Climate change, internal migration and depopulation: evidence from global census data

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The causes and consequences of depopulation
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In many regions of the world, changes in environmental and climatic conditions are linked to migration dynamics and human mobility.

Strength and direction of the relationship depend on local conditions and type and intensity of the experienced environmental influences.

Source: Hoffmann et al. (2020), Nature Climate Change
Estimating the impact of gradual aridification and desertification processes on internal migration flows worldwide.

Using novel data source on bilateral internal migration flows from 68 countries based on harmonized IPUMS International census data.

Exploring mechanisms and differences across contexts to understand who migrates, under which conditions, and to which locations.

Approach closely related to Garcia et al. 2015: “Modeling internal migration flows in sub-Saharan Africa using census microdata”, Migration Studies.
Already today, large parts of the world are characterized by aridity and high temporal and spatial rainfall variability.

Drylands comprise more than 40% of the global terrestrial area and are home to around 3 billion people or one third of the global population.

Source: IPCC (2019), Special Report on Climate Change and Land
Climate change is expected to further increase aridity, potentially contributing to a further expansion of drylands (together with human factors).

Increased aridity and land degradation can have severe socioeconomic impacts.

Strong impacts expected on food security, poverty, and biodiversity (all with high confidence).

Source: IPCC (2019), Special Report on Climate Change and Land
Data

- **IPUMS International** as primary data source providing harmonized census data from more than 100 countries worldwide.

- **Construction of migration measure:**
  - Information on subnational region of residence.
  - Census question: Which region did you live in 1/5 years ago?
  - How many people have migrated from region A to B in past 1/5 years?

- **Unit of analysis**: Geo1 census regions over time.

- **Climate data** on desertification trends from CGIAR, the Copernicus Programme, and CRU.
Regional sample

1284 Geo1 census regions
68 countries
188 censuses

Time series:
Census data available from 1960 to 2015
~98000 bilateral flows
Regional sample

Data availability

Climate change, desertification and internal migration
Measurement

- **Outcome:** Annual out-migration rate

- **Measures for aridification:**
  - Aridity Index (AI), average past 10 years
  - Normalized Density Vegetation Index (NDVI), average past 10 years
  - Standardised Precipitation Evapotranspiration Index (SPEI), average past 10 years

- **Controls:**
  - Population size (origin and destination)
  - Census interval for migration measurement (1 vs 5 years)
\[
\ln \left( \frac{N_{ij,t}}{N_{ii,t}} \right) = \beta C_{it} + \theta C_{jt} + \gamma Z_{ij,t} + \alpha_i + \delta_j + \theta_t + \varepsilon_{ij,t}
\]

- \( N_{ij,t} \): Annual outmigration rate (relative to origin population)
- \( N_{ii,t} \): Annual inmigration rate (relational to total population)
- \( C_{it} \): Climatic conditions in origin in past 10 years (standardized)
- \( C_{jt} \): Climatic conditions in destination in past 10 years (standardized)
- \( Z_{ij,t} \): Further census specific controls
- \( \alpha_i \): Origin fixed effects
- \( \delta_j \): Destination fixed effects
- \( \theta_t \): Time period effects (5 year intervals)
- \( \varepsilon_{ij,t} \): Random error term
## Baseline PPML models

<table>
<thead>
<tr>
<th>Outcome: Annual out-migration rate</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI (mean past 10y)</td>
<td>-0.1456*** (0.03627)</td>
<td>-0.1582*** (0.03318)</td>
</tr>
<tr>
<td>NDVI (mean past 10y)</td>
<td>-0.05221*** (0.01113)</td>
<td>-0.7934*** (0.0666)</td>
</tr>
<tr>
<td>SPEI (mean past 10y)</td>
<td>-0.8452*** (0.0706)</td>
<td>-0.7015*** (0.0467)</td>
</tr>
<tr>
<td>log(population origin)</td>
<td>-0.8452*** (0.0706)</td>
<td>-0.7015*** (0.0467)</td>
</tr>
<tr>
<td>log(population destination)</td>
<td>0.1872*** (0.0590)</td>
<td>0.1138** (0.0537)</td>
</tr>
<tr>
<td>Census interval</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time FE</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Origin FE</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Destination FE</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>S.E.: Clustered by: origin</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>98,868</td>
<td>95,276</td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>0.20017</td>
<td>0.16484</td>
</tr>
<tr>
<td>BIC</td>
<td>32,415.70</td>
<td>31,511.60</td>
</tr>
</tbody>
</table>

Significant and sizeable effects of aridification on outmigration

1 SD increase in aridity in a region leads to a 14.6% increase in the outmigration rate

Poisson Fixed effects models. Coefficients in cells with clustered standard errors in parentheses. *** p< 0.01, ** p<0.05, * p<0.01
Effect size heterogeneity

Climate change, desertification and internal migration
Spatial patterns in relationships

Climate change, desertification and internal migration
Differential migration impacts

(a) Migration impacts by education
- Less than primary
- Primary completed
- Secondary completed
- Tertiary completed

(b) Migration impacts by age groups
- Age 0-14
- Age 15-29
- Age 30-44
- Age 45-60
- Age 60+
Conclusion and Discussion

- Study on impacts of aridification as gradual environmental change on internal migration using novel global data on bilateral internal migration flows
- Findings indicate **meaningful migration impacts**, but also considerable differences across regions depending on environmental and socio-economic conditions

**Limitations:**
- Broad migration measure
- Not accounting for circular migration
- International migration flows not captured

**More comparative evidence** needed that allows understanding some of the underlying mechanisms of environmental migration and its impacts on depopulation
Thank you for your attention!

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Migration in Sub-Saharan Africa

Internal migration in Africa
Rates based on last available census for each country. Year in parentheses

South Africa (2016)
Morocco (2004)
Botswana (2011)
Guinea (2014)
Senegal (2013)
Togo (2010)
Kenya (2009)
Cameroon (2005)
Zambia (2010)
South Sudan (2008)
Sudan (2008)
Tanzania (2012)
Mozambique (2007)
Mali (2009)
Zimbabwe (2012)
Benin (2013)
Ghana (2000)
Malawi (2008)
Uganda (2014)

Outmigration rate (weighted)

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