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**Document name: REF3**

**Link:** [**https://www.science.org/doi/10.1126/science.aao0432#BIBL**](https://www.science.org/doi/10.1126/science.aao0432#BIBL)

International negotiations on climate change, along with recent upsurges in migration across the Mediterranean Sea, have highlighted the need to better understand the possible effects of climate change on human migration—in particular, across national borders. Here we examine how, in the recent past (2000–2014), weather variations in 103 source countries translated into asylum applications to the European Union, which averaged 351,000 per year in our sample. We find that temperatures that deviated from the moderate optimum (~20°C) increased asylum applications in a nonlinear fashion, which implies an accelerated increase under continued future warming. Holding everything else constant, asylum applications by the end of the century are predicted to increase, on average, by 28% (98,000 additional asylum applications per year) under representative concentration pathway (RCP) scenario 4.5 and by 188% (660,000 additional applications per year) under RCP 8.5 for the 21 climate models in the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP).

a 2015 study has shown that the unrest in Syria was preceded by a record drought that led to lower agricultural yields and forced farmers to migrate to urban areas (2). Although that study does not attribute the Syrian conflict to the drought, the authors argue that it added another stressor.

Two centuries ago, the “year without a summer” (1816), following the volcanic eruption of Mount Tambora in Indonesia, saw massive crop failures throughout the Northern Hemisphere, caused by the aerosol-obscured atmosphere and unseasonal climate. It triggered sizeable migrations as peasants deserted their fruitless farms (7).

Migration’s response to income or wealth corresponds in an inverted U shape: Pos- itive income shocks in the home country enable individuals to overcome liquidity constraints and finance migration costs (8). Richer households are not liquidity-constrained and show a negative migration-income relationship as improving con- ditions at home make it less desirable to leave (9)

Recent research (12) sug- gests that, in agricultural production areas, there should be a negative relationship between eco- nomic conditions and conflict, which then trans- lates into asylum applications.

In other words, we link anomalies in log applications to weather anomalies once common annual shocks are absorbed (e.g., the global financial crisis in 2008).

Our specification examines whether hotter-than-normal temper- atures will increase or decrease asylum applica- tions from a given source country. Because our dependent variable is in logs, we estimate relative impacts, which is preferable as the number of ap- plications differs greatly among source countries in absolute terms.

We allow the effect to vary by the average weather variable: Hotter-than-usual temperatures can reduce asylum applications for cold countries and increase them for hot countries. Our model includes both average tem- perature and precipitation. The coefficients and standard errors are given in table S1.

We find a statistically significant relationship between fluctuations in asylum applications and weather anomalies: Applications are lowest for average temperatures around 20°C and increase if the weather is too cold or too hot. A graph showing the difference between temperature and the temperature

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The coefficients on temperature are displayed in Fig. 1. We show a quadratic response function (dashed brown line), as well as flexible restricted cubic splines (solid brown line). Both use the contemporaneous average temperature in the source country, averaged over the maize growing area and season.

Because the re- gression is in log points, a y value of 1 implies an increase of 100 log points, or a e1 = 2.72-fold increase in the number of applications.

Total precipitation, on the other hand, is not an important predictor of migration, consistent with previous research on conflict that indicates that temperature, as opposed to precipitation, is a stronger predictor of conflict (15).

predicted changes under the 21 global climate models in the NEX-GDDP (NASA Earth Exchange Global Daily Downscaled Projections) CMIP5 (Coupled Model Intercomparison Pro- ject phase 5).

The likelihood of an in- crease in applications is shown as a blue line in Fig. 2 (right y axis) and ranges from 85% under +1°C warming to 99% under both +4° and +5°C warming. The change in the volume of applica- tions is highly nonlinear: A 1°C warming results in a relative modest 6% increase in applications, but a 5°C warming leads to a 175% increase.

