# Climate Change and Migration: the case of Africa

Bruno Conte

Universitat Pompeu Fabra &

Barcelona School of Economics

# Motivation

- Implications of climate change (C$\Delta$): at the center of the policy debate
- Drastic (potential) consequences for Sub-Saharan Africa (SSA):
  - High dependence on agriculture
  - Low usage of modern inputs
  - Rapid population growth

# Motivation

- Implications of climate change (C$\Delta$): at the center of the policy debate
- Drastic (potential) consequences for Sub-Saharan Africa (SSA):
  - High dependence on agriculture
  - Low usage of modern inputs
  - Rapid population growth
- Great Climate Migration (Lustgarten, 2020):
  - High vulnerability of SSA (in terms of migration responses to C$\Delta$)
  - Rigaud et al. (2018): intranational climate migration $\sim$ millions by 2050

# Research Questions and Outline

1. How can C$\Delta$ lead to migration flows in SSA (within/across countries)?
2. How economic mechanisms and potential policies interact with C$\Delta$ effects?

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2. How economic mechanisms and potential policies interact with CΔ effects?

This project: Data + Model = long-run GE effects of climate change

1. Climate change: agricultural productivity shock
   - FAO-GAEZ data: variation at location-crop level
2. Embed it in a multi-sector spatial GE model to quantify:
   - CΔ migration by the end of the 21st century
   - Role of migration and trade policies on CΔ effects

# Main Results and Takeaways

1. Aggregate C$\Delta$ effects:
   - Migration flows (22 million) and real GDP pc losses (-2%)
   - Magnitude of results: determined by spatial frictions
2. Distributional effects:
   - Heterogeneous migration responses across space [-280K, 270K]
   - Country-level welfare effects: [-14%, 3%]
   - Production adaptation across sectors + trade: mitigate C$\Delta$ effects
3. SSA as the European Union ($\downarrow$ trade and migration barriers):
   - EU's migration and trade policies: aggregate vs. distributional trade-offs
   - Main channel: C$\Delta$-induced structural change

# Data

# Spatial Data: $1^\circ \times 1^\circ$ grid cells ($\sim$ 2000 cells)

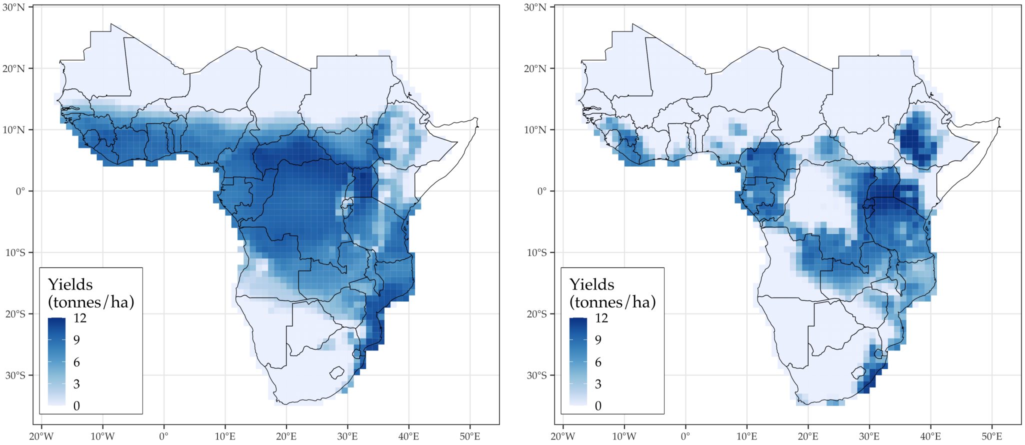
1. GDP and Population:
   - 2000: both values from (G-Econ, Nordhaus et al., 2006)
   - 1975: population from (GHSP, Florczyk et al., 2019)
   - 2080: population estimates (UN's Population Prospects, at the country level)

2. Transportation network: African extract from gROADS and transportation friction surface from Weiss et al. (2018)

3. Agriculture: GAEZ agro-climatic potential yields (IIASA and FAO, 2012):
   - Unit: tons/ha, subsistence (rainfed) technology
   - Crops: cassava, maize, millet, rice, sorghum, wheat
   - Time periods: 1975, 2000 and 2080 (RCP 8.5)

# CΔ and Agricultural Productivity spatial–crop heter.

Figure 1: CΔ effects on potential yields of cassava for 2000 (left) and 2080 (right).



