPC scenarios (as captured in the IPPC SRES (Special report Emissions Sscenarios)). Potential yield is purely physical Process models of potential yield include topographic information (altitude, soil characteristics) as well as temperature variation, producing natural or potential yield estimates for each crop. Costinot et al. (2016) give a succinct comprehensive description of GAEZ estimates.

[18] Gouel and Laborde (2021, table 1).

Margins of adaptation include to what extent farmers can alter production levels of existing crops (intensive margins); switches in crops (e.g. rice to wheat); changes in land utilization (when included explicitly as a factor of production); labor (relocation across crops, to urban areas or to neighboring countries). For trade, adaptation possibilities are captured by either constraining export shares in output at the crop level of in the volume of trade at different scales (regional or international) or by changes in trade policies and/or trade facilitation.

3.1. African Agriculture under a hotter climate: Simulation estimates

No model captures all these margins of adjustments. Models also differ along other dimensions: partial equilibrium (PE) or general equilibrium (GE), the number of crops and countries. Table 1 gives headline results for 5 selected models, two for comparing the role of model choice on the same CC shock, the others for focusing on the different margins of adjustment and selection of outcome (risk of hunger, migration).

3.1.1 Headline estimates

All models ask the same question: how is the economy (modelled at the field level) likely to adjust to reduction potential crops yields in 2080 predicted by GAEZ fed in to the model as the CC. Six observations.[19] First, except for Costinot et al. (CDS) and Gouel and Laborde (GL), the reported simulations are different, making comparisons difficult. Second, while all models focus on agriculture (the rest of the economy is treated as a residual in all models), the coverage of crops and countries differs. Third, all studies report that the losses from global warming are mitigated when the margins of adaptation are increased. Suppressing the trade channel as a tool of adjustment raises the cost of the climate shock. Likewise, suppressing the migration channel raises the estimated costs of the CC shock. This plausible result built into the models is a useful reminder of the importance of friendly trade (and migration) policies to face global warming. Fourth, when comparable, as in the case of CDS and GL, modelling assumptions reflected in selected elasticities and crop coverage matter in determining the scale of results. Fifth, when included, the rest of the economy is only included sketchily since input-output relationships are not included, e.g. food industries are not modelled explicitly. Sixth, except Burzyinski et al. not reported in table 1 to save space but referred to in box 2, no model addresses the issue of warming on labor productivity and on the propensity of conflict.

Some comments below on each model in table 1. Sotelo focusses on improvements in infrastructure in Peru, an important bottleneck for successful transformation across Africa. His study of Peru is informative because it shares much of the geographical landscape heterogeneity across Africa. Sotelo draws on coffee prices to estimate how transport costs vary according to the quality of infrastructure. Because coffee is grown across districts, he is able to exploit differences in coffee prices at destinations to estimate that unpaved roads raise the cost of transit by 11.5 times relative to paved roads. His simulations also suggest that improvements in market access for remote areas are likely to have strong spatial distributional consequences. Changes in infrastructure are covered in the other models, but are not a focus of inquiry. What happens to African infrastructure by 2080, will certainly have important consequences on the possibilities of adjustment, and also on the spatial distribution of these adjustments.

[19] Data constraints prevent strict comparisons of results across because all studies give results in percentage changes from an equilibrium that is not computed. This is because there is no information on production (or exports) at the plot level to calibrate that initial equilibrium.

Table 1: Headline results from Selected simulation models

Authors[a]	Spatial dimension[b]	Adaptation Margins [c]	Model estimate of CC shock	Results
Janssens et al. (2021) [2050] PE (world)	11 regions	exogenous GDP and pop.growth, CE; TI	With ●Tariff elimination ●Trade facilitation	Combination of tariff elimination on agricultural trade and trade facilitation compensates for CC shock effects on poverty estimated at increasing population at risk of hunger from 30 to 45 million
Conte (2021) [2080], (GE Africa)	42 African countries 8 subsistence crops	CI; TI. Migration	With ●Shift to modern management techniques ●Lower trade frictions	GDP loss of 4% and 11% of population displaced. Switching crops, urbanizing, dampens CC shock Adopting modern inputs and trading frictions reduces impact of CC shock
Costinot et al. (2016) [2080], GE (world)	50 largest crop producers 10 GAEZ crops;	CE, Unused land. TI	Under ●Full adjustment (ΔW_F) ●Crop only(ΔW_C) ●Trade only (ΔW_T)	Welfare loss in percentage of GDP (worldwide) ΔW_F=(-0.26%); ΔW_C=(-0.78%); ΔW_T =(-0.27%)
Gouel and Laborde (GL), GE (world)	All (35) GAEZ crops (includes livestock) All countries (51 modelled individually)	CI, TI. All land used	Under ●Full adjustment (ΔW_F) ●Crop only (ΔW_C) ●Trade only (ΔW_{FT})	Welfare loss in percentage of GDP (worldwide) ΔW_F=(-1.0%); ΔW_C=(-1.59%); ΔW_T =(-1.30%) Welfare loss in percentage of GDP (across SSA) ΔW_F=(-6.6%); ΔW_C=(-7.3%); ΔW_T =(-10.1%)
Sotelo (2021) [2080], GE (Peru)	141 districts in Peru Each farmer focuses on single crop	CI, TE	With ●Paving roads, ●Removing subsidies on grains	Paving roads increases productivity (4.7%) Median farmer's income up but increased competition from remote suppliers lowers income for 20% of farmers.

Notes: All estimates of field-level productivity are at 1^0 x1^0 resolution (except Costinot et al. at 5 arcminute 8,500 hectares at equator to 1500 hectares at polar fields). GL also report estimates at 5-arcminute. Welfare losses estimates are slightly lower: ΔW_F=(-0.94.0%); ΔW_{NC}=(-1.72%); ΔW_{NT} =(-1.21%)

First order productivity loss as a share of included crops in model: ΔW_F/crop share in GDP. CDS (world)= 0.0027/0.0187 ≈ 13.9%; GL (world) =0.0100/0.0287 ≈34.8% ; GL (SSA) =0.0655/0.2256 ≈52%

[a] PE: Partial equilibrium. GE: general equilibrium. Year of application of changes in crop yields in brackets.