Asy- lum applications are predicted to increase, on average, by 28% under representative concentra- tion pathway (RCP) scenario 4.5 and 188% under RCP 8.5 by the end of the century

These predictions are ceteris paribus. On the one hand, they might overstate the responsive- ness, as the model uses historic weather shocks to identify the relationship while we apply it to a permanent warming scenario in which coun- tries can engage in adaptive responses (e.g., shift- ing the growing season). On the other hand, these predictions might also be underestimates, as historic weather shocks are small enough in size that they likely do not capture disruptive events (such as major civil unrest) in case of continuous warming.

There are several likely mechanisms behind the sensitivity of fluctuations in asylum applica- tions to temperature anomalies. First, there is a strong nonlinear relationship between agricul- tural yields and temperature.

Second, gross domestic product (GDP) growth rates have been found to be very sensitive to temperature, even on the nonagricultural components of the GDP and even in industrialized countries (19, 20).

We do find that the weather-induced spikes in applications trans- late into roughly three times higher acceptance rates in the following two years (see supplementary text section 2.4 for more detail), suggesting that destination countries classify the additional cases as more deserving than the average applicant and see them as refugees and not economic migrants.

wonder whether these additional applications are caused by heightened persecution or just by changing economic conditions, with both being credible intermediates in a causal chain link- ing weather anomalies and demand for asylum.

In summary, we link annual asylum applica- tions received by the EU member states to average temperature over the maize growing area and season in the source country and find a nonlinear relationship, especially for those applications filed into the richer EU member states. Moderate tem- peratures around 20°C minimize asylum appli- cations. Both colder and hotter temperatures increase migration flows. Extrapolating those results, an increase in temperatures in source countries is predicted to lead to an increase in asylum applications to the EU as well, follow- ing a highly nonlinear response function.

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An annual average of 21.5 million people have fled their homes because of sudden weather-related onset hazards—such as floods, storms or wildfires—since 2008 [IDMC (2016)].

A 2018 World Bank Group report, for instance, finds that climate change might push over 140 million people in sub-Saharan Africa, South Asia, and Latin America to migrate within their countries by 2050 [Rigaud et al. (2018)].

Cai et al. (2016), for instance, find that long-term warming induces out-migration only in agricultural-dependent countries, while Cattaneo and Peri (2016) conclude that it reduces migration in extremely poor countries, which are exactly the ones likely to depend strongly on agriculture.

* Are my top 10 countries agricultural-dependent?

Furthermore, findings vary with the migration measure (flows vs. stocks), the type of climatic factors (e.g., sudden vs. slow onset, or rainfall vs. temperature), the sample under consideration (geographical region, time period), as well as the estimation strategy. Yet, as the costs of migration and other sorts of adaptation considerably differ across regions and countries, we do not expect to find the same effects and patterns in all parts of the world. Beine and Jeusette (2018) indicate that the effect of climatic shocks on the propensity to move might depend on the level of development [see also Cattaneo and Peri (2016)], the type of economic activity [Cai et al. (2016)], available adaptation mechanisms and external options. Berlemann and Steinhardt (2017) also add that formal (e.g., labor market) and informal institutions (e.g., religion, marriage habits, etc.) can have important effects on the magnitude and pattern of environmental migration.

Our study goes beyond the state of the art by exploiting an innovative source of individual-level data, the GWP, which provide information on people’s stated migration intentions and their self-reported exposure to environmental stress for a large number of countries. This allows for a comprehensive micro-level analysis in which structural regional differences can be isolated from those related to the chosen research design [the ideal methodological setup put forward by Berlemann and Steinhardt (2017)].

* Look into GWP (Global warming potential)
* Whether they intend to move in the next 12 months
* Asya’s question: How long does it take a climate refugee to migrate?

the GWP use a stronger formulation which directly asks for the likely response under ideal conditions [Manchin and Orazbayev (2018); Ruyssen and Salomone (2018)] (see section 3.1 for more details).

Yet, as the number of domestic migrants worldwide is roughly three times that of international migrants [IOM (2015)], such an omission might be quite serious [Dustmann and Okatenko (2014)].

Understanding how climate change induces domestic and international migration flows is hence important for policymakers in sending countries, but it is equally relevant for policymakers in destination countries.