# Model, Calibration, and Counterfactuals

# Model and CΔ Counterfactuals Outlook

- Static, multi-sector spatial GE model
  - Love for varieties (consumers) **+**
  - Trade frictions (production and trade) **+**
  - Congestion forces (location choice) **=**
  - Main outcomes: sectoral production takes place in the most productive regions

- Calibration: replicates SSA economy by early 21st century
  - Crop productivities by early 2000's (FAO-GAEZ)
  - Migration frictions $\leftrightarrow$ internal **+** international migration data go
  - Trade frictions $\leftrightarrow$ international trade flows **+** crop price data go

- Climate change: shock to the crop productivities (end of century)
  - Reshuffles economic activity (and population)

# Main Counterfactual

- Solve for the model's spatial equilibrium with:
  - Population estimates for end of 21 century**+**

  1. Crop suitabilities with C$\Delta$ **-**
  2. Crop suitabilities with (no C$\Delta$)

# Main Counterfactual

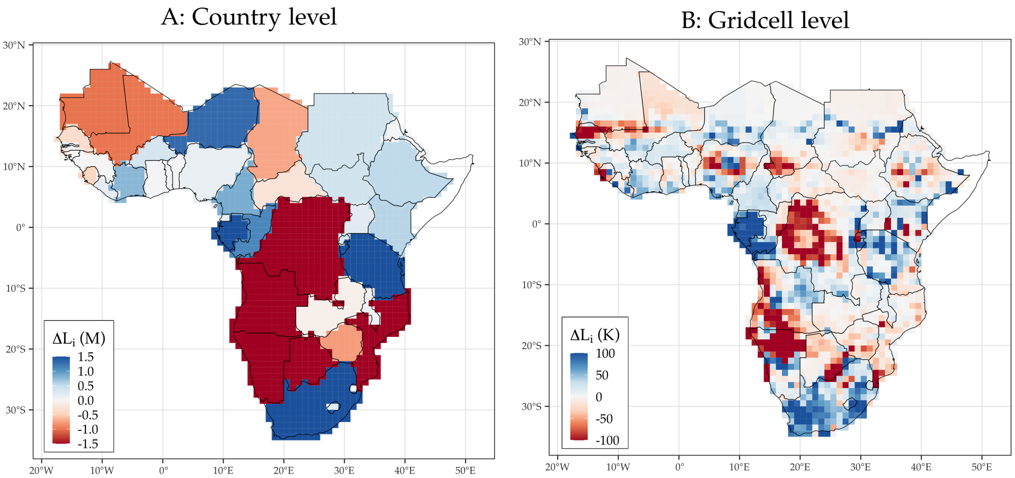
- Solve for the model's spatial equilibrium with:
  - Population estimates for end of 21 century**+**

1. Crop suitabilities with CΔ **-**
2. Crop suitabilities with (no CΔ)

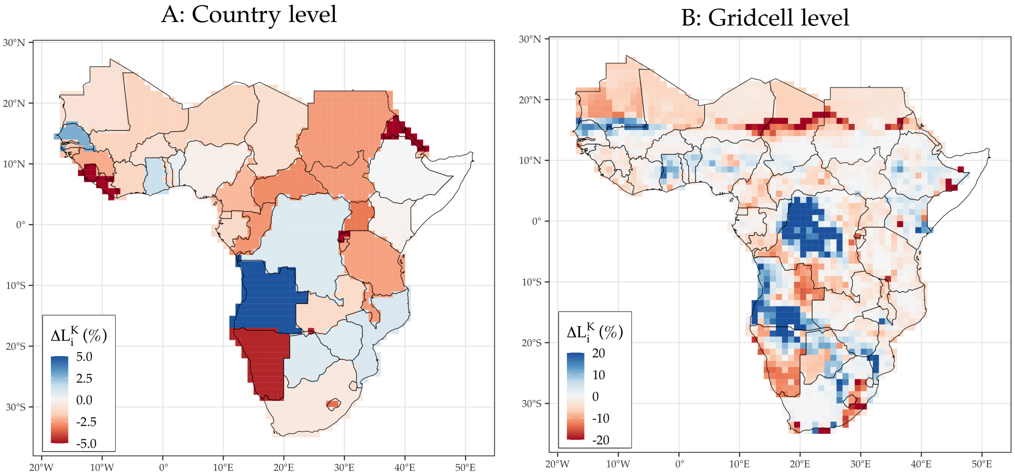
- Results: CΔ migration ($\sim$ 22 million), welfare losses (real GDP pc $\downarrow$ 1.7%), non-agricultural employment ($\downarrow$ 0.82%)

| | | Location Level | | | Country Level | | | |
|---|---|---|---|---|---|---|---|---|
| | Aggregate | Bottom decile | Median | Top decile | Angola | Senegal | Nigeria | Tanzania |
| Δ Population (K) | 22,315.27 | -108.05 | -0.63 | 94.59 | -1,686.26 | -347.16 | 133.24 | 2,760.20 |
| Δ Non–agric. | -0.82 | -10.89 | -1.40 | 16.16 | 4.92 | 2.78 | -0.31 | -2.53 |
| Δ Real GDP pc | -1.76 | -22.86 | -3.76 | 4.56 | -16.60 | -32.81 | -1.11 | 2.50 |