[b] Costinot et al. selected 10 largest crops (71% percent of all crop values) and 50 most important countries by all-crop value (90% of value) covered in GAEZ

[c] On crops, extensive margins (CE) means new crops possible after shock. On trade, intensive margin (TI) is with Armington preferences (crops differentiated by country of origin). Extensive margin (TE) is only possible when world markets are integrated (Ethiopian wheat is the same as Moroccan wheat).

Source: Authors' based on cited studies.

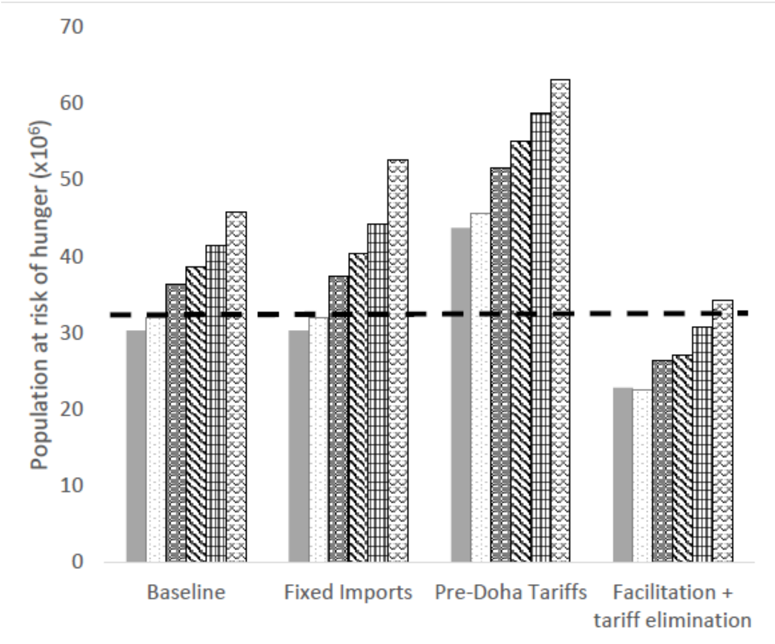
3.1.2 Partial Equilibrium (PE) estimates

Janssens et al. (2020) report on predicted changes in hunger[20] in a Partial Equilibrium (PE) model of agriculture under three scenarios of progressive trade integration where GDP growth, technical progress, population growth, and the crop management systems are given as inputs for all scenarios. Four scenarios capture the effects of increasing trade integration: (i) **fixed imports** (limits imports to those simulated under the no-CC scenario); (ii) **pre-Doha tariffs** excludes the tariff reductions during the 2000-2010 period; (iii); (v) **tariff elimination + trade facilitation** [21].

In the baseline scenario simulation, no CC takes place. At the global level, population at risk of hunger increases by 33-47% under restricted trade scenarios (fixed imports) and decreased by 11-64% under open trade scenarios. So, as built into the model, trade facilitation (including removal of trade barriers) is an important adaptation enabler with reductions in poverty differing across regions.

Net food-importing regions like SSA with already low-yields are the most impacted. Figure 4 suggests an increase in poverty of 40%-50% in SSA under the worst CC with inclusion of CO2 fertilization associated with warming. Further inspection of results shows that trade integration operates through 3 channels: reducing agricultural prices, increasing food availability and crop production efficiency. In contrast with the General Equilibrium (GE) results discussed below, comparative advantage across regions is not much affected.

Figure 4: Population at risk of hunger in SSA in 2050 under different trade scenarios



Source: Janssens et al. (2020 figure 2). Data available at https://tinyurl.com/xapath3n

[20] Population at risk of hunger is the percentage of people whose food availability falls below the mean minimum dietary energy requirement.

[21] This amounts to removing the convexity built into the bilateral trade costs linked to trade volumes, i.e. "the hurdle to substantially expand trade in a give period because of limited infrastructure, non-tariff barriers, regional preferences, and other factors, is reduced to almost zero" (Baker et al. 2018, p.3). Bilateral transport costs kept constant in the base scenario, but a quadratic function was used for new trade flows to reflect capacity constraints each ten-year period with the cost reset function reset for each 10-year step. Outcomes from this reduced-form short-cut is not confronted with experiences like those in Ethiopia where the road network was multiplied by 4 in the past 20 years.

Notes: The dotted line is the predicted population at risk of hunger under the SSP2 (Shared Socioeconomic Pathway) middle of the road CC scenario. Each block of results covers a different trade scenario under increasing warming (from left to right) within each bloc. The outcome under no CC is in solid grey and the dotted bar on the right corresponds to no CO2 fertilization. The baseline bloc shows the effects of increasing temperature under no trade scenario. The strongest reductions in predicted population at risk of hunger occur under the composite scenario of trade facilitation and tariff elimination. Pre-Doha tariff reductions show an increase in population at risk from 30 to 43 million under no trade adjustment.

Regarding relative magnitudes across scenarios, Doha round tariff reductions reduces hunger risk from 43 to 30 million. Since Doha Round negotiations did not conclude, reductions in applied tariffs during the period as captured by ITC tariff data, must have captured unilateral reductions or reductions under the implementation of regional trade agreements. Estimates appear large since, generally, NTBs were not reduced during the period. As to trade facilitation improvements, they are captured by an ad-hoc reduction in trade costs whose predicted magnitude on trade flows is not compared with historical episodes. In sum, it is difficult to judge the plausibility of these PE estimates.

3.2 Comparing General equilibrium estimates

Start with Conte. Three aspects of Conte's study make it interesting. First, he restricts adaptation possibilities to those taking place at the Africa level. This is helpful to isolate some of the expected effects of the AU2063 agenda, like full implementation of the AfCFTA and of the completion of the Trans Africa Highway project. Second, the study estimates that migration will be an important adaptation margin to CC. Third, he shows that production at the crop level is positively correlated with potential yields.