Yet, the optimal policy response depends on expected migration dynamics: (i) in countries where internal migration is the most prevalent, sustaining urban development (SDG11) is key; (ii) in countries where short-distance international migration is frequent, regional integration is desirable; and (iii) in countries with high rates of long-distance migration, partnership with OECD countries is advisable.

* Why?

Our estimation results indicate that self-reported exposure to environmental stress is associated with a higher probability of intending to migrate within the next 12 months both within and across national borders.

* Asya’s question: How long does it take a climate refugee to migrate?

We find a significant positive impact of self-reported environmental stress on migration intentions towards all three destination types (domestic, intraregional, and towards the OECD) though the effect is most pronounced for intending to migrate intraregionally. In fact, the increase in the probability of intending to migrate due to environmental stress is largest for domestic migration (in absolute terms), but correcting for the fact that this is by far the most common form of migration, this is a smaller change than that obtained for intraregional migration (in relative terms).

Our results indicate that domestic migration intentions in the face of environmental stress are higher for high skilled individuals living in urban areas with a higher household income per capita, while low skilled individuals living in rural areas with lower household income per capita are more inclined to respond to environmental stress by moving intraregionally.

* From which economic strata does the climate refugee come from?

Given that environmental conditions in nearby areas are likely to be strongly correlated, the optimal coping strategy for these individuals concerns longer-distance (cross-border) migration to escape these harsh local conditions, though these movements typically occur within the same subcontinent.

Intentions to migrate towards the OECD following environmental stress are, in contrast, particularly larger among the high skilled living in urban areas with a relatively high household income per capita. But the likelihood to intend to migrate towards the OECD is significantly higher for those having experienced environmental stress in Latin America and the Caribbean.

A breakdown by countries’ development level, finally, reveals that in low- and middle-income countries, environmental stress primarily leads to more intraregional migration, while in high-income countries, and in Europe in particular, it seems to foster only domestic migration intentions.

The rest of the paper is structured as follows. Section 2 describes the various strands of literature to which our paper is related. Section 3 discusses the data that we use in the empirical analysis and provides descriptive statistics on migration intentions as well as exposure to environmental stress. Section 4 provides the theoretical foundations for our empirical analysis. Section 5 describes the econometric analysis and estimation results. Section 6 concludes.

2. Related Literature

A rapidly growing body of literature empirically analyses the relationship between environmental factors and human migration. Climate has been shown to interact and work on migration behavior through a variety of direct and indirect transmission channels, including through income [Beine and Parsons (2015); Coniglio and Pesce (2015); Cattaneo and Peri (2016)], crop production and subsequent food security [Gray and Mueller (2012b); Cai et al. (2016); Jacobson et al. (2019)], amenities [Marchiori et al. (2012)], urbanisation [Marchiori et al. (2012); Maurel and Tuccio (2016)] and violence [Abel et al. (2019)].

* Variables to consider for migration: Income, crop production and subsequent food security, amenities, urbanization, and violence.

The diversity in outcomes is hence not surprising, given the widely varying research methodologies used and the many different contexts in which the climate-migration nexus has been studied.

and also in Latin America, the number of people affected by natural disasters, such as flooding, forest fires, and tropical storms, is not to be underestimated [Robalino et al. (2015); IDMC (2016)].

* Natural disasters in Latin America

They make reference on many country-specific immigration in many papers:

An important advantage of these studies, however, is that they allow to explore individual heterogeneity in migration decisions depending on age, gender, level of education, wealth, etc. [Black et al. (2011b)]

Look for paper:

Thiede, Brian, Clark Gray and Valerie Mueller (2016) Climate variability and inter-provincial migration in

South America, 1970–2011. Global Environmental Change 41, 228–240.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5389124/>

Cross-country studies, on the other hand, typically consider a larger group of countries and time span, which allows to estimate the overall impact of climate change on migration for the countries under study (as well as to explore heterogeneous effects across groups of countries).