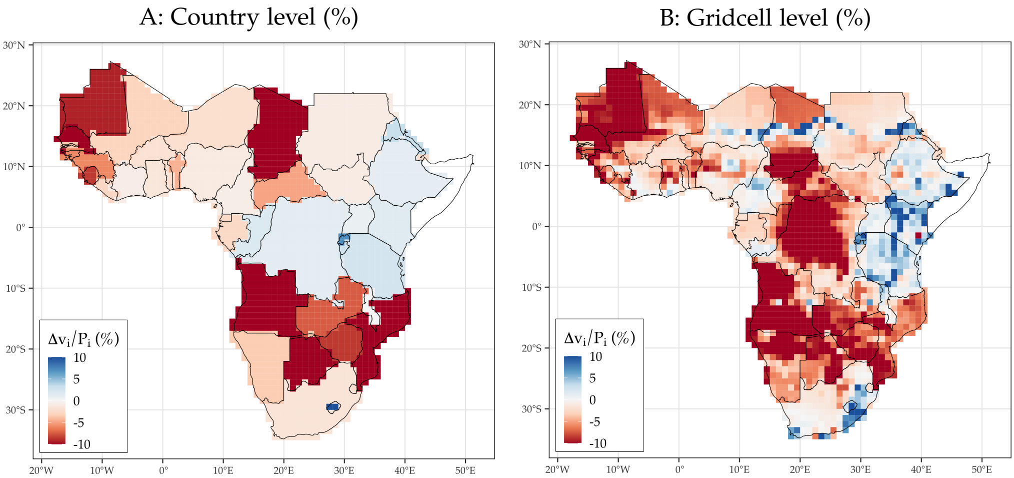
Figure 2: Climate migration in SSA – baseline results for 2080



## Figure 3: Climate change impact on non-agricultural employment



# Figure 4: Climate change impact on real GDP per capita



# Policy Experiment: SSA as frictionless as the European Union

A. Trade, Migration, and Sectoral Specialization: mitigating role

- Trade: attenuates "the food problem" (Gollin et al., 2007; Nath, 2022)
- Trade and migration: subsitutes as adaptation (Conte et al., 2021)
- Migration: key adaptation (Cruz and Rossi-Hansberg, 2023)

B. Policy Experiment: SSA as the European Union (trade/migration policies)

| | | SSA as frictionless as the EU | | |
|---|---|---|---|---|
| | Baseline | Migration Policy | Trade Policy | Both |
| Δ Pop. (M) | 22.32 | 34 | 9.18 | 20.46 |
| Δ Non–agric. (%) | -0.82 | -0.54 | -0.84 | -0.76 |
| Δ GDP pc (%) | -1.76 | -1.01 | -1.31 | -1.41 |
| [bottom, top] | [-14.62; 3.27] | [-11.32; 4.69] | [-6.32; 3.69] | [-5.64; 3.35] |

EU vs SSA spatial frictions | Alternative welfare measures | Level CΔ effects

# Additional Experiments, Extensions, and Robustness Checks

1. One-crop vs. multi-crop: larger welfare losses
2. Homothetic preferences: major welfare gains
   - Economy substitutes out agricultural consumption for non-agriculture
3. Endogenous fertility: reduces population growth in damaged locations
   - Less climate migration
4. Rest of the World: larger migration flows and welfare losses
   - Attenuated if reducing migration and trade barriers with ROW
5. Productivity growth: attenuates welfare losses; ambiguous migration effects
6. Alternative climate damages: (amenities, non-agric.) mildly magnifies effects
7. C$\Delta$ assumptions: weaker effects with RCP 4.5 (less severe)

# Final Remarks

# Final Remarks

- Study and quantify climate migration in SSA by combining:
  - Rich spatial data for SSA
  - Tractable, transparent spatial GE model
- Main results: C$\Delta$ effects on migration, welfare, and structural change
  - Sector adaptation and trade: key adaptation mechanisms
  - Trade and migration policies: powerful mitigation tools (EU as benchmark)