Of importance to the trade models reviewed here, Conte also shows a strong correlation between changes in bilateral crop exports across Africa and changes in relative yields over the period 1975-2000. These observed patterns conform to predictions from a view that trade in agricultural goods is governed by differences in comparative advantage (as predicted by Ricardo).[22] This leads him to conclude that, across Africa, the natural suitability to grow crops explains are large degree of crop specialization and trade across SSA. In view of uncertainty, this statistically significant correlation over the past is reassuring for the Ricardian model results using GAEZ data. Box 2 summarizes results.

Compare now the headline results in CDS with those in GL. Differences are substantial for two reasons. First differences in coverage (GL cover more crops and more countries so the crop share in GDP is higher than in CDS). This alone would result in larger welfare losses because of the crop share in their coverage is 50% higher. Suppressing the trade adjustment channel in CDS has much less effect than in GL because supply, and especially, demand elasticities are higher than in GL.[23]

[22] Netting out fixed effects that control for omitted variables, the volume of crop exports from countries 1% more suitable in terms of yield relative to the importing country, is about 0.5% higher on average (table D2, col. 3).
[23] In CDS, the unitary the price elasticity of demand for food (estimated from their cross-section data) is about 5 times larger than those in other studies which are used in GL. As a result, adjustment to the negative productivity shock is easy.

Box 2: Within-Africa Adaptation to Climate change: the roles of Trade and Migration[1]

Conte (2022) sets up a spatial multi-sector spatial equilibrium model to explore the role of trade and migration in adaptation to climate change by 2080 across the 42 SSA countries, that is all adjustments take place across countries within Africa—there is no outside world. As in CDS (2016) and GL (2021), the climate shock is captured by the FAO-GAEZ forecasts of productivity change at the crop level for 10^0 x10^0 cells (area around 100 km2). The model distinguishes the 6 important crops in the consumption of subsistence farming (cassava, maize, millet, rice, sorghum and wheat). In SSA Africa, 34% of agriculture is subsistence farming (Janssens et al. 2020, p.837). Markets are integrated (wheat from Ethiopia is a perfect substitute with wheat from Kenya) Margins of adjustment include: Crop adjustment, migration to cities or neighboring countries and trade (which depends on trade costs). Food is an essential good (limited substitution of food for other consumption goods) implying that when trade frictions are high, labour has to be reallocated to the rural sector to supply food. An urban sector serves as residual. Multi-crops are partial substitutes as subsistence. A reduction in migration barriers has a welfare-increasing role.

Trade costs are calibrated on observed trade in crops along the existing road infrastructure with unobserved parameters calculated to fit data in the base year 2000. A backcasting exercise carried over 1975-2000 shows that the model replicates population changes over the period. This good fit is probably helped by path dependence as the densest locations in 1975 are also the densest in 2000, a reflection of high mobility frictions.

Table B2 reports results from Climate change (abbreviated as CΔ in the table). Panel A shows that under multi-crop specification (col. 1), the GDP loss is estimated at 1.2% with a climate migration of 4.02 million individuals and a reduction of urban employment of 0.85%. Panel B displays the great heterogeneity across cells. Panel C shows that international migration flows are 11% of total migration.

Eliminating crop diversity (col.2) triples GDP loss. Cols. 3 and 4 show that reducing trade barriers or migration frictions substantially increase migration, both internal and cross-country. Less frictions result in a better allocation of labor across space resulting in positive GDP growth, albeit with large variations across cells displayed in panel B. Raising trade costs (col. 5) forces a reallocation of labour to rural areas, reduces migration and increases the estimated GDP loss 7.05%.

Because climate change is altering the ranking of crop suitabilities, low trade and migration frictions are necessary to allow migration policy to adapt to climate change, although this is at the expense of higher regional inequality. Columns 6 reports the result of a hypothetical scenario in which migration and trade frictions in SSA are equated to those in the EU (trade frictions in the EU are calibrated at less than one hundredth of a percent of those across Africa). Reducing trade frictions to EU levels reduces climate migration by half and attenuates migration flows. Reducing migration barriers to EU levels (col. 7) increases climate migration, primarily between countries.

Table B2: Aggregate and disaggregate results of climate change in 2080 under different scenarios and assumptions about frictions*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Baseline	Baseline	No country	No migration	Higher	EU trade	EU migration
	(6 crops)	(1 crop agric.)	barriers	frictions	Trade costs	frictions	frictions
Panel A-Aggregate CΔ effects							
Climate migration [1]	4.02	3.23	62.05	114.63	17.4	2.78	29.14
Δ GDP (%)	-1.18	-3.48	3.65	9.23	-7.05	-0.31	0.03
Δ non-agricultural employment	-0.85	-2.73	0.27	1.36	-3.19	0.33	-0.64
Panel B- Selected country-level CΔ effects							
Median Δ Population[1]	0.03	0.01	0.03	-035	0.16	0.02	0.11
Bottom/top deciles	[-0.31;0.25]	[-0.31;0.25]	[-4.55;2.63]	[-7.21;7.32]	[-1.05;1.53]	[-0.31;0.25]	[-2.83;1.56]
Median Δ GDP pc (%)	-0.72	-4.42	1.2	-0.43	-2.32		
Bottom/top deciles	[-6.01;6.53]	[-10.45;1.27]	[-9.35;19.62]	[-13.21;49.59]	[-29.65;17.82]	[-2.97;1.68]	[-7.02;12.36]
Panel C Cross migration with CΔ							
Ratio international/internal migration flows	0.11	0.11	5.06	19.42	0.14	0.11	1.21

*Source: Conte (2022) tables 2 and 3

Notes:
Abbreviations: Δ: "change", CΔ "Climate change". Outcomes from predicted climate change for 2080. Col. 1 is baseline version with 6 crops, and col.2 is for version with one crop used in counterfactuals based on EU trade and migration barriers in cols. 6-7.