The migration response to environmental stress has been shown to depend on countries’ development level [Cattaneo and Peri (2016); Gröschl and Steinwachs (2017); Beine and Parsons (2017)] and their agricultural dependence or main type of economic activity [Marchiori et al. (2012); Cai et al. (2016); Falco et al. (2018)]. Cai et al. (2016)

Yet, these cross-country studies rely on the assumption that every resident of a country is affected by environmental factors in the same way, and they typically focus only on international migration, thereby ignoring domestic population movements.10

**Perceptions of people to climate change**

In that light, Koubi et al. (2016b) argue that “perceptions of risk can act as a mediating factor between environmental stress and migration [Meze-Hausken (2008); Black et al. (2011a, 2011b); Hunteretal. (2015)]. The reason is that environmental perception is the means by which individuals seek to understand their environment in order to arrive at the most effective response to environmental hazards given their individual and household level circumstances.”

Also, Parsons (2019) explicitly states that a focus on how the climate is experienced brings meaning to mobility as no two people experience climate change in the same manner due to a variety of objective (i.e., economy, demography, etc.) and subjective realities (norms, emotions, and culture). Understanding individual environmental experience and perceptions can thus help explain migratory movements in response to these changes.

Look into this paper:

Docquier et al. (2014), disentangle the role of macroeconomic determinants of migration intentions aggregated at the country level, as well as the probability that these intentions translate into actual migration.

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**Document name: REF6**

**Link:** [**https://repositorio.cepal.org/server/api/core/bitstreams/7cd75817-9d2b-4ec4-a7e9-88645eb247d3/content**](https://repositorio.cepal.org/server/api/core/bitstreams/7cd75817-9d2b-4ec4-a7e9-88645eb247d3/content)

in 2023, the summer season in the northern hemisphere (June, July and August) was the warmest on record, 0.66°C above the 1991–2020 average.

From 2011 to 2020, the average land surface temperature was 1.1°C higher than in 1850–1900; increases were greater over land (1.6°C) than over the ocean (0.9°C) (IPCC, 2021)

more than 50% of Mexico has been affected by severe to exceptional drought (WMO, 2023).

In addition, climate change is projected to exacerbate eight key risks in the region (IPCC, 2022a):

(i) Risk of food insecurity owing to more frequent or extreme droughts.

(ii) Risk to life and infrastructure owing to flooding and landslides.

(iii) Risk of water insecurity.

(iv) Risk of severe health impacts owing to increasing epidemics, particularly vector-borne diseases.

(v) Systemic risks of surpassing infrastructure and public service systems.

(vi) Risk of large-scale changes and biome shifts in the Amazon.

(vii) Risk to ecosystems associated with coral reefs, owing to coral bleaching.

(viii) Risks to socioecological systems in coastal areas owing to sea level rise, storm surges and

coastal erosion.

Changes in the climate system have negative effects on economic activities, ecosystems and human well-being.1 There are several recent estimates of the global economic impact of climate change (see figure 2). These estimates, which differ in terms of scope, methodology and time horizon, show that the impact of climate change on per capita GDP would range from 4.6% to 30% by 2100, under a high-emissions scenario. Estimates for 2030 already show a loss of between 0.8% and 5% of per capita GDP (Alatorre and Fernández, 2022).

A graph of a graph with numbers and a green bar

Description automatically generated with medium confidence

Estimates for Latin America and the Caribbean show that, depending on the study, the decline in per capita GDP would be between 0.8% and 6.3% by 2030, and up to 23% in 2050 (see figure 3). Van Der Borght and others (2023) estimate that factoring in temperature increase alone already indicates lasting negative effects on economic growth. In a high-emissions scenario this would lead to a reduction of 1.3% and 3.3% in per capita GDP in 2030 and 2050, respectively, relative to a scenario with no temperature increase (Van Der Borght and others, 2023), which could result in a 3.2 million increase in people living in poverty (ECLAC, 2022a). To this calculation must be added the effects of extreme weather events such as droughts, storms and hurricanes or price shocks linked to disorganized transitions in the energy, transport and food markets. The impact among countries is mixed (see figure 3).2

For Latin America and the Caribbean, an additional 1°C translates into a loss of 1 percentage

point in per capita growth (Van der Borght and others, 2023).

This would have an impact on productivity and, therefore, long-term economic performance.