**Thank you!**

bruno.conte@upf.edu

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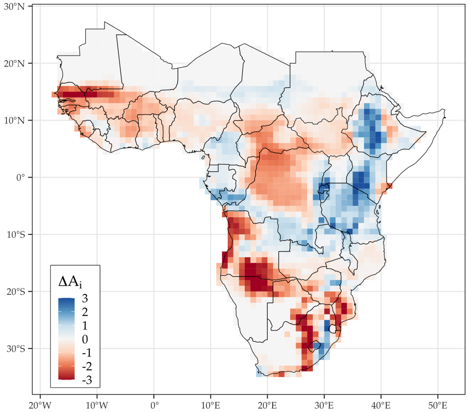
# Appendix

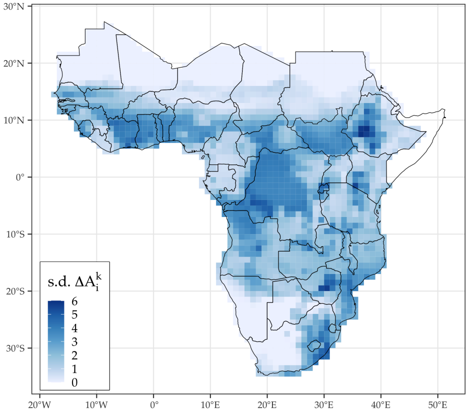
# Heterogeneous Effects of CΔ

back

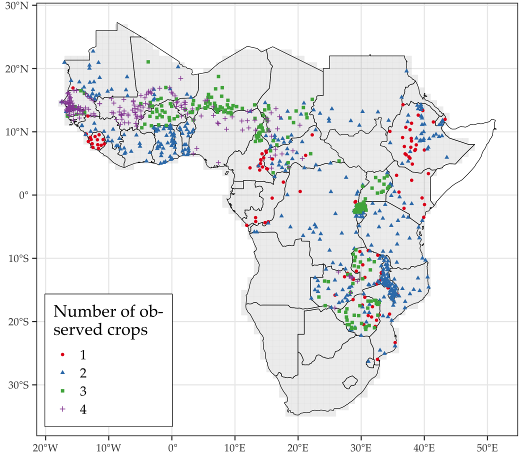
A: Change in average suitability to agriculture (ton/ha)




B: Standard deviation of changes in crop suitabilities at the location level



# Newly Collected Price Data back



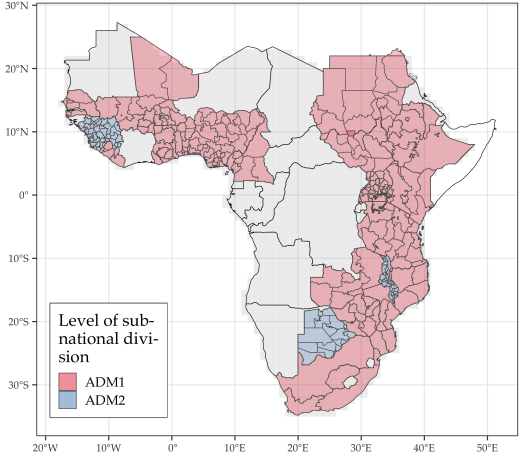

Crop price data from WFP-VAM project (FAO):

- $\sim$ 40 countries and 900 markets (coordinates)
- 4 crops: maize, millet, sorghum, rice
- Covers 2000–2018