1. Climate migration in million individuals.

Conte (2022) *Climate Change and Migration: the case of Africa.*

These migration estimates can be compared with those reported in other studies. Rigaud et al. (2018) focus on the ecological and socioeconomic aspects of climate change. They estimate by 2050. 86, 40 and 17 million internal migrants for SSA, South Asia and LA respectively. Burzynski et al. (2022) use a two-sector rural-urban model with skilled and unskilled labour where fertility and migration decisions have micro-foundations. Assuming unchanged migration policies, their overlapping generations model predicts GDP loss of 10% for SSA by 2070 with most migration within countries (200 to 300 million migrants worldwide over the century).

3.3 Lessons from simulation models

All models show that enlarging the channels of adjustment (possibility and ease of switching crop production, possibility of changing trade patterns on the demand side through changes in bilateral trade patterns) mitigate the amplitude of the loss in welfare resulting from CC. Exploring the possibility of labor migration both internal and to other countries suggests large movements because of the heterogeneity in potential productivity shocks across crops.

Decomposing the welfare changes into components suggests two conclusions. First adjustments in crop selection and in bilateral trade partners contribute approximately equally to reducing the costs of adjustments. Second, the expected sharp increase in food prices resulting from warming is likely to hit SSA strongly. This estimate reflects the combination of three forces at work in the models. First, food is a large share in consumer expenditures in SSA. Second, SSA is a net food importer. Third, SSA is largely specialized in subsistence crops that are not currently traded, so that channel of adjustment is effectively shut off in the models' result.

4. Trade Facilitation policies to help Africa's resilience

To achieve the global climate goals that will help African economies, the rules and institutions of global economic governance must align around a green economic transition. First, all countries will have to 'green' their economies with most efforts coming from high-income countries to remove their harmful subsidies (e.g. on agriculture, fuels and fishing). Second, the WTO needs an overhaul with respect to members' rights and obligations. This means shifting from a 'negative' contract where members are essentially free to decide on their environmental policies as an internal choice so long as non-discrimination is applied to a 'positive' contract where preservation of the environment becomes an obligation.[24] In short 'greening the WTO' to preserve the environment will have to be included in the new contract.

An open rule-based world trading system with preservation of the environment as a prime objective is essential for small low-income countries. High income countries should reduce tariffs and NTBs on EPPs in which African and other low-income countries have a comparative advantage. At the African level, success at adapting to warming will also depend on trade-facilitation [25] measures on green goods

[24] Birbeck (2019) proposes 10 trade-related policy reforms necessary to remove barriers to, and create drivers for, climate action. Mavroidis and Melo (2015) discuss the status of the three main instruments to address climate change mitigation objectives (labelling, taxes and subsidies) at the WTO. They suggest implementable improvements (e.g. 'green' subsidies, climate clubs with uniform tariffs applied to non-signatories to entice participation).

[25] Trade facilitation includes improvements in 'hard infrastructure' like roads (see section 3.xx) and in 'soft infrastructure' like border measures (tariffs and non-tariff measures (NTMs) when these act as Non-Tariff Barriers (NTBs) or efficiency improvements at customs as emphasized by the Trade Facilitation Agreement, the only plurilateral agreement signed by all WTO members since its creation. Trade facilitation also includes behind-the-border measures like standards.

at two levels. First, all countries should reduce tariffs and Non Tariff Barriers (NTBs) on Environmental Goods (EGs) and on Environmentally Preferable Products (EPPs), either unilaterally, regionally, or multilaterally. African countries should concentrate on reducing their barriers on imports of Adaptation-related Environmental goods (AEGs). Second, greening the AFCFTA by bringing environmental provisions in the treaty and excluding green goods from exception lists would mainstream protection of the environment into the African policy architecture and jump start cooperation across the continent.

4.1 Reduce Trade barriers in Green Goods and Services

Globalization is increasing spillovers either embodied in the activity of international trade (carbon embodied in goods, invasive species, pests) or as a by-product of production (e.g. pollution in the air and water). Continuing to negotiate trade and environmental policies separately is no longer conducive to the preservation of the environment. Although the WTO holds recurrent meetings on key environmental issues, bringing the preservation of the environment to the fore into the global architecture of policy-making has so far proved elusive. A good place to start a rapprochement between the trade and climate regimes is to succeed in the reduction of policy-imposed barriers to trade on Environmental Goods (EGs) and Environmental Services (ESs). These negotiations have failed for two decades.

A reduction in the protection of EGs and ESs would reduce the costs of adaptation strategies to CC across Africa. Just as trade in EGs helps lower price of cleaner equipment and technologies, trade in ESs allows producers to source the services they need from foreign suppliers[26]. Brenton and Chermutai (2021, box 4.1) report that Information and Communications Technologies (ICT) could deliver up to a 15 percent reduction of business as usual CO2 emissions.

In short, reduction in policy-imposed barriers to trade in EGs and ESs would represent a triple win. For trade as barriers are reduced. For the environment as the costs of preservation are reduced. For developing and African countries as they get access to an enlarged choice of goods and they get access for their exports as high-income countries reduce barriers to trade on goods with a lesser footprint on the environment (called Environmentally Preferable Products (EPPs)) in which developing countries have a comparative advantage. A successful elimination or deep cut in trade barriers on EGs and EPPs would also help avoid a clash between the climate and trade regimes.

4.1.1 Policy Measures for high-income countries

Concluding negotiations on a plurilateral Environmental Goods Agreement (EGA) would be a boost for the environment. Because applied tariffs in EGs and ESs are low, success would be from the demonstration effect rather than meaningful gains in efficiency. This would hopefully open the way to include negotiations in ESs that are embodied in EG projects.

More ambitiously, in the future, subsidies on pollution-intensive activities should also be on the negotiating table. As shown by Schapiro (2021), raw materials and intermediate goods industries around the world are the highest emitters of CO2 per unit of value-added because tariffs and non-tariff barriers (NTBs) are much lower on these industries (mainly because of counter-lobbying by downstream industries).[27] Schapiro (2021) estimates that removing this global implicit subsidy to CO2

[26] As aptly put by Steenblik and Droge (2019) "If environmental Goods are the hardware for addressing climate change, environmental services are the software that ensures that they work as intended". Studies on GVCs by the OECD (2014) report that, when measured in value-added, more than 50 percent of exports come from services.
[27] In the sample of 48 countries and 163 industries, average tariffs are 1.7%, AVE of NTBs are 3.6%. For all other industries, the averages are 3.9% and 9.6%. Schapiro (2021)

emissions ($550 to $800 billion per year) by applying equal tariffs and NTBs across sectors would lower global CO2 emissions with estimated effects similar in magnitude to the estimated effects of some of the world's proposed climate change policies. One can interpret the magnitude of these estimates as a ballpark estimate of the cost for the environment of non-coordination in trade policies, coordination that would require a change in the WTO mandate.

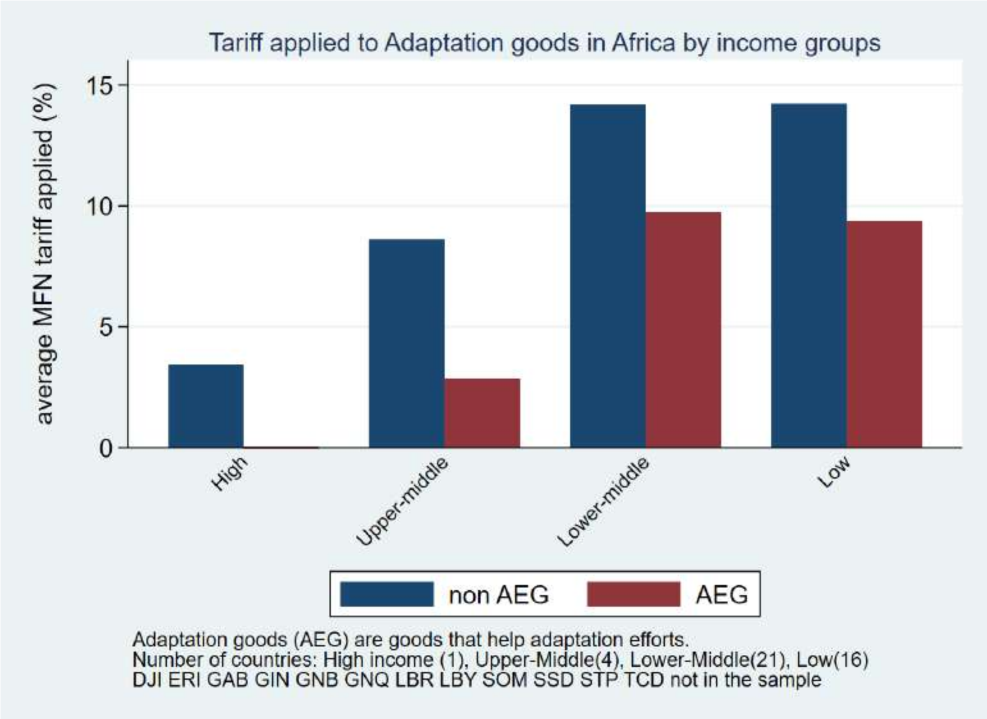
4.1.2 Removing tariffs on Adaptation-related EGs (AEGs) in African agriculture

Eliminating barriers to trade in AEGs would significantly reduce the cost of acquiring foreign inputs that are critical to carry adaptation measures. Take tariffs. Selecting any list of EGs for tariff reductions is difficult. Here rather than rely on existing lists that reflect, at least partly, the mercantilistic behavior of negotiators, a minimal, but arguably representative, and sufficiently comprehensive, list of products is selected (here dubbed the Adaptation-related EG (AEG) list). It includes stress-tolerant cultivars, pesticides for weed control, early warning systems, elements of renewable off grid power generation, irrigation technology). The list of 56 products is detailed in the annex. [28]

Figure 5 displays average applied MFN tariffs for AEGs vs non-AEGs by income group. Two patterns observed in other regions hold for Africa. First, average applied tariffs are lower in the higher income groups. Second, average applied tariffs are lower for the AEGs. This is because they belong to intermediates and semi-processed goods that are subject to counter-lobbying by downstream industries, the pattern observed by Shapiro referred to above.

[28] Defining a list of "adaptation-relevant" goods is a tall order, as most goods helpful for climate adaptation efforts have other usages as well. The tentative list of 56 "Adaptation goods" selected for this chapter is described in Annex 2. The overlap with APEC (54 goods) is small (12 goods), a reflection that the APEC list covers other objectives. Furthermore "adaptation" is a misnomer as all proposed measures are part of good management practices, not necessarily related to CC. See Hertel (2018) for discussion and pitfalls of using this classification.

Figure 5: Average MFN applied tariff by African countries
Adaptation-related Environmental Goods (AEGs) vs. non-AEGs