No origin-destination structure: use price dispersion to pin down $\delta$

# Newly Collected Migration Data

back

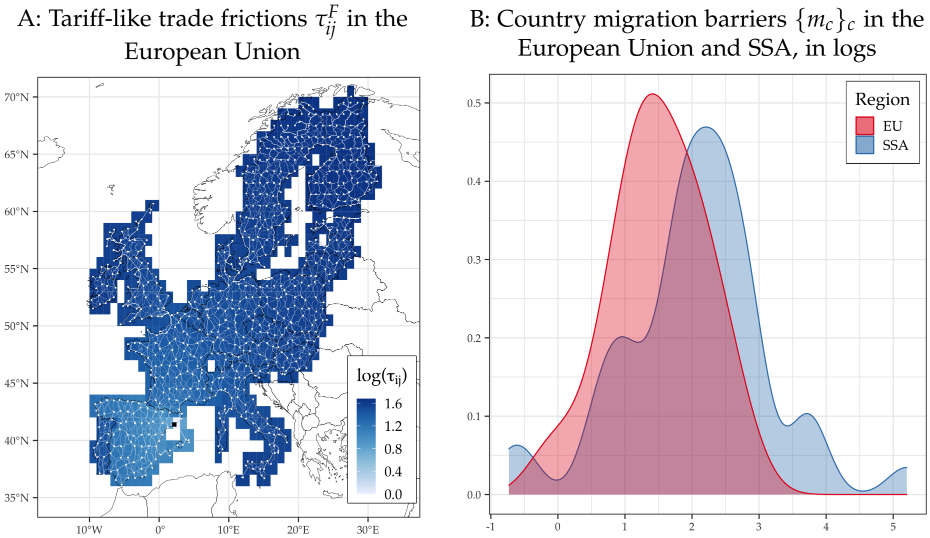



Internal migration data from IPUMS (census):

- $\sim$ 24 countries, 40 years
- Individual-level data ($\sim$ 17 mi obs.)
- Aggregated at admin $\times$ admin level

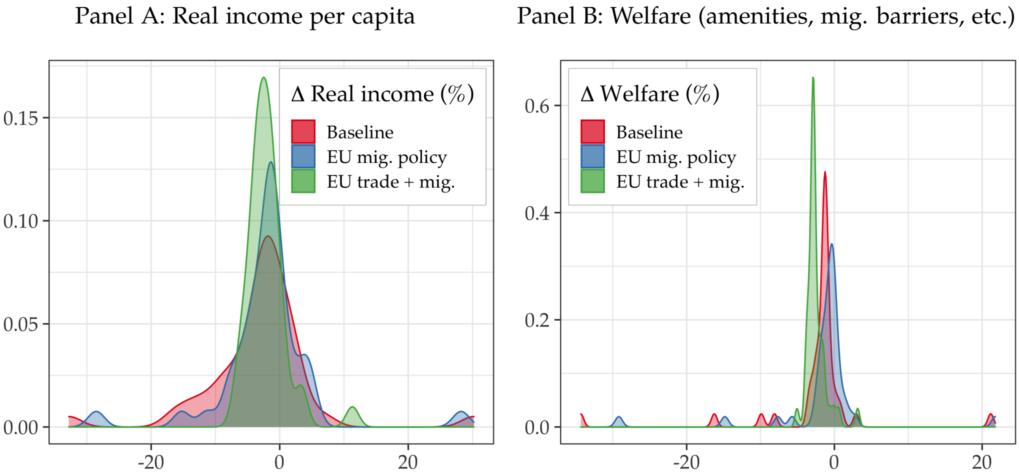
Identification: total internal migration to pin down $\phi$

Figure 5: Estimated trade and migration frictions in the European Union back




**Notes:** Panel A presents trade frictions in the EU as done for SSA in **??** (in this context, trade frictions are relative to Barcelona (Spain), represented by the black dot). Panel B plots the distribution of country migration barriers $\{m_c\}_c$ in SSA and the EU.

Figure 6: Welfare effects of climate change for the baseline and different EU policies back




**Notes:** Panel A and B plot the country-level distributions of welfare in three different policy scenarios for SSA: baseline, EU migration policy, and EU trade and migration policy. Panel A refers to the baseline welfare measure (real income per capita). Panel B refers to an alternative welfare measure that also account for mobility barriers and congestion.

| | (1) With climate change | (2) No climate change | (3) Climate change effect (%) |
|---|---|---|---|
| *Panel A - Welfare $W_R$:* | | | |
| Baseline | 1.01 | 1.00 | 1.16 |
| EU mig. policy | 0.88 | 0.87 | 1.18 |
| EU trade policy | 1.65 | 1.69 | -2.12 |
| Both policies | 1.84 | 1.90 | -3.32 |
| No mig. barriers ($\bar{m}_{ij} = 1$) | 5.34 | 5.39 | -0.89 |
| *Panel B - Real income per capita $v_j/P_j$:* | | | |
| Baseline | 0.98 | 1.00 | -1.76 |
| EU mig. policy | 1.18 | 1.19 | -1.01 |
| EU trade policy | 1.35 | 1.36 | -1.31 |
| Both policies | 1.63 | 1.65 | -1.41 |
| No mig. barriers ($\bar{m}_{ij} = 1$) | 1.32 | 1.32 | -0.66 |

**Notes:** Columns 1 and 2 document the aggregate welfare and real income in levels normalized to the baseline, no climate change scenario. Column 3 refers to their percentage difference. back