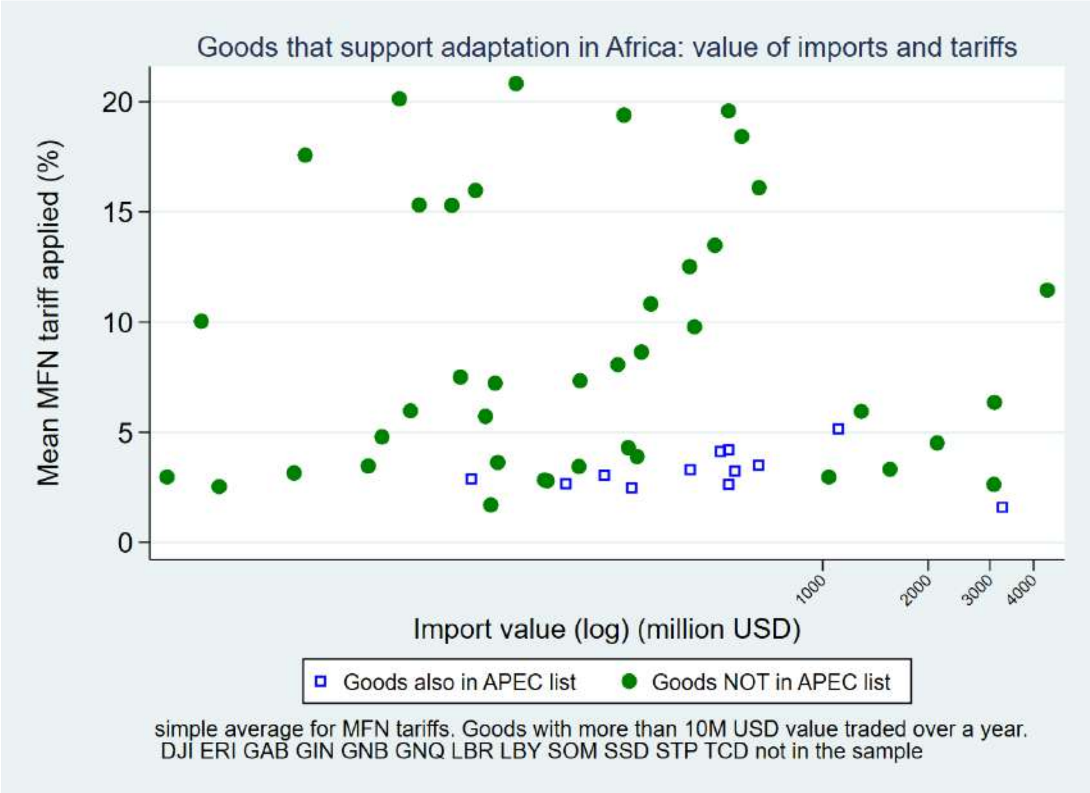


Notes: Simple average of applied MFN tariffs for the two categories of goods. Averages per income group obtained by taking the Simple average applied tariff for all AEGs and countries in the corresponding income group. The list of 57 goods includes goods used for generating renewable energy (biogas stoves, wind-turbine, solar-cells) irrigation, captor and sensor. See annex for the list. Seychelles is the high-income group country.
Source: Authors' from WITS Database.

Figure 6 plots average import values against applied tariffs for the 56 products in the AEG list. Import values are negatively correlated with applied tariffs. Wind turbines and solar cells which have the largest average import values over 2017-19 are also on the APEC EG list. If only the 20 largest African countries imported AEGs, the average import value would be $ 50 million. The evidence suggests that the impact of R&D on agricultural productivity is much lower than in other regions (Fuglie 2018). Extension services, critical for the uptake of new varieties may not be available in Africa because of the lack of mobility of extension services across countries. This low value for imports of AEGs probably reflects, at least in part, the observation that the green revolution has largely by-passed Africa so far.[29]

[29] The adoption of High-yielding crop Varieties (HYVs) started in Mexico and Phillipines then spread to India. For a variety of reasons, among which small markets, high trade costs (including barriers to trade), HYVs did not hit Africa. As a result, up until the start of 21st century, the benefits of the green revolution (estimated as increased yields documented by Gollin et al. (2014) (higher productivity and GDP growth, lower population growth) largely escaped SSA. Notably HYVs were not introduced for sorghum and cassava, two key crops for subsistence agriculture.

Figure 6: Import value and average applied MFN tariffs of Adaptation goods in Africa



Notes: Single average of MFN tariffs applied. Average Import value over 3 years (2017-2019) and 42 countries in million USD. AEG list in annex 2. Table A1 gives the names of each of the 9 most traded AEGs in figure 4.2.

Source: Authors' from WITS Database.

4.2 Greening the AfCFTA

The AfCFTA signed in 2018 is operational since January 2021. Negotiations on Phase I are nearing completion. To be prepared for CC, the AfCFTA phase I should exclude AEGs and, potentially other green goods (EPPs) from the exclusion list (of tariff reductions) covering 3% of the tariff lines (provided they do not account for more than 10% of their total trade). Phase II negotiations are to cover competition policies, intellectual property and investment and schedules of specific commitments in services. This is an opportunity to mainstream measures for the preservation of the environment into the phase II agenda by including provisions to protect the environment and fight CC.

4.2.1 Include Environmental Provisions in AfCFTA

It is remarkable that the environment appears nowhere in the AfCFTA, not even in the preamble. In short, integration efforts in Africa at the regional and continental level have failed to attract attention on preservation of the environment. A first next necessary step for AfCFTA is to amend the preamble to mention the environment. The preamble would then recognize the necessity to balance environment and trade (this language is in the preamble for more than 90% of the 280 trade agreement signed since 1956 scrutinized by the authors).[30]

[30] When entering provisions in the data base, the authors measure depth by evaluating if the provision is: (i) aspirational or legally binding under international law; (ii) whether it is applicable in Dispute Settlement (DS) proceedings brought by other parties either in State-to-State (DS) or by private persons (state-private)

Next, an environmental agenda focused on adaptation to CC would first need to focus on the environmental objectives that are in line with existing Multilateral Environmental Agreements (MEAs) to which African countries are parties (UNFCCC, Aichi Convention on Biodiversity…). This will be a challenge for the many SSA countries with limited implementation capabilities, especially because the measures in this 'positive' trade policy agenda (the 'negative' agenda releases resources) requires resources that are also needed to reboot the post-pandemic economy.

Environment-related provisions should be on Phase II negotiations agenda. For example, the protocol on competition policy could include environmental provisions as avoiding an environmental race to the bottom should be a top priority. Provisions could target environmental standards for public procurement or mutual recognition of the certificates and accreditation procedure provided inspection and certification comply with environmental norms.

The AfCFTA (or ECOWAS) could introduce provisions to limit deforestation as there is evidence that these provisions have had some success. Controlling for many confounding factors, Abman, Lundberg, and Ruta (2021) show that the inclusion of deforestation provisions in trade agreements in fact reduced forest loss by 7,571 km2 from 1960 to 2020, the effects being most pronounced in ecologically sensitive areas. These provisions limited agricultural land expansion but not total production, indicating that agricultural intensification on existing land may still have occurred. Environmental provisions are becoming more diverse and extensive but, for most developing countries, provisions lack specificity.

Finally, the National Implementation Strategies for Member States and RECs could be directly included in the AFCTA. EAC is currently carrying out a Strategic Environmental Assessment (SEA) to this effect, which could serve as a plea for the inclusion of environmental dimensions.

4.2.2 SPS measures for safe trade

As intra and extra-regional trade in agricultural commodities is likely to increase with climate change, national regulatory bodies that set Sanitary and Phytosanitary (SPS) measures will have to be designed to deliver safe trade at least cost. This will be particularly critical in the face of new challenges brought by climate change as pest and disease are expected to spread across borders. For SPS measures to fulfil their role by remaining precautionary rather than protectionist (i.e an NTB).

African agriculture needs new technologies to adapt to CC. In Africa fertilizer application rates are substantially lower than elsewhere, especially so in Land-locked countries. SPS measures are needed for safe trade. The WTO SPS Agreement is to ensure that SPS measures are evidence-based and used only to protect against SPS risks.[31] This is particularly important for Environmentally Preferable Products (EPPs). Countries that are unable to provide traceability in the value chain and the necessary trading infrastructure such as certification and inspection services to ensure that the product is genuinely preferable may be excluded from markets overseas. The same issues apply to trade in agricultural products across Africa.

[31] Indexes of product complexity are increasing in value over time and they are higher for EGs on the WTO list (Melo and Solleder (2017, figure 2)).

Box 3: Recommendations on improving SPS related measures: findings from Southern Africa[1]

As part of applying the SPS Agreement, the STDF (standards and Trade Development Facility) of the WTO has conducted field research on the implementation of SPS standards on agricultural goods trade in South Africa, Malawi and Zambia. to facilitate safe trade, a rising concern in a globalized world heightened by the prospects that climate change could increase the flow of invasive species and pests. Structured interviews were carried out with government officials and private sector actors. The report stresses the challenge of implementing SPS schemes on a large scale in an environment with limited capabilities. Following is a list of recommendations:

- Introduce risk-based approach to SPS-related border inspections: focus inspections on high-risk commodities, limit them on low risk (processed food). Relying on business operators using good practices or third-party certification can be a way to reduce cost associated with controls.
- Use international standards to align SPS regionally. Do not set regional standards higher than international ones and avoid mixing up voluntary quality issues with SPS requirement.
- Implement transparency in fees, delay time, and documents needed by publishing the information on internet. (Increased transparency is an objective of the TFA.)
- Overlap and fragmentation of SPS systems to be avoided. Coordination with border authorities to be improved.

The report also documents the hurdles faced by small producers when it comes to SPS certification. Certification should be simplified to the largest possible extent, otherwise small producers may escape SPS norms altogether and turn to informal trade if the perceived cost of certification is too high.

Other successful regional trade facilitation schemes that are not exclusively about SPS mentioned in the report should help reduce trading costs:

- The Tripartite NTM Reporting, Monitoring and Eliminating Mechanism in COMESA, EAC and SADC: online system that record and publicised complaints about NTB through SMS
- Comprehensive Tripartite Trade and Transport Facilitation Programme (SADC): draft guidelines to establish all border agencies in one place.
- Trade Information Desks in COMESA that acts as a liaison between the private sector and border authorities, helping with trade and SPS formalities.
- The SADC and COMESA harmonized system for seed variety release that recognize the certification of other country members. Any seeds approved in 2 members state can be freely traded within the REC without further registration.

[1] Rathebe, J. "The Implementation of SPS Measures to facilitate safe trade: Selected practices and experiences in Malawi, South Africa and Zambia"

Box 3 shows that implementing an SPS strategy faces challenges even among 3 countries (South Africa, Malawi and Zambia) as comprehensive criteria may lead traders into informality. At the same time, accumulating a comprehensive data base on cross-country equivalences, Schmidt and Steingrass (2019) show that the introduction of harmonized standards increases trade at the intensive and extensive margins. Melo and Solleder (2020b) using a structural gravity model show that an increase in regulatory overlap that would result from regulatory harmonization would increase bilateral trade in EGs.

5. Conclusion Lessons for policy and the trading system

This paper has reported on three dimensions along which trade can help Africa adapt to Climate Change (CC): (i) fast-onset events from short-lived extreme occurrences (floods, extreme temperatures); (ii) slow-onset events (rise in average temperatures and sea-level rise); (iii) trade facilitation policies including changes in the architecture of the global trading system.

Fast onset events. Trade reduces the amplitude of extreme events like a drought. But policy reactions to large shocks can increase the amplitude of the shock. During the South African drought of 2015-6, policies had spillovers in neighboring countries. Following the 2008-09 financial crisis, export restrictions by major crop exporters and reduction in tariffs by importers amplified the shock. Policy coordination is needed to control spillover effects.

Slow-onset events. These are to occur over the century. The paper reviews models exploring the 'margins' of adjustment to CC in agriculture: changes in production levels of existing crops; switches in crops; changes in land utilization; labor relocating to urban areas/migration; adjustments in the volume of trade at different scales (regional or international). Enlarging the channels of adjustment mitigate the amplitude of the loss in welfare from expected CC over the 21st Century. Decomposing the welfare changes suggests two conclusions. First adjustments in crop selection and in bilateral trade partners contribute approximately equally to reducing the costs of adjustments. Second, the expected sharp increase in food prices resulting from warming is likely to hit SSA most strongly.

Trade facilitation. A functioning global trading system is a public good that will become more valuable in the future under CC. Free and unfettered access to global food (and other key) supplies must be ensured, especially for Africa. This requires a rapprochement between the trade and climate regimes. As an entry point, developed countries would conclude a plurilateral Environmental Goods Agreement (EGA) that would be a small (because applied barriers on EGs and ESs are small) step in the right direction, yet a triple win for trade, for the environment, and for African agriculture that needs access to AEGs.

African countries could improve the functioning of the continental policy architecture by several measures. First by removing AEGs from exclusion lists on the AfCFTA while simultaneously reducing their barriers to trade on AEGs and EPPs. Second, preserving the environment should be mainstreamed in the African trade architecture by including environmental provisions. One such example would be environmental provisions to control deforestation. Third, improvements are needed in the application of the SPS agreement so that trade becomes effectively safe by the selection of measures that traders will not seek to avoid because compliance is excessively onerous.

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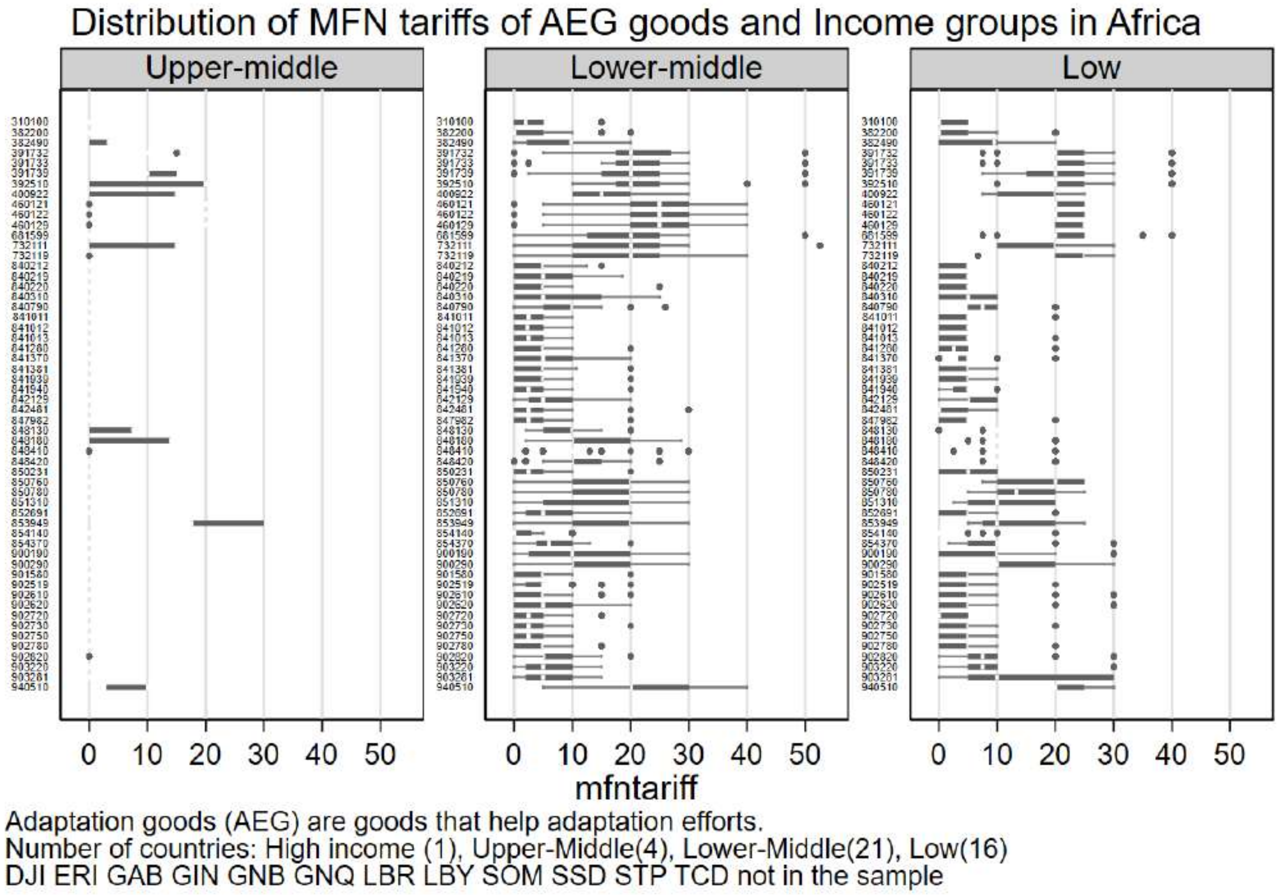
ANNEX

Figure A1. Distribution of MFN tariffs on AEG goods in Africa by income group



Source: Authors from WITS database. MFN tariffs in %. Boxes represent the interquartile range, whiskers the range of the 1st and 3rdh quartile and dots are outliers observation.

Table A1. Import values of the most imported AEGs (ranked in descending order)

(1)	(2)	(4)	(5)	(6)
HS6 product code	Averages (million USD)	EG good APEC	avg MFN tariff	Products description
850231	114.6	Yes	3.5%	Electric generating sets and rotary converters: - Other generating sets: wind- powered
854140	54.6	yes	1.6%	Diodes, transistors and similar semiconductor devices; photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes; mounted piezo- electric crystals:
382490	48.8	No	6.4%	Prepared binders for foundry molds or cores; chemical products and preparations of the chemical or allied industries (including those consisting of mixtures of natural products), not elsewhere specified or included:
848180	42.3	No	11.5%	Taps, cocks, valves and similar appliances for pipes, boiler shells, tanks, vats or the like, including pressure- reducing valves and thermostatically controlled valves:
382200	34.4	No	2.6%	Diagnostic or laboratory reagents on a backing and prepared diagnostic or laboratory reagents whether or not on a backing, other than those of heading 3002 or 3006; certified reference materials.
841370	34.4	No	4.5%	Pumps for liquids, whether or not fitted with a measuring device; liquid elevators:
840212	29.4	No	3.4%	Steam or other vapor generating boilers (other than central heating hot water boilers capable also of producing low pressure steam); super- heated water boilers: - Steam or other vapor generating boilers: water tube boilers with a steam production not exceeding 45 t per hour
842481	27.0	No	3.0%	Mechanical appliances (whether or not hand- operated) for projecting, dispersing or spraying liquids or powders; fire extinguishers, whether or not charged; spray guns and similar appliances; steam or sand blasting machines and similar jet projecting machines:
840219	18.6	No	4.3%	Centrifuges, including centrifugal dryers; filtering or purifying machinery and apparatus for liquids or gases:

Source: Authors

Notes: Data used in figure 4.2. Col. 2: Total imports averaged over 2017-2019. Col. 3: Average Applied MFN tariff over 41 countries.

"Sur quoi la fondera-t-il l'économie du monde qu'il veut gouverner? Sera-ce sur le caprice de chaque particulier? Quelle confusion! Sera-ce sur la justice? Il l'ignore."

Pascal